THE ACQUISITION AND ANALYSIS OF CRANIOFACIAL DATA IN THREE DIMENSIONS

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A thesis submitted for the degree of Doctor of Philosophy

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December 1988

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PREFACE

All coordinate positions and distances are in units of millimetres.

All angles are in units of degrees.

Table entries of 999.99 indicate that the parameter was not measured or determined.

Table entries of 0.000 for standard deviations indicate that there was only one measurement for the population.

For definitions of landmark abbreviations and numerical assignments see Tables 2.13 (a) and (b) and 3.3 (a) and (b).

Table 2.1   Equipment and projection parameters of the radiographic setups at both hospitals.

	ADH	ACH
Equipment		
Tube 1		
. Unit	Philips[1], Medio 30	Siemens[2], Cephoralix
. Filter	1mm Aluminium	1mm Aluminium
Tube 2		
. Unit	-	Siemens[2]
. Filter	-	1mm Aluminium
. Header Holder	Lumex[3]	Cephoralix[2]
. Film	Kodak[4] Ortho G	Dupont[5] Cronex-7
. Screen	Kodak[4] Lanex Fine	Kodak[4] Rare Earth
. Anti-Scatter	36/cm stationary ratio 1: 8	36/cm stationary ratio 1: 8
. Processing/Processor	Automatic* in Kodak[4] RPX-Omat	Automatic* in Dupont[5] QCI/T6 90 sec.
Projection Parameters		
dist. Source to Film	1977mm	1362mm
dist. Source to MSP[++]	1817.5mm (8.8%)[+]	1207mm (12.8%)[+]
dist. Source to Film	1977mm	1345mm
dist. Source to TPP**	1817.5mm (8.8%)[+]	1190mm (13.0%)[+]

[1] Philips, Holland   [2] Siemens, West Germany   [3] Lumex, Copenhagen

[4] Kodak, U.S.A.   [5] Dupont, Wellington, Delaware, U.S.A.

* processing conditions as recommended by the manufacturer   [+] percentage enlargement

[++] Mid-Sagittal Plane   ** Trans-Porionic Plane

Table 2.2   Adelaide Dental Hospital radiographic equipment modifications.

Modification	Description
· Fiducial Backing Plate	An acrylic alignment sheet, containing three metal spheres (diameter = 0.7mm) used as fiducial markers, for aligning pairs of radiographs (Figure 2.6 (a)). The sheet was placed as close as practicable to the film to minimize magnification, and was rigidly mounted so that it could not be moved when either changing cassettes or the orientation of the test objects (Figure 2.6 (b)).
· Levelling Device	Three orthogonal levels with head band.This was employed when simultaneous exposures of two films was not possible. The levelling device enabled the user to ensure that the position of dry skulls (or patients) within the head holder remained orthogonal between exposures (Figure 2.7).
· Brass Rings	Two brass rings with an internal diameter equal to 5.90mm and 11.70mm respectively (Figure 2.8 (a)), which could be fitted over the left and right ear rods (Figure 2.8 (b)). These were used to check the alignment of the anode with the ear rods. If the shadows of the brass rings were concentric on the film, this was taken to indicate satisfactory alignment of the central beam projection with the cephalostat (Figure 2.8 (c)).

Table 2.3 Adelaide Children's Hospital radiographic equipment modifications.

Modification	Description
· Oil Damped Plumb Bob	A plumb line with four affixed metal markers was immersed into an acrylic tube partially filled with oil. The plumb line and markers appear on both films and enable the vertical to be determined and the two radiographs aligned (Figure 2.9).
· Height Fixing Rod	Brass rod with fixing screw. As the ACH biplanar setup is not dedicated equipment, the brass rod enables the user to accurately reposition the anodes to the same horizontal height (Figure 2.10).
· Brass Rings	Two brass rings with an internal diameter equal to 5.90mm and 11.70mm respectively (Figure 2.8 (a)), which could be fitted over the left and right ear rods (Figure 2.8 (b)). These were used to check the alignment of the anode with the ear rods. If the shadows of the brass rings were concentric on the film, this was taken to indicate satisfactory alignment of the central beam projection with the cephalostat (Figure 2.8 (c)).

Table 2.4   Description of the cephalometric coordinate data collection programs used in this study.

Cephs 3D 3

This Apple II Basic program accesses the real space coordinates of each landmark, created by Cephs 3D5 and stored on diskette, and calculates optionally the distance between any two named landmarks or all the distances between the collected landmarks.

Cephs 3D 4

This Apple II Basic program utilizes an IEEE interface between the Apple II Plus[1] computer and a HP[2] 9872A flat-bed plotter. Three dimensional plots are produced with options to vary pen colour, viewing distances, object rotation, and type of projection (orthographic or perspective view).

Cephs 3D 5

This Apple II Basic program controls the Digitizer HP-9874A, Plotter 9872A, and C-ITOH Dot Matrix Printer. The program firstly performs the appropriate alignment procedure as outlined in Sections 2.4.2.1 and 2.4.2.2. It then collects and stores digitized data from the lateral and coronal tracings and optionally uses the prediction method to produce the three dimensional coordinates. Collected data is simultaneously plotted for later verification. A table is also printed showing alignment corrections, the two dimensional film coordinates and the calculated three dimensional coordinates.

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[1] Apple Computer, Inc., California, U.S.A.
[2] Hewlett Packard Company, Colorado, U.S.A.

Table 2.5 (a) Mean difference and $d\sqrt{n}/\sigma$-score calculated for the double determination of the digitizing error.

Landmark No.	Mean Residual (mm)			$d\sqrt{n}/\sigma$	n	Landmark Name
	x	y	Magnt			
1	0.008	0.018	0.020	1.235	10	sella
2	-0.002	0.000	0.002	0.089	10	nasion
3	0.018	0.004	0.019	1.020	10	glabella
4	-0.003	-0.013	0.013	0.607	10	vertex
5	-0.007	0.025	0.025	0.842	10	opisthocranion
6	-0.020	-0.010	0.022	1.092	10	opisthion
7	-0.025	-0.018	0.031	1.739*	10	mastoid tip (L)
8	0.005	-0.002	0.005	0.221	10	mastoid tip (R)
9	0.018	-0.033	0.038	1.831*	10	basion
10	0.015	-0.006	0.016	1.386	10	ext aud meatus (R)
11	0.016	0.027	0.032	1.482	10	ext aud meatus (L)
12	-0.002	0.004	0.004	0.207	10	condylion (R)
13	0.005	-0.017	0.018	0.819	10	condylion (L)
14	-0.019	0.008	0.020	1.192	10	articulare (R)
15	-0.020	0.009	0.021	1.513	9	articulare (L)
16	-0.007	0.007	0.010	0.332	10	gonion (R)
17	-0.007	0.004	0.008	0.394	10	gonion (L)
20	0.010	-0.018	0.020	1.374	10	gnathion
21	-0.009	-0.005	0.010	0.468	10	pogonion
22	-0.008	-0.012	0.014	0.810	10	infradentale
24	0.012	0.015	0.019	0.773	9	ant nasal spine
26	0.022	0.001	0.022	1.373	10	upper molar (R)
27	0.014	0.024	0.028	1.129	10	upper molar (L)
28	-0.008	-0.008	0.011	0.638	9	lower molar (R)
29	-0.007	-0.002	0.007	0.329	10	lower molar (L)

* probability less than 5%

Table 2.5 (b) Standard deviation calculated for the double determination of the
digitizing error.

Landmark No.	Standard deviation (mm)			n	Landmark Name
	x	y	Magnt		
1	0.037	0.035	0.051	10	sella
2	0.057	0.060	0.083	10	nasion
3	0.040	0.043	0.058	10	glabella
4	0.043	0.055	0.070	10	vertex
5	0.048	0.082	0.095	10	opisthocranion
6	0.048	0.042	0.064	10	opisthion
7	0.038	0.041	0.056	10	mastoid tip (L)
8	0.056	0.053	0.077	10	mastoid tip (R)
9	0.042	0.050	0.065	10	basion
10	0.023	0.029	0.037	10	ext aud meatus (R)
11	0.037	0.057	0.067	10	ext aud meatus (L)
12	0.052	0.038	0.064	10	condylion (R)
13	0.048	0.050	0.069	10	condylion (L)
14	0.042	0.035	0.054	10	articulare (R)
15	0.032	0.029	0.043	9	articulare (L)
16	0.064	0.075	0.099	10	gonion (R)
17	0.029	0.059	0.066	10	gonion (L)
20	0.025	0.040	0.047	10	gnathion
21	0.047	0.047	0.067	10	pogonion
22	0.044	0.034	0.056	10	infradentale
24	0.045	0.059	0.075	9	ant nasal spine
26	0.039	0.033	0.051	10	upper molar (R)
27	0.037	0.070	0.079	10	upper molar (L)
28	0.020	0.050	0.054	9	lower molar (R)
29	0.055	0.036	0.065	10	lower molar (L)

Table 2.5 (c) Digitizing reproducibility calculated from the double determination.

Landmark No.	Coordinate (mm)			n	Landmark Name
	x	y	Magnt		
1	0.025	0.027	0.037	10	sella
2	0.038	0.040	0.055	10	nasion
3	0.030	0.029	0.041	10	glabella
4	0.029	0.038	0.048	10	vertex
5	0.032	0.058	0.066	10	opisthocranion
6	0.035	0.029	0.046	10	opisthion
7	0.031	0.030	0.044	10	mastoid tip (L)
8	0.038	0.036	0.052	10	mastoid tip (R)
9	0.031	0.041	0.051	10	basion
10	0.019	0.020	0.027	10	ext aud meatus (R)
11	0.027	0.042	0.050	10	ext aud meatus (L)
12	0.035	0.025	0.043	10	condylion (R)
13	0.032	0.036	0.048	10	condylion (L)
14	0.031	0.024	0.039	10	articulare (R)
15	0.025	0.020	0.032	9	articulare (L)
16	0.043	0.051	0.067	10	gonion (R)
17	0.020	0.040	0.044	10	gonion (L)
20	0.018	0.029	0.035	10	gnathion
21	0.032	0.032	0.045	10	pogonion
22	0.030	0.025	0.039	10	infradentale
24	0.031	0.041	0.052	9	ant nasal spine
26	0.030	0.022	0.037	10	upper molar (R)
27	0.027	0.050	0.057	10	upper molar (L)
28	0.014	0.034	0.037	9	lower molar (R)
29	0.037	0.024	0.044	10	lower molar (L)

Overall standard deviation of the digitizing error = 0.046 mm

Median standard deviation of the digitizing error = 0.044 mm

Table 2.6   Replicability of the location of the acrylic test object markers using a travelling microscope on two separate occasions.

Marker	x coordinate		y coordinate	
	Difference Det.1 - Det. 2	Average $(x_1 + x_2)/2$	Difference Det.1 - Det. 2	Average $(y_1 + y_2)/2$
1	0.012	-75.99	-0.015	90.66
2	0.011	3.79	-0.007	89.44
3	0.066	83.66	-0.007	88.57
4	0.066	-36.41	-0.005	56.37
5	0.032	-36.67	0.003	39.82
6	-0.010	43.23	0.030	39.15
7	0.016	-77.22	-0.001	-9.36
8	-0.005	2.69	0.014	-10.65
9	-0.018	82.62	0.013	-11.43
10	-0.061	-37.58	0.024	-50.15
11	-0.002	42.27	0.013	-50.93
12	0.049	-78.28	0.022	-89.42
13	-0.004	1.98	0.004	-90.69
14	-0.001	81.92	-0.007	-91.38

N.B. All z components were set to zero as all holes were drilled to a constant depth.

$$\bar{x}_{diff} = \frac{1}{n}\Sigma(x_1 - x_2) \pm \frac{S_{x_{diff}}}{\sqrt{n}} t_{0.975}(13) = 0.011 \pm 0.020 \text{ mm}$$

$$\bar{y}_{diff} = \frac{1}{n}\Sigma(y_1 - y_2) \pm \frac{S_{y_{diff}}}{\sqrt{n}} t_{0.975}(13) = 0.006 \pm 0.008 \text{ mm}$$

Standard deviation of the location of a single point,

$$S = \sqrt{\frac{\Sigma(x^2 diff + y^2 diff)}{2n}} = 0.03 \text{ mm}$$

The mean x and y differences, $\bar{x}_{diff}$ and $\bar{y}_{diff}$ are not significantly different from zero according to the t-test at the 95% confidence level.

Table 2.7 (a) Mean and standard deviation for the residual z coordinate of the acrylic test object metal markers as determined using mode 1.

Marker	Mode 1 Landmark located on both lateral and coronal films					
	Adelaide Dental Hospital			Adelaide Children's Hospital		
	Mean	SD	t	Mean	SD	t
1	-0.086	0.018	- 10.68*	-0.115	0.043	- 7.56*
2	-0.007	0.059	- 0.27	-0.019	0.041	- 1.31
3	0.108	0.074	3.26*	0.182	0.049	10.51*
4	-0.095	0.049	- 4.34*	-0.126	0.051	- 6.99*
5	-0.042	0.041	- 2.29	-0.005	0.050	- 0.28
6	0.075	0.017	9.87*	0.075	0.025	8.49*
7	-0.008	0.057	- 0.31	-0.060	0.045	- 3.77*
8	0.017	0.022	1.73	0.005	0.060	0.24
9	-0.172	0.033	- 11.66*	-0.144	0.057	- 7.15*
10	0.387	0.016	54.09*	0.358	0.057	17.77*
11	0.107	0.041	5.84*	0.064	0.069	2.62*
12	-0.058	0.083	- 1.56	0.072	0.044	4.63*
13	-0.172	0.044	- 8.74*	-0.192	0.049	-11.08*
14	-0.055	0.055	- 2.24	-0.096	0.061	- 4.45*

* probability less than 5%

ADH : n = 5 test angles
ACH : n = 8 test angles

Table 2.7 (b) Mean and standard deviation for the residual z coordinate of the acrylic test object metal markers as determined using mode 2.

Marker	Mode 2 Landmark located on the lateral film and on a contour on the coronal film.					
	Adelaide Dental Hospital			Adelaide Children's Hospital		
	Mean	SD	t	Mean	SD	t
1	-0.075	0.026	- 6.45*	-0.123	0.056	- 6.21*
2	-0.025	0.069	- 0.81	-0.021	0.050	- 1.19
3	0.114	0.086	2.96*	0.190	0.057	9.43*
4	-0.088	0.049	- 4.02*	-0.122	0.062	- 5.57*
5	-0.040	0.051	- 1.75	-0.011	0.067	- 0.46
6	0.068	0.042	3.62*	0.069	0.026	7.51*
7	-0.004	0.050	- 0.18	-0.050	0.061	- 2.32
8	0.031	0.022	3.15*	0.033	0.067	1.39
9	-0.158	0.047	- 7.52*	-0.157	0.058	- 7.66*
10	0.341	0.046	16.58*	0.334	0.064	14.76*
11	0.091	0.024	8.48*	0.071	0.064	3.14*
12	-0.045	0.117	- 0.86	0.064	0.061	2.97*
13	-0.157	0.030	-11.70*	-0.163	0.048	- 9.61*
14	-0.052	0.060	- 1.94	-0.113	0.068	- 4.70*

* probability less than 5%

ADH : n = 5 test angles
ACH : n = 8 test angles

Table 2.7 (c) Mean and standard deviation for the residual z coordinate of the acrylic test object metal markers as determined using mode 3.

Marker	Mode 3 Landmark located on the coronal film and on a contour on the lateral film.					
	Adelaide Dental Hospital			Adelaide Children's Hospital		
	Mean	SD	t	Mean	SD	t
1	-0.062	0.016	- 8.67*	- 0.137	0.053	- 7.31*
2	-0.018	0.053	- 0.76	-0.008	0.032	- 0.71
3	0.118	0.061	4.33*	0.193	0.041	13.31*
4	-0.106	0.044	- 5.39*	-0.104	0.036	- 8.17*
5	-0.052	0.034	- 3.42*	-0.019	0.053	- 1.01
6	0.065	0.021	6.92*	0.065	0.029	6.34*
7	0.008	0.037	0.48	-0.031	0.053	- 1.65
8	0.016	0.025	1.43	0.010	0.055	0.51
9	-0.165	0.036	-10.25*	-0.163	0.063	- 7.32*
10	0.371	0.039	21.27*	0.348	0.040	24.61*
11	0.065	0.030	4.85*	0.039	0.056	1.97
12	-0.063	0.070	- 2.01	0.048	0.065	2.09
13	-0.149	0.037	- 9.01*	-0.512	0.051	- 28.40*
14	-0.029	0.039	- 1.66	-0.089	0.064	- 3.93*

* probability less than 5%

ADH : n = 5 test angles
ACH : n = 8 test angles

Table 2.8   Final acrylic test object coordinates.

Marker	x	y	z
1	- 75.99	90.66	- 0.10
2	3.79	89.44	0.00
3	83.66	88.57	0.15
4	- 36.41	56.37	- 0.11
5	- 36.67	39.82	0.00
6	43.23	39.15	0.07
7	- 77.22	- 09.36	0.00
8	2.69	- 10.65	0.00
9	82.62	- 11.43	- 0.16
10	- 37.58	- 50.15	0.36
11	42.27	- 50.93	0.07
12	- 78.28	- 89.42	0.00
13	1.98	- 90.69	- 0.16
14	81.92	- 91.38	- 0.07

Table 2.9 (a)   Mean and standard deviation of the error in determination of acrylic test object marker coordinates using mode 1 and the Adelaide Dental Hospital biplanar radiographic equipment.

Marker	Average residuals (mm)				$d\sqrt{n}/\sigma$	n
	x	y	z	Magnt		
1	-0.026	0.044	-0.026	0.057	0.775	5
2	-0.063	0.040	0.000	0.075	1.535	5
3	-0.026	-0.008	0.040	0.048	0.415	5
4	-0.031	-0.060	-0.019	0.070	1.254	5
5	0.043	0.036	0.035	0.066	1.310	5
6	-0.014	-0.015	-0.007	0.022	0.811	5
7	0.039	0.026	0.001	0.047	0.794	5
8	0.025	0.040	-0.019	0.051	2.085*	5
9	-0.006	-0.024	0.013	0.028	0.460	5
10	0.019	0.025	-0.034	0.046	0.765	5
11	-0.015	0.016	-0.033	0.040	0.604	5
12	0.082	0.022	0.054	0.101	1.229	5
13	-0.030	-0.061	0.009	0.069	1.279	5
14	0.003	-0.081	-0.012	0.082	1.165	5

* Probability less than 5%

Marker	Standard deviation (mm)			
	x	y	z	Magnt
1	0.106	0.124	0.017	0.164
2	0.081	0.042	0.059	0.109
3	0.167	0.186	0.075	0.261
4	0.059	0.098	0.049	0.125
5	0.087	0.059	0.041	0.113
6	0.035	0.046	0.017	0.060
7	0.065	0.101	0.057	0.133
8	0.047	0.019	0.022	0.055
9	0.027	0.127	0.033	0.134
10	0.083	0.103	0.016	0.134
11	0.074	0.120	0.041	0.146
12	0.110	0.121	0.082	0.183
13	0.108	0.032	0.044	0.121
14	0.110	0.099	0.055	0.158

Table 2.9 (b) Mean and standard deviation of the error in determination of acrylic test object marker coordinates using mode 2 and the Adelaide Dental Hospital biplanar radiographic equipment.

Marker	Average residuals (mm)				$d\sqrt{n}/\sigma$	n
	x	y	z	Magnt		
1	-0.016	0.025	-0.037	0.047	0.540	5
2	-0.062	0.048	0.018	0.080	1.312	5
3	0.019	0.019	0.034	0.043	0.360	5
4	-0.031	-0.076	-0.027	0.086	1.312	5
5	0.032	0.043	0.033	0.063	0.979	5
6	-0.007	-0.036	-0.001	0.037	0.733	5
7	0.047	0.025	-0.003	0.053	0.933	5
8	-0.013	0.038	-0.034	0.052	1.371	5
9	0.004	-0.024	0.000	0.024	0.348	5
10	0.011	0.016	0.013	0.023	0.376	5
11	-0.032	0.037	-0.017	0.051	0.826	5
12	0.109	0.015	0.040	0.117	1.282	5
13	-0.067	-0.070	-0.007	0.097	1.535	5
14	0.006	-0.058	-0.015	0.061	0.717	5

Marker	Standard deviation (mm)			
	x	y	z	Magnt
1	0.113	0.156	0.025	0.194
2	0.097	0.066	0.069	0.136
3	0.183	0.178	0.086	0.269
4	0.086	0.109	0.049	0.147
5	0.092	0.097	0.051	0.143
6	0.046	0.093	0.042	0.112
7	0.055	0.104	0.050	0.128
8	0.076	0.033	0.022	0.086
9	0.014	0.150	0.046	0.157
10	0.101	0.080	0.046	0.137
11	0.079	0.112	0.023	0.139
12	0.095	0.137	0.117	0.204
13	0.134	0.032	0.030	0.142
14	0.147	0.102	0.060	0.189

Table 2.9 (c) Mean and standard deviation of the error in determination of acrylic test object marker coordinates using mode 3 and the Adelaide Dental Hospital biplanar radiographic equipment.

Marker	Average residuals (mm)				$d\sqrt{n}/\sigma$	n
	x	y	z	Magnt		
1	0.077	-0.049	-0.050	0.104	0.915	5
2	0.018	0.095	0.010	0.097	0.885	5
3	0.100	0.097	0.029	0.142	1.132	5
4	0.046	-0.075	-0.010	0.088	1.185	5
5	0.080	-0.037	0.044	0.099	1.652*	5
6	-0.009	0.041	0.002	0.042	0.644	5
7	0.038	-0.069	-0.015	0.080	0.826	5
8	-0.006	0.023	-0.019	0.030	0.893	5
9	-0.031	0.074	0.007	0.080	0.740	5
10	-0.014	-0.013	-0.017	0.026	0.343	5
11	-0.075	0.060	0.010	0.096	1.750*	5
12	-0.003	-0.172	0.060	0.182	1.313	5
13	-0.129	0.005	-0.013	0.130	1.757*	5
14	-0.091	0.020	-0.038	0.101	0.801	5

* probability less than 5%

Marker	Standard deviation (mm)			
	x	y	z	Magnt
1	0.160	0.197	0.016	0.255
2	0.236	0.038	0.053	0.245
3	0.150	0.229	0.062	0.281
4	0.100	0.126	0.044	0.167
5	0.081	0.100	0.035	0.134
6	0.086	0.117	0.022	0.147
7	0.084	0.196	0.037	0.216
8	0.055	0.045	0.025	0.075
9	0.020	0.239	0.036	0.243
10	0.099	0.129	0.039	0.167
11	0.072	0.095	0.030	0.123
12	0.252	0.169	0.069	0.311
13	0.151	0.055	0.036	0.165
14	0.184	0.209	0.039	0.281

Table 2.9 (d) Mean and standard deviation of the error in determination of acrylic test object marker coordinates using mode 1 and the Adelaide Children's Hospital biplanar radiographic equipment.

Marker	Average residuals (mm)				$d\sqrt{n}/\sigma$	n
	x	y	z	Magnt		
1	-0.072	-0.002	0.004	0.072	1.286	8
2	-0.029	0.069	0.012	0.076	1.634*	8
3	0.021	-0.030	-0.033	0.049	0.568	8
4	-0.008	-0.044	0.012	0.046	0.986	8
5	0.029	0.005	-0.002	0.030	0.702	8
6	-0.014	-0.001	-0.007	0.015	0.429	8
7	0.024	0.014	0.052	0.059	0.987	8
8	0.009	0.031	-0.008	0.033	0.964	8
9	-0.031	0.008	-0.015	0.035	0.598	8
10	0.040	0.012	-0.005	0.042	0.896	8
11	-0.012	0.000	0.010	0.016	0.289	8
12	0.048	0.042	-0.077	0.100	1.456	8
13	0.007	-0.015	0.027	0.032	0.582	8
14	-0.015	-0.090	0.029	0.096	1.167	8

* probability less than 5%

Marker	Standard deviation (mm)			
	x	y	z	Magnt
1	0.093	0.120	0.042	0.158
2	0.112	0.055	0.042	0.132
3	0.205	0.124	0.050	0.245
4	0.060	0.105	0.051	0.131
5	0.049	0.098	0.050	0.120
6	0.061	0.078	0.025	0.102
7	0.052	0.155	0.045	0.170
8	0.054	0.052	0.060	0.096
9	0.053	0.145	0.057	0.164
10	0.078	0.090	0.057	0.132
11	0.073	0.116	0.069	0.153
12	0.148	0.117	0.043	0.194
13	0.142	0.044	0.049	0.157
14	0.108	0.196	0.062	0.232

Table 2.9 (e) Mean and standard deviation of the error in determination of acrylic test object marker coordinates using mode 2 and the Adelaide Children's Hospital biplanar radiographic equipment.

Marker	Average residuals (mm)				$d\sqrt{n}/\sigma$	n
	x	y	z	Magnt		
1	-0.056	-0.019	0.012	0.060	1.047	8
2	-0.028	0.050	0.014	0.059	1.215	8
3	0.040	0.011	-0.042	0.059	0.752	8
4	-0.006	-0.061	0.008	0.062	1.279	8
5	0.042	-0.015	0.004	0.044	1.071	8
6	-0.024	0.009	-0.002	0.026	0.801	8
7	0.017	0.016	0.044	0.049	0.728	8
8	0.023	0.028	-0.035	0.050	1.564	8
9	-0.019	0.007	-0.002	0.020	0.351	8
10	0.045	0.005	0.020	0.049	0.985	8
11	-0.031	0.013	0.003	0.034	0.654	8
12	0.004	0.044	-0.068	0.081	1.356	8
13	0.011	-0.015	-0.001	0.019	0.290	8
14	-0.018	-0.073	0.046	0.088	1.250	8

Marker	Standard deviation (mm)			
	x	y	z	Magnt
1	0.105	0.112	0.056	0.163
2	0.121	0.046	0.050	0.138
3	0.168	0.133	0.056	0.221
4	0.039	0.115	0.062	0.137
5	0.052	0.080	0.067	0.117
6	0.065	0.057	0.026	0.090
7	0.023	0.180	0.061	0.191
8	0.036	0.050	0.067	0.091
9	0.065	0.134	0.058	0.160
10	0.078	0.100	0.065	0.142
11	0.062	0.116	0.064	0.146
12	0.130	0.090	0.063	0.170
13	0.173	0.049	0.047	0.186
14	0.091	0.164	0.067	0.199

Table 2.9 (f) Mean and standard deviation of the error in determination of acrylic test object marker coordinates using mode 3 and the Adelaide Children's Hospital biplanar radiographic equipment.

Marker	Average residuals (mm)				$d\sqrt{n}/\sigma$	n
	x	y	z	Magnt		
1	0.096	0.095	0.026	0.137	1.425	8
2	0.032	0.154	0.001	0.157	1.967*	8
3	0.008	0.147	-0.044	0.153	1.225	8
4	0.069	-0.027	-0.010	0.074	0.940	8
5	0.108	-0.055	0.012	0.122	1.861*	8
6	-0.035	0.034	0.002	0.049	0.860	8
7	0.111	-0.111	0.024	0.158	1.768*	8
8	0.002	0.008	-0.012	0.015	0.460	8
9	-0.110	0.069	0.005	0.130	1.218	8
10	0.072	-0.068	0.005	0.099	1.332	8
11	-0.110	0.025	0.035	0.118	1.682*	8
12	0.031	-0.200	-0.052	0.209	1.622*	8
13	-0.074	-0.072	-0.012	0.104	1.607	8
14	-0.200	0.002	0.022	0.201	1.722*	8

* probability less than 5%

Marker	Standard deviation (mm)			
	x	y	z	Magnt
1	0.189	0.188	0.053	0.272
2	0.213	0.070	0.032	0.226
3	0.229	0.267	0.041	0.354
4	0.174	0.137	0.036	0.224
5	0.145	0.103	0.053	0.185
6	0.081	0.137	0.029	0.162
7	0.059	0.241	0.053	0.254
8	0.060	0.043	0.055	0.092
9	0.088	0.282	0.062	0.302
10	0.150	0.143	0.040	0.211
11	0.151	0.117	0.056	0.199
12	0.198	0.299	0.065	0.364
13	0.158	0.077	0.051	0.183
14	0.212	0.245	0.064	0.330

Table 2.10 (a)   Radiographic marker location error using biplanar radiography. Root-mean-square (rms) differences between the biplanar radiographic determination of the acrylic test object marker locations and the calibrated positions for mode 1 at the Adelaide Dental Hospital.

| Marker | rms differences (mm) | | | |
	x	y	z	Magnt
1	0.098	0.120	0.030	0.158
2	0.096	0.055	0.053	0.123
3	0.152	0.167	0.078	0.238
4	0.061	0.106	0.048	0.131
5	0.088	0.064	0.050	0.120
6	0.034	0.043	0.017	0.058
7	0.070	0.094	0.051	0.128
8	0.049	0.044	0.027	0.071
9	0.025	0.116	0.033	0.123
10	0.077	0.096	0.037	0.128
11	0.068	0.108	0.049	0.137
12	0.128	0.110	0.091	0.192
13	0.101	0.068	0.040	0.128
14	0.098	0.120	0.051	0.163

Pooled biplanar radiographic marker location error   = 0.142mm

F test: sqr(max location error)/sqr(min location error) = 16.84

Table 2.10 (b) Radiographic marker location error using biplanar radiography. Root-mean-square (rms) differences between the biplanar radiographic determination of the acrylic test object marker locations and the calibrated positions for mode 2 at the Adelaide Dental Hospital.

| Marker | rms differences (mm) | | | |
	x	y	z	Magnt
1	0.102	0.141	0.043	0.180
2	0.106	0.076	0.064	0.146
3	0.165	0.160	0.084	0.245
4	0.083	0.123	0.051	0.157
5	0.089	0.097	0.056	0.143
6	0.042	0.091	0.038	0.107
7	0.068	0.096	0.045	0.126
8	0.069	0.048	0.039	0.093
9	0.013	0.136	0.041	0.143
10	0.091	0.074	0.043	0.125
11	0.078	0.107	0.027	0.135
12	0.138	0.123	0.112	0.217
13	0.137	0.076	0.028	0.160
14	0.131	0.109	0.056	0.179

Pooled biplanar radiographic marker location error   = 0.159mm

F test: sqr(max location error)/sqr(min location error) = 6.94

Table 2.10 (c)   Radiographic marker location error using biplanar radiography. Root-mean-square (rms) differences between the biplanar radiographic determination of the acrylic test object marker locations and the calibrated positions for mode 3 at the Adelaide Dental Hospital.

Marker	rms differences (mm)			
	x	y	z	Magnt
1	0.163	0.183	0.052	0.250
2	0.212	0.101	0.048	0.240
3	0.167	0.226	0.063	0.288
4	0.101	0.135	0.040	0.173
5	0.108	0.097	0.054	0.155
6	0.078	0.112	0.019	0.138
7	0.084	0.188	0.037	0.209
8	0.050	0.046	0.029	0.074
9	0.036	0.226	0.033	0.231
10	0.090	0.116	0.039	0.152
11	0.099	0.104	0.029	0.146
12	0.225	0.229	0.086	0.333
13	0.187	0.049	0.035	0.196
14	0.188	0.188	0.052	0.271

Pooled biplanar radiographic marker location error   = 0.215mm

F test: sqr(max location error)/sqr(min location error) = 20.25

Table 2.10 (d)   Radiographic marker location error using biplanar radiography. Root-mean-square (rms) differences between the biplanar radiographic determination of the acrylic test object marker locations and the calibrated positions for mode 1 at the Adelaide Children's Hospital.

| Marker | rms differences (mm) | | | |
	x	y	z	Magnt
1	0.113	0.113	0.040	0.164
2	0.109	0.087	0.041	0.145
3	0.193	0.120	0.057	0.234
4	0.057	0.107	0.049	0.131
5	0.054	0.092	0.046	0.116
6	0.058	0.073	0.025	0.097
7	0.054	0.146	0.067	0.169
8	0.051	0.058	0.057	0.096
9	0.058	0.136	0.055	0.158
10	0.083	0.085	0.053	0.130
11	0.069	0.108	0.065	0.144
12	0.147	0.117	0.087	0.207
13	0.133	0.044	0.053	0.150
14	0.102	0.205	0.065	0.238

Pooled biplanar radiographic marker location error   = 0.162mm

F test: sqr(max location error)/sqr(min location error) = 6.15

Table 2.10 (e)   Radiographic marker location error using biplanar radiography. Root-mean-square (rms) differences between the biplanar radiographic determination of the acrylic test object marker locations and the calibrated positions for mode 2 at the Adelaide Children's Hospital.

| Marker | rms differences (mm) | | | |
	x	y	z	Magnt
1	0.113	0.106	0.054	0.164
2	0.116	0.066	0.049	0.142
3	0.162	0.125	0.067	0.215
4	0.037	0.124	0.059	0.142
5	0.064	0.076	0.063	0.118
6	0.065	0.054	0.025	0.088
7	0.027	0.169	0.072	0.186
8	0.041	0.055	0.072	0.099
9	0.063	0.126	0.054	0.151
10	0.085	0.094	0.063	0.142
11	0.066	0.109	0.060	0.141
12	0.121	0.095	0.090	0.178
13	0.162	0.048	0.044	0.175
14	0.087	0.170	0.078	0.206

Pooled biplanar radiographic marker location error   = 0.157mm

F test: sqr(max location error)/sqr(min location error) = 5.97

Table 2.10 (f)   Radiographic marker location error using biplanar radiography. Root-mean-square (rms) differences between the biplanar radiographic determination of the acrylic test object marker locations and the calibrated positions for mode 3 at the Adelaide Children's Hospital.

Marker	rms differences (mm)			
	x	y	z	Magnt
1	0.201	0.200	0.056	0.289
2	0.202	0.167	0.030	0.264
3	0.214	0.289	0.058	0.365
4	0.176	0.131	0.035	0.222
5	0.173	0.111	0.051	0.212
6	0.084	0.133	0.027	0.159
7	0.124	0.251	0.055	0.285
8	0.056	0.041	0.053	0.087
9	0.137	0.273	0.059	0.311
10	0.157	0.150	0.038	0.221
11	0.179	0.113	0.063	0.221
12	0.188	0.344	0.081	0.400
13	0.165	0.102	0.050	0.200
14	0.281	0.229	0.064	0.368

Pooled biplanar radiographic marker location error   = 0.270mm

F test: sqr(max location error)/sqr(min location error) = 21.14

Table 2.11 Summary of F tests applied between the minimum and maximum marker location errors for each radiographic determination mode and for both Adelaide Dental Hospital and Adelaide Children's Hospital.

	Mode 1	Mode 2	Mode 3
Adelaide Dental Hospital			
S_{max}	0.238	0.245	0.333
S_{min}	0.058	0.093	0.074
S_{max}^2/S_{min}^2	16.84*	6.94*	20.25*
Adelaide Children's Hospital			
S_{max}	0.238	0.215	0.400
S_{min}	0.096	0.088	0.087
S_{max}^2/S_{min}^2	6.15*	5.97*	21.14*

* probability less than 5%

F test significance level for ADH on $F(15,15) = 2.78$

F test significance level for ACH on $F(24,24) = 2.27$

S_{max} - maximum marker location error
S_{min} - minimum marker location error

Table 2.12 (a)   Pooled marker location errors for the three modes at both the Adelaide Dental Hospital and Adelaide Children's Hospital.

	S_1	S_2	S_3
Adelaide Dental Hospital	0.142	0.159	0.215
Adelaide Children's Hospital	0.162	0.157	0.270

Table 2.12 (b)   F tests between modes.

	S_1^2/S_2^2	S_3^2/S_1^2	S_3^2/S_2^2	5% significance level
Adelaide Dental Hospital	1.25[+]	2.29*	1.83*	F(210,210)
Adelaide Children's Hospital	1.07	2.78*	2.96*	F(336,336)

* probability less than 5%

[+] reciprocal

S_1 - pooled marker location error for Mode 1
S_2 - pooled marker location error for Mode 2
S_3 - pooled marker location error for Mode 3

Table 2.13 (a)

Osseous Landmark Definitions

Where no special comment is made, the landmarks are readily identifiable for craniometric and biplanar radiographic determination. The craniometric definitions have been based on Wilder (1920), Martin (1928) or Ashley-Montagu (1960) with minor modifications in some instances. For biplanar radiographic determination most of the landmarks have been based on the traditional lateral cephalometric definitions of Björk (1960, 1963) and Solow (1966) again with minor modifications in some instances. In each of these cases the landmarks are determined on the lateral view using the given definition and located on the coronal view using the "projection line" technique (see Sections 2.3 and 2.5).

anterior nasal spine (ans) or spinal point (sp): The apex of the anterior nasal spine.

articulare left/right (arl/arr): This is a derived lateral radiographic point defined as the intersection of the contour of the cranial base and the dorsal contour of the mandibular neck or condyle, on a lateral radiograph. This landmark was located on coronal radiographs using the projection line technique using a contour following the lateral surface of the posterior ramus. Although the accuracy of this landmark was assessed for the biplanar measurement technique it was not retained for use in the shape analyses.

basion (ba): The mid-sagittal point on the anterior margin of the foramen magnum.

bregma (br): The intersection of the sagittal and the coronal sutures on the surface of the cranial vault.

Chin Line (CL): The line through infradentale, tangent to the anterior border of the mandible in the mid-sagittal plane.

condylion left/right (cdl/cdr): In craniometry the bi-condylar breadth is defined as the distance between the lateral surfaces of the mandibular condyles.

Therefore for craniometric measurement the most lateral point of the condylar head is measured. In cephalometry the crest of the condylar head is more readily determined, as it is the top of the shadow caused by the condylar head. For this reason distinct definitions of condylion are required: condylion lateral and condylion crest. As the initial emphasis of the material in this thesis related to biplanar radiographic three dimensional coordinate determination, the craniometric measurements were taken to be suitable for comparison with this method. Therefore the craniometric determination of the bi-condylar breadth was between left and right condylion crests.

external auditory meatus left/right (eaml/eamr): The centre of the external auditory meatus. In biplanar radiography this landmark is located on the lateral radiograph at the centre of the ear-rod, and on the coronal radiograph it is located using the projection line technique using a vertical contour through the mastoid tip (see Section 2.6.2). Craniometric measurement requires care as the landmark is not on a bony surface.

Frankfort Horizontal Plane (FHP): The plane intersecting right and left porion and right and left orbitale (see for example, Enlow, 1982).

glabella (g): The most prominent point in the mid-sagittal plane between the eyebrow ridges. Glabella is located slightly superior to the fronto-nasal suture. This definition is suitable for both craniometric measurement, but in biplanar radiographic measurement from the lateral radiograph, the eyebrow ridges are more prominent, obscuring this landmark. For this reason the most anterior point on the frontal bone on the lateral radiograph is used because it can be reproducibly identified. The biplanar measurement of the landmark glabella is therefore antero-superior to the craniometric measurement of that landmark.

gnathion (gn): The most inferior point on the mandibular symphysis in the mid-sagittal plane.

gonion left/right (gol/gor): A point on the angle of the mandible located by the bisection of the angle formed by the mandibular line and the ramus line.

infradentale (id): The most antero-superior point on the mandibular alveolar process in the mid-sagittal plane.

lambda (l): The intersection between the lambdoid and sagittal sutures on the surface of the cranial vault.

lower molar left/right (lml/lmr): The mid-point between the lower first and second molars at the level of the buccal alveolar margin.

Mandibular Line left/right (ML(l)/ML(r)): The line through gnathion, tangent to the lower border of the mandible at the region of the angle.

mastoid tip left/right (mtl/mtr): The most inferior point on the mastoid process.

nasale (na): The tip of the nasal bone (Stramrud, 1959).

Nasal Line (NL): The line through anterior nasal spine and posterior nasal spine.

Nasion-Sella Line (NSL): The line through nasion and sella.

nasion (n): The most anterior point of the frontonasal suture.

opisthion (o): The mid-sagittal point on the posterior margin of the foramen magnum. This landmark is difficult to locate on live patients due to the presence of the spinal column, in which case a good knowledge of related anatomical features aids identification .

opisthocranion (op): The most distal point on the skull from glabella in the mid-sagittal plane, excluding the external occipital protuberance (Brown, 1973).

optic foramen left/right (ofl/ofr): For craniometric determinations, the mid-point of the optic foramen viewed from both the front and from above (if the top of the skull had been sectioned). For biplanar measurement this landmark was located on the lateral radiograph at the intersection of the plane through upper pterygomaxillare with the contour of the anterior cranial fossa and on the coronal radiograph on the vertical contour through the most medial point of the superior oblique fissure. This biplanar method of location of the landmark was found to be unsatisfactory (see Section 4.2).

pogonion (pg): The most anterior point on the mandibular symphysis in the mid-sagittal plane.

posterior nasal spine (pns): The apex of the posterior nasal spine.

prosthion (pr): The most antero-inferior point on the maxillary alveolar process in the mid-sagittal plane.

Ramus Line left/right (RL(l)/RL(r)): The line through articulare, tangent to the posterior border of the mandibular ramus at the region of the angle.

sella (s): The centre of the sella turcica.

upper molar left/right (uml/umr): The mid-point between the upper first and second molars at the level of the buccal alveolar margin.

upper pterygomaxillare left/right (upml/upmr): The uppermost point of the pterygomaxillary fissure.

vertex (v): The most superior point in the mid-sagittal plane when the skull is oriented along the Frankfort Horizontal.

Table 2.13 (b) Numerical assignment to each of the osseous landmarks.

Landmark No.	Landmark Name
1	sella (s)
2	nasion (n)
3	glabella (g)
4	vertex (v)
5	opisthocranion (op)
6	opisthion (o)
7	mastoid tip L (mtl)
8	mastoid tip R (mtr)
9	basion (ba)
10	external auditory meatus R (eamr)
11	external auditory meatus L (eaml)
12	condylion R (cdr)
13	condylion L (cdl)
14	articulare R (arr)
15	articulare L (arl)
16	gonion R (gor)
17	gonion L (gol)
20	gnathion (gn)
21	pogonion (pg)
22	infradentale (id)
23	prosthion (pr)
24	anterior nasal spine (ans)
25	posterior nasal spine (pns)
26	upper molar R (umr)
27	upper molar L (uml)
28	lower molar R (lmr)
29	lower molar L (lml)
32	coronoid tip R (ctr)
33	coronoid tip L (ctl)

Table 2.13 (b) (continued)

Landmark No.	Landmark Name
40	optic foramen R (ofr)
41	optic foramen L (ofl)
42	nasale (na)
43	bregma (br)
44	lambda (l)

Table 2.14 (a)   Differences between the two Adelaide Dental Hospital biplanar radiographic determinations of osseous landmark coordinates for skull A38.

Landmark No.	Difference between determinations (mm) x	y	z	Magnt	Landmark Name
1	0.714	0.345	0.504	0.940	sella
2	-0.725	1.133	1.416	1.953	nasion
3	-0.107	1.268	0.441	1.347	glabella
4	0.796	0.289	4.546	4.624	vertex
6	0.776	-0.172	-0.066	0.798	opisthion
7	-0.332	-0.219	-0.548	0.677	mastoid tip (L)
8	-1.464	0.142	-0.747	1.650	mastoid tip (R)
9	0.457	0.132	-0.384	0.612	basion
10	-1.804	0.182	0.648	1.926	ext aud meatus (R)
11	-0.481	0.296	1.026	1.171	ext aud meatus (L)
12	-1.962	-0.275	-0.120	1.985	condylion (R)
13	-0.633	-0.245	0.231	0.717	condylion (L)
14	0.836	-0.264	-0.716	1.132	articulare (R)
15	-0.562	-0.183	-0.069	0.595	articulare (L)
16	0.008	-0.025	-0.056	0.062	gonion (R)
17	0.165	-0.117	-0.212	0.293	gonion (L)
20	0.132	-0.106	-0.061	0.180	gnathion
21	0.066	1.942	0.429	1.990	pogonion
22	-0.008	-0.359	0.007	0.359	infradentale
23	0.355	-1.307	0.950	1.655	prosthion
24	-0.458	0.186	-0.243	0.551	ant nasal spine
25	-0.079	0.532	-0.007	0.538	post nasal spine
26	0.510	0.025	-0.122	0.525	upper molar (R)
27	-1.463	0.195	0.191	1.488	upper molar (L)
28	-0.638	0.419	0.087	0.768	lower molar (R)
29	-3.067	-0.839	0.555	3.228	lower molar (L)
32	2.378	-0.562	0.261	2.458	coronoid tip (R)
33	1.059	0.486	2.045	2.353	coronoid tip (L)
40	0.137	-0.262	-0.689	0.750	optic foramen (R)
41	0.303	-0.264	-0.477	0.624	optic foramen (L)
42	0.316	-0.190	-0.050	0.372	nasale
43	-0.157	0.496	0.682	0.858	bregma

Table 2.14 (b)   Differences between the two Adelaide Dental Hospital biplanar radiographic determinations of osseous landmark coordinates for skull A90.

Landmark No.	\multicolumn{4}{c}{Difference between determinations (mm)}	Landmark Name
	x	y	z	Magnt	
1	0.156	0.122	-0.050	0.204	sella
2	-0.012	0.318	0.495	0.589	nasion
3	-0.580	0.355	0.207	0.711	glabella
4	-0.066	0.612	-2.212	2.296	vertex
6	0.929	0.265	-0.042	0.967	opisthion
7	-0.489	0.114	-0.188	0.536	mastoid tip (L)
8	0.563	0.704	1.438	1.697	mastoid tip (R)
9	0.611	-0.453	-0.284	0.812	basion
10	0.738	0.220	1.173	1.403	ext aud meatus (R)
11	-0.540	0.367	1.015	1.207	ext aud meatus (L)
12	0.775	-0.313	0.437	0.943	condylion (R)
13	-0.533	-0.345	0.515	0.818	condylion (L)
14	1.276	0.159	0.303	1.321	articulare (R)
15	-1.405	0.147	0.000	1.413	articulare (L)
16	0.119	-0.177	-0.153	0.263	gonion (R)
17	0.000	-0.709	-0.172	0.729	gonion (L)
20	0.011	-0.034	-0.245	0.247	gnathion
21	-0.106	-0.060	0.076	0.143	pogonion
22	0.105	-0.156	0.195	0.270	infradentale
23	0.692	0.831	0.210	1.102	prosthion
24	0.652	-0.132	-0.488	0.825	ant nasal spine
25	0.746	0.400	-0.123	0.855	post nasal spine
26	-2.279	-0.260	0.106	2.297	upper molar (R)
27	-0.204	-0.227	0.315	0.439	upper molar (L)
28	-2.180	-0.146	-0.054	2.186	lower molar (R)
29	-0.092	-0.039	0.201	0.225	lower molar (L)
32	-1.084	-0.098	0.140	1.098	coronoid tip (R)
33	0.473	0.223	-0.471	0.704	coronoid tip (L)
40	-0.181	0.000	-0.378	0.419	optic foramen (R)
41	-0.818	0.086	-0.353	0.895	optic foramen (L)
42	0.813	-0.090	0.526	0.972	nasale

Table 2.14 (c)   Differences between the two Adelaide Dental Hospital biplanar radiographic determinations of osseous landmark coordinates for skull A13184.

Landmark No.	Difference between determinations (mm) x	y	z	Magnt	Landmark Name
1	-0.365	0.401	0.294	0.617	sella
2	-0.052	0.266	-0.186	0.329	nasion
3	-0.185	-1.587	-0.253	1.617	glabella
4	2.034	-0.406	5.099	5.505	vertex
5	-0.311	2.659	-0.134	2.680	opisthocranion
6	-0.023	-0.160	0.097	0.189	opisthion
7	-0.126	-0.637	-2.219	2.312	mastoid tip (L)
8	0.083	-0.866	-2.245	2.408	mastoid tip (R)
9	0.157	-0.331	-0.091	0.378	basion
10	0.135	0.354	2.062	2.097	ext aud meatus (R)
11	0.116	0.648	1.901	2.012	ext aud meatus (L)
12	0.241	0.421	-0.711	0.861	condylion (R)
14	0.087	-0.177	0.237	0.308	articulare (R)
15	-0.332	-0.212	-0.042	0.397	articulare (L)
16	-0.392	0.792	-0.827	1.211	gonion (R)
17	0.029	0.163	0.000	0.166	gonion (L)
20	-2.014	-0.089	-0.477	2.071	gnathion
21	-2.083	0.023	0.382	2.118	pogonion
22	-0.614	0.681	0.209	0.940	infradentale
23	-0.033	-0.116	0.145	0.189	prosthion
24	0.367	0.557	-0.785	1.029	ant nasal spine
25	-0.164	0.000	0.381	0.415	post nasal spine
26	2.379	0.120	-0.351	2.408	upper molar (R)
27	2.258	0.804	-0.486	2.446	upper molar (L)
28	-1.311	-0.322	0.557	1.461	lower molar (R)
29	1.744	0.084	0.368	1.785	lower molar (L)
32	0.003	-0.119	0.044	0.127	coronoid tip (R)
33	0.268	0.431	0.115	0.521	coronoid tip (L)
40	-0.213	-0.185	0.477	0.554	optic foramen (R)
41	0.916	-0.025	-0.164	0.931	optic foramen (L)
42	0.000	-0.058	-0.321	0.326	nasale

Table 2.14 (d) Differences between the two Adelaide Dental Hospital biplanar
radiographic determinations of osseous landmark coordinates
for skull A38778.

Landmark No.	Difference between determinations (mm)				Landmark Name
	x	y	z	Magnt	
1	-1.141	0.598	-0.182	1.301	sella
2	0.323	-0.269	-0.078	0.428	nasion
3	-0.262	0.002	0.228	0.347	glabella
4	0.392	-0.002	-0.050	0.395	vertex
5	-0.534	-0.310	0.312	0.691	opisthocranion
6	-0.632	-0.048	0.018	0.634	opisthion
7	-0.081	0.475	-1.248	1.338	mastoid tip (L)
8	0.161	0.218	-0.800	0.845	mastoid tip (R)
9	-0.016	0.101	0.074	0.126	basion
10	0.392	-0.255	1.489	1.561	ext aud meatus (R)
11	0.140	-0.020	0.918	0.929	ext aud meatus (L)
12	0.388	-0.331	-0.361	0.625	condylion (R)
13	0.100	1.878	-0.989	2.125	condylion (L)
14	0.514	-0.114	0.524	0.743	articulare (R)
15	-0.109	0.438	-0.018	0.451	articulare (L)
16	-0.418	0.696	-0.156	0.827	gonion (R)
17	-0.297	-0.003	0.334	0.447	gonion (L)
20	0.009	0.518	0.991	1.118	gnathion
21	-0.211	-0.460	-0.148	0.527	pogonion
22	-0.460	0.560	0.803	1.082	infradentale
23	0.051	-0.034	0.351	0.356	prosthion
24	0.245	-2.462	2.625	3.607	ant nasal spine
25	0.049	-0.089	-0.811	0.817	post nasal spine
32	-0.009	-0.049	0.279	0.283	coronoid tip (R)
33	-0.135	0.108	-0.129	0.216	coronoid tip (L)
40	1.355	0.155	-1.523	2.045	optic foramen (R)
41	-2.117	0.201	-1.517	2.612	optic foramen (L)
42	-0.298	0.617	-0.104	0.693	nasale
43	0.724	0.260	0.335	0.839	bregma
44	0.295	-0.004	0.109	0.315	lambda

Table 2.14 (e) Differences between the two Adelaide Dental Hospital biplanar radiographic determinations of osseous landmark coordinates for skull A57590.

Landmark No.	Difference between determinations (mm) x	y	z	Magnt	Landmark Name
1	-0.176	0.199	-0.186	0.324	sella
2	0.618	-0.227	-0.554	0.861	nasion
3	0.072	1.012	0.110	1.020	glabella
4	-0.197	0.340	1.539	1.588	vertex
6	-2.419	-0.245	0.355	2.457	opisthion
7	0.632	0.287	0.551	0.886	mastoid tip (L)
8	0.154	-0.765	-1.907	2.061	mastoid tip (R)
9	-0.988	0.526	-2.207	2.474	basion
10	0.173	-1.361	4.219	4.437	ext aud meatus (R)
11	0.677	0.132	2.575	2.666	ext aud meatus (L)
12	0.330	-0.475	-0.329	0.665	condylion (R)
14	0.248	-0.415	1.246	1.336	articulare (R)
15	1.040	1.294	-2.053	2.640	articulare (L)
16	0.000	-0.814	1.304	1.537	gonion (R)
17	0.017	1.258	-1.819	2.211	gonion (L)
20	-0.567	0.389	0.967	1.187	gnathion
21	-0.464	0.109	0.194	0.514	pogonion
22	-0.354	-0.591	-0.029	0.689	infradentale
23	-0.315	-0.755	0.000	0.818	prosthion
24	-0.226	-0.278	0.266	0.446	ant nasal spine
25	-0.982	-0.266	0.202	1.037	post nasal spine
26	2.130	-0.572	-1.074	2.453	upper molar (R)
28	-0.768	-0.111	-0.326	0.841	lower molar (R)
29	0.726	1.500	1.033	1.961	lower molar (L)
32	-1.670	1.516	-4.214	4.779	coronoid tip (R)
33	-1.676	-1.077	0.849	2.166	coronoid tip (L)
40	1.065	0.135	-1.162	1.582	optic foramen (R)
41	-1.672	0.518	-1.029	2.031	optic foramen (L)
42	0.466	0.000	-0.256	0.532	nasale

Table 2.15 (a)   Differences between the two Adelaide Children's Hospital biplanar radiographic determinations of osseous landmark coordinates for skull A38.

Landmark No.	Difference between determinations (mm)				Landmark Name
	x	y	z	Magnt	
1	0.077	0.152	0.118	0.207	sella
2	-0.112	-1.122	-0.694	1.324	nasion
3	-1.092	0.845	-0.272	1.408	glabella
4	0.002	-0.715	-4.319	4.377	vertex
5	0.297	-1.035	0.005	1.076	opisthocranion
6	0.379	-0.607	1.058	1.277	opisthion
7	-0.163	0.159	0.868	0.897	mastoid tip (L)
8	-2.602	0.012	-0.316	2.621	mastoid tip (R)
9	0.199	-0.047	0.176	0.269	basion
10	-0.672	-0.327	-0.440	0.867	ext aud meatus (R)
11	-0.196	-0.243	-0.362	0.478	ext aud meatus (L)
12	-0.649	1.110	-0.514	1.385	condylion (R)
13	-0.113	0.163	-0.493	0.531	condylion (L)
14	-0.002	0.158	0.599	0.619	articulare (R)
15	0.429	0.185	0.590	0.753	articulare (L)
16	-0.832	0.908	-0.489	1.325	gonion (R)
17	0.239	-0.252	0.529	0.633	gonion (L)
20	-0.292	-0.238	-0.005	0.376	gnathion
21	-0.129	0.161	-0.216	0.299	pogonion
22	0.059	0.222	0.042	0.234	infradentale
23	0.232	0.317	-0.469	0.611	prosthion
24	-0.167	-0.250	-0.200	0.361	ant nasal spine
25	-0.103	0.043	0.118	0.162	post nasal spine
26	-0.695	0.381	0.687	1.049	upper molar (R)
27	0.585	0.035	0.121	0.598	upper molar (L)
28	0.085	-0.012	1.585	1.588	lower molar (R)
29	0.453	0.104	-0.347	0.580	lower molar (L)
32	-0.099	-0.312	-0.807	0.871	coronoid tip (R)
33	0.600	-0.366	-0.303	0.766	coronoid tip (L)
40	0.322	-0.119	0.236	0.417	optic foramen (R)
41	0.102	-0.015	0.270	0.289	optic foramen (L)
42	0.131	-0.500	-0.140	0.536	nasale
43	0.194	-0.372	0.242	0.485	bregma
44	-1.320	0.205	0.453	1.410	lambda

Table 2.15 (b) Differences between the two Adelaide Children's Hospital biplanar radiographic determinations of osseous landmark coordinates for skull A90.

Landmark No.	Difference between determinations (mm)				Landmark Name
	x	y	z	Magnt	
1	-0.086	0.399	0.000	0.408	sella
2	0.999	-0.031	0.077	1.003	nasion
3	-0.102	0.591	0.078	0.605	glabella
4	1.889	0.399	-1.183	2.265	vertex
5	-0.351	0.017	-0.021	0.352	opisthocranion
6	-0.666	0.639	0.422	1.014	opisthion
7	0.279	0.123	0.486	0.574	mastoid tip (L)
8	-0.902	-0.528	1.364	1.719	mastoid tip (R)
9	-0.200	0.488	0.760	0.925	basion
10	0.670	-0.284	-0.522	0.895	ext aud meatus (R)
11	-0.789	-0.119	-0.785	1.119	ext aud meatus (L)
12	0.658	-0.558	-0.735	1.133	condylion (R)
13	-0.781	-2.093	-0.210	2.243	condylion (L)
14	-1.579	-0.215	-0.116	1.598	articulare (R)
15	3.111	-1.916	0.280	3.665	articulare (L)
16	0.069	0.391	-0.819	0.910	gonion (R)
17	0.000	0.392	-0.426	0.579	gonion (L)
20	-2.027	0.096	0.275	2.048	gnathion
21	-1.628	-0.531	-0.451	1.770	pogonion
22	-0.520	-0.492	-0.044	0.717	infradentale
23	0.045	0.170	0.046	0.182	prosthion
24	0.140	-0.128	0.348	0.396	ant nasal spine
25	-0.330	0.000	0.478	0.581	post nasal spine
26	0.159	-1.781	0.088	1.790	upper molar (R)
27	0.307	0.744	0.111	0.812	upper molar (L)
28	2.351	0.856	-0.886	2.654	lower molar (R)
32	-0.430	0.148	-0.488	0.667	coronoid tip (R)
33	2.282	0.072	-0.015	2.283	coronoid tip (L)
40	-1.907	-1.061	0.492	2.238	optic foramen (R)
41	0.623	-1.044	0.442	1.293	optic foramen (L)
42	0.321	-0.371	-0.045	0.493	nasale

Table 2.15 (c)   Differences between the two Adelaide Children's Hospital biplanar radiographic determinations of osseous landmark coordinates for skull A13184.

Landmark No.	Difference between determinations (mm)				Landmark Name
	x	y	z	Magnt	
1	0.369	-0.146	0.094	0.407	sella
2	-0.109	-0.031	-0.040	0.120	nasion
3	0.163	0.883	0.151	0.910	glabella
5	0.533	0.982	-0.036	1.118	opisthocranion
6	-0.456	0.498	-1.312	1.476	opisthion
7	-0.131	-0.093	-0.160	0.227	mastoid tip (L)
8	0.119	-0.078	-0.118	0.185	mastoid tip (R)
9	-0.667	0.605	0.205	0.923	basion
10	0.309	-0.582	0.039	0.660	ext aud meatus (R)
11	0.000	-0.567	0.000	0.567	ext aud meatus (L)
12	0.290	-0.519	-0.148	0.612	condylion (R)
13	0.024	-0.798	-0.109	0.806	condylion (L)
14	-0.050	0.274	0.541	0.609	articulare (R)
15	-0.160	0.881	0.022	0.896	articulare (L)
16	0.458	0.008	0.205	0.501	gonion (R)
17	0.185	0.252	0.020	0.313	gonion (L)
20	-0.147	0.321	-0.052	0.357	gnathion
21	-0.102	0.269	-0.078	0.298	pogonion
22	0.295	-0.345	0.045	0.456	infradentale
23	-0.108	0.231	0.061	0.262	prosthion
24	-0.770	-0.522	0.547	1.079	ant nasal spine
25	-0.466	0.445	-0.174	0.668	post nasal spine
26	0.153	-0.136	1.071	1.090	upper molar (R)
27	2.231	0.000	0.155	2.236	upper molar (L)
32	-0.654	-1.229	-4.787	4.986	coronoid tip (R)
33	-0.198	-0.643	-1.210	1.385	coronoid tip (L)
40	-0.071	0.598	-0.170	0.626	optic foramen (R)
41	0.419	0.569	-0.159	0.724	optic foramen (L)
42	0.403	-0.172	0.010	0.438	nasale

Table 2.15 (d) Differences between the two Adelaide Children's Hospital biplanar radiographic determinations of osseous landmark coordinates for skull A38778.

Landmark No.	Difference between determinations (mm)				Landmark Name
	x	y	z	Magnt	
1	-0.121	0.264	0.481	0.562	sella
2	0.129	-0.364	0.647	0.753	nasion
3	0.079	0.590	0.543	0.806	glabella
4	0.273	-0.057	-5.004	5.012	vertex
5	0.123	-1.457	1.174	1.875	opisthocranion
7	0.076	0.333	0.327	0.473	mastoid tip (L)
8	-0.209	0.011	0.041	0.213	mastoid tip (R)
9	0.800	0.474	0.474	1.044	basion
10	-0.115	-0.520	0.501	0.731	ext aud meatus (R)
11	-0.063	-0.501	0.726	0.885	ext aud meatus (L)
12	-0.134	-0.484	-0.770	0.919	condylion (R)
13	0.030	-0.457	-0.646	0.792	condylion (L)
14	-0.618	0.191	0.192	0.674	articulare (R)
15	0.331	0.413	0.381	0.652	articulare (L)
16	-0.461	0.870	-0.962	1.377	gonion (R)
17	-0.261	0.499	-0.405	0.693	gonion (L)
20	-0.779	-0.142	-0.748	1.090	gnathion
21	-0.912	0.674	-0.041	1.135	pogonion
22	-0.038	-0.655	-0.068	0.659	infradentale
23	0.489	-0.579	0.207	0.786	prosthion
24	0.587	0.509	-1.585	1.765	ant nasal spine
25	0.450	0.000	0.848	0.960	post nasal spine
26	-0.940	0.664	-0.431	1.229	upper molar (R)
27	-0.146	0.853	-0.093	0.870	upper molar (L)
28	-2.297	-0.214	-0.315	2.328	lower molar (R)
29	0.997	-0.282	-0.163	1.049	lower molar (L)
32	0.786	0.055	0.571	0.973	coronoid tip (R)
33	2.572	2.631	-2.803	4.625	coronoid tip (L)
40	0.196	-0.067	-0.891	0.915	optic foramen (R)
41	1.325	-0.042	-0.795	1.546	optic foramen (L)
42	-0.136	-0.420	0.409	0.602	nasale
43	-0.030	0.000	1.132	1.133	bregma

Table 2.15 (e) Differences between the two Adelaide Children's Hospital biplanar radiographic determinations of osseous landmark coordinates for skull A57590.

Landmark No.	Difference between determinations (mm)				Landmark Name
	x	y	z	Magnt	
1	-0.109	-0.435	-0.366	0.579	sella
2	-0.024	-0.065	0.185	0.197	nasion
3	0.412	-0.965	-0.179	1.065	glabella
4	-0.802	-0.658	-3.218	3.381	vertex
5	-0.660	0.782	-0.266	1.057	opisthocranion
7	0.014	-0.480	0.573	0.748	mastoid tip (L)
8	0.308	0.725	3.246	3.340	mastoid tip (R)
9	-0.135	1.979	2.661	3.319	basion
10	0.057	0.410	0.061	0.418	ext aud meatus (R)
11	-0.052	0.721	-0.404	0.828	ext aud meatus (L)
12	0.120	0.000	0.398	0.415	condylion (R)
13	-0.072	-0.021	0.257	0.267	condylion (L)
14	0.007	-0.449	-0.387	0.593	articulare (R)
15	0.533	0.235	-0.094	0.590	articulare (L)
16	0.012	-0.491	0.202	0.532	gonion (R)
17	0.114	-0.211	0.077	0.252	gonion (L)
20	0.000	-0.332	0.143	0.361	gnathion
21	0.226	-0.700	0.255	0.779	pogonion
22	-0.184	1.147	0.135	1.170	infradentale
23	-0.310	-0.117	-0.210	0.392	prosthion
24	0.260	-0.024	0.496	0.561	ant nasal spine
25	-0.772	0.025	-0.683	1.031	post nasal spine
26	-0.831	0.840	-0.460	1.269	upper molar (R)
27	-2.569	0.740	0.626	2.746	upper molar (L)
28	0.351	-0.162	-2.360	2.392	lower molar (R)
29	-0.784	-1.124	2.750	3.072	lower molar (L)
32	0.327	0.326	-1.600	1.665	coronoid tip (R)
33	0.623	0.500	-5.022	5.085	coronoid tip (L)
40	-0.074	0.293	-0.099	0.318	optic foramen (R)
41	-0.571	0.354	-0.194	0.700	optic foramen (L)
42	0.288	0.084	0.000	0.300	nasale

Table 2.16 (a) The mean and standard deviation of the residuals of
Tables 2.14 (a) to (e).

Landmark No.	Mean residual (mm)				$d\sqrt{n}/\sigma$	n	Landmark Name
	x	y	z	Magnt			
1	-0.162	0.333	0.076	0.378	1.095	5	sella
2	0.030	0.244	0.219	0.329	0.683	5	nasion
3	-0.212	0.210	0.147	0.333	0.632	5	glabella
4	0.592	0.167	1.784	1.887	1.305	5	vertex
5	-0.422	1.174	0.089	1.251	0.831	2	opisthocranion
6	-0.274	-0.072	0.072	0.292	0.473	5	opisthion
7	-0.079	0.004	-0.730	0.735	1.345	5	mastoid tip (L)
8	-0.101	-0.113	-0.852	0.866	1.090	5	mastoid tip (R)
9	0.044	-0.005	-0.578	0.580	1.093	5	basion
10	-0.073	-0.172	1.918	1.927	2.336*	5	ext aud meatus (R)
11	-0.018	0.285	1.487	1.514	3.682*	5	ext aud meatus (L)
12	-0.046	-0.195	-0.217	0.295	0.540	5	condylion (R)
13	-0.355	0.429	-0.081	0.563	0.633	3	condylion (L)
14	0.592	-0.162	0.319	0.692	1.767*	5	articulare (R)
15	-0.274	0.297	-0.436	0.594	0.945	5	articulare (L)
16	-0.137	0.094	0.022	0.168	0.355	5	gonion (R)
17	-0.017	0.118	-0.374	0.392	0.788	5	gonion (L)
20	-0.486	0.136	0.235	0.556	1.061	5	gnathion
21	-0.560	0.311	0.187	0.667	1.145	5	pogonion
22	-0.266	0.027	0.237	0.357	1.105	5	infradentale
23	0.150	-0.276	0.331	0.457	1.056	5	prosthion
24	0.116	-0.426	0.275	0.520	0.624	5	ant nasal spine
25	-0.086	0.115	-0.072	0.161	0.429	5	post nasal spine
26	0.685	-0.172	-0.360	0.793	0.713	4	upper molar (R)
27	0.197	0.257	0.007	0.324	0.279	3	upper molar (L)
28	-1.224	-0.040	0.066	1.227	2.872*	4	lower molar (R)
29	-0.172	0.177	0.539	0.593	0.512	4	lower molar (L)
32	-0.076	0.138	-0.754	0.770	0.660	5	coronoid tip (R)
33	-0.002	0.034	0.482	0.483	0.687	5	coronoid tip (L)
40	0.433	-0.031	-0.655	0.786	1.631*	5	optic foramen (R)
41	-0.678	0.103	-0.708	0.985	1.544	5	optic foramen (L)
42	0.259	0.056	-0.041	0.268	0.951	5	nasale
43	0.283	0.378	0.508	0.694	1.423	2	bregma
44	0.295	-0.004	0.109	0.315	0.000	1	lambda

* probability less than 5%

Table 2.16 (a) (continued)

Landmark No.	Standard deviation of the residuals (mm)				n	Landmark Name
	x	y	z	Magnt		
1	0.683	0.185	0.309	0.773	5	sella
2	0.503	0.566	0.768	1.078	5	nasion
3	0.240	1.124	0.254	1.177	5	glabella
4	0.897	0.387	3.083	3.234	5	vertex
5	0.158	2.099	0.315	2.129	2	opisthocranion
6	1.355	0.201	0.170	1.380	5	opisthion
7	0.430	0.440	1.055	1.221	5	mastoid tip (L)
8	0.785	0.677	1.441	1.776	5	mastoid tip (R)
9	0.627	0.393	0.927	1.187	5	basion
10	0.997	0.703	1.384	1.845	5	ext aud meatus (R)
11	0.503	0.253	0.727	0.920	5	ext aud meatus (L)
12	1.091	0.352	0.423	1.222	5	condylion (R)
13	0.397	1.256	0.799	1.540	3	condylion (L)
14	0.476	0.212	0.703	0.876	5	articulare (R)
15	0.883	0.618	0.904	1.407	5	articulare (L)
16	0.250	0.664	0.780	1.054	5	gonion (R)
17	0.170	0.717	0.836	1.114	5	gonion (L)
20	0.897	0.295	0.695	1.172	5	gnathion
21	0.873	0.938	0.235	1.302	5	pogonion
22	0.304	0.565	0.334	0.723	5	infradentale
23	0.386	0.807	0.368	0.967	5	prosthion
24	0.451	1.183	1.369	1.864	5	ant nasal spine
25	0.616	0.337	0.456	0.838	5	post nasal spine
26	2.143	0.312	0.511	2.225	4	upper molar (R)
27	1.893	0.518	0.431	2.009	3	upper molar (L)
28	0.701	0.320	0.369	0.854	4	lower molar (R)
29	2.071	0.973	0.360	2.316	4	lower molar (L)
32	1.548	0.798	1.942	2.609	5	coronoid tip (R)
33	1.030	0.640	0.999	1.571	5	coronoid tip (L)
40	0.730	0.187	0.770	1.077	5	optic foramen (R)
41	1.283	0.289	0.555	1.427	5	optic foramen (L)
42	0.427	0.321	0.335	0.631	5	nasale
43	0.623	0.167	0.245	0.690	2	bregma
44	0.000	0.000	0.000	0.000	1	lambda

Table 2.16 (b) The mean and standard deviation of the residuals of
Tables 2.15 (a) to (e).

Landmark No.	Mean residual (mm)				$d\sqrt{n}/\sigma$	n	Landmark Name
	x	y	z	Magnt			
1	0.026	0.047	0.065	0.085	0.380	5	sella
2	0.177	-0.323	0.035	0.369	1.006	5	nasion
3	-0.108	0.389	0.064	0.409	0.900	5	glabella
4	0.341	-0.258	-3.431	3.457	3.319*	4	vertex
5	-0.012	-0.142	0.171	0.223	0.379	5	opisthocranion
6	-0.248	0.177	0.056	0.309	0.355	3	opisthion
7	0.015	0.008	0.419	0.419	1.796*	5	mastoid tip (L)
8	-0.657	0.028	0.843	1.070	1.221	5	mastoid tip (R)
9	-0.001	0.700	0.855	1.105	1.772*	5	basion
10	0.050	-0.261	-0.072	0.275	0.807	5	ext aud meatus (R)
11	-0.220	-0.142	-0.165	0.309	0.828	5	ext aud meatus (L)
12	0.057	-0.090	-0.354	0.370	0.836	5	condylion (R)
13	-0.182	-0.641	-0.240	0.709	1.555	5	condylion (L)
14	-0.448	-0.008	0.166	0.478	1.241	5	articulare (R)
15	0.849	-0.040	0.236	0.882	1.154	5	articulare (L)
16	-0.151	0.337	-0.373	0.525	1.230	5	gonion (R)
17	0.055	0.136	-0.041	0.152	0.607	5	gonion (L)
20	-0.649	-0.059	-0.077	0.656	1.541	5	gnathion
21	-0.509	-0.025	-0.106	0.521	1.186	5	pogonion
22	-0.078	-0.025	0.022	0.084	0.236	5	infradentale
23	0.070	0.004	-0.073	0.101	0.413	5	prosthion
24	0.010	-0.083	-0.079	0.115	0.234	5	ant nasal spine
25	-0.244	0.103	0.117	0.290	0.841	5	post nasal spine
26	-0.431	-0.006	0.191	0.471	0.770	5	upper molar (R)
27	0.082	0.474	0.184	0.515	0.639	5	upper molar (L)
28	0.123	0.117	-0.494	0.522	0.408	4	lower molar (R)
29	0.222	-0.434	0.747	0.892	0.750	3	lower molar (L)
32	-0.014	-0.202	-1.422	1.437	1.456	5	coronoid tip (R)
33	1.176	0.439	-1.871	2.253	1.852*	5	coronoid tip (L)
40	-0.307	-0.071	-0.086	0.327	0.598	5	optic foramen (R)
41	0.380	-0.036	-0.087	0.391	0.834	5	optic foramen (L)
42	0.201	-0.276	0.047	0.345	2.025*	5	nasale
43	0.082	-0.186	0.687	0.716	1.447	2	bregma
44	-1.320	0.205	0.453	1.411	0.000	1	lambda

* probability less than 5%

Table 2.16 (b) (continued)

Landmark No.	Standard deviation of the residuals (mm)				n	Landmark Name
	x	y	z	Magnt		
1	0.208	0.336	0.303	0.498	5	sella
2	0.470	0.468	0.484	0.821	5	nasion
3	0.580	0.769	0.320	1.015	5	glabella
4	1.129	0.529	1.670	2.084	4	vertex
5	0.486	1.080	0.571	1.315	5	opisthocranion
6	0.553	0.682	1.227	1.509	3	opisthion
7	0.178	0.312	0.379	0.522	5	mastoid tip (L)
8	1.181	0.449	1.496	1.958	5	mastoid tip (R)
9	0.544	0.758	1.037	1.395	5	basion
10	0.500	0.395	0.417	0.762	5	ext aud meatus (R)
11	0.326	0.516	0.570	0.835	5	ext aud meatus (L)
12	0.488	0.708	0.488	0.989	5	condylion (R)
13	0.340	0.894	0.351	1.019	5	condylion (L)
14	0.684	0.310	0.423	0.862	5	articulare (R)
15	1.292	1.084	0.275	1.709	5	articulare (L)
16	0.501	0.593	0.553	0.953	5	gonion (R)
17	0.198	0.347	0.395	0.562	5	gonion (L)
20	0.824	0.265	0.396	0.952	5	gnathion
21	0.752	0.575	0.258	0.981	5	pogonion
22	0.303	0.733	0.081	0.798	5	infradentale
23	0.308	0.365	0.267	0.547	5	prosthion
24	0.513	0.380	0.893	1.097	5	ant nasal spine
25	0.457	0.192	0.589	0.770	5	post nasal spine
26	0.543	1.059	0.679	1.369	5	upper molar (R)
27	1.732	0.420	0.266	1.802	5	upper molar (L)
28	1.904	0.500	1.632	2.557	4	lower molar (R)
29	0.913	0.628	1.737	2.061	3	lower molar (L)
32	0.580	0.619	2.036	2.206	5	coronoid tip (R)
33	1.193	1.300	2.070	2.720	5	coronoid tip (L)
40	0.911	0.625	0.523	1.222	5	optic foramen (R)
41	0.696	0.619	0.481	1.048	5	optic foramen (L)
42	0.213	0.235	0.211	0.381	5	nasale
43	0.158	0.263	0.629	0.700	2	bregma
44	0.000	0.000	0.000	0.000	1	lambda

Table 2.17 (a)   Landmark relocation error for the biplanar radiographic equipment at Adelaide Dental Hospital determined from the results of Table 2.16 (a).

Landmark No.	Landmark relocation error (mm)				n	Landmark Name
	x	y	z	Magnt		
1	0.447	0.263	0.203	0.557	5	sella
2	0.319	0.397	0.510	0.721	5	nasion
3	0.214	0.726	0.191	0.781	5	glabella
4	0.705	0.272	2.322	2.442	5	vertex
5	0.309	1.339	0.170	1.384	2	opisthocranion
6	0.878	0.137	0.119	0.897	5	opisthion
7	0.278	0.278	0.844	0.931	5	mastoid tip (L)
8	0.502	0.436	1.093	1.279	5	mastoid tip (R)
9	0.398	0.249	0.715	0.855	5	basion
10	0.633	0.461	1.614	1.794	5	ext aud meatus (R)
11	0.318	0.257	1.148	1.218	5	ext aud meatus (L)
12	0.690	0.262	0.308	0.800	5	condylion (R)
13	0.340	0.786	0.465	0.974	3	condylion (L)
14	0.516	0.177	0.499	0.739	5	articulare (R)
15	0.591	0.443	0.650	0.984	5	articulare (L)
16	0.185	0.425	0.493	0.677	5	gonion (R)
17	0.108	0.461	0.591	0.757	5	gonion (L)
20	0.663	0.210	0.470	0.839	5	gnathion
21	0.679	0.632	0.199	0.949	5	pogonion
22	0.269	0.358	0.270	0.523	5	infradentale
23	0.266	0.546	0.330	0.692	5	prosthion
24	0.297	0.806	0.887	1.235	5	ant nasal spine
25	0.395	0.228	0.239	0.542	5	post nasal spine
26	1.399	0.226	0.404	1.473	4	upper molar (R)
27	1.102	0.350	0.249	1.182	3	upper molar (L)
28	0.966	0.198	0.231	1.013	4	lower molar (R)
29	1.274	0.609	0.440	1.479	4	lower molar (L)
32	0.981	0.514	1.339	1.737	5	coronoid tip (R)
33	0.651	0.405	0.718	1.051	5	coronoid tip (L)
40	0.554	0.120	0.672	0.879	5	optic foramen (R)
41	0.942	0.197	0.611	1.140	5	optic foramen (L)
42	0.327	0.207	0.214	0.442	5	nasale
43	0.370	0.280	0.380	0.600	2	bregma
44	0.209	0.003	0.077	0.222	1	lambda

Overall single landmark location error = 1.084 mm

Median single landmark location error = 0.914 mm

Table 2.17 (b)   Landmark relocation error for the biplanar radiographic equipment at Adelaide Children's Hospital determined from the results of Table 2.16 (b).

Landmark No.	Landmark relocation error (mm)				n	Landmark Name
	x	y	z	Magnt		
1	0.133	0.215	0.197	0.320	5	sella
2	0.322	0.374	0.307	0.581	5	nasion
3	0.375	0.559	0.207	0.704	5	glabella
4	0.732	0.372	2.633	2.758	4	vertex
5	0.308	0.691	0.381	0.847	5	opisthocranion
6	0.364	0.413	0.709	0.898	3	opisthion
7	0.113	0.198	0.381	0.444	5	mastoid tip (L)
8	0.880	0.285	1.119	1.451	5	mastoid tip (R)
9	0.344	0.689	0.892	1.178	5	basion
10	0.318	0.311	0.269	0.520	5	ext aud meatus (R)
11	0.258	0.341	0.379	0.572	5	ext aud meatus (L)
12	0.312	0.452	0.397	0.678	5	condylion (R)
13	0.251	0.725	0.280	0.816	5	condylion (L)
14	0.536	0.196	0.292	0.641	5	articulare (R)
15	1.014	0.686	0.241	1.248	5	articulare (L)
16	0.335	0.444	0.438	0.708	5	gonion (R)
17	0.131	0.240	0.251	0.371	5	gonion (L)
20	0.694	0.173	0.257	0.760	5	gnathion
21	0.597	0.364	0.180	0.722	5	pogonion
22	0.199	0.464	0.053	0.508	5	infradentale
23	0.201	0.231	0.177	0.353	5	prosthion
24	0.324	0.247	0.567	0.699	5	ant nasal spine
25	0.337	0.142	0.382	0.529	5	post nasal spine
26	0.459	0.669	0.450	0.928	5	upper molar (R)
27	1.097	0.428	0.212	1.197	5	upper molar (L)
28	1.169	0.317	1.059	1.609	4	lower molar (R)
29	0.550	0.475	1.134	1.346	3	lower molar (L)
32	0.367	0.417	1.634	1.726	5	coronoid tip (R)
33	1.123	0.879	1.861	2.345	5	coronoid tip (L)
40	0.616	0.398	0.336	0.807	5	optic foramen (R)
41	0.515	0.393	0.310	0.718	5	optic foramen (L)
42	0.196	0.245	0.137	0.343	5	nasale
43	0.098	0.186	0.579	0.616	2	bregma
44	0.933	0.145	0.320	0.997	1	lambda

Overall single landmark location error = 1.059 mm

Median single landmark location error = 0.720 mm

Table 2.18   Osseous landmark relocation error (mm).

	Min	Max	Median
Adelaide Dental Hospital	0.222	2.442	0.914
Adelaide Children's Hospital	0.320	2.758	0.720

Table 2.19   Mean differences between osseous landmark positions
determined on the Adelaide Dental Hospital and Adelaide
Children's Hospital biplanar radiographic systems.

Landmark No.	Mean residual (mm) x	y	z	Magnt	d√n/σ	n	Landmark Name
1	0.427	-0.497	0.352	0.744	2.385*	5	sella
2	-0.034	0.532	0.409	0.672	1.035	5	nasion
3	0.174	0.002	0.075	0.190	0.225	5	glabella
4	0.043	-0.256	-4.478	4.485	1.294	4	vertex
5	2.175	3.441	-1.435	4.316	3.091*	4	opisthocranion
6	0.674	-2.046	1.520	2.636	1.586	3	opisthion
7	0.368	1.290	1.400	1.939	2.071*	5	mastoid tip (L)
8	-0.112	-0.207	-0.581	0.627	0.894	5	mastoid tip (R)
9	0.505	-0.508	-1.186	1.386	1.539	5	basion
10	-0.217	1.472	0.515	1.574	1.296	5	ext aud meatus (R)
11	0.737	1.277	1.477	2.087	2.045*	5	ext aud meatus (L)
12	-1.028	-0.424	-0.250	1.140	1.261	5	condylion (R)
13	1.034	0.061	0.158	1.048	1.150	4	condylion (L)
14	0.168	0.661	1.421	1.576	2.405*	5	articulare (R)
15	-0.288	-0.666	-1.866	2.003	2.083*	5	articulare (L)
16	-0.402	-0.537	0.534	0.857	1.134	5	gonion (R)
17	-0.099	-0.112	-1.310	1.319	2.355*	5	gonion (L)
20	-0.203	0.174	0.802	0.845	1.204	5	gnathion
21	-0.122	0.661	0.470	0.820	1.501	5	pogonion
22	0.168	0.233	-0.047	0.291	0.542	5	infradentale
23	-0.178	-0.253	0.285	0.420	1.733*	5	prosthion
24	-0.521	-0.011	-0.002	0.521	1.612	5	ant nasal spine
25	0.052	0.076	1.609	1.612	2.074*	5	post nasal spine
26	5.070	-0.705	1.338	5.291	4.033*	4	upper molar (R)
27	-3.033	-0.034	-0.962	3.182	2.652*	3	upper molar (L)
28	2.809	-1.020	0.143	2.992	1.443	3	lower molar (R)
29	-1.188	0.436	-1.935	2.312	1.884*	2	lower molar (L)
32	1.506	-2.440	0.506	2.912	1.780*	5	coronoid tip (R)
33	-0.999	1.679	-1.552	2.495	2.202*	5	coronoid tip (L)
40	-0.674	0.400	-0.176	0.803	1.525	5	optic foramen (R)
41	0.810	-0.508	-1.212	1.544	2.638*	5	optic foramen (L)
42	-0.360	-0.116	0.010	0.379	1.464	5	nasale
43	-0.463	-0.075	0.905	1.019	1.283	2	bregma
44	2.804	0.260	-0.380	2.842	0.000	1	lambda

* probability less than 5%

Table 2.20 Single osseous landmark relocation error determined by ascribing errors equally to both Adelaide Dental Hospital and Adelaide Children's Hospital systems.

Landmark No.	Landmark relocation error (mm)				n	Landmark Name
	x	y	z	Magnt		
1	0.373	0.358	0.451	0.686	5	sella
2	0.339	0.666	0.714	1.034	5	nasion
3	0.332	1.124	0.264	1.201	5	glabella
4	0.523	0.192	5.268	5.298	4	vertex
5	1.810	2.793	1.078	3.499	4	opisthocranion
6	0.775	1.758	1.595	2.497	3	opisthion
7	0.419	1.301	1.329	1.906	5	mastoid tip (L)
8	0.533	0.554	0.767	1.086	5	mastoid tip (R)
9	0.445	0.803	1.318	1.607	5	basion
10	1.051	1.244	1.241	2.047	5	ext aud meatus (R)
11	0.866	1.116	1.505	2.064	5	ext aud meatus (L)
12	1.272	0.752	0.315	1.511	5	condylion (R)
13	1.018	0.784	0.378	1.339	4	condylion (L)
14	0.510	0.712	1.155	1.449	5	articulare (R)
15	0.688	0.828	1.641	1.963	5	articulare (L)
16	0.308	0.930	0.743	1.229	5	gonion (R)
17	0.315	0.308	1.141	1.223	5	gonion (L)
20	0.450	0.348	1.010	1.159	5	gnathion
21	0.321	0.808	0.421	0.966	5	pogonion
22	0.231	0.682	0.317	0.787	5	infradentale
23	0.188	0.302	0.282	0.454	5	prosthion
24	0.460	0.169	0.323	0.587	5	ant nasal spine
25	0.124	0.271	1.555	1.583	5	post nasal spine
26	3.886	0.647	1.029	4.072	4	upper molar (R)
27	2.421	0.105	0.795	2.550	3	upper molar (L)
28	2.831	0.826	0.279	2.962	3	lower molar (R)
29	1.089	0.445	1.428	1.851	2	lower molar (L)
32	1.586	1.896	1.866	3.097	5	coronoid tip (R)
33	0.729	1.570	1.638	2.383	5	coronoid tip (L)
40	0.627	0.494	0.489	0.936	5	optic foramen (R)
41	0.769	0.570	0.979	1.370	5	optic foramen (L)
42	0.387	0.137	0.192	0.454	5	nasale
43	0.423	0.077	0.806	0.914	2	bregma
44	1.983	0.184	0.269	2.009	1	lambda

Overall single landmark location error = 2.049 mm

Median single landmark location error = 1.480 mm

Table 2.21   Statistics of the differences between the two determinations of the craniometric distance measurements for the five skulls.

Landmk Nos.		Mean	SD	t-score	D	n	Landmk Abbrev.	
3	5	-0.120	0.362	0.742	0.244	5	g	op
10	11	-0.698	0.759	2.056	0.688	5	eamr	eaml
9	4	0.640	0.416	3.441*	0.523	5	ba	v
9	43	-0.020	0.268	0.167	0.170	5	ba	br
2	9	-0.260	0.288	2.018	0.259	5	n	ba
7	8	0.170	0.539	0.705	0.361	5	mtl	mtr
6	9	-0.652	0.352	4.139*	0.512	5	o	ba
2	42	-0.182	0.835	0.487	0.544	5	n	na
43	44	0.096	0.537	0.399	0.347	5	br	l
48	54	-0.452	0.288	3.507*	0.368	5	sorr	orr
46	50	-0.376	0.753	1.117	0.545	5	morr	lorr
62	52	0.250	0.862	0.649	0.573	5	zcr	oorr
49	55	-0.012	0.410	0.065	0.259	5	sorl	orl
47	51	-0.334	0.389	1.921	0.341	5	morl	lorl
63	53	0.180	0.739	0.545	0.485	5	zcl	oorl
56	57	0.302	1.074	0.628	0.712	5	iofr	iofl
2	24	-0.278	0.618	1.006	0.438	5	n	ans
23	24	0.098	0.414	0.529	0.271	5	pr	ans
24	25	-0.200	0.945	0.473	0.614	5	ans	pns
26	30	0.524	0.465	2.518	0.473	5	mur	zmr
27	31	-0.232	0.470	1.104	0.339	5	mul	zml
30	31	0.236	1.813	0.291	1.159	5	zmr	zml
66	67	0.058	0.109	1.188	0.080	5	nabr	nabl
36	37	-0.392	0.229	3.836*	0.313	5	scr	scl
58	59	0.108	0.498	0.484	0.324	5	aer	ael
62	63	0.420	0.444	2.116	0.409	5	zcr	zcl
64	65	0.042	0.226	0.416	0.146	5	zfr	zfl
12	13	-0.008	1.067	0.017	0.675	5	cdr	cdl
16	17	-0.122	0.490	0.557	0.322	5	gor	gol
12	16	-0.390	0.156	5.589*	0.293	5	cdr	gor
13	17	-0.104	0.332	0.700	0.222	5	cdl	gol
20	22	0.362	0.662	1.223	0.491	5	gn	id
21	22	-0.504	0.693	1.627	0.565	5	pg	id
32	33	-0.498	1.587	0.702	1.064	5	ctr	ctl
68	69	0.012	0.188	0.143	0.119	5	cnr	cnl
70	71	-0.072	0.679	0.237	0.433	5	eolr	eoll
72	73	-0.092	0.433	0.475	0.281	5	mfovr	mfovl
74	75	0.206	0.786	0.586	0.518	5	mfspr	mfspl
78	79	0.054	0.121	0.995	0.086	5	fmbr	fmbl

D - single distance determination error   * probability less than 5%

For landmark numbers greater than 44 see Tables 3.3 (a) and (b) for landmark definitions.

Table 2.22 (a)   Average anthropometric distances for A38.

Landmark Nos.		Distance (mm)	Landmark Abbrev.	
3	5	188.90	g	op
10	11	102.46	eamr	eaml
9	4	130.50	ba	v
9	43	130.50	ba	br
2	9	101.65	n	ba
7	8	96.03	mtl	mtr
6	9	36.41	o	ba
2	42	21.03	n	na
43	44	118.63	br	l
48	54	36.58	sorr	orr
46	50	41.59	morr	lorr
62	52	18.10	zcr	oorr
49	55	36.19	sorl	orl
47	51	42.55	morl	lorl
63	53	18.74	zcl	oorl
56	57	53.24	iofr	iofl
2	24	49.98	n	ans
23	24	10.98	pr	ans
24	25	55.50	ans	pns
26	30	25.69	mur	zmr
27	31	26.33	mul	zml
30	31	98.92	zmr	zml
66	67	25.31	nabr	nabl
36	37	29.18	scr	scl
58	59	118.93	aer	ael
62	63	117.60	zcr	zcl
64	65	93.05	zfr	zfl
12	13	99.41	cdr	cdl
14	15	103.13	arr	arl
16	17	95.87	gor	gol
12	16	62.69	cdr	gor
14	16	50.26	arr	gor
13	17	57.53	cdl	gol
15	17	47.47	arl	gol
20	22	28.40	gn	id
21	22	19.39	pg	id
32	33	88.54	ctr	ctl
68	69	90.49	cnr	cnl
70	71	79.96	eolr	eoll
72	73	46.23	mfovr	mfovl
74	75	61.50	mfspr	mfspl
78	79	30.55	fmbr	fmbl

For landmark numbers greater than 44 see Tables 3.3 (a) and (b) for landmark definitions.

Table 2.22 (b)   Average anthropometric distances for A90.

Landmark Nos.		Distance (mm)	Landmark	Abbrev.
3	5	186.28	g	op
10	11	91.42	eamr	eaml
9	4	120.75	ba	v
9	43	121.00	ba	br
2	9	97.20	n	ba
7	8	90.92	mtl	mtr
6	9	36.82	o	ba
2	42	17.20	n	na
43	44	118.30	br	l
48	54	37.72	sorr	orr
46	50	41.13	morr	lorr
62	52	15.97	zcr	oorr
49	55	33.98	sorl	orl
47	51	41.45	morl	lorl
63	53	17.05	zcl	oorl
56	57	50.59	iofr	iofl
2	24	47.25	n	ans
23	24	15.53	pr	ans
24	25	54.88	ans	pns
26	30	23.74	mur	zmr
27	31	21.95	mul	zml
30	31	92.75	zmr	zml
66	67	23.63	nabr	nabl
36	37	26.22	scr	scl
58	59	113.96	aer	ael
62	63	113.95	zcr	zcl
64	65	97.46	zfr	zfl
12	13	98.30	cdr	cdl
14	15	96.42	arr	arl
16	17	86.03	gor	gol
12	16	55.12	cdr	gor
14	16	43.71	arr	gor
13	17	52.62	cdl	gol
15	17	42.13	arl	gol
20	22	26.71	gn	id
21	22	18.42	pg	id
32	33	82.47	ctr	ctl
68	69	85.24	cnr	cnl
70	71	78.12	eolr	eoll
72	73	42.17	mfovr	mfovl
74	75	54.80	mfspr	mfspl
78	79	30.31	fmbr	fmbl

For landmark numbers greater than 44 see Tables 3.3 (a) and (b) for landmark definitions.

Table 2.22 (c)   Average anthropometric distances for A13184.

Landmark Nos.		Distance (mm)	Landmark	Abbrev.
3	5	181.75	g	op
10	11	103.28	eamr	eaml
9	4	118.35	ba	v
9	43	118.30	ba	br
2	9	93.00	n	ba
7	8	98.85	mtl	mtr
6	9	37.43	o	ba
2	42	19.99	n	na
43	44	103.58	br	l
48	54	32.07	sorr	orr
46	50	40.22	morr	lorr
62	52	14.11	zcr	oorr
49	55	31.66	sorl	orl
47	51	38.61	morl	lorl
63	53	16.75	zcl	oorl
56	57	54.07	iofr	iofl
2	24	47.48	n	ans
23	24	17.37	pr	ans
24	25	51.73	ans	pns
26	30	30.44	mur	zmr
27	31	29.84	mul	zml
30	31	88.58	zmr	zml
66	67	25.29	nabr	nabl
36	37	24.66	scr	scl
58	59	117.22	aer	ael
62	63	110.45	zcr	zcl
64	65	90.51	zfr	zfl
12	13	94.41	cdr	cdl
14	15	95.43	arr	arl
16	17	80.39	gor	gol
12	16	59.34	cdr	gor
14	16	45.65	arr	gor
13	17	59.83	cdl	gol
15	17	47.03	arl	gol
20	22	28.85	gn	id
21	22	21.10	pg	id
32	33	90.01	ctr	ctl
68	69	89.97	cnr	cnl
70	71	76.19	eolr	eoll
72	73	42.69	mfovr	mfovl
74	75	55.33	mfspr	mfspl
78	79	28.34	fmbr	fmbl

For landmark numbers greater than 44 see Tables 3.3 (a) and (b) for landmark definitions.

Table 2.22 (d)   Average anthropometric distances for A38778.

Landmark Nos.		Distance (mm)	Landmark Abbrev.	
3	5	165.53	g	op
10	11	98.09	eamr	eaml
9	4	117.00	ba	v
9	43	117.35	ba	br
2	9	90.05	n	ba
7	8	94.96	mtl	mtr
6	9	37.36	o	ba
2	42	16.90	n	na
43	44	99.43	br	l
48	54	31.03	sorr	orr
46	50	40.95	morr	lorr
62	52	15.49	zcr	oorr
49	55	29.68	sorl	orl
47	51	39.03	morl	lorl
63	53	15.62	zcl	oorl
56	57	50.06	iofr	iofl
2	24	41.43	n	ans
23	24	15.23	pr	ans
24	25	46.15	ans	pns
26	30	23.42	mur	zmr
27	31	23.42	mul	zml
30	31	85.21	zmr	zml
66	67	20.95	nabr	nabl
36	37	25.56	scr	scl
58	59	114.65	aer	ael
62	63	109.45	zcr	zcl
64	65	89.48	zfr	zfl
12	13	90.24	cdr	cdl
14	15	94.93	arr	arl
16	17	87.85	gor	gol
12	16	55.66	cdr	gor
14	16	43.49	arr	gor
13	17	53.83	cdl	gol
15	17	41.92	arl	gol
20	22	25.60	gn	id
21	22	18.44	pg	id
32	33	80.12	ctr	ctl
68	69	83.98	cnr	cnl
70	71	73.82	eolr	eoll
72	73	41.91	mfovr	mfovl
74	75	54.63	mfspr	mfspl
78	79	29.02	fmbr	fmbl

For landmark numbers greater than 44 see Tables 3.3 (a) and (b) for landmark definitions.

Table 2.22 (e)   Average anthropometric distances for A57590.

Landmark Nos.		Distance (mm)	Landmark	Abbrev.
3	5	177.35	g	op
10	11	93.59	eamr	eaml
9	4	122.00	ba	v
9	43	122.10	ba	br
2	9	97.55	n	ba
7	8	94.71	mtl	mtr
6	9	32.69	o	ba
2	42	20.53	n	na
43	44	103.58	br	l
48	54	36.03	sorr	orr
46	50	40.17	morr	lorr
62	52	17.78	zcr	oorr
49	55	36.08	sorl	orl
47	51	39.28	morl	lorl
63	53	19.38	zcl	oorl
56	57	52.16	iofr	iofl
2	24	49.64	n	ans
23	24	19.70	pr	ans
24	25	52.15	ans	pns
26	30	26.80	mur	zmr
27	31	25.33	mul	zml
30	31	91.42	zmr	zml
66	67	27.90	nabr	nabl
36	37	29.22	scr	scl
58	59	111.96	aer	ael
62	63	110.20	zcr	zcl
64	65	92.63	zfr	zfl
12	13	88.14	cdr	cdl
14	15	91.36	arr	arl
16	17	88.82	gor	gol
12	16	60.10	cdr	gor
14	16	44.09	arr	gor
13	17	57.40	cdl	gol
15	17	44.20	arl	gol
20	22	26.33	gn	id
21	22	18.73	pg	id
32	33	89.01	ctr	ctl
68	69	87.27	cnr	cnl
70	71	77.06	eolr	eoll
72	73	38.72	mfovr	mfovl
74	75	51.16	mfspr	mfspl
78	79	27.73	fmbr	fmbl

For landmark numbers greater than 44 see Tables 3.3 (a) and (b) for landmark definitions.

Table 2.23 (a)   Statistics of the difference between craniometric and Adelaide
Dental Hospital biplanar radiographic measurement of distances
over five skulls.

Landmk Nos.		Mean	SD	t-score	n	Landmark Abbrev.	
3	5	2.795	0.835	6.695*	4	g	op
10	11	-2.418	3.108	-1.740	5	eamr	eaml
9	4	0.296	2.986	0.222	5	ba	v
9	43	0.900	0.354	3.600	2	ba	br
2	9	-0.438	3.074	-0.319	5	n	ba
7	8	-0.442	0.179	-5.510*	5	mtl	mtr
6	9	0.246	2.830	0.194	5	o	ba
2	42	-0.248	0.652	-0.850	5	n	na
2	24	-0.196	0.607	-0.722	5	n	ans
23	24	-0.714	1.195	-1.336	5	pr	ans
24	25	-1.812	1.675	-2.419	5	ans	pns
12	13	0.795	6.495	0.245	4	cdr	cdl
16	17	1.426	1.748	1.824	5	gor	gol
12	16	-0.944	0.829	-2.548	5	cdr	gor
13	17	0.002	1.191	0.004	4	cdl	gol
20	22	-0.470	1.194	-0.880	5	gn	id
21	22	-0.522	1.241	-0.941	5	pg	id
32	33	-2.874	2.465	-2.607	5	ctr	ctl

* probability less than 5%

Table 2.23 (b)   Statistics of the difference between craniometric and Adelaide
Children's Hospital biplanar radiographic measurement of
distances over five skulls.

Landmk Nos.		Mean	SD	t-score	n	Landmark Abbrev.	
3	5	2.878	1.055	6.101*	5	g	op
10	11	-2.742	3.856	-1.590	5	eamr	eaml
9	4	0.355	3.325	0.214	4	ba	v
9	43	1.540	0.042	51.332*	2	ba	br
2	9	-1.684	3.258	-1.156	5	n	ba
7	8	-0.250	0.772	-0.724	5	mtl	mtr
6	9	1.497	1.738	1.492	3	o	ba
2	42	-0.488	0.708	-1.541	5	n	na
2	24	-0.332	0.851	-0.873	5	n	ans
23	24	-0.946	1.294	-1.635	5	pr	ans
24	25	0.122	1.832	0.149	5	ans	pns
12	13	0.032	4.067	0.018	5	cdr	cdl
16	17	1.692	1.990	1.901	5	gor	gol
12	16	-0.840	2.247	-0.836	5	cdr	gor
13	17	0.766	2.259	0.758	5	cdl	gol
20	22	-0.078	0.794	-0.220	5	gn	id
21	22	0.110	1.138	0.216	5	pg	id
32	33	0.176	2.690	0.146	5	ctr	ctl

* probability less than 5%

Table 2.24   Average difference between the two determinations of the osseous landmarks of the patient with Treacher Collins Syndrome pre- and post-operative.

Landmark No.	Average difference (mm)				n	Landmark Name
	x	y	z	Magnt		
1	0.431	0.204	0.553	0.730	2	sella
2	0.195	-0.030	-0.219	0.295	2	nasion
3	0.143	0.169	-0.056	0.228	2	glabella
4	-0.189	-0.127	-1.080	1.104	2	vertex
5	0.170	1.418	-0.195	1.441	2	opisthocranion
6	0.220	0.220	-0.596	0.673	2	opisthion
7	-0.431	-0.389	0.309	0.658	2	mastoid tip (L)
8	0.209	0.081	0.289	0.366	2	mastoid tip (R)
9	-0.055	-0.073	-0.097	0.134	2	basion
10	0.486	0.066	-0.069	0.495	2	ext aud meatus (R)
11	-0.406	-0.169	0.130	0.458	2	ext aud meatus (L)
12	0.886	-0.349	0.565	1.107	2	condylion (R)
13	-0.105	-0.147	0.847	0.866	2	condylion (L)
14	0.326	0.251	-0.012	0.411	2	articulare (R)
15	-0.103	0.138	0.227	0.285	2	articulare (L)
16	0.011	0.180	-0.195	0.265	2	gonion (R)
17	-0.018	0.657	-0.071	0.661	2	gonion (L)
20	1.073	-0.114	0.154	1.090	2	gnathion
21	0.989	-0.227	0.187	1.032	2	pogonion
22	-0.071	0.890	1.076	1.398	1	infradentale
23	-0.291	0.373	0.064	0.478	2	prosthion
24	0.044	-0.132	0.129	0.190	2	ant nasal spine
25	-0.025	-0.011	-0.242	0.243	2	post nasal spine
26	-0.034	-0.131	1.027	1.036	2	upper molar (R)
27	-1.683	0.224	-0.601	1.802	2	upper molar (L)
28	-0.390	0.112	-0.194	0.450	2	lower molar (R)
29	1.760	0.571	0.339	1.880	2	lower molar (L)
32	-0.053	-0.342	0.590	0.684	2	coronoid tip (R)
33	0.335	0.245	-0.359	0.549	2	coronoid tip (L)
40	1.868	-0.083	-0.665	1.985	1	optic foramen (R)
41	-1.677	-0.090	-0.552	1.768	1	optic foramen (L)
42	-0.103	0.264	-0.270	0.391	2	nasale
43	-0.089	0.138	-0.150	0.223	2	bregma

Table 2.25   Indicative single osseous landmark relocation errors for the patient with Treacher Collins Syndrome.

Landmark No.	Landmark relocation error (mm)				n	Landmark Name
	x	y	z	Magnt		
1	0.417	0.204	0.470	0.661	2	sella
2	0.577	0.028	0.257	0.632	2	nasion
3	0.137	0.353	0.086	0.389	2	glabella
4	0.136	0.192	0.810	0.844	2	vertex
5	1.193	3.046	0.188	3.276	2	opisthocranion
6	0.227	0.178	0.500	0.577	2	opisthion
7	0.592	0.305	0.327	0.742	2	mastoid tip (L)
8	0.230	0.190	0.240	0.383	2	mastoid tip (R)
9	0.102	0.362	0.105	0.390	2	basion
10	0.348	0.049	0.203	0.406	2	ext aud meatus (R)
11	0.560	0.216	0.231	0.643	2	ext aud meatus (L)
12	0.714	0.297	0.573	0.962	2	condylion (R)
13	0.105	0.108	0.599	0.618	2	condylion (L)
14	0.420	0.291	0.111	0.523	2	articulare (R)
15	0.078	0.185	0.226	0.302	2	articulare (L)
16	0.082	0.203	0.255	0.336	2	gonion (R)
17	0.136	0.589	0.602	0.853	2	gonion (L)
20	0.822	0.128	0.250	0.868	2	gnathion
21	0.789	0.196	0.187	0.835	2	pogonion
22	0.050	0.629	0.761	0.989	1	infradentale
23	0.377	0.418	0.054	0.565	2	prosthion
24	0.092	0.132	0.185	0.245	2	ant nasal spine
25	0.063	0.058	0.179	0.199	2	post nasal spine
26	0.709	0.120	1.035	1.260	2	upper molar (R)
27	1.869	0.194	1.018	2.137	2	upper molar (L)
28	0.341	0.113	0.205	0.413	2	lower molar (R)
29	1.829	0.760	0.241	1.995	2	lower molar (L)
32	0.132	0.360	0.429	0.575	2	coronoid tip (R)
33	0.476	0.345	0.537	0.797	2	coronoid tip (L)
40	1.321	0.059	0.470	1.403	1	optic foramen (R)
41	1.186	0.064	0.390	1.250	1	optic foramen (L)
42	0.219	0.264	0.254	0.427	2	nasale
43	0.195	0.174	0.113	0.284	2	bregma

Overall single landmark location error = 1.280 mm

Median single landmark location error = 0.656 mm

Table 3.1   Mean and standard deviation of the differences between CT slice determinations of the marker coordinates and the calibrated marker positions.

Marker No.	Mean residual (mm)				$d\sqrt{n}/\sigma$	n
	x	y	z	Magnt		
1	0.041	-0.132	0.000	0.138	0.667	5
2	-0.340	0.235	0.000	0.413	1.096	5
3	0.090	-0.172	0.000	0.194	0.824	5
4	-0.076	-0.186	0.000	0.201	1.695	5
5	0.270	-0.030	0.000	0.272	1.281	5
6	-0.030	-0.211	0.000	0.213	0.942	5
7	0.026	0.052	0.000	0.058	0.302	5
8	-0.006	0.302	0.000	0.302	1.124	5
9	0.273	0.250	0.000	0.370	2.780*	5
10	-0.232	0.109	0.000	0.256	1.345	5
11	0.086	0.012	0.000	0.087	0.353	5
12	0.110	0.069	0.000	0.130	0.979	5
13	-0.254	-0.257	0.000	0.361	1.204	5
14	0.041	-0.040	0.000	0.058	0.207	5

* probability less than 5%

Marker No.	Standard deviation of the residuals (mm)			
	x	y	z	Magnt
1	0.261	0.383	0.000	0.464
2	0.814	0.217	0.000	0.842
3	0.483	0.212	0.000	0.527
4	0.148	0.220	0.000	0.265
5	0.124	0.458	0.000	0.475
6	0.464	0.203	0.000	0.507
7	0.184	0.386	0.000	0.428
8	0.586	0.130	0.000	0.600
9	0.121	0.272	0.000	0.298
10	0.420	0.071	0.000	0.426
11	0.512	0.200	0.000	0.550
12	0.268	0.125	0.000	0.296
13	0.428	0.517	0.000	0.671
14	0.541	0.304	0.000	0.620

Table 3.2   Marker location error using CT.

| Marker No. | Marker location error (rms) (mm) | | | |
	x	y	z	Magnt
1	0.237	0.367	0.000	0.437
2	0.803	0.305	0.000	0.859
3	0.441	0.256	0.000	0.510
4	0.152	0.271	0.000	0.311
5	0.292	0.411	0.000	0.504
6	0.416	0.279	0.000	0.501
7	0.167	0.350	0.000	0.387
8	0.524	0.323	0.000	0.616
9	0.293	0.349	0.000	0.456
10	0.442	0.126	0.000	0.459
11	0.466	0.180	0.000	0.500
12	0.264	0.131	0.000	0.295
13	0.459	0.529	0.000	0.700
14	0.485	0.275	0.000	0.558

Pooled marker location error = 0.526 mm

Table 3.3 (a)

Osseous Landmark Definitions

Where no special comment is made, the landmarks are readily identifiable for craniometric, biplanar radiographic and CT determination. The craniometric definitions were based on Wilder (1920), Martin (1928) or Ashley-Montagu (1960) with minor modifications in some instances. For biplanar radiographic determination most of the landmarks have been based on the traditional lateral cephalometric definitions of Björk (1960, 1963) and Solow (1966) again with minor modifications in some instances. In each of these cases the landmarks are determined on the lateral view using the given definition and located on the coronal view using the "projection line" technique (see Sections 2.3 and 2.5).

anterior clinoid left/right (acl/acr): The mid-point of the tip of the anterior clinoid of the lesser wing of the sphenoid bone.

anterior nasal spine (ans) or spinal point (sp): The apex of the anterior nasal spine.

articulare left/right (arl/arr): This is a derived lateral radiographic point defined as the intersection of the contour of the cranial base and the dorsal contour of the mandibular neck or condyle, on a lateral radiograph. This landmark was located on coronal radiographs using the projection line technique using a contour following the lateral surface of the posterior ramus. Although the accuracy of this landmark was assessed for the biplanar measurement technique it was not retained for use in the shape analyses.

articular eminence left/right (ael/aer): The most inferior point on the articular eminence of the zygomatic process of the temporal bone.

basion (ba): The mid-sagittal point on the anterior margin of the foramen magnum.

bregma (br): The intersection of the sagittal and the coronal sutures on the surface of the cranial vault.

Chin Line (CL): The line through infradentale, tangent to the anterior border of the mandible in the mid-sagittal plane.

condylion left/right (cdl/cdr): In craniometry the bi-condylar breadth is defined as the distance between the lateral surfaces of the mandibular condyles. Therefore for craniometric measurement the most lateral point of the condylar head is measured. In cephalometry the crest of the condylar head is more readily determined, as it is the top of the shadow caused by the condylar head. For this reason distinct definitions of condylion are required: condylion lateral and condylion crest. As the initial emphasis of the material in this thesis related to biplanar radiographic three dimensional coordinate determination, the craniometric measurements were taken to be suitable for comparison with this method. Therefore the craniometric determination of the bi-condylar breadth was between left and right condylion crests. Using CT, on the other hand, condylion lateral is more easily determined because the condylar head is seated in the mandibular fossa of the temporal bone obscuring condylion crest. In the body of this thesis, the distinction between condylion crest and condylion lateral was not made and where comparisons were made between CT measurements and biplanar or craniometric measurements relating to condylion, significant differences were found.
The measured landmark using CT was actually neither the condylion crest nor the condylion lateral defined above, but rather the most superior lateral point on the condylar head. This was the closest point to the condylar crest that was visible on the condylar head using CT. In future, condylion lateral will be utilised for CT determinations.

coronoid notch left/right (cnl/cnr): The most inferior point of the coronoid notch (mandibular notch).

coronoid tip left/right (ctl/ctr): The tip of the coronoid process.

disto-molare inferius left/right (dmil/dmir): The disto-buccal cusp of the lower first molar.

disto-molare superius left/right (dmsl/dmsr): The disto-buccal cusp of the upper first molar.

external auditory meatus left/right (eaml/eamr): The centre of the external auditory meatus. In biplanar radiography this landmark is located on the

lateral radiograph at the centre of the ear-rod, and on the coronal radiograph it is located using the projection line technique using a vertical contour through the mastoid tip (see Section 2.6.2). With CT measurement the centre of the external auditory meatus is readily identified. Although the centre of an aperture can be determined from CT reconstructions using the techniques developed in this thesis, this is not feasible using measurement packages that locate on bony surfaces. In the future, a landmark on the rim could be utilised such as porion. Craniometric measurement requires care as the landmark is not on a bony surface.

external oblique line left/right (eoll/eolr): The intersection of the line of the ascending part of the coronoid process with the oblique line.

foramen caecum (fc): The mid-point of the foramen caecum.

foramen magnum breadth left/right (fmbl/fmbr): The most lateral point on the margin of the foramen magnum.

Frankfort Horizontal Plane (FHP): The plane intersecting right and left porion and right and left orbitale (see for example, Enlow, 1982).

glabella (g): The most prominent point in the mid-sagittal plane between the eyebrow ridges. Glabella is located slightly superior to the fronto-nasal suture. This definition is suitable for both craniometric and CT measurement, but in biplanar radiographic measurement from the lateral radiograph, the eyebrow ridges are more prominent, obscuring this landmark. For this reason the most anterior point on the frontal bone on the lateral radiograph is used because it can be reproducibly identified. The biplanar measurement of the landmark glabella is therefore antero-superior to the craniometric or CT measurement of that landmark.

gnathion (gn): The most inferior point on the mandibular symphysis in the mid-sagittal plane.

gonion left/right (gol/gor): A point on the angle of the mandible located by the bisection of the angle formed by the mandibular line and the ramus line.

incision inferius left/right (iil/iir): The mid-point of the incisal edge of the lower central incisor.

incision superius left/right (isl/isr): The mid-point of the incisal edge of the upper central incisor.

infradentale (id): The most antero-superior point on the mandibular alveolar process in the mid-sagittal plane.

infraorbital foramen left/right (iofl/iofr): The mid-point of the infraorbital foramen. This landmark is not reliably located using biplanar radiography.

lambda (l): The intersection between the lambdoid and sagittal sutures on the surface of the cranial vault.

lateral orbitale left/right (lorl/lorr): The most lateral point on the lateral orbital rim.

lesser wing of sphenoid left/right (lsl/lsr): The mid-point of the arc of the lesser wing of the sphenoid bone.

lower molar left/right (lml/lmr): The mid-point between the lower first and second molars at the level of the buccal alveolar margin.

Mandibular Line left/right (ML(l)/ML(r)): The line through gnathion, tangent to the lower border of the mandible at the region of the angle.

mastoid tip left/right (mtl/mtr): The most inferior point on the mastoid process.

medial anterior clinoid left/right (macl/macr): The most lateral point on the tuberculum sella at the level of the inferior margin of the optic groove.

medial foramen ovale left/right (mfol/mfor): The most medial point of the foramen ovale.

medial foramen spinosum left/right (mfsl/mfsr): The most antero-medial point of the foramen spinosum.

medial orbitale left/right (morl/morr): The most medial point on the medial orbital margin in the region of the fronto-lacrimal suture.

nasal breadth left/right (nabl/nabr): The most lateral point of the external edge of the nasal aperture.

nasale (na): The tip of the nasal bone (Stramrud, 1959).

Nasal Line (NL): The line through anterior nasal spine and posterior nasal spine.

Nasion-Sella Line (NSL): The line through nasion and sella.

nasion (n): The most anterior point of the frontonasal suture.

odontoid peg (odp): The apex of the odontoid process of the second cervical vertebra (Solow and Tallgren, 1976).

opisthion (o): The mid-sagittal point on the posterior margin of the foramen magnum. This landmark is difficult to locate on live patients due to the presence of the spinal column, in which case a good knowledge of related anatomical features aids identification .

opisthocranion (op): The most distal point on the skull from glabella in the mid-sagittal plane, excluding the external occipital protuberance (Brown, 1973).

opposite orbitale left/right (oorl/oorr): The point on the orbital rim horizontally opposite the zygomatic corner.

optic foramen left/right (ofl/ofr): For craniometric and CT determinations, the mid-point of the optic foramen viewed from both the front and from above (with the top of the skull removed). For biplanar measurement this landmark was located on the lateral radiograph at the intersection of the plane through upper pterygomaxillare with the contour of the anterior cranial fossa and on the coronal radiograph on the vertical contour through the most medial point of the superior oblique fissure. This biplanar method of location of the landmark was found to be unsatisfactory (see Section 4.2).

orbitale left/right (orl/orr): The most inferior point on the infraorbital margin in the region of the zygomaticomaxillary suture.

palatine tubercle left/right (scl/scr): The posterior point on the mid-line of the pterygoid fossa on the tubercle process of the palatine bone.

pogonion (pg): The most anterior point on the mandibular symphysis in the mid-sagittal plane.

porion left/right (pol/por): The most superior point on the margin of the external auditory meatus.

posterior clinoid left/right (pcl/pcr): The most lateral point of the dorsum sella at the height of the clinoid process.

posterior nasal spine (pns): The apex of the posterior nasal spine.

prosthion (pr): The most antero-inferior point on the maxillary alveolar process in the mid-sagittal plane.

Ramus Line left/right (RL(l)/RL(r)): The line through articulare, tangent to the posterior border of the mandibular ramus at the region of the angle.

sella (s): The centre of the sella turcica.

subspinale (ss): The most posterior point on the anterior contour of the upper alveolar process in the mid-sagittal plane.

superior orbitale left/right (sorl/sorr): The most superior point on the upper orbital margin.

supramentale (sm): The most posterior point on the anterior contour of the lower alveolar process in the mid-sagittal plane.

upper molar left/right (uml/umr): The mid-point between the upper first and second molars at the level of the buccal alveolar margin.

upper pterygomaxillare left/right (upml/upmr): The uppermost point of the pterygomaxillary fissure.

vertex (v): The most superior point in the mid-sagittal plane when the skull is oriented along the Frankfort Horizontal.

zygomatic corner left/right (zcl/zcr): The mid-point in the angle between the frontal and temporal processes of the zygomatic bone.

zygomatic frontal left/right (zfl/zfr): The point on the superior temporal line where the ridge between the anterior and lateral surfaces of the zygomatic process of the frontal bone flattens.

zygomaxillare left/right (zml/zmr): The most inferior point on the zygomaticomaxillary suture.

<u>Derived Landmarks</u>

95 The intersection of the plane parallel to the mid-sagittal plane through the landmark "lesser wing of sphenoid left" with the superior margin of the temporal bone.

96 The intersection of the plane parallel to the mid-sagittal plane through the landmark "lesser wing of sphenoid right" with the superior margin of the temporal bone.

97 The intersection of the plane parallel to the mid-sagittal plane through the landmark "anterior clinoid left" with the superior margin of the temporal bone.

98 The intersection of the plane parallel to the mid-sagittal plane through the landmark "anterior clinoid right" with the superior margin of the temporal bone.

99 The mid-point between the landmarks "anterior clinoid left" and "97".

100 The mid-point between the landmarks "anterior clinoid right" and "98".

101 The mid-point between the landmarks "lesser wing of sphenoid left" and "95".

102 The mid-point between the landmarks "lesser wing of sphenoid right" and "96".

Table 3.3 (b)   Numerical assignment to each of the osseous landmarks.

Landmark No.	Landmark Name
1	sella (s)
2	nasion (n)
3	glabella (g)
4	vertex (v)
5	opisthocranion (op)
6	opisthion (o)
7	mastoid tip L (mtl)
8	mastoid tip R (mtr)
9	basion (ba)
10	external auditory meatus R (eamr)
11	external auditory meatus L (eaml)
12	condylion R (cdr)
13	condylion L (cdl)
14	articulare R (arr)
15	articulare L (arl)
16	gonion R (gor)
17	gonion L (gol)
20	gnathion (gn)
21	pogonion (pg)
22	infradentale (id)
23	prosthion (pr)
24	anterior nasal spine (ans)
25	posterior nasal spine (pns)
26	upper molar R (umr)
27	upper molar L (uml)
28	lower molar R (lmr)
29	lower molar L (lml)
30	zygomaxillare R (zmr)
31	zygomaxillare L (zml)
32	coronoid tip R (ctr)

Table 3.3 (b) (continued)

Landmark No.	Landmark Name
33	coronoid tip L (ctl)
34	upper pterygomaxillare R (upmr)
35	upper pterygomaxillare L (upml)
36	palatine tubercle R (scr)
37	palatine tubercle L (scl)
40	optic foramen R (ofr)
41	optic foramen L (ofl)
42	nasale (na)
43	bregma (br)
44	lambda (l)
46	medial orbitale R (morr)
47	medial orbitale L (morl)
48	superior orbitale R (sorr)
49	superior orbitale L (sorl)
50	lateral orbitale R (lorr)
51	lateral orbitale L (lorl)
52	opposite orbitale R (oorr)
53	opposite orbitale L (oorl)
54	orbitale R (orr)
55	orbitale L (orl)
56	infraorbital foramen R (iofr)
57	infraorbital foramen L (iofl)
58	articular eminence R (aer)
59	articular eminence L (ael)
62	zygomatic corner R (zcr)
63	zygomatic corner L (zcl)
64	zygomatic frontal R (zfr)
65	zygomatic frontal L (zfl)
66	nasal breadth R (nabr)
67	nasal breadth L (nabl)

Table 3.3 (b) (continued)

Landmark No.	Landmark Name
68	coronoid notch R (cnr)
69	coronoid notch L (cnl)
70	external oblique line R (eolr)
71	external oblique line L (eoll)
72	medial foramen ovale R (mfor)
73	medial foramen ovale L (mfol)
74	medial foramen spinosum R (mfsr)
75	medial foramen spinosum L (mfsl)
78	foramen magnum breadth R (fmbr)
79	foramen magnum breadth L (fmbl)
80	incision superius R (isr)
81	incision superius L (isl)
82	incision inferius R (iir)
83	incision inferius L (iil)
84	disto-molare superius R (dmsr)
85	disto-molare superius L (dmsl)
86	disto-molare inferius R (dmir)
87	disto-molare inferius L (dmil)
88	subspinale (ss)
89	supramentale (sm)
90	odontoid peg (op)
91	anterior clinoid point L (acl)
92	anterior clinoid point R (acr)
93	lesser wing of sphenoid L (lsl)
94	lesser wing of sphenoid R (lsr)
95	
96	
97	
98	
99	

Table 3.3 (b) (continued)

Landmark No.	Landmark Name
100	
101	
102	
103	medial anterior clinoid L (macl)
104	medial anterior clinoid R (macr)
105	posterior clinoid L (pcl)
106	posterior clinoid R (pcr)
109	foramen caecum (fc)

Table 3.4 (a)   Difference between two CT determinations of landmark
coordinates for skull A38.

Landmark No.	Difference (mm) x	y	z	Magnt	Landmark Name
1	0.547	0.908	2.157	2.403	sella
2	-0.186	-2.375	-0.192	2.390	nasion
3	2.948	-0.520	1.290	3.259	glabella
6	0.624	-0.110	-0.549	0.839	opisthion
7	-0.049	0.282	0.072	0.295	mastoid tip (L)
8	0.973	-0.709	-0.152	1.213	mastoid tip (R)
9	0.207	0.678	0.036	0.710	basion
10	-0.967	-0.478	0.128	1.086	ext auditory meatus (R)
11	-0.365	0.099	-0.507	0.633	ext auditory meatus (L)
12	-2.067	-0.060	0.491	2.126	condylion (R)
13	0.085	0.359	-0.304	0.478	condylion (L)
16	0.530	-0.173	-0.124	0.571	gonion (R)
17	-0.386	0.595	-0.648	0.961	gonion (L)
24	1.782	-0.115	-0.273	1.806	ant nasal spine
25	0.330	0.442	-0.811	0.980	post nasal spine
26	-0.354	-2.032	0.506	2.124	upper molar (R)
27	-0.081	-0.481	0.221	0.535	upper molar (L)
28	0.317	0.137	1.099	1.152	lower molar (R)
29	-0.368	-0.302	0.262	0.543	lower molar (L)
30	0.049	0.771	0.406	0.873	zygomaxillare (R)
31	-2.101	-0.513	-2.264	3.131	zygomaxillare (L)
32	1.348	-1.833	-0.055	2.275	coronoid tip (R)
33	0.342	0.244	0.542	0.686	coronoid tip (L)
36	0.416	0.172	-0.017	0.451	palatine tubercle (R)
37	-0.284	0.990	-0.870	1.348	palatine tubercle (L)
40	1.124	0.377	0.010	1.186	optic foramen (R)
41	0.944	0.233	1.501	1.789	optic foramen (L)
42	1.898	-0.123	-0.122	1.906	nasale
46	-1.579	1.001	0.980	2.111	medial orbitale (R)
47	-0.997	-0.339	1.016	1.464	medial orbitale (L)
48	-0.078	1.515	-0.058	1.518	superior orbitale (R)
49	-0.503	2.456	-0.418	2.542	superior orbitale (L)
50	-0.118	0.060	0.670	0.683	lateral orbitale (R)
51	0.472	-0.832	-0.241	0.986	lateral orbitale (L)
52	-0.152	-0.375	-0.942	1.025	opposite orbitale (R)
53	-0.802	-1.245	-0.195	1.493	opposite orbitale (L)
54	6.154	0.260	0.618	6.190	orbitale (R)

Table 3.4 (a) (continued)

Landmark No.	Difference (mm)				Landmark Name
	x	y	z	Magnt	
55	0.489	1.067	-0.092	1.177	orbitale (L)
56	0.209	-0.946	-0.071	0.971	infraorbital foramen (R)
57	-0.115	0.387	-0.346	0.532	infraorbital foramen (L)
58	0.553	0.171	-0.010	0.579	articular eminence (R)
59	-0.315	-0.489	-0.105	0.591	articular eminence (L)
62	0.612	0.105	-0.485	0.787	zygomatic corner (R)
63	-0.361	-0.806	0.045	0.884	zygomatic corner (L)
64	-0.130	-1.186	0.350	1.243	zygomatic frontal (R)
65	-1.182	2.101	3.440	4.201	zygomatic frontal (L)
66	-0.950	-1.037	-2.431	2.809	nasal breadth (R)
67	-0.673	0.360	-1.269	1.481	nasal breadth (L)
68	-0.102	-0.606	-0.306	0.686	coronoid notch (R)
69	-0.433	-0.362	0.177	0.591	coronoid notch (L)
70	-0.783	-0.625	-0.277	1.040	ext oblique line (R)
71	-2.407	0.317	-0.082	2.429	ext oblique line (L)
78	0.327	-2.660	1.716	3.183	foramen mag breadth (R)
79	0.476	-0.547	0.027	0.726	foramen mag breadth (L)
91	-0.428	1.263	1.349	1.897	anterior clinoid (L)
92	0.581	0.285	-0.077	0.652	anterior clinoid (R)
93	-1.313	-0.444	-0.160	1.396	lesser wing of sphenoid (L)
94	0.900	0.341	1.295	1.613	lesser wing of sphenoid (R)
95	-1.616	-1.537	-0.193	2.238	
96	0.854	0.384	-0.280	0.977	
97	-0.681	-1.569	0.781	1.880	
98	0.628	-0.195	2.125	2.225	
99	-0.479	-0.195	0.733	0.897	
100	0.573	-0.540	-0.571	0.972	
101	-1.321	-1.005	1.586	2.295	
102	0.931	0.519	0.782	1.322	
103	0.140	0.932	1.946	2.163	medial anterior clinoid (L)
104	0.767	0.296	1.265	1.509	medial anterior clinoid (R)
105	1.398	4.131	8.969	9.973	posterior clinoid (L)
106	0.466	1.621	1.239	2.093	posterior clinoid (R)

Table 3.4 (b)   Difference between two CT determinations of landmark coordinates for skull A90.

Landmark No.	x	Difference (mm) y	z	Magnt	Landmark Name
1	0.043	0.172	0.760	0.780	sella
2	-0.092	0.353	0.844	0.919	nasion
3	1.178	-0.401	-3.846	4.043	glabella
7	-0.330	-0.171	-0.949	1.019	mastoid tip (L)
8	0.718	0.106	-1.073	1.296	mastoid tip (R)
9	-0.241	-0.056	-0.416	0.484	basion
10	3.637	-0.021	3.605	5.121	ext auditory meatus (R)
11	-0.809	-2.865	0.689	3.056	ext auditory meatus (L)
12	-2.292	0.233	-0.228	2.315	condylion (R)
13	1.607	-1.061	-0.434	1.974	condylion (L)
16	0.342	0.422	0.099	0.553	gonion (R)
17	-1.670	2.576	0.648	3.138	gonion (L)
24	0.959	-1.006	-0.140	1.397	ant nasal spine
25	-0.393	0.157	-4.539	4.559	post nasal spine
26	0.722	0.749	-0.297	1.082	upper molar (R)
27	-0.107	-0.432	-0.004	0.445	upper molar (L)
30	0.824	-0.382	1.055	1.392	zygomaxillare (R)
31	-0.336	-0.530	-0.212	0.662	zygomaxillare (L)
32	0.025	-0.812	-0.113	0.820	coronoid tip (R)
33	-1.405	-0.938	-0.083	1.691	coronoid tip (L)
36	0.037	0.631	-3.133	3.196	palatine tubercle (R)
37	0.188	-0.691	-0.873	1.129	palatine tubercle (L)
40	-0.580	-0.622	0.467	0.970	optic foramen (R)
41	0.090	-0.857	0.497	0.995	optic foramen (L)
42	0.512	-0.987	0.245	1.138	nasale
46	-0.179	2.084	-0.291	2.112	medial orbitale (R)
47	0.123	-1.255	1.158	1.712	medial orbitale (L)
48	-0.309	-0.156	-0.009	0.347	superior orbitale (R)
49	-2.235	0.110	-1.862	2.911	superior orbitale (L)
50	0.613	0.202	0.296	0.710	lateral orbitale (R)
51	0.000	-0.468	0.601	0.761	lateral orbitale (L)
52	0.609	0.385	0.830	1.099	opposite orbitale (R)
53	1.401	-0.689	0.139	1.567	opposite orbitale (L)
54	1.276	2.008	-0.814	2.515	orbitale (R)
55	2.111	-1.884	-4.586	5.388	orbitale (L)
56	-0.209	0.000	-0.391	0.443	infraorbital foramen (R)
57	-1.149	0.595	-3.662	3.884	infraorbital foramen (L)

Table 3.4 (b) (continued)

Landmark No.	x	Difference (mm) y	z	Magnt	Landmark Name
58	-0.919	0.178	0.000	0.936	articular eminence (R)
59	-0.291	-1.073	-0.042	1.112	articular eminence (L)
62	1.521	0.375	-0.235	1.584	zygomatic corner (R)
63	-0.469	0.251	-0.204	0.569	zygomatic corner (L)
64	0.954	-2.956	-5.699	6.490	zygomatic frontal (R)
65	1.477	-0.185	4.356	4.603	zygomatic frontal (L)
66	0.539	-0.144	1.828	1.911	nasal breadth (R)
67	0.289	-0.644	0.484	0.856	nasal breadth (R)
68	-0.320	0.286	0.219	0.482	coronoid notch (R)
69	-1.952	0.061	0.624	2.051	coronoid notch (L)
70	0.611	0.174	0.501	0.809	ext oblique line (R)
71	0.131	-0.061	-0.498	0.518	ext oblique line (L)
72	-0.172	0.222	-2.079	2.098	medial foramen ovale (R)
73	0.158	-0.041	-0.854	0.870	medial foramen ovale (L)
78	0.200	0.597	0.697	0.939	foramen mag breadth (R)
79	-0.069	2.492	0.089	2.494	foramen mag breadth (L)
81	-1.295	1.946	0.543	2.400	incision superius (L)
85	0.157	0.152	-0.803	0.832	disto-molare superius (L)
91	-0.338	1.042	2.962	3.158	anterior clinoid (L)
92	-0.462	0.447	0.123	0.655	anterior clinoid (R)
97	-0.529	-1.165	0.161	1.290	
98	-0.389	0.469	1.865	1.962	
99	-0.437	-0.325	0.138	0.562	
100	-0.292	0.546	1.166	1.320	
103	0.655	4.859	0.993	5.002	medial anterior clinoid (L)
104	1.770	5.229	-3.559	6.568	medial anterior clinoid (R)
105	-0.206	-1.401	0.387	1.468	posterior clinoid (L)
106	-0.105	-0.611	-1.876	1.976	posterior clinoid (R)

Table 3.4 (c)   Difference between two CT determinations of landmark coordinates for skull A13184.

Landmark No.	Difference (mm) x	y	z	Magnt	Landmark Name
1	0.494	-2.207	0.843	2.413	sella
2	-0.355	-0.034	0.139	0.382	nasion
3	3.826	0.798	0.240	3.915	glabella
9	0.125	-0.607	-0.895	1.089	basion
10	-0.323	-0.301	-0.124	0.459	ext auditory meatus (R)
11	6.492	1.028	0.162	6.575	ext auditory meatus (L)
12	-1.391	1.497	-0.091	2.045	condylion (R)
13	5.460	2.933	0.269	6.204	condylion (L)
16	2.623	-0.094	0.208	2.633	gonion (R)
17	1.477	-1.287	-3.228	3.776	gonion (L)
21	-0.826	-0.228	-2.049	2.221	pogonion
23	0.113	-0.049	-2.642	2.645	prosthion
24	1.662	0.883	-0.068	1.883	ant nasal spine
25	0.430	-0.708	0.722	1.099	post nasal spine
26	-0.292	0.257	-0.520	0.649	upper molar (R)
27	0.168	0.959	-0.318	1.024	upper molar (L)
30	-0.923	-0.351	0.425	1.075	zygomaxillare (R)
31	0.491	-1.184	-0.185	1.295	zygomaxillare (L)
32	-0.133	0.102	0.123	0.208	coronoid tip (R)
33	4.461	1.082	-0.542	4.622	coronoid tip (L)
36	0.119	-0.843	0.823	1.184	palatine tubercle (R)
37	0.235	-0.999	-1.854	2.119	palatine tubercle (L)
42	0.000	0.000	0.149	0.149	nasale
46	-1.356	-2.412	0.396	2.796	medial orbitale (R)
47	-0.385	1.941	-2.081	2.872	medial orbitale (L)
48	1.504	-0.273	0.298	1.558	superior orbitale (R)
49	-1.520	4.657	0.349	4.911	superior orbitale (L)
50	0.013	-0.016	0.020	0.029	lateral orbitale (R)
51	-4.770	12.207	-1.412	13.182	lateral orbitale (L)
52	-3.128	-1.399	-0.455	3.457	opposite orbitale (R)
53	-0.237	3.297	-0.410	3.331	opposite orbitale (L)
54	-1.250	-1.237	-0.178	1.768	orbitale (R)
55	-0.935	6.521	0.367	6.598	orbitale (L)
56	-1.573	-3.880	6.329	7.589	infraorbital foramen (R)
57	-0.446	5.717	0.000	5.734	infraorbital foramen (L)
58	-4.937	1.626	0.507	5.223	articular eminence (R)
59	9.197	1.470	-0.027	9.314	articular eminence (L)

Table 3.4 (c) (continued)

Landmark No.	Difference (mm)			Magnt	Landmark Name
	x	y	z		
62	-0.854	0.310	-0.327	0.966	zygomatic corner (R)
63	1.181	2.474	-0.024	2.742	zygomatic corner (L)
64	-1.977	-0.664	1.190	2.401	zygomatic frontal (R)
65	0.213	2.759	0.164	2.772	zygomatic frontal (L)
66	-0.658	-1.013	2.014	2.349	nasal breadth (R)
67	-2.478	7.258	-1.715	7.859	nasal breadth (L)
68	-0.435	0.411	-0.089	0.606	coronoid notch (R)
69	0.260	1.849	0.299	1.891	coronoid notch (L)
70	1.185	-0.207	-1.974	2.312	ext oblique line (R)
71	8.230	1.583	-1.773	8.567	ext oblique line (L)
72	-0.573	-0.519	1.064	1.315	medial foramen ovale (R)
73	0.233	-0.909	2.579	2.744	medial foramen ovale (L)

Table 3.4 (d)   Difference between two CT determinations of landmark
coordinates for skull A38778.

| Landmark No. | Difference (mm) | | | | Landmark Name |
	x	y	z	Magnt	
1	0.026	0.019	0.516	0.517	sella
2	-1.104	-0.562	0.029	1.239	nasion
3	0.290	0.140	0.178	0.368	glabella
6	0.248	0.039	-0.238	0.346	opisthion
7	-0.719	-0.507	-0.260	0.917	mastoid tip (L)
8	0.485	0.528	-0.264	0.764	mastoid tip (R)
9	-0.342	-0.198	-0.617	0.733	basion
10	0.406	-0.287	-0.170	0.526	ext auditory meatus (R)
11	-0.726	0.086	0.025	0.731	ext auditory meatus (L)
12	-3.151	-0.001	2.159	3.819	condylion (R)
13	-2.775	-0.414	-0.161	2.811	condylion (L)
16	-0.395	-0.710	-1.054	1.331	gonion (R)
17	0.621	-0.739	-0.625	1.150	gonion (L)
21	-1.833	-0.498	-0.712	2.029	pogonion
25	-0.026	-0.317	-0.324	0.454	post nasal spine
26	0.151	-0.410	-1.437	1.502	upper molar (R)
27	-0.720	-0.439	-1.035	1.335	upper molar (L)
28	0.149	-0.971	0.287	1.024	lower molar (R)
29	-0.647	-1.381	0.624	1.648	lower molar (L)
30	0.264	-0.988	-1.176	1.558	zygomaxillare (R)
31	0.041	-0.991	-0.803	1.276	zygomaxillare (L)
32	0.731	0.001	-0.794	1.079	coronoid tip (R)
33	-0.940	0.461	0.590	1.202	coronoid tip (L)
42	-0.112	1.442	0.647	1.584	nasale
46	-0.344	0.052	-0.205	0.404	medial orbitale (R)
47	-0.811	-0.216	-0.919	1.245	medial orbitale (L)
48	4.851	0.613	0.690	4.938	superior orbitale (R)
49	0.252	2.454	0.176	2.473	superior orbitale (L)
50	0.714	0.562	-1.751	1.973	lateral orbitale (R)
51	-1.386	1.047	-0.828	1.924	lateral orbitale (L)
52	-1.015	-0.790	-1.288	1.820	opposite orbitale (R)
53	2.727	0.757	0.445	2.865	opposite orbitale (L)
54	-0.703	0.081	0.062	0.710	orbitale (R)
55	2.260	-0.097	-0.451	2.307	orbitale (L)
58	-1.310	0.208	-0.154	1.335	articular eminence (R)
59	-0.842	-0.260	0.064	0.883	articular eminence (L)

Table 3.4 (d) (continued)

Landmark No.	Difference (mm)				Landmark Name
	x	y	z	Magnt	
62	0.350	-0.160	0.011	0.385	zygomatic corner (R)
63	-1.423	0.313	-0.167	1.466	zygomatic corner (L)
64	0.429	0.784	0.595	1.074	zygomatic frontal (R)
65	-1.237	3.137	2.707	4.324	zygomatic frontal (L)
66	-0.088	1.376	0.657	1.527	nasal breadth (R)
67	-0.305	-1.294	-0.681	1.494	nasal breadth (L)
68	-0.087	0.333	-0.408	0.534	coronoid notch (R)
69	-1.750	1.024	-0.011	2.028	coronoid notch (L)
70	-1.308	0.065	-1.121	1.724	ext oblique line (R)
71	0.130	-0.007	0.076	0.151	ext oblique line (L)
78	0.290	-0.796	2.999	3.117	foramen mag breadth (R)
79	0.198	-0.713	1.290	1.487	foramen mag breadth (L)
93	0.886	0.207	0.470	1.024	lesser wing of sphenoid (L)
94	1.148	-0.505	0.047	1.255	lesser wing of sphenoid (R)
95	1.073	1.551	0.479	1.946	
96	1.482	-1.013	2.662	3.211	
101	0.956	0.632	0.468	1.238	
102	1.344	0.438	2.327	2.723	

Table 3.4 (e)   Difference between two CT determinations of landmark coordinates for skull A57590.

Landmark No.	Difference (mm) x	y	z	Magnt	Landmark Name
1	-0.238	-5.391	-2.925	6.138	sella
2	0.500	-1.140	-0.599	1.381	nasion
3	-1.381	-0.296	-0.306	1.445	glabella
7	-0.895	-4.094	1.100	4.333	mastoid tip (L)
8	1.304	-3.296	-0.510	3.581	mastoid tip (R)
9	0.063	-8.262	0.408	8.273	basion
10	0.488	1.209	-0.341	1.347	ext auditory meatus (R)
11	-1.376	0.852	0.089	1.621	ext auditory meatus (L)
12	0.203	0.758	0.517	0.940	condylion (R)
13	-1.206	2.283	-0.189	2.589	condylion (L)
16	-1.498	1.107	-0.764	2.013	gonion (R)
17	-0.901	1.360	-1.675	2.339	gonion (L)
24	-0.779	-0.320	-0.316	0.900	ant nasal spine
25	0.562	-4.651	0.871	4.765	post nasal spine
26	-1.056	-0.364	-0.681	1.308	upper molar (R)
27	0.310	0.864	-1.035	1.384	upper molar (L)
28	-0.488	0.270	-1.070	1.206	lower molar (R)
32	-0.280	0.821	0.406	0.958	coronoid tip (R)
33	1.689	0.643	-0.210	1.819	coronoid tip (L)
36	1.293	-5.540	1.088	5.792	palatine tubercle (R)
37	-1.096	-6.562	1.151	6.752	palatine tubercle (L)
42	-0.019	-0.931	0.125	0.940	nasale
46	0.221	0.589	-1.496	1.623	medial orbitale (R)
47	0.483	2.052	0.050	2.109	medial orbitale (L)
48	-0.666	-1.603	1.063	2.035	superior orbitale (R)
49	5.654	5.622	-0.590	7.995	superior orbitale (L)
50	-0.876	0.370	0.847	1.274	lateral orbitale (R)
51	0.329	0.457	0.144	0.581	lateral orbitale (L)
52	-1.755	0.434	0.163	1.815	opposite orbitale (R)
53	-0.777	1.606	0.187	1.794	opposite orbitale (L)
54	0.092	0.000	0.044	0.102	orbitale (R)
55	1.906	2.342	0.138	3.023	orbitale (L)
56	-2.215	-2.457	0.701	3.382	infraorbital foramen (R)
57	0.939	0.929	-0.376	1.373	infraorbital foramen (L)
58	0.128	0.178	-0.305	0.376	articular eminence (R)
59	2.945	1.651	0.447	3.406	articular eminence (L)

Table 3.4 (e) (continued)

Landmark No.	Difference (mm) x	y	z	Magnt	Landmark Name
62	-1.078	0.710	0.324	1.331	zygomatic corner (R)
63	1.682	-0.534	0.101	1.768	zygomatic corner (L)
64	-2.205	0.054	3.097	3.802	zygomatic frontal (R)
65	0.837	1.502	0.000	1.719	zygomatic frontal (L)
66	0.254	0.603	0.821	1.050	nasal breadth (R)
67	0.852	-0.369	-0.742	1.189	nasal breadth (L)
69	-1.351	0.365	-0.349	1.443	coronoid notch (L)
72	1.671	-6.186	0.128	6.409	medial foramen ovale (R)
73	-1.334	-6.503	0.786	6.685	medial foramen ovale (L)
93	-1.766	-5.119	-0.523	5.440	lesser wing of sphenoid (L)
94	1.420	-5.170	-1.100	5.473	lesser wing of sphenoid (R)
95	-1.302	-8.027	0.649	8.158	
96	1.618	-8.749	-1.231	8.982	
101	-1.397	-6.741	-0.343	6.893	
102	1.436	-7.092	-1.726	7.439	
105	-0.423	-6.552	-3.916	7.645	posterior clinoid (L)
106	0.000	-7.045	-3.950	8.077	posterior clinoid (R)

Table 3.5 (a)   Mean of the differences between the two CT determinations of the five skulls.

| Landmk No. | Mean differences (mm) | | | | $d\sqrt{n}/\sigma$ | n | Landmark Name |
	x	y	z	Magnt			
1	0.174	-1.300	0.270	1.339	0.933	5	sella
2	-0.247	-0.752	0.044	0.793	1.339	5	nasion
3	1.372	-0.056	-0.489	1.458	1.120	5	glabella
6	0.436	-0.036	-0.394	0.588	2.307*	2	opisthion
7	-0.498	-1.122	-0.009	1.228	1.109	4	mastoid tip (L)
8	0.870	-0.843	-0.500	1.310	1.458	4	mastoid tip (R)
9	-0.038	-1.689	-0.297	1.715	1.023	5	basion
10	0.648	0.024	0.620	0.897	0.792	5	ext auditory meatus (R)
11	0.643	-0.160	0.092	0.669	0.408	5	ext auditory meatus (L)
12	-1.740	0.485	0.570	1.894	2.486*	5	condylion (R)
13	0.634	0.820	-0.164	1.049	0.653	5	condylion (L)
16	0.320	0.110	-0.327	0.471	0.601	5	gonion (R)
17	-0.172	0.501	-1.106	1.226	1.112	5	gonion (L)
21	-1.329	-0.363	-1.381	1.951	2.301*	2	pogonion
23	0.113	-0.049	-2.642	2.645	0.000	1	prosthion
24	0.906	-0.140	-0.199	0.938	1.321	4	ant nasal spine
25	0.181	-1.015	-0.816	1.315	0.964	5	post nasal spine
26	-0.166	-0.360	-0.486	0.627	0.985	5	upper molar (R)
27	-0.086	0.094	-0.434	0.453	0.987	5	upper molar (L)
28	-0.007	-0.188	0.105	0.216	0.275	3	lower molar (R)
29	-0.507	-0.842	0.443	1.078	1.840*	2	lower molar (L)
30	0.054	-0.237	0.178	0.301	0.429	4	zygomaxillare (R)
31	-0.476	-0.804	-0.866	1.274	1.662*	4	zygomaxillare (L)
32	0.338	-0.344	-0.087	0.490	0.842	5	coronoid tip (R)
33	0.829	0.298	0.059	0.883	0.782	5	coronoid tip (L)
36	0.466	-1.395	-0.310	1.503	0.864	4	palatine tubercle (R)
37	-0.239	-1.815	-0.612	1.931	1.081	4	palatine tubercle (L)
40	0.272	-0.122	0.238	0.382	0.377	2	optic foramen (R)
41	0.517	-0.312	0.999	1.167	1.365	2	optic foramen (L)
42	0.456	-0.120	0.209	0.515	0.870	5	nasale
46	-0.647	0.263	-0.123	0.709	0.769	5	medial orbitale (R)
47	-0.317	0.437	-0.155	0.562	0.596	5	medial orbitale (L)
48	1.060	0.019	0.397	1.132	0.975	5	superior orbitale (R)
49	0.330	3.060	-0.469	3.113	1.788*	5	superior orbitale (L)
50	0.069	0.236	0.016	0.246	0.443	5	lateral orbitale (R)
51	-1.071	2.482	-0.347	2.726	1.022	5	lateral orbitale (L)
52	-1.088	-0.349	-0.338	1.192	1.439	5	opposite orbitale (R)
53	0.462	0.745	0.033	0.878	0.812	5	opposite orbitale (L)

Table 3.5 (a) (continued)

Landmk No.	Mean differences (mm) x	y	z	Magnt	$d\sqrt{n}/\sigma$	n	Landmark Name
54	1.114	0.222	-0.054	1.137	0.786	5	orbitale (R)
55	1.166	1.590	-0.925	2.178	1.211	5	orbitale (L)
56	-0.947	-1.821	1.642	2.628	1.396	4	infraorbital foramen (R)
57	-0.193	1.907	-1.096	2.208	1.382	4	infraorbital foramen (L)
58	-1.297	0.472	0.008	1.380	1.351	5	articular eminence (R)
59	2.139	0.260	0.067	2.156	1.095	5	articular eminence (L)
62	0.110	0.268	-0.142	0.323	0.618	5	zygomatic corner (R)
63	0.122	0.340	-0.050	0.364	0.448	5	zygomatic corner (L)
64	-0.586	-0.794	-0.093	0.991	0.571	5	zygomatic frontal (R)
65	0.022	1.863	2.133	2.832	2.391*	5	zygomatic frontal (L)
66	-0.181	-0.043	0.578	0.607	0.628	5	nasal breadth (R)
67	-0.463	1.062	-0.785	1.399	0.818	5	nasal breadth (L)
68	-0.236	0.106	-0.146	0.297	1.028	4	coronoid notch (R)
69	-1.045	0.587	0.148	1.208	2.039*	5	coronoid notch (L)
70	-0.074	-0.148	-0.718	0.737	0.909	4	ext oblique line (R)
71	1.521	0.458	-0.569	1.687	0.708	4	ext oblique line (L)
72	0.309	-2.161	-0.296	2.203	0.944	3	medial foramen ovale (R)
73	-0.314	-2.484	0.837	2.640	1.142	3	medial foramen ovale (L)
78	0.272	-0.953	1.804	2.058	1.781	3	foramen mag breadth (R)
79	0.202	0.411	0.469	0.655	0.579	3	foramen mag breadth (L)
81	-1.295	1.946	0.543	2.400	0.000	1	incision superius (L)
85	0.157	0.152	-0.803	0.832	0.000	1	disto-molare superius (L)
91	-0.383	1.153	2.155	2.474	3.035*	2	anterior clinoid (L)
92	0.059	0.366	0.023	0.372	0.692	2	anterior clinoid (R)
93	-0.731	-1.785	-0.071	1.930	1.022	3	lesser wing of sphenoid (L)
94	1.156	-1.778	0.081	2.122	1.145	3	lesser wing of sphenoid (R)
95	-0.615	-2.671	0.312	2.759	0.932	3	
96	1.318	-3.126	0.384	3.414	1.108	3	
97	-0.605	-1.367	0.471	1.567	4.149*	2	
98	0.120	0.137	1.995	2.003	3.226*	2	
99	-0.458	-0.260	0.435	0.683	2.239*	2	
100	0.141	0.003	0.298	0.329	0.296	2	
101	-0.587	-2.371	0.570	2.509	1.032	3	
102	1.237	-2.045	0.461	2.434	0.872	3	
103	0.397	2.896	1.469	3.271	1.606	2	medial anterior clinoid (L)
104	1.268	2.763	-1.147	3.249	0.932	2	medial anterior clinoid (R)
105	0.256	-1.274	1.813	2.231	0.454	3	posterior clinoid (L)
106	0.120	-2.012	-1.529	2.530	0.841	3	posterior clinoid (R)

* probability less than 5%

Table 3.5 (b)   Standard deviation of the differences between the two CT determinations of the five skulls.

Landmark No.	Standard deviation (mm)				n	Landmark Name
	x	y	z	Magnt		
1	0.336	2.566	1.897	3.209	5	sella
2	0.577	1.067	0.529	1.324	5	nasion
3	2.079	0.538	1.965	2.911	5	glabella
6	0.266	0.105	0.220	0.361	2	opisthion
7	0.381	2.007	0.853	2.214	4	mastoid tip (L)
8	0.351	1.714	0.410	1.797	4	mastoid tip (R)
9	0.240	3.704	0.520	3.748	5	basion
10	1.773	0.682	1.677	2.534	5	ext auditory meatus (R)
11	3.290	1.572	0.426	3.671	5	ext auditory meatus (L)
12	1.255	0.651	0.950	1.703	5	condylion (R)
13	3.144	1.723	0.265	3.595	5	condylion (L)
16	1.514	0.687	0.554	1.752	5	gonion (R)
17	1.242	1.564	1.444	2.465	5	gonion (L)
21	0.712	0.191	0.945	1.199	2	pogonion
23	0.000	0.000	0.000	0.000	1	prosthion
24	1.181	0.781	0.115	1.420	4	ant nasal spine
25	0.388	2.080	2.197	3.050	5	post nasal spine
26	0.658	1.050	0.701	1.423	5	upper molar (R)
27	0.395	0.747	0.581	1.025	5	upper molar (L)
28	0.425	0.681	1.096	1.358	3	lower molar (R)
29	0.197	0.763	0.256	0.829	2	lower molar (L)
30	0.728	0.734	0.951	1.405	4	zygomaxillare (R)
31	1.135	0.336	0.975	1.533	4	zygomaxillare (L)
32	0.685	1.014	0.444	1.302	5	coronoid tip (R)
33	2.361	0.757	0.492	2.527	5	coronoid tip (L)
36	0.575	2.831	1.940	3.480	4	palatine tubercle (R)
37	0.617	3.283	1.263	3.571	4	palatine tubercle (L)
40	1.205	0.706	0.323	1.434	2	optic foramen (R)
41	0.604	0.771	0.710	1.209	2	optic foramen (L)
42	0.842	0.983	0.280	1.324	5	nasale
46	0.780	1.671	0.923	2.062	5	medial orbitale (R)
47	0.621	1.480	1.363	2.106	5	medial orbitale (L)
48	2.276	1.155	0.477	2.596	5	superior orbitale (R)
49	3.124	2.153	0.872	3.894	5	superior orbitale (L)
50	0.641	0.234	1.039	1.243	5	lateral orbitale (R)
51	2.195	5.487	0.793	5.963	5	lateral orbitale (L)
52	1.446	0.783	0.851	1.852	5	opposite orbitale (R)
53	1.552	1.821	0.336	2.416	5	opposite orbitale (L)

Table 3.5 (b) (continued)

Landmark No.	Standard deviation (mm)				n	Landmark Name
	x	y	z	Magnt		
54	2.973	1.161	0.517	3.233	5	orbitale (R)
55	1.370	3.165	2.069	4.022	5	orbitale (L)
56	1.137	1.705	3.158	3.765	4	infraorbital foramen (R)
57	0.869	2.550	1.719	3.196	4	infraorbital foramen (L)
58	2.171	0.645	0.306	2.285	5	articular eminence (R)
59	4.221	1.225	0.221	4.401	5	articular eminence (L)
62	1.077	0.323	0.317	1.168	5	zygomatic corner (R)
63	1.277	1.288	0.132	1.819	5	zygomatic corner (L)
64	1.429	1.419	3.314	3.877	5	zygomatic frontal (R)
65	1.210	1.305	1.963	2.649	5	zygomatic frontal (L)
66	0.620	1.045	1.785	2.159	5	nasal breadth (R)
67	1.267	3.514	0.825	3.826	5	nasal breadth (L)
68	0.170	0.477	0.277	0.578	4	coronoid notch (R)
69	0.934	0.867	0.361	1.325	5	coronoid notch (L)
70	1.166	0.356	1.068	1.621	4	ext oblique line (R)
71	4.630	0.768	0.838	4.767	4	ext oblique line (L)
72	1.197	3.505	1.614	4.040	3	medial foramen ovale (R)
73	0.884	3.507	1.717	4.004	3	medial foramen ovale (L)
78	0.065	1.634	1.154	2.001	3	foramen mag breadth (R)
79	0.273	1.804	0.712	1.959	3	foramen mag breadth (L)
81	0.000	0.000	0.000	0.000	1	incision superius (L)
85	0.000	0.000	0.000	0.000	1	disto-molare superius (L)
91	0.064	0.156	1.141	1.153	2	anterior clinoid (L)
92	0.738	0.115	0.141	0.760	2	anterior clinoid (R)
93	1.419	2.905	0.502	3.272	3	lesser wing of sphenoid (L)
94	0.260	2.968	1.198	3.211	3	lesser wing of sphenoid (R)
95	1.470	4.889	0.445	5.124	3	
96	0.408	4.920	2.030	5.337	3	
97	0.107	0.286	0.438	0.534	2	
98	0.719	0.470	0.184	0.878	2	
99	0.030	0.092	0.421	0.432	2	
100	0.612	0.768	1.228	1.572	2	
101	1.337	3.872	0.969	4.209	3	
102	0.269	4.371	2.045	4.833	3	
103	0.364	2.777	0.674	2.881	2	medial anterior clinoid (L)
104	0.709	3.488	3.411	4.930	2	medial anterior clinoid (R)
105	0.995	5.343	6.560	8.518	3	posterior clinoid (L)
106	0.304	4.500	2.612	5.212	3	posterior clinoid (R)

Table 3.6   Osseous landmark relocation error for dried skulls using CT.

Landmark No.	Relocation error (mm)				n	Landmark Name
	x	y	z	Magnt		
1	0.245	1.865	1.215	2.239	5	sella
2	0.405	0.859	0.336	1.007	5	nasion
3	1.634	0.343	1.290	2.110	5	glabella
6	0.336	0.058	0.299	0.453	2	opisthion
7	0.423	1.463	0.522	1.610	4	mastoid tip (L)
8	0.652	1.207	0.434	1.439	4	mastoid tip (R)
9	0.154	2.629	0.390	2.663	5	basion
10	1.211	0.432	1.148	1.724	5	ext auditory meatus (R)
11	2.130	1.000	0.277	2.369	5	ext auditory meatus (L)
12	1.464	0.536	0.723	1.719	5	condylion (R)
13	2.039	1.235	0.204	2.392	5	condylion (L)
16	0.984	0.441	0.420	1.157	5	gonion (R)
17	0.795	1.051	1.202	1.784	5	gonion (L)
21	1.005	0.274	1.085	1.504	2	pogonion
23	0.080	0.035	1.868	1.870	1	prosthion
24	0.966	0.488	0.158	1.094	4	ant nasal spine
25	0.277	1.498	1.505	2.142	5	post nasal spine
26	0.432	0.711	0.561	1.003	5	upper molar (R)
27	0.257	0.477	0.479	0.723	5	upper molar (L)
28	0.245	0.415	0.637	0.799	3	lower molar (R)
29	0.372	0.707	0.338	0.868	2	lower molar (L)
30	0.448	0.480	0.596	0.886	4	zygomaxillare (R)
31	0.772	0.605	0.855	1.301	4	zygomaxillare (L)
32	0.495	0.686	0.287	0.893	5	coronoid tip (R)
33	1.604	0.523	0.314	1.716	5	coronoid tip (L)
36	0.482	1.995	1.208	2.381	4	palatine tubercle (R)
37	0.414	2.385	0.886	2.578	4	palatine tubercle (L)
40	0.632	0.364	0.234	0.766	2	optic foramen (R)
41	0.474	0.444	0.791	1.023	2	optic foramen (L)
42	0.623	0.627	0.231	0.913	5	nasale
46	0.673	1.073	0.590	1.397	5	medial orbitale (R)
47	0.453	0.986	0.869	1.390	5	medial orbitale (L)
48	1.623	0.731	0.412	1.827	5	superior orbitale (R)
49	1.990	2.557	0.644	3.303	5	superior orbitale (L)
50	0.408	0.223	0.657	0.805	5	lateral orbitale (R)
51	1.581	3.889	0.559	4.235	5	lateral orbitale (L)
52	1.195	0.553	0.589	1.443	5	opposite orbitale (R)
53	1.035	1.267	0.214	1.649	5	opposite orbitale (L)
54	2.039	0.751	0.329	2.197	5	orbitale (R)

Table 3.6 (continued)

Landmark No.	Relocation error (mm) x	y	z	Magnt	n	Landmark Name
55	1.196	2.296	1.463	2.973	5	orbitale (L)
56	0.966	1.658	2.256	2.961	4	infraorbital foramen (R)
57	0.549	2.063	1.307	2.503	4	infraorbital foramen (L)
58	1.651	0.527	0.193	1.744	5	articular eminence (R)
59	3.068	0.797	0.147	3.174	5	articular eminence (L)
62	0.686	0.279	0.224	0.773	5	zygomatic corner (R)
63	0.812	0.849	0.091	1.179	5	zygomatic corner (L)
64	0.994	1.058	2.097	2.550	5	zygomatic frontal (R)
65	0.765	1.554	1.954	2.611	5	zygomatic frontal (L)
66	0.412	0.662	1.201	1.431	5	nasal breadth (R)
67	0.866	2.346	0.762	2.614	5	nasal breadth (L)
68	0.197	0.302	0.199	0.411	4	coronoid notch (R)
69	0.946	0.688	0.251	1.197	5	coronoid notch (L)
70	0.716	0.242	0.828	1.121	4	ext oblique line (R)
71	3.032	0.571	0.652	3.154	4	ext oblique line (L)
72	0.725	2.536	0.955	2.805	3	medial foramen ovale (R)
73	0.557	2.681	1.155	2.971	3	medial foramen ovale (L)
78	0.196	1.159	1.439	1.858	3	foramen mag breadth (R)
79	0.212	1.081	0.528	1.222	3	foramen mag breadth (L)
81	0.916	1.376	0.384	1.697	1	incision superius (L)
85	0.111	0.107	0.568	0.588	1	disto-molare superius (L)
91	0.273	0.819	1.627	1.842	2	anterior clinoid (L)
92	0.371	0.265	0.073	0.462	2	anterior clinoid (R)
93	0.968	2.099	0.294	2.331	3	lesser wing of sphenoid (L)
94	0.831	2.125	0.694	2.385	3	lesser wing of sphenoid (R)
95	0.954	3.396	0.339	3.544	3	
96	0.961	3.599	1.203	3.915	3	
97	0.431	0.977	0.399	1.140	2	
98	0.369	0.254	1.414	1.483	2	
99	0.324	0.190	0.373	0.529	2	
100	0.322	0.384	0.649	0.820	2	
101	0.877	2.794	0.689	3.009	3	
102	0.888	2.909	1.225	3.279	3	
103	0.335	2.474	1.092	2.725	2	medial anterior clinoid (L)
104	0.965	2.619	1.889	3.370	2	medial anterior clinoid (R)
105	0.602	3.213	3.998	5.165	3	posterior clinoid (L)
106	0.195	2.962	1.855	3.500	3	posterior clinoid (R)

Overall point location error (pooled Dahlberg) = 2.144 mm

Median point location error (median Dahlberg) = 1.721 mm

Table 3.7 (a)   Comparison of distances derived from CT three dimensional coordinates of osseous landmarks with craniometric distance measurements for skull A38.

Landmark Nos.		Cranio. Dist.	3D Data Dist.	Difference	Landmark Abbrev.	
10	11	102.46	98.16	-4.30	eamr	eaml
2	9	101.65	103.44	1.79	n	ba
7	8	96.03	96.97	0.94	mtl	mtr
6	9	36.41	36.43	0.02	o	ba
2	42	21.03	20.81	-0.22	n	na
48	54	36.58	32.92	-3.66	sorr	orr
46	50	41.59	40.51	-1.08	morr	lorr
62	52	18.10	19.99	1.89	zcr	oorr
49	55	36.19	32.75	-3.44	sorl	orl
47	51	42.55	39.21	-3.34	morl	lorl
63	53	18.74	21.17	2.43	zcl	oorl
56	57	53.24	55.57	2.33	iofr	iofl
2	24	49.98	48.64	-1.34	n	ans
23	24	10.98	11.94	0.96	pr	ans
24	25	55.50	55.94	0.44	ans	pns
26	30	25.69	26.21	0.52	mur	zmr
27	31	26.33	27.64	1.31	mul	zml
30	31	98.92	97.91	-1.01	zmr	zml
66	67	25.31	27.08	1.77	nabr	nabl
36	37	29.18	27.98	-1.20	scr	scl
58	59	118.93	118.44	-0.49	aer	ael
62	63	117.60	119.17	1.57	zcr	zcl
64	65	93.05	96.49	3.44	zfr	zfl
12	13	99.41	108.86	9.45	cdr	cdl
16	17	95.87	94.01	-1.86	gor	gol
12	16	62.69	60.63	-2.06	cdr	gor
13	17	57.53	57.49	-0.04	cdl	gol
32	33	88.54	86.72	-1.82	ctr	ctl
68	69	90.49	90.39	-0.10	cnr	cnl
78	79	30.55	31.09	0.54	fmbr	fmbl

Table 3.7 (b)   Comparison of distances derived from CT three dimensional coordinates of osseous landmarks with craniometric distance measurements for skull A90.

Landmark Nos.		Cranio. Dist.	3D Data Dist.	Difference	Landmark Abbrev.	
10	11	91.42	95.81	4.39	eamr	eaml
2	9	97.20	99.62	2.42	n	ba
7	8	90.92	89.37	-1.55	mtl	mtr
2	42	17.20	17.63	0.43	n	na
48	54	37.72	33.92	-3.80	sorr	orr
46	50	41.13	39.49	-1.64	morr	lorr
62	52	15.97	17.28	1.31	zcr	oorr
49	55	33.98	28.91	-5.07	sorl	orl
47	51	41.45	39.59	-1.86	morl	lorl
63	53	17.05	16.97	-0.08	zcl	oorl
56	57	50.59	53.14	2.55	iofr	iofl
2	24	47.25	44.01	-3.24	n	ans
23	24	15.53	12.95	-2.58	pr	ans
24	25	54.88	56.12	1.24	ans	pns
26	30	23.74	29.09	5.35	mur	zmr
27	31	21.95	24.69	2.74	mul	zml
30	31	92.75	93.55	0.80	zmr	zml
66	67	23.63	26.29	2.66	nabr	nabl
36	37	26.22	25.28	-0.94	scr	scl
58	59	113.96	114.40	0.44	aer	ael
62	63	113.95	113.85	-0.10	zcr	zcl
64	65	97.46	98.39	0.93	zfr	zfl
12	13	98.30	106.78	8.48	cdr	cdl
16	17	86.03	83.25	-2.78	gor	gol
12	16	55.12	57.13	2.01	cdr	gor
13	17	52.62	50.87	-1.75	cdl	gol
32	33	82.47	79.54	-2.93	ctr	ctl
68	69	85.24	81.10	-4.14	cnr	cnl
72	73	42.17	41.30	0.87	mfovr	mfovl
78	79	30.31	30.34	0.03	fmbr	fmbl

Table 3.7 (c)   Comparison of distances derived from CT three dimensional coordinates of osseous landmarks with craniometric distance measurements for skull A13184.

Landmark Nos.		Cranio. Dist.	3D Data Dist.	Difference	Landmark Abbrev.	
10	11	103.28	96.31	-6.97	eamr	eaml
2	9	93.00	93.22	0.22	n	ba
2	42	19.99	18.36	-1.63	n	na
48	54	32.07	29.34	-2.73	sorr	orr
46	50	40.22	39.81	-0.41	morr	lorr
62	52	14.11	19.03	4.92	zcr	oorr
49	55	31.66	30.26	-1.40	sorl	orl
47	51	38.61	38.87	0.26	morl	lorl
63	53	16.75	21.49	4.74	zcl	oorl
56	57	54.07	53.36	-0.71	iofr	iofl
2	24	47.48	44.74	-2.74	n	ans
23	24	17.37	15.82	-1.55	pr	ans
24	25	51.73	53.99	2.26	ans	pns
26	30	30.44	33.79	3.35	mur	zmr
27	31	29.84	32.35	2.51	mul	zml
30	31	88.58	92.42	3.84	zmr	zml
66	67	25.29	26.24	0.95	nabr	nabl
36	37	24.66	24.67	0.01	scr	scl
58	59	117.22	105.21	-12.01	aer	ael
62	63	110.45	111.93	1.48	zcr	zcl
64	65	90.51	92.34	1.83	zfr	zfl
12	13	94.41	102.02	7.61	cdr	cdl
16	17	80.39	75.73	-4.66	gor	gol
12	16	59.34	60.50	1.16	cdr	gor
13	17	59.83	58.37	-1.46	cdl	gol
32	33	90.01	87.55	-2.46	ctr	ctl
68	69	89.97	88.56	-1.41	cnr	cnl
72	73	42.69	42.67	-0.02	mfovr	mfovl

Table 3.7 (d)   Comparison of distances derived from CT three dimensional coordinates of osseous landmarks with craniometric distance measurements for skull A38778.

Landmark Nos.		Cranio. Dist.	3D Data Dist.	Difference	Landmark Abbrev.	
10	11	98.09	94.71	-3.38	eamr	eaml
2	9	90.05	88.23	-1.82	n	ba
7	8	94.96	94.96	0.00	mtl	mtr
6	9	37.36	37.70	0.34	o	ba
2	42	16.90	14.22	-2.68	n	na
48	54	31.03	29.68	-1.35	sorr	orr
46	50	40.95	40.12	-0.83	morr	lorr
62	52	15.49	14.97	-0.52	zcr	oorr
49	55	29.68	29.59	-0.09	sorl	orl
47	51	39.03	38.54	-0.49	morl	lorl
63	53	15.62	18.18	2.56	zcl	oorl
56	57	50.06	54.70	4.64	iofr	iofl
2	24	41.43	39.31	-2.12	n	ans
24	25	46.15	42.19	-3.96	ans	pns
26	30	23.42	28.10	4.68	mur	zmr
27	31	23.42	27.70	4.28	mul	zml
30	31	85.21	90.42	5.21	zmr	zml
66	67	20.95	21.77	0.82	nabr	nabl
58	59	114.65	108.30	-6.35	aer	ael
62	63	109.45	109.70	0.25	zcr	zcl
64	65	89.48	91.62	2.14	zfr	zfl
12	13	90.24	99.74	9.50	cdr	cdl
16	17	87.85	82.66	-5.19	gor	gol
12	16	55.66	56.53	0.87	cdr	gor
13	17	53.83	56.61	2.78	cdl	gol
21	22	18.44	19.92	1.48	pg	id
32	33	80.12	79.84	-0.28	ctr	ctl
68	69	83.98	82.74	-1.24	cnr	cnl
78	79	29.02	30.42	1.40	fmbr	fmbl

Table 3.7 (e)   Comparison of distances derived from CT three dimensional coordinates of osseous landmarks with craniometric distance measurements for skull A57590.

Landmark Nos.		Cranio. Dist.	3D Data Dist.	Difference	Landmark Abbrev.	
10	11	93.59	93.65	0.06	eamr	eaml
2	9	97.55	107.92	10.37	n	ba
7	8	94.71	98.05	3.34	mtl	mtr
2	42	20.53	20.26	-0.27	n	na
48	54	36.03	29.47	-6.56	sorr	orr
46	50	40.17	39.17	-1.00	morr	lorr
62	52	17.78	19.12	1.34	zcr	oorr
49	55	36.08	32.02	-4.06	sorl	orl
47	51	39.28	38.87	-0.41	morl	lorl
63	53	19.38	20.75	1.37	zcl	oorl
56	57	52.16	53.16	1.00	iofr	iofl
2	24	49.64	48.41	-1.23	n	ans
24	25	52.15	54.36	2.21	ans	pns
26	30	26.80	26.08	-0.72	mur	zmr
27	31	25.33	24.75	-0.58	mul	zml
30	31	91.42	90.84	-0.58	zmr	zml
66	67	27.90	28.85	0.95	nabr	nabl
36	37	29.22	29.87	0.65	scr	scl
58	59	111.96	102.42	-9.54	aer	ael
62	63	110.20	110.13	-0.07	zcr	zcl
64	65	92.63	97.35	4.72	zfr	zfl
12	13	88.14	99.81	11.67	cdr	cdl
16	17	88.82	87.33	-1.49	gor	gol
12	16	60.10	61.62	1.52	cdr	gor
13	17	57.40	60.41	3.01	cdl	gol
32	33	89.01	88.00	-1.01	ctr	ctl
68	69	87.27	86.70	-0.57	cnr	cnl
72	73	38.72	41.94	3.22	mfovr	mfovl

Table 3.8   Statistics of the comparison of distances derived from CT three dimensional coordinates of osseous landmarks with craniometric distance measurements for the five test skulls.

Landmk Nos.		Mean	SD	t	n	Landmk Abbrev.	
10	11	-2.040	4.386	1.040	5	eamr	eaml
2	9	2.596	4.644	1.250	5	n	ba
7	8	0.683	2.048	0.667	4	mtl	mtr
6	9	0.180	0.226	1.125	2	o	ba
2	42	-0.874	1.258	1.554	5	n	na
62	52	1.788	1.973	2.026	5	zcr	oorr
47	51	-1.168	1.438	1.816	5	morl	lorl
56	57	1.962	1.982	2.213	5	iofr	iofl
23	24	-1.057	1.821	1.005	3	pr	ans
24	25	0.438	2.571	0.381	5	ans	pns
26	30	2.636	2.636	2.236	5	mur	zmr
27	31	2.052	1.811	2.533	5	mul	zml
30	31	1.652	2.750	1.343	5	zmr	zml
36	37	-0.370	0.856	0.864	4	scr	scl
58	59	-5.590	5.472	2.284	5	aer	ael
62	63	0.626	0.833	1.681	5	zcr	zcl
12	16	0.700	1.601	0.978	5	cdr	gor
13	17	0.508	2.275	0.499	5	cdl	gol
68	69	-1.492	1.571	2.124	5	cnr	cnl
78	79	0.657	0.692	1.643	3	fmbr	fmbl
72	73	0.777	2.158	0.623	3	mfovr	mfovl
48	54	-3.620	1.912	4.234*	5	sorr	orr
46	50	-0.992	0.445	4.983*	5	morr	lorr
49	55	-2.812	2.028	3.100*	5	sorl	orl
63	53	2.204	1.769	2.785*	5	zcl	oorl
2	24	-2.134	0.872	5.475*	5	n	ans
66	67	1.430	0.784	4.076*	5	nabr	nabl
64	65	2.612	1.483	3.939*	5	zfr	zfl
12	13	9.342	1.516	13.775*	5	cdr	cdl
16	17	-3.196	1.657	4.312*	5	gor	gol
32	33	-1.700	1.072	3.546*	5	ctr	ctl

* probability less than 5%

Table 3.9 (a)   Difference between two CT determinations of landmark coordinates for patient 796025.

Landmark No.	Difference (mm) x	y	z	Magnt	Landmark Name
1	-0.115	0.120	-1.809	1.816	sella
2	-0.060	-0.284	-0.586	0.654	nasion
7	-0.332	0.781	-0.248	0.885	mastoid tip (L)
8	-0.522	0.935	-0.523	1.192	mastoid tip (R)
11	2.033	0.421	0.975	2.294	ext auditory meatus (L)
12	-0.018	0.107	0.124	0.165	condylion (R)
13	0.191	1.416	0.363	1.474	condylion (L)
16	-2.613	-0.357	1.047	2.838	gonion (R)
17	0.375	2.722	1.301	3.041	gonion (L)
23	-0.037	-0.343	0.923	0.985	prosthion
24	0.609	0.218	0.328	0.726	ant nasal spine
26	-0.341	-0.061	-0.554	0.653	upper molar (R)
27	-0.003	-0.174	1.302	1.314	upper molar (L)
29	0.363	-0.346	-0.202	0.540	lower molar (L)
32	1.074	0.535	0.565	1.326	coronoid tip (R)
33	1.837	-0.251	-0.308	1.879	coronoid tip (L)
40	-0.391	-0.257	-1.076	1.174	optic foramen (R)
41	0.550	-0.171	-3.462	3.510	optic foramen (L)
42	-10.969	-2.017	-1.838	11.303	nasale
46	-3.281	-0.261	-3.800	5.027	medial orbitale (R)
47	-0.141	-1.073	1.148	1.578	medial orbitale (L)
48	-0.372	0.664	0.100	0.768	superior orbitale (R)
49	0.238	-0.415	0.540	0.722	superior orbitale (L)
50	-0.472	-0.500	-0.265	0.737	lateral orbitale (R)
51	0.670	0.000	2.038	2.145	lateral orbitale (L)
52	0.885	1.128	1.065	1.786	opposite orbitale (R)
53	-1.320	2.104	-0.160	2.489	opposite orbitale (L)
54	-0.914	0.152	0.344	0.989	orbitale (R)
55	2.421	1.044	-0.185	2.643	orbitale (L)
56	0.416	0.775	0.000	0.879	infraorbital foramen (R)
57	0.100	0.677	0.118	0.694	infraorbital foramen (L)
62	-1.431	-2.836	0.976	3.323	zygomatic corner (R)
63	1.671	-2.515	0.522	3.065	zygomatic corner (L)
64	-4.630	0.110	3.224	5.643	zygomatic frontal (R)
65	-0.037	-0.930	-0.593	1.104	zygomatic frontal (L)
66	-0.016	-0.218	1.650	1.664	nasal breadth (R)
67	-0.548	1.224	-0.593	1.466	nasal breadth (L)

Table 3.9 (a) (continued)

Landmark No.	Difference (mm)				Landmark Name
	x	y	z	Magnt	
68	-2.917	-0.277	-0.208	2.937	coronoid notch (R)
69	0.100	1.462	0.541	1.562	coronoid notch (L)
73	-0.183	0.536	-1.993	2.072	medial foramen ovale (L)
78	-0.158	-2.840	1.242	3.104	foramen mag breadth (R)
79	1.016	-3.011	3.471	4.706	foramen mag breadth (L)
80	-0.171	1.177	0.605	1.335	incision superius (R)
81	0.000	2.138	0.420	2.178	incision superius (L)
82	0.614	1.417	0.355	1.585	incision inferius (R)
83	0.283	0.896	-0.293	0.985	incision inferius (L)
84	2.481	0.588	-1.068	2.764	disto-molare superius (R)
85	-0.347	0.663	0.477	0.887	disto-molare superius (L)
87	0.516	0.328	0.147	0.629	disto-molare inferius (L)
88	2.479	0.321	0.440	2.539	subspinale
90	0.524	-0.568	-0.317	0.835	odontoid peg
91	0.438	-0.113	-1.027	1.122	anterior clinoid (L)
92	0.228	-1.269	0.142	1.297	anterior clinoid (R)
93	-0.538	0.830	-1.424	1.734	lesser wing of sphenoid (L)
94	0.502	-0.854	-0.146	1.001	lesser wing of sphenoid (R)
95	-0.459	-0.078	-2.310	2.357	
96	-0.158	1.653	9.654	9.796	
97	0.264	-0.702	0.217	0.781	
98	0.281	-0.475	-2.170	2.240	
99	0.311	-0.391	-0.079	0.506	
100	0.371	-1.124	-0.967	1.529	
101	-0.591	0.409	-1.625	1.776	
102	0.272	-0.007	4.550	4.558	
103	0.886	-0.124	-1.030	1.364	medial anterior clinoid (L)
104	-0.888	0.680	-0.470	1.213	medial anterior clinoid (R)
105	0.624	-0.105	-0.567	0.850	posterior clinoid (L)
106	-0.313	0.246	-1.560	1.610	posterior clinoid (R)

Table 3.9 (b)   Difference between two CT determinations of landmark
                 coordinates for patient 864405.

Landmark No.	Difference (mm) x	y	z	Magnt	Landmark Name
1	-0.098	0.700	1.569	1.721	sella
2	-0.346	0.285	0.858	0.968	nasion
3	-2.073	0.773	-0.454	2.259	glabella
7	-0.286	0.268	-0.627	0.740	mastoid tip (L)
8	-1.219	-0.732	-0.424	1.483	mastoid tip (R)
9	0.036	0.824	0.387	0.911	basion
10	0.698	-0.303	-0.314	0.823	ext auditory meatus (R)
11	-0.740	0.915	0.857	1.456	ext auditory meatus (L)
12	0.078	0.161	-0.111	0.211	condylion (R)
13	0.803	-1.155	0.360	1.452	condylion (L)
16	-1.311	-1.149	-2.633	3.157	gonion (R)
17	1.774	-1.727	-2.199	3.311	gonion (L)
23	0.205	-0.986	-0.151	1.018	prosthion
24	-0.242	0.703	1.397	1.583	ant nasal spine
32	0.010	0.329	0.016	0.330	coronoid tip (R)
33	0.629	-0.263	-0.452	0.818	coronoid tip (L)
42	-0.129	-0.707	-0.334	0.793	nasale
46	3.166	1.326	0.910	3.551	medial orbitale (R)
48	1.211	-1.907	0.000	2.258	superior orbitale (R)
49	3.536	-8.086	1.218	8.909	superior orbitale (L)
50	-0.450	-0.004	-0.550	0.711	lateral orbitale (R)
51	-0.151	-0.095	0.196	0.265	lateral orbitale (L)
52	0.217	0.534	-0.270	0.636	opposite orbitale (R)
54	-1.456	0.935	-0.939	1.968	orbitale (R)
55	1.352	-0.445	-0.494	1.507	orbitale (L)
62	-0.341	-0.135	0.269	0.454	zygomatic corner (R)
63	0.055	0.251	-0.768	0.809	zygomatic corner (L)
64	-6.914	-2.874	-0.317	7.494	zygomatic frontal (R)
65	3.074	3.771	8.546	9.834	zygomatic frontal (L)
66	-5.811	-2.008	-0.590	6.176	nasal breadth (R)
69	2.100	1.127	-0.856	2.533	coronoid notch (L)
71	0.029	-0.210	-0.671	0.704	ext oblique line (L)
78	-0.518	0.689	0.463	0.978	foramen mag breadth (R)
79	-0.500	1.189	7.716	7.823	foramen mag breadth (L)

Table 3.9 (b) (continued)

Landmark No.	x	y	z	Magnt	Landmark Name
80	-0.218	-1.480	-0.026	1.496	incision superius (R)
81	-1.936	-0.376	-0.460	2.025	incision superius (L)
90	-0.048	0.427	-0.845	0.948	odontoid peg
91	-0.365	0.110	0.430	0.575	anterior clinoid (L)
92	0.530	0.542	-0.073	0.761	anterior clinoid (R)
93	-0.796	1.344	1.838	2.412	lesser wing of sphenoid (L)
94	1.269	0.000	2.146	2.493	lesser wing of sphenoid (R)
95	-1.050	-0.474	0.516	1.262	
96	0.760	-0.108	0.982	1.246	
97	-0.277	-0.052	0.727	0.780	
98	0.409	0.192	0.050	0.455	
99	-0.376	-0.405	0.655	0.857	
100	0.472	0.525	0.674	0.976	
101	-0.837	0.028	0.725	1.108	
102	0.991	0.104	1.637	1.917	
103	0.278	-1.009	3.219	3.385	medial anterior clinoid (L)
104	-0.345	-0.439	3.460	3.505	medial anterior clinoid (R)
105	0.000	2.554	-1.428	2.926	posterior clinoid (L)
106	0.399	-0.676	-0.012	0.785	posterior clinoid (R)

Table 3.9 (c) Difference between two CT determinations of landmark coordinates for patient 866790.

Landmark No.	Difference (mm) x	y	z	Magnt	Landmark Name
1	-0.512	0.454	2.104	2.212	sella
2	-0.114	-1.735	0.211	1.751	nasion
3	0.008	0.393	0.234	0.458	glabella
16	1.128	0.567	0.327	1.304	gonion (R)
17	0.471	0.102	0.869	0.993	gonion (L)
22	1.264	-1.506	-1.348	2.384	infradentale
23	1.110	-0.941	-0.752	1.638	prosthion
24	-0.740	-0.641	-0.932	1.352	ant nasal spine
27	-4.770	-0.196	-0.165	4.777	upper molar (L)
28	-1.535	0.715	-1.381	2.185	lower molar (R)
29	-0.246	-0.886	0.237	0.950	lower molar (L)
42	-0.253	-0.174	0.063	0.313	nasale
47	-3.024	3.897	1.860	5.272	medial orbitale (L)
48	-0.623	1.167	-0.353	1.369	superior orbitale (R)
49	0.176	2.333	0.336	2.364	superior orbitale (L)
50	0.290	0.560	-0.742	0.974	lateral orbitale (R)
51	-0.027	-0.475	-0.511	0.698	lateral orbitale (L)
52	-0.008	1.009	0.479	1.117	opposite orbitale (R)
54	-0.282	0.449	0.383	0.654	orbitale (R)
55	-0.231	1.452	-0.043	1.471	orbitale (L)
57	-1.833	2.489	-0.516	3.134	infraorbital foramen (L)
62	-0.495	-0.290	-0.003	0.574	zygomatic corner (R)
63	1.043	2.097	-1.601	2.837	zygomatic corner (L)
64	1.344	9.233	-6.012	11.100	zygomatic frontal (R)
65	-0.134	0.318	0.154	0.378	zygomatic frontal (L)
66	0.368	0.439	0.003	0.572	nasal breadth (R)
67	0.868	-1.264	-0.296	1.561	nasal breadth (L)
68	0.469	0.634	-0.353	0.864	coronoid notch (R)
69	-3.447	1.414	0.315	3.739	coronoid notch (L)
80	-0.346	1.258	0.044	1.305	incision superius (R)
81	1.692	-1.089	-0.816	2.171	incision superius (L)
82	-0.474	-0.851	-0.597	1.142	incision inferius (R)
83	-0.567	0.023	-0.019	0.568	incision inferius (L)
85	0.559	-0.404	-0.377	0.786	disto-molare superius (L)
86	-2.077	-2.617	-1.190	3.547	disto-molare inferius (R)

Table 3.9 (c) (continued)

Landmark No.	Difference (mm)				Landmark Name
	x	y	z	Magnt	
87	0.305	0.186	-0.216	0.417	disto-molare inferius (L)
88	1.026	-0.568	-0.038	1.173	subspinale
91	-0.037	0.321	-1.463	1.498	anterior clinoid (L)
92	0.081	-0.043	0.422	0.431	anterior clinoid (R)
93	-0.194	0.121	0.189	0.296	lesser wing of sphenoid (L)
94	1.065	-0.129	-0.697	1.279	lesser wing of sphenoid (R)
95	0.026	0.228	0.157	0.278	
96	0.981	-1.752	0.188	2.017	
97	0.045	-2.727	11.370	11.693	
98	0.282	-0.968	0.223	1.033	
99	-0.220	-1.428	4.874	5.084	
100	0.172	-0.877	0.799	1.199	
101	-0.018	0.246	0.031	0.248	
102	1.172	-0.809	-0.925	1.698	
103	-1.120	-0.428	1.897	2.244	medial anterior clinoid (L)
104	0.824	-0.258	1.743	1.945	medial anterior clinoid (R)
105	0.162	0.205	-0.559	0.617	posterior clinoid (L)
106	-0.047	-0.023	-1.678	1.679	posterior clinoid (R)

Table 3.10   Mean of the differences between the two CT determinations of the three patients.

Landmark No.	Mean difference (mm)				n	Landmark Name
	x	y	z	Magnt		
1	-0.242	0.425	0.621	0.790	3	sella
2	-0.173	-0.578	0.161	0.625	3	nasion
3	-1.033	0.583	-0.110	1.191	2	glabella
7	-0.309	0.525	-0.438	0.750	2	mastoid tip (L)
8	-0.871	0.102	-0.474	0.996	2	mastoid tip (R)
9	0.036	0.824	0.387	0.911	1	basion
10	0.698	-0.303	-0.314	0.823	1	ext auditory meatus (R)
11	0.646	0.668	0.916	1.305	2	ext auditory meatus (L)
12	0.030	0.134	0.006	0.137	2	condylion (R)
13	0.497	0.131	0.362	0.628	2	condylion (L)
16	-0.932	-0.313	-0.420	1.069	3	gonion (R)
17	0.873	0.366	-0.010	0.947	3	gonion (L)
22	1.264	-1.506	-1.348	2.384	1	infradentale
23	0.426	-0.757	0.007	0.868	3	prosthion
24	-0.124	0.093	0.264	0.307	3	ant nasal spine
26	-0.341	-0.061	-0.554	0.653	1	upper molar (R)
27	-2.386	-0.185	0.569	2.460	2	upper molar (L)
28	-1.535	0.715	-1.381	2.185	1	lower molar (R)
29	0.058	-0.616	0.017	0.619	2	lower molar (L)
32	0.542	0.432	0.290	0.752	2	coronoid tip (R)
33	1.233	-0.257	-0.380	1.316	2	coronoid tip (L)
40	-0.391	-0.257	-1.076	1.173	1	optic foramen (R)
41	0.550	-0.171	-3.462	3.510	1	optic foramen (L)
42	-3.784	-0.966	-0.703	3.968	3	nasale
46	-0.058	0.532	-1.445	1.541	2	medial orbitale (R)
47	-1.582	1.412	1.504	2.600	2	medial orbitale (L)
48	0.072	-0.025	-0.084	0.114	3	superior orbitale (R)
49	1.317	-2.056	0.698	2.539	3	superior orbitale (L)
50	-0.211	0.019	-0.519	0.560	3	lateral orbitale (R)
51	0.164	-0.190	0.574	0.627	3	lateral orbitale (L)
52	0.365	0.890	0.425	1.052	3	opposite orbitale (R)
53	-1.320	2.104	-0.160	2.489	1	opposite orbitale (L)
54	-0.884	0.512	-0.071	1.024	3	orbitale (R)
55	1.181	0.684	-0.241	1.385	3	orbitale (L)
56	0.416	0.775	0.000	0.880	1	infraorbital foramen (R)
57	-0.866	1.583	-0.199	1.816	2	infraorbital foramen (L)

Table 3.10 (continued)

Landmark No.	Mean difference (mm)				n	Landmark Name
	x	y	z	Magnt		
62	-0.756	-1.087	0.414	1.387	3	zygomatic corner (R)
63	0.923	-0.056	-0.616	1.111	3	zygomatic corner (L)
64	-3.400	2.156	-1.035	4.157	3	zygomatic frontal (R)
65	0.968	1.053	2.702	3.057	3	zygomatic frontal (L)
66	-1.820	-0.596	0.354	1.947	3	nasal breadth (R)
67	0.160	-0.020	-0.444	0.473	2	nasal breadth (L)
68	-1.224	0.178	-0.280	1.268	2	coronoid notch (R)
69	-0.416	1.334	0.000	1.398	3	coronoid notch (L)
71	0.029	-0.210	-0.671	0.704	1	ext oblique line (L)
73	-0.183	0.536	-1.993	2.072	1	medial foramen ovale (L)
78	-0.338	-1.076	0.853	1.413	2	foramen mag breadth (R)
79	0.258	-0.911	5.594	5.673	2	foramen mag breadth (L)
80	-0.245	0.318	0.208	0.452	3	incision superius (R)
81	-0.081	0.224	-0.285	0.372	3	incision superius (L)
82	0.070	0.283	-0.121	0.316	2	incision inferius (R)
83	-0.142	0.460	-0.156	0.506	2	incision inferius (L)
84	2.481	0.588	-1.068	2.764	1	disto-molare superius (R)
85	0.106	0.129	0.050	0.175	2	disto-molare superius (L)
86	-2.077	-2.617	-1.190	3.547	1	disto-molare inferius (R)
87	0.410	0.257	-0.035	0.486	2	disto-molare inferius (L)
88	1.753	-0.124	0.201	1.768	2	subspinale
90	0.238	-0.071	-0.581	0.632	2	odontoid peg
91	0.012	0.106	-0.687	0.695	3	anterior clinoid (L)
92	0.280	-0.257	0.164	0.413	3	anterior clinoid (R)
93	-0.509	0.765	0.201	0.941	3	lesser wing of sphenoid (L)
94	0.945	-0.328	0.434	1.091	3	lesser wing of sphenoid (R)
95	-0.494	-0.108	-0.546	0.744	3	
96	0.528	-0.069	3.608	3.647	3	
97	0.011	-1.160	4.105	4.266	3	
98	0.324	-0.417	-0.632	0.824	3	
99	-0.095	-0.741	1.817	1.964	3	
100	0.338	-0.492	0.169	0.620	3	
101	-0.482	0.228	-0.290	0.607	3	
102	0.812	-0.237	1.754	1.947	3	
103	0.015	-0.520	1.362	1.458	3	medial anterior clinoid (L)
104	-0.136	-0.006	1.578	1.584	3	medial anterior clinoid (R)
105	0.262	0.885	-0.851	1.255	3	posterior clinoid (L)
106	0.013	-0.151	-1.083	1.094	3	posterior clinoid (R)

Table 3.11   Indicative CT osseous landmark relocation errors for the three patients discussed in Section 3.8.

Landmark No.	Relocation error (mm)				n	Landmark Name
	x	y	z	Magnt		
1	0.218	0.344	1.301	1.364	3	sella
2	0.151	0.727	0.433	0.860	3	nasion
3	1.037	0.434	0.255	1.152	2	glabella
7	0.219	0.413	0.337	0.576	2	mastoid tip (L)
8	0.663	0.594	0.337	0.952	2	mastoid tip (R)
9	0.025	0.583	0.274	0.644	1	basion
10	0.494	0.214	0.222	0.582	1	ext auditory meatus (R)
11	1.082	0.504	0.649	1.358	2	ext auditory meatus (L)
12	0.040	0.097	0.083	0.134	2	condylion (R)
13	0.413	0.914	0.256	1.035	2	condylion (L)
16	1.279	0.543	1.164	1.813	3	gonion (R)
17	0.765	1.317	1.102	1.880	3	gonion (L)
22	0.894	1.065	0.953	1.686	1	infradentale
23	0.461	0.574	0.490	0.884	3	prosthion
24	0.404	0.398	0.699	0.900	3	ant nasal spine
26	0.241	0.043	0.392	0.462	1	upper molar (R)
27	2.385	0.131	0.656	2.477	2	upper molar (L)
28	1.085	0.506	0.977	1.545	1	lower molar (R)
29	0.219	0.476	0.156	0.546	2	lower molar (L)
32	0.537	0.314	0.283	0.683	2	coronoid tip (R)
33	0.971	0.182	0.273	1.025	2	coronoid tip (L)
40	0.276	0.182	0.761	0.830	1	optic foramen (R)
41	0.389	0.121	2.448	2.482	1	optic foramen (L)
42	4.480	0.875	0.763	4.628	3	nasale
46	2.280	0.676	1.954	3.077	2	medial orbitale (R)
47	1.514	2.021	1.093	2.751	2	medial orbitale (L)
48	0.576	0.952	0.150	1.123	3	superior orbitale (R)
49	1.449	3.440	0.561	3.774	3	superior orbitale (L)
50	0.291	0.306	0.392	0.577	3	lateral orbitale (R)
51	0.281	0.198	0.861	0.927	3	lateral orbitale (L)
52	0.372	0.655	0.489	0.898	3	opposite orbitale (R)
53	0.933	1.488	0.113	1.760	1	opposite orbitale (L)
54	0.711	0.428	0.437	0.938	3	orbitale (R)
55	1.136	0.752	0.216	1.380	3	orbitale (L)
56	0.294	0.548	0.000	0.622	1	infraorbital foramen (R)
57	0.918	1.290	0.265	1.605	2	infraorbital foramen (L)
62	0.634	1.165	0.413	1.389	3	zygomatic corner (R)
63	0.804	1.341	0.756	1.737	3	zygomatic corner (L)

Table 3.11 (continued)

Landmark No.	Relocation error (mm) x	y	z	Magnt	n	Landmark Name
64	3.441	3.948	2.788	5.933	3	zygomatic frontal (R)
65	1.256	1.591	3.498	4.043	3	zygomatic frontal (L)
66	2.377	0.844	0.715	2.622	3	nasal breadth (R)
67	0.513	0.880	0.331	1.071	2	nasal breadth (L)
68	1.477	0.346	0.205	1.531	2	coronoid notch (R)
69	1.648	0.949	0.433	1.951	3	coronoid notch (L)
71	0.021	0.148	0.474	0.498	1	ext oblique line (L)
73	0.129	0.379	1.409	1.465	1	medial foramen ovale (L)
78	0.271	1.461	0.663	1.627	2	foramen mag breadth (R)
79	0.566	1.619	4.230	4.565	2	foramen mag breadth (L)
80	0.181	0.927	0.248	0.977	3	incision superius (R)
81	1.050	0.991	0.419	1.504	3	incision superius (L)
82	0.388	0.826	0.347	0.977	2	incision inferius (R)
83	0.317	0.448	0.147	0.568	2	incision inferius (L)
84	1.754	0.416	0.755	1.955	1	disto-molare superius (R)
85	0.329	0.388	0.304	0.593	2	disto-molare superius (L)
86	1.469	1.850	0.841	2.508	1	disto-molare inferius (R)
87	0.300	0.189	0.131	0.377	2	disto-molare inferius (L)
88	1.341	0.326	0.221	1.398	2	subspinale
90	0.263	0.355	0.451	0.632	2	odontoid peg
91	0.233	0.146	0.751	0.799	3	anterior clinoid (L)
92	0.238	0.564	0.184	0.639	3	anterior clinoid (R)
93	0.400	0.647	0.952	1.219	3	lesser wing of sphenoid (L)
94	0.707	0.353	0.923	1.215	3	lesser wing of sphenoid (R)
95	0.468	0.217	0.968	1.097	3	
96	0.511	0.984	3.962	4.115	3	
97	0.157	1.150	4.652	4.795	3	
98	0.233	0.447	0.891	1.024	3	
99	0.219	0.627	2.008	2.115	3	
100	0.255	0.620	0.581	0.887	3	
101	0.418	0.195	0.727	0.861	3	
102	0.636	0.333	2.010	2.134	3	
103	0.594	0.450	1.582	1.749	3	medial anterior clinoid (L)
104	0.514	0.347	1.593	1.710	3	medial anterior clinoid (R)
105	0.263	1.047	0.667	1.269	3	posterior clinoid (L)
106	0.208	0.294	0.935	1.002	3	posterior clinoid (R)

Overall point location error (pooled Dahlberg) = 2.035 mm

Median point location error (median Dahlberg) = 1.244 mm

Table 4.1 (a)   Mean of the differences between CT and biplanar radiographic
determinations of osseous landmark positions.

Landmk No.	Mean residual (mm) x	y	z	Magnt	$d\sqrt{n}/\sigma$	n	Landmark Name
1	-0.556	0.626	-1.289	1.537	1.158	5	sella
2	0.097	0.407	2.170	2.210	2.323*	5	nasion
3	1.586	0.694	-1.269	2.146	1.112	5	glabella
6	-0.190	0.448	-3.851	3.882	0.000	1	opisthion
7	-0.092	1.479	-0.611	1.603	1.252	4	mastoid tip (L)
8	-0.429	-0.112	0.409	0.603	0.715	4	mastoid tip (R)
9	-2.100	-3.490	1.247	4.259	1.566	5	basion
10	-0.660	0.445	0.186	0.818	0.619	5	ext aud meatus (R)
11	-0.216	-0.680	1.060	1.278	0.911	5	ext aud meatus (L)
12	5.209	1.379	-0.113	5.390	4.931*	5	condylion (R)
13	-2.925	0.034	1.020	3.098	2.278*	5	condylion (L)
16	-3.248	0.533	-0.394	3.315	4.847*	5	gonion (R)
17	2.852	-1.444	-0.270	3.208	2.494*	5	gonion (L)
21	1.730	0.570	0.026	1.821	0.790	4	pogonion
22	0.367	1.069	-2.794	3.014	0.000	1	infradentale
23	0.895	0.065	-0.990	1.336	1.224	3	prosthion
24	-0.308	-0.710	-0.075	0.778	0.758	5	ant nasal spine
25	-0.331	-0.266	-1.641	1.695	1.096	5	post nasal spine
26	1.472	2.710	3.527	4.685	2.845*	5	upper molar (R)
27	-0.723	-0.282	0.670	1.025	1.441	5	upper molar (L)
28	0.214	2.609	0.800	2.737	3.327*	4	lower molar (R)
29	1.016	-0.506	-1.646	1.999	1.828	3	lower molar (L)
32	-1.151	1.164	-1.619	2.302	1.677	5	coronoid tip (R)
33	1.794	-0.819	-1.043	2.231	1.858	5	coronoid tip (L)
40	-1.094	-6.507	-2.264	6.976	2.518*	3	optic foramen (R)
41	3.057	-7.261	-4.781	9.216	2.705*	3	optic foramen (L)
42	0.441	-1.024	2.354	2.605	3.481*	5	nasale

* probability less than 1%

Table 4.1 (b) Standard deviation of the differences between CT and biplanar radiographic determinations of osseous landmark positions.

Landmk No.	Standard deviation (mm)				n	Landmark Name
	x	y	z	Magnt		
1	1.342	2.183	1.502	2.970	5	sella
2	0.192	1.654	1.324	2.127	5	nasion
3	2.810	1.775	2.755	4.317	5	glabella
6	0.000	0.000	0.000	0.000	1	opisthion
7	1.157	2.042	1.026	2.562	4	mastoid tip (L)
8	0.683	1.228	0.935	1.688	4	mastoid tip (R)
9	1.528	4.521	3.770	6.081	5	basion
10	1.658	1.309	2.064	2.953	5	ext aud meatus (R)
11	1.513	1.174	2.483	3.136	5	ext aud meatus (L)
12	2.008	0.856	1.099	2.444	5	condylion (R)
13	2.698	1.097	0.877	3.041	5	condylion (L)
16	0.784	0.412	1.247	1.529	5	gonion (R)
17	1.623	1.605	1.751	2.877	5	gonion (L)
21	4.410	0.996	0.896	4.609	4	pogonion
22	0.000	0.000	0.000	0.000	1	infradentale
23	0.242	1.130	1.497	1.891	3	prosthion
24	1.915	1.251	0.182	2.295	5	ant nasal spine
25	1.454	2.305	2.127	3.457	5	post nasal spine
26	2.004	0.779	2.990	3.683	5	upper molar (R)
27	1.111	0.596	0.971	1.591	5	upper molar (L)
28	0.529	0.912	1.263	1.646	4	lower molar (R)
29	0.532	1.559	0.934	1.894	3	lower molar (L)
32	1.315	0.979	2.596	3.070	5	coronoid tip (R)
33	0.891	0.897	2.368	2.685	5	coronoid tip (L)
40	2.069	3.992	1.672	4.797	3	optic foramen (R)
41	1.269	4.521	3.575	5.902	3	optic foramen (L)
42	0.490	0.630	1.470	1.673	5	nasale

Table 4.2 (a) Three dimensional coordinates of the osseous landmarks for skull A38 derived from the integration of CT and biplanar landmark determinations.

Landmk No.	Landmark Position (mm)			Landmark Name
	x	y	z	
1	0.862	8.332	26.162	sella
2	4.859	-57.275	34.844	nasion
3	5.801	-63.077	45.791	glabella
4	-0.348	38.125	118.595	vertex (bi)
5	-2.972	129.080	36.657	opisthocranion (bi)
6	0.404	68.878	-14.644	opisthion
7	48.536	46.530	-18.505	mastoid tip (L)
8	-47.091	43.964	-20.219	mastoid tip (R)
9	1.786	33.013	-12.640	basion
10	-46.569	30.178	3.282	ext aud meatus (R)
11	50.046	36.012	6.589	ext aud meatus (L)
12	-55.602	16.456	4.787	condylion (R)
13	51.639	22.174	6.429	condylion (L)
16	-44.201	12.892	-53.824	gonion (R)
17	48.298	18.566	-50.079	gonion (L)
20	8.048	-59.186	-72.493	gnathion (bi)
21	10.360	-63.743	-67.847	pogonion
22	8.376	-70.862	-47.476	infradentale (bi)
23	5.334	-74.408	-21.739	prosthion
24	4.358	-67.942	-11.946	ant nasal spine
25	1.227	-12.856	-10.789	post nasal spine
26	-29.623	-40.537	-27.809	upper molar (R)
27	35.938	-35.787	-26.769	upper molar (L)
28	-24.958	-41.494	-42.423	lower molar (R)
29	35.471	-34.241	-40.958	lower molar (L)
30	-45.330	-35.801	-7.818	zygomaxillare (R)
31	51.123	-31.698	-4.489	zygomaxillare (L)
32	-40.420	-18.655	-5.986	coronoid tip (R)
33	45.041	-14.775	-4.752	coronoid tip (L)
36	-12.267	-5.628	-9.484	palatine tubercle (R)
37	15.144	-2.670	-8.014	palatine tubercle (L)
40	-9.364	0.078	27.999	optic foramen (R)
41	12.303	0.036	29.521	optic foramen (L)
42	5.205	-66.109	16.308	nasale
43	0.381	21.113	118.202	bregma (bi)
46	-8.545	-54.651	27.348	medial orbitale (R)
47	17.370	-50.877	28.803	medial orbitale (L)

Table 4.2 (a) (continued)

Landmk No.	Landmark Position (mm)			Landmark Name
	x	y	z	
48	-25.013	-53.710	42.667	superior orbitale (R)
49	32.322	-46.806	43.960	superior orbitale (L)
50	-45.346	-39.518	23.582	lateral orbitale (R)
51	52.371	-34.573	26.490	lateral orbitale (L)
52	-43.126	-42.393	14.068	opposite orbitale (R)
53	46.925	-37.572	16.083	opposite orbitale (L)
54	-28.414	-51.025	10.479	orbitale (R)
55	35.159	-48.624	11.824	orbitale (L)
56	-22.362	-52.479	-1.476	infraorbital foramen (R)
57	32.364	-49.583	0.093	infraorbital foramen (L)
58	-58.114	7.149	0.508	articular eminence (R)
59	58.517	13.583	3.874	articular eminence (L)
62	-56.151	-27.597	13.362	zygomatic corner (R)
63	61.270	-22.400	16.417	zygomatic corner (L)
64	-45.402	-34.853	64.798	zygomatic frontal (R)
65	49.542	-27.931	64.679	zygomatic frontal (L)
66	-10.457	-63.191	-5.786	nasal breadth (R)
67	15.766	-58.621	-3.456	nasal breadth (L)
68	-42.797	-5.015	-10.168	coronoid notch (R)
69	46.229	-0.034	-8.658	coronoid notch (L)
70	-37.163	-19.587	-33.631	ext oblique line (R)
71	43.429	-15.411	-32.032	ext oblique line (L)
78	-14.446	49.108	-17.681	foramen mag breadth (R)
79	16.189	47.892	-16.740	foramen mag breadth (L)
91	16.049	3.736	29.270	anterior clinoid (L)
92	-12.970	4.119	28.209	anterior clinoid (R)
93	34.949	-6.984	39.313	lesser wing of sphenoid (L)
94	-27.049	-9.540	34.130	lesser wing of sphenoid (R)
95	34.861	48.431	20.250	
96	-27.093	38.476	18.746	
97	16.021	26.996	18.248	
98	-12.876	23.964	18.265	
99	16.066	15.700	23.713	
100	-12.910	14.051	23.066	
101	34.917	21.054	29.328	
102	-27.011	14.671	26.537	
103	9.005	3.185	27.409	medial anterior clinoid (L)
104	-6.364	2.994	27.226	medial anterior clinoid (R)
105	7.283	11.351	25.282	posterior clinoid (L)
106	-8.532	11.755	28.635	posterior clinoid (R)

Table 4.2 (b)   Three dimensional coordinates of the osseous landmarks for
skull A90 derived from the integration of CT and biplanar
landmark determinations.

Landmk No.	Landmark Position (mm)			Landmark Name
	x	y	z	
1	4.266	7.079	21.504	sella
2	5.478	-57.092	23.870	nasion
3	3.307	-64.283	42.313	glabella
4	-0.695	23.125	115.805	vertex (bi)
5	-4.521	129.238	39.590	opisthocranion (bi)
6	-1.002	73.003	-11.008	opisthion (bi)
7	45.069	47.763	-16.740	mastoid tip (L)
8	-44.275	43.315	-17.939	mastoid tip (R)
9	4.316	38.268	-5.297	basion
10	-47.283	29.684	2.056	ext aud meatus (R)
11	48.386	36.415	0.896	ext aud meatus (L)
12	-52.699	19.365	4.890	condylion (R)
13	53.945	25.374	0.731	condylion (L)
16	-37.851	21.524	-50.303	gonion (R)
17	45.336	26.514	-49.453	gonion (L)
20	6.133	-39.871	-78.709	gnathion (bi)
21	6.470	-48.196	-73.584	pogonion (bi)
22	6.223	-56.609	-58.004	infradentale (bi)
23	5.204	-62.481	-32.734	prosthion
24	5.644	-59.504	-20.119	ant nasal spine
25	4.786	-4.106	-10.837	post nasal spine
26	-25.049	-32.502	-40.685	upper molar (R)
27	33.720	-30.062	-32.690	upper molar (L)
28	-23.280	-29.340	-50.697	lower molar (R)
30	-42.472	-30.304	-17.454	zygomaxillare (R)
31	51.149	-29.324	-15.174	zygomaxillare (L)
32	-36.993	-16.112	-9.175	coronoid tip (R)
33	42.281	-9.952	-13.503	coronoid tip (L)
36	-7.806	2.115	-12.109	palatine tubercle (R)
37	17.405	3.260	-10.231	palatine tubercle (L)
40	-8.709	-5.754	25.387	optic foramen (R)
41	16.028	-5.933	25.855	optic foramen (L)
42	5.214	-61.983	6.913	nasale
46	-6.244	-53.740	18.611	medial orbitale (R)
47	17.627	-50.302	18.863	medial orbitale (L)

Table 4.2 (b) (continued)

Landmk No.	Landmark Position (mm)			Landmark Name
	x	y	z	
48	-24.003	-52.464	31.076	superior orbitale (R)
49	36.076	-48.761	34.961	superior orbitale (L)
50	-41.550	-38.411	9.584	lateral orbitale (R)
51	53.847	-34.427	21.503	lateral orbitale (L)
52	-38.528	-39.352	1.466	opposite orbitale (R)
53	50.354	-36.725	8.649	opposite orbitale (L)
54	-23.200	-47.503	-2.505	orbitale (R)
55	37.478	-43.573	6.520	orbitale (L)
56	-19.843	-48.064	-10.405	infraorbital foramen (R)
57	33.079	-43.334	-7.796	infraorbital foramen (L)
58	-53.353	8.161	-1.554	articular eminence (R)
59	61.044	12.264	-4.946	articular eminence (L)
62	-52.596	-29.347	2.518	zygomatic corner (R)
63	61.027	-23.528	9.279	zygomatic corner (L)
64	-45.785	-34.892	54.163	zygomatic frontal (R)
65	52.538	-28.985	54.354	zygomatic frontal (L)
66	-6.612	-54.820	-20.117	nasal breadth (R)
67	16.712	-50.336	-8.776	nasal breadth (L)
68	-39.405	-0.601	-12.177	coronoid notch (R)
69	41.242	7.501	-16.900	coronoid notch (L)
70	-36.401	-10.472	-41.053	ext oblique line (R)
71	44.151	-7.140	-38.920	ext oblique line (L)
72	-17.219	13.833	4.866	medial foramen ovale (R)
73	24.105	13.852	6.167	medial foramen ovale (L)
78	-12.871	57.336	-4.269	foramen mag breadth (R)
79	17.469	57.859	-3.038	foramen mag breadth (L)
81	10.571	-62.172	-46.127	incision superius (L)
85	33.840	-30.244	-37.081	disto-molare superius (L)
91	16.677	2.988	20.628	anterior clinoid (L)
92	-10.047	3.904	23.097	anterior clinoid (R)
97	16.835	23.526	22.047	
98	-10.024	22.596	17.420	
99	16.812	13.247	20.849	
100	-10.078	13.185	20.236	
103	9.993	-0.857	23.882	medial anterior clinoid (L)
104	-4.180	-1.288	23.504	medial anterior clinoid (L)
105	10.404	14.938	22.000	posterior clinoid (L)
106	-1.181	15.193	23.428	posterior clinoid (R)

Table 4.2 (c) Three dimensional coordinates of the osseous landmarks for skull A13184 derived from the integration of CT and biplanar landmark determinations.

Landmk No.	Landmark Position (mm)			Landmark Name
	x	y	z	
1	2.685	19.693	35.190	sella
2	9.128	-43.511	32.516	nasion
3	7.496	-52.512	51.511	glabella
5	-9.151	129.544	57.996	opisthocranion (bi)
6	-5.761	80.799	3.160	opisthion (bi)
7	48.055	66.686	-3.725	mastoid tip (L) (bi)
8	-48.591	55.976	-4.797	mastoid tip (R) (bi)
9	2.157	44.639	7.033	basion
10	-46.758	40.364	14.469	ext aud meatus (R)
11	47.728	49.942	18.737	ext aud meatus (L)
12	-51.186	25.206	14.696	condylion (R)
13	49.009	35.350	14.819	condylion (L)
14	-51.131	33.852	8.112	articulare (R) (bi)
15	53.579	39.852	11.697	articulare (L) (bi)
16	-36.125	27.588	-43.044	gonion (R)
17	37.651	39.535	-41.510	gonion (L)
20	8.847	-30.479	-71.62	gnathion (bi)
21	9.654	-39.130	-66.743	pogonion
22	10.388	-44.677	-46.652	infradentale (bi)
23	7.462	-50.897	-26.431	prosthion
24	8.428	-46.212	-11.561	ant nasal spine
25	3.334	6.500	-5.550	post nasal spine
26	-22.895	-21.431	-30.029	upper molar (R)
27	33.560	-15.133	-28.038	upper molar (L)
30	-39.823	-22.423	-1.303	zygomaxillare (R)
31	51.115	-15.163	-1.367	zygomaxillare (L)
32	-39.212	-4.607	0.861	coronoid tip (R)
33	46.776	4.069	0.261	coronoid tip (L)
36	-8.725	8.979	-0.609	palatine tubercle (R)
37	15.616	9.727	-0.417	palatine tubercle (L)
42	8.306	-48.767	15.186	nasale
46	-1.746	-41.378	28.529	medial orbitale (R)
47	19.785	-41.204	28.793	medial orbitale (L)
48	-19.058	-42.632	42.292	superior orbitale (R)
49	38.654	-41.305	42.285	superior orbitale (L)

Table 4.2 (c) (continued)

Landmk No.	Landmark Position (mm)			Landmark Name
	x	y	z	
50	-39.789	-31.650	27.055	lateral orbitale (R)
51	55.959	-28.497	27.383	lateral orbitale (L)
52	-35.902	-33.192	18.079	opposite orbitale (R)
53	48.903	-26.604	17.872	opposite orbitale (L)
54	-19.579	-38.626	13.608	orbitale (R)
55	36.504	-33.297	13.589	orbitale (L)
56	-18.317	-36.311	0.154	infraorbital foramen (R)
57	34.185	-32.296	1.610	infraorbital foramen (L)
58	-53.336	14.010	9.922	articular eminence (R)
59	49.728	26.789	10.222	articular eminence (L)
62	-48.968	-19.696	17.785	zygomatic corner (R)
63	61.020	-9.189	18.039	zygomatic corner (L)
64	-37.764	-32.321	61.737	zygomatic frontal (R)
65	52.861	-23.267	65.521	zygomatic frontal (L)
66	-5.816	-43.664	-4.772	nasal breadth (R)
67	19.996	-41.995	-3.417	nasal breadth (L)
68	-39.928	7.865	-3.005	coronoid notch (R)
69	46.655	19.839	-4.701	coronoid notch (L)
70	-34.738	0.887	-29.470	ext oblique line (R)
71	39.519	8.012	-27.365	ext oblique line (L)
72	-18.166	21.349	16.447	medial foramen ovale (R)
73	23.725	25.749	16.203	medial foramen ovale (L)
91	14.994	17.170	36.634	anterior clinoid (L)
97	15.260	36.280	33.577	
99	15.160	26.577	34.717	
103	10.869	12.488	34.747	medial anterior clinoid (L)
105	8.652	25.897	36.113	posterior clinoid (L)
106	-5.019	24.330	33.182	posterior clinoid (R)

Table 4.2 (d) Three dimensional coordinates of the osseous landmarks for skull A38778 derived from the integration of CT and biplanar landmark determinations.

Landmk No.	Landmark Position (mm)			Landmark Name
	x	y	z	
1	0.190	-0.366	22.933	sella
2	1.236	-59.808	30.247	nasion
3	-3.375	-65.821	44.334	glabella
4	-0.564	20.064	112.482	vertex (bi)
5	-4.155	101.733	36.050	opisthocranion (bi)
6	1.120	57.164	-9.999	opisthion
7	48.253	31.795	-7.414	mastoid tip (L)
8	-46.451	30.086	-9.510	mastoid tip (R)
9	1.179	19.621	-7.693	basion
10	-47.524	20.138	9.386	ext aud meatus (R)
11	46.910	23.254	10.354	ext aud meatus (L)
12	-48.782	9.406	8.318	condylion (R)
13	50.681	11.959	10.118	condylion (L)
16	-39.135	6.122	-47.150	gonion (R)
17	43.276	8.979	-45.799	gonion (L)
20	2.436	-53.315	-65.885	gnathion (bi)
21	1.232	-62.482	-59.238	pogonion
22	2.485	-67.719	-40.112	infradentale
23	2.485	-70.879	-20.723	prosthion (bi)
24	5.643	-60.788	-8.712	ant nasal spine
25	0.891	-18.979	-7.587	post nasal spine
26	-28.116	-43.490	-25.038	upper molar (R)
27	29.220	-40.129	-23.553	upper molar (L)
28	-25.211	-40.326	-37.913	lower molar (R)
29	27.965	-38.755	-37.115	lower molar (L)
30	-44.808	-40.601	-2.705	zygomaxillare (R)
31	45.373	-38.874	-1.160	zygomaxillare (L)
32	-38.492	-21.972	-5.650	coronoid tip (R)
33	41.060	-19.081	-2.856	coronoid tip (L)
42	1.306	-63.867	16.656	nasale
43	0.127	-2.419	108.328	bregma (bi)
46	-8.025	-58.404	24.369	smedial orbitale (R)
47	11.150	-54.408	25.669	medial orbitale (L)
48	-30.928	-58.347	37.870	superior orbitale (R)
49	28.845	-52.472	38.792	superior orbitale (L)

Table 4.2 (d) (continued)

Landmk No.	Landmark Position (mm)			Landmark Name
	x	y	z	
50	-45.811	-45.388	22.089	lateral orbitale (R)
51	47.430	-41.884	23.336	lateral orbitale (L)
52	-44.207	-48.750	12.587	opposite orbitale (R)
53	44.028	-46.494	13.212	opposite orbitale (L)
54	-27.920	-54.687	8.638	orbitale (R)
55	30.056	-51.123	9.330	orbitale (L)
56	-28.346	-54.111	0.384	infraorbital foramen (R)
57	25.204	-43.570	0.288	infraorbital foramen (L)
58	-54.897	-0.741	4.665	articular eminence (R)
59	53.093	2.685	5.737	articular eminence (L)
62	-53.589	-37.134	12.286	zygomatic corner (R)
63	55.766	-32.662	13.043	zygomatic corner (L)
64	-45.042	-42.962	56.994	zygomatic frontal (R)
65	46.174	-37.095	56.269	zygomatic frontal (L)
66	-9.520	-59.781	-3.530	nasal breadth (R)
67	12.128	-58.069	-3.930	nasal breadth (L)
68	-40.315	-9.271	-10.396	coronoid notch (R)
69	42.116	-5.399	-8.338	coronoid notch (L)
70	-37.173	-18.596	-29.021	ext oblique line (R)
71	39.643	-16.750	-26.516	ext oblique line (L)
78	-15.077	37.391	-13.000	foramen mag breadth (R)
79	15.249	37.948	-11.869	foramen mag breadth (L)
93	32.119	-19.232	32.214	lesser wing of sphenoid (L)
94	-31.292	-18.837	32.150	lesser wing of sphenoid (R)
95	32.350	28.954	21.389	
96	-31.053	32.709	13.293	
101	32.285	4.977	27.080	
102	-31.154	7.560	23.660	

Table 4.2 (e) Three dimensional coordinates of the osseous landmarks for skull A57590 derived from the integration of CT and biplanar landmark determinations.

Landmk No.	Landmark Position (mm)			Landmark Name
	x	y	z	
1	1.267	19.668	8.810	sella
2	2.917	-49.301	9.523	nasion
3	3.112	-51.256	22.071	glabella
4	-2.310	22.895	99.174	vertex (bi)
5	-3.186	135.218	33.505	opisthocranion (bi)
7	51.239	57.146	-33.288	mastoid tip (L)
8	-47.542	52.963	-34.872	mastoid tip (R)
9	1.421	51.784	-30.774	basion
10	-45.506	36.090	-10.644	ext aud meatus (R)
11	48.843	40.066	-9.149	ext aud meatus (L)
12	-49.507	24.071	-10.418	condylion (R)
13	51.101	26.823	-8.681	condylion (L)
14	-49.511	34.194	-19.850	articulare (R) (bi)
15	53.642	33.379	-15.684	articulare (L) (bi)
16	-40.198	34.201	-71.021	gonion (R)
17	47.841	35.599	-68.882	gonion (L)
20	7.195	-39.669	-103.837	gnathion (bi)
21	-0.997	-47.802	-99.503	pogonion
22	6.488	-52.817	-80.396	infradentale (bi)
23	4.162	-63.351	-55.845	prosthion (bi)
24	2.491	-57.458	-38.610	ant nasal spine
25	2.507	-2.647	-37.560	post nasal spine
26	-26.641	-30.544	-58.387	upper molar (R)
27	32.861	-28.346	-56.582	upper molar (L)
28	-24.413	-26.963	-70.476	lower molar (R)
29	33.051	-22.371	-68.856	lower molar (L)
30	-43.488	-28.056	-38.345	zygomaxillare (R)
31	48.093	-26.011	-36.951	zygomaxillare (L)
32	-42.230	-2.378	-22.509	coronoid tip (R)
33	46.478	0.049	-21.452	coronoid tip (L)
36	-12.905	8.716	-35.028	palatine tubercle (R)
37	17.147	10.422	-36.194	palatine tubercle (L)
40	-12.602	0.940	6.110	optic foramen (R)
41	12.511	3.945	15.214	optic foramen (L)
42	3.286	-60.815	-7.348	nasale
46	-11.376	-47.360	1.263	medial orbitale (R)
47	15.144	-45.091	1.746	medial orbitale (L)

Table 4.2 (e) (continued)

Landmk No.	Landmark Position (mm)			Landmark Name
	x	y	z	
48	-27.685	-44.647	13.825	superior orbitale (R)
49	31.302	-42.450	17.257	superior orbitale (L)
50	-47.571	-31.738	-1.299	lateral orbitale (R)
51	50.839	-28.892	1.221	lateral orbitale (L)
52	-45.314	-37.628	-12.194	opposite orbitale (R)
53	49.712	-35.991	-9.897	opposite orbitale (L)
54	-27.220	-40.575	-15.607	orbitale (R)
55	33.973	-39.896	-14.819	orbitale (L)
56	-22.885	-40.238	-28.266	infraorbital foramen (R)
57	30.510	-35.877	-26.300	infraorbital foramen (L)
58	-49.588	13.998	-18.068	articular eminence (R)
59	53.567	18.482	-15.172	articular eminence (L)
62	-53.447	-20.146	-12.121	zygomatic corner (R)
63	57.542	-16.589	-10.104	zygomatic corner (L)
64	-47.923	-27.608	32.438	zygomatic frontal (R)
65	50.164	-23.396	32.481	zygomatic frontal (L)
66	-12.421	-51.273	-32.270	nasal breadth (R)
67	16.572	-49.145	-30.976	nasal breadth (L)
68	-41.390	8.903	-26.740	coronoid notch (R)
69	45.962	12.670	-26.100	coronoid notch (L)
70	-36.443	-0.023	-56.084	ext oblique line (R)
71	43.334	2.209	-55.138	ext oblique line (L)
72	-19.267	22.634	-11.188	medial foramen ovale (R)
73	22.951	24.392	-9.272	medial foramen ovale (L)
91	13.773	14.060	7.531	anterior clinoid (L)
92	-12.119	11.635	3.563	anterior clinoid (R)
93	31.453	0.410	13.681	lesser wing of sphenoid (L)
94	-33.237	0.442	13.025	lesser wing of sphenoid (R)
95	30.071	54.884	5.429	
96	-35.294	55.848	-5.299	
97	13.483	30.827	-1.557	
98	-12.665	31.515	2.692	
99	13.611	22.332	2.453	
100	-12.359	21.640	3.158	
101	30.794	27.832	9.866	
102	-34.235	28.099	4.064	
103	7.023	10.011	5.979	medial anterior clinoid (L)
104	-5.404	9.629	6.751	medial anterior clinoid (R)
105	6.385	27.140	7.546	posterior clinoid (L)
106	-4.518	26.424	8.854	posterior clinoid (R)

Table 4.3   Three dimensional coordinates of the osseous landmarks for patient 864405 derived from the integration of CT and biplanar landmark determinations.

Landmk No.	Landmark Position (mm)			Landmark Name
	x	y	z	
1	0.108	4.991	28.524	sella
2	0.627	-57.255	19.336	nasion
3	3.371	-65.274	53.758	glabella
4	-1.081	20.464	139.434	vertex (bi)
5	-2.347	117.568	85.069	opisthocranion (bi)
6	-0.995	70.697	10.837	opisthion (bi)
7	53.172	41.211	1.394	mastoid tip (L)
8	-50.220	44.633	-0.014	mastoid tip (R)
9	2.514	34.829	1.077	basion
10	-48.584	29.703	16.997	ext aud meatus (R)
11	52.735	26.382	19.375	ext aud meatus (L)
12	-50.506	14.374	18.153	condylion (R)
13	50.688	12.080	17.499	condylion (L)
16	-41.231	25.760	-25.687	gonion (R)
17	46.172	25.262	-23.691	gonion (L)
20	1.412	-6.449	-67.561	gnathion (bi)
21	1.549	-14.261	-67.323	pogonion (bi)
22	1.739	-29.785	-51.325	infradentale (bi)
23	0.868	-44.062	-36.143	prosthion
24	1.061	-49.229	-21.622	ant nasal spine
25	0.744	-6.808	-8.241	post nasal spine (bi)
26	-19.310	-17.761	-20.067	upper molar (R) (bi)
27	23.120	-17.422	-20.224	upper molar (L) (bi)
28	-25.574	-10.271	-31.401	lower molar (R) (bi)
29	21.128	-8.616	-35.962	lower molar (L) (bi)
32	-45.284	-8.557	5.175	coronoid tip (R)
33	47.968	-10.618	8.242	coronoid tip (L)
40	-11.350	-1.265	26.425	optic foramen (R)
41	9.468	-2.775	28.426	optic foramen (L)
42	-0.926	-61.154	-0.022	nasale
43	-0.227	-15.258	125.181	bregma (bi)
46	-14.691	-50.661	14.254	medial orbitale (R)
48	-23.194	-49.331	26.268	superior orbitale (R)
49	21.752	-51.472	27.397	superior orbitale (L)
50	-44.856	-26.540	8.437	lateral orbitale (R)

Table 4.3 (continued)

Landmk No.	Landmark Position (mm)			Landmark Name
	x	y	z	
51	45.838	-28.797	12.553	lateral orbitale (L)
52	-39.657	-26.234	-0.273	opposite orbitale (R)
53	42.380	-30.632	2.596	opposite orbitale (L)
54	-26.265	-33.762	-1.261	orbitale (R)
55	29.458	-36.130	2.817	orbitale (L)
62	-43.298	-22.138	-0.458	zygomatic corner (R)
63	47.715	-20.295	1.804	zygomatic corner (L)
64	-48.548	-25.312	31.784	zygomatic frontal (R)
65	51.561	-26.184	44.479	zygomatic frontal (L)
66	-7.400	-41.995	-14.615	nasal breadth (R)
67	13.622	-44.251	-13.124	nasal breadth (L)
69	44.701	4.520	7.375	coronoid notch (L)
71	39.705	-1.705	-15.987	ext oblique line (L)
78	-12.782	53.996	5.043	foramen mag breadth (R)
79	16.362	51.444	4.624	foramen mag breadth (L)
80	-3.225	-39.366	-49.510	incision superius (R)
81	5.398	-38.312	-49.279	incision superius (L)
90	2.254	40.313	1.743	odontoid peg
91	13.075	0.705	28.976	anterior clinoid (L)
92	-14.887	2.648	29.211	anterior clinoid (R)
93	41.012	-20.603	39.110	lesser wing of sphenoid (L)
94	-40.041	-14.970	34.829	lesser wing of sphenoid (R)
95	40.832	31.062	25.156	
96	-40.289	41.184	27.216	
97	13.093	12.549	25.819	
98	-14.856	19.292	29.244	
99	13.056	6.582	27.398	
100	-14.850	10.944	29.104	
101	40.933	5.294	32.404	
102	-40.055	13.084	31.180	
103	6.497	0.721	28.599	medial anterior clinoid (L)
104	-7.766	0.799	28.079	medial anterior clinoid (R)
105	10.009	6.911	32.371	posterior clinoid (L)
106	-8.080	11.148	30.977	posterior clinoid (R)

Table 4.4   Osseous landmark location errors corresponding to the integrated coordinate data.

Landmk No.	Landmark location error (mm)				n	Landmark Name
	x	y	z	Magnt		
1	0.245	1.865	1.215	2.239	5	sella
2	0.405	0.859	0.336	1.007	5	nasion
3	1.634	0.343	1.290	2.110	5	glabella
4	0.732	0.372	2.633	2.758	4	vertex (bi)
5	0.308	0.691	0.381	0.847	5	opisthocranion (bi)
6	0.336	0.058	0.299	0.453	2	opisthion
7	0.423	1.463	0.522	1.610	4	mastoid tip (L)
8	0.652	1.207	0.434	1.439	4	mastoid tip (R)
9	0.154	2.629	0.390	2.663	5	basion
10	1.211	0.432	1.148	1.724	5	ext aud meatus (R)
11	2.130	1.000	0.277	2.369	5	ext aud meatus (L)
12	1.464	0.536	0.723	1.719	5	condylion (R)
13	2.039	1.235	0.204	2.392	5	condylion (L)
16	0.984	0.441	0.420	1.157	5	gonion (R)
17	0.795	1.051	1.202	1.784	5	gonion (L)
20	0.694	0.173	0.257	0.760	5	gnathion (bi)
21	1.005	0.274	1.085	1.504	2	pogonion
22	0.199	0.464	0.053	0.508	5	infradentale (bi)
23	0.080	0.035	1.868	1.870	1	prosthion
24	0.966	0.488	0.158	1.094	4	ant nasal spine
25	0.277	1.498	1.505	2.142	5	post nasal spine
26	0.432	0.711	0.561	1.003	5	upper molar (R)
27	0.257	0.477	0.479	0.723	5	upper molar (L)
28	0.245	0.415	0.637	0.799	3	lower molar (R)
29	0.372	0.707	0.338	0.868	2	lower molar (L)
30	0.448	0.480	0.596	0.886	4	zygomaxillare (R)
31	0.772	0.605	0.855	1.301	4	zygomaxillare (L)
32	0.495	0.686	0.287	0.893	5	coronoid tip (R)
33	1.604	0.523	0.314	1.716	5	coronoid tip (L)
36	0.482	1.995	1.208	2.381	4	palatine tubercle (R)
37	0.414	2.385	0.886	2.578	4	palatine tubercle (L)
40	0.632	0.364	0.234	0.766	2	optic foramen (R)
41	0.474	0.444	0.791	1.023	2	optic foramen (L)
42	0.623	0.627	0.231	0.913	5	nasale
43	0.098	0.186	0.579	0.616	2	bregma (bi)
46	0.673	1.073	0.590	1.397	5	medial orbitale (R)
47	0.453	0.986	0.869	1.390	5	medial orbitale (L)
48	1.623	0.731	0.412	1.827	5	superior orbitale (R)
49	1.990	2.557	0.644	3.303	5	superior orbitale (L)
50	0.408	0.223	0.657	0.805	5	lateral orbitale (R)

Table 4.4 (continued)

Landmk No.	Landmark location error (mm)				n	Landmark Name
	x	y	z	Magnt		
51	1.581	3.889	0.559	4.235	5	lateral orbitale (L)
52	1.195	0.553	0.589	1.443	5	opposite orbitale (R)
53	1.035	1.267	0.214	1.649	5	opposite orbitale (L)
54	2.039	0.751	0.329	2.197	5	orbitale (R)
55	1.196	2.296	1.463	2.973	5	orbitale (L)
56	0.966	1.658	2.256	2.961	4	infraorbital foramen (R)
57	0.549	2.063	1.307	2.503	4	infraorbital foramen (L)
58	1.651	0.527	0.193	1.744	5	articular eminence (R)
59	3.068	0.797	0.147	3.174	5	articular eminence (L)
62	0.686	0.279	0.224	0.773	5	zygomatic corner (R)
63	0.812	0.849	0.091	1.179	5	zygomatic corner (L)
64	0.994	1.058	2.097	2.550	5	zygomatic frontal (R)
65	0.765	1.554	1.954	2.611	5	zygomatic frontal(L)
66	0.412	0.662	1.201	1.431	5	nasal breadth (R)
67	0.866	2.346	0.762	2.614	5	nasal breadth (L)
68	0.197	0.302	0.199	0.411	4	coronoid notch (R)
69	0.946	0.688	0.251	1.197	5	coronoid notch (L)
70	0.716	0.242	0.828	1.121	4	ext oblique line (R)
71	3.032	0.571	0.652	3.154	4	ext oblique line (L)
72	0.725	2.536	0.955	2.805	3	medial foramen ovale (R)
73	0.557	2.681	1.155	2.971	3	medial foramen ovale (L)
78	0.196	1.159	1.439	1.858	3	foramen mag breadth (R)
79	0.212	1.081	0.528	1.222	3	foramen mag breadth (L)
81	0.916	1.376	0.384	1.697	1	incision superius (L)
85	0.111	0.107	0.568	0.588	1	disto-molare superius (L)
91	0.273	0.819	1.627	1.842	2	anterior clinoid (L)
92	0.371	0.265	0.073	0.462	2	anterior clinoid (R)
93	0.968	2.099	0.294	2.331	3	lesser wing of sphenoid (L)
94	0.831	2.125	0.694	2.385	3	lesser wing of sphenoid (R)
95	0.954	3.396	0.339	3.544	3	
96	0.961	3.599	1.203	3.915	3	
97	0.431	0.977	0.399	1.140	2	
98	0.369	0.254	1.414	1.483	2	
99	0.324	0.190	0.373	0.529	2	
100	0.322	0.384	0.649	0.820	2	
101	0.877	2.794	0.689	3.009	3	
102	0.888	2.909	1.225	3.279	3	
103	0.335	2.474	1.092	2.725	2	medial anterior clinoid (L)
104	0.965	2.619	1.889	3.370	2	medial anterior clinoid (R)
105	0.602	3.213	3.998	5.165	3	posterior clinoid (L)
106	0.195	2.962	1.855	3.500	3	posterior clinoid (R)

Table 5.1   Two dimensional test example of least squares (LSQ) fitting of a rotated, scaled and translated rectangle (green) onto the original rectangle (red), illustrated in Figure 5.6.

Red rectangle			Green rectangle		
Vertex No.	Coordinate x	y	Vertex No.	Coordinate x	y
1	0.000	0.000	1	2.324	-8.709
2	0.000	10.000	2	-21.349	-0.673
3	20.000	10.000	3	-5.277	46.673
4	20.000	0.000	4	18.396	38.637

LSQ FIT

Residuals at each vertex after LSQ fit

Vertex No.	Coordinate x	y	Magnitude
1	0.000	0.000	0.000
2	0.000	0.000	0.000
3	0.000	0.000	0.000
4	0.000	0.000	0.000

Angle about z axis = -71.25°

Scale factor = 0.4000

$d^2 = 3 \times 10^{-12}$ mm^2

Table 5.2   Two dimensional test example of least squares (LSQ) fitting of a rotated, scaled, translated and deformed rectangle (green) onto the original rectangle (red), illustrated in Figure 5.7.

Red rectangle			Green rectangle		
Vertex No.	Coordinate x	y	Vertex No.	Coordinate x	y
1	0.000	0.000	1	2.324	-8.709
2	0.000	10.000	2	-21.349	-0.673
3	20.000	10.000	3	-5.277	46.673
4	20.000	0.000	4	15.268	44.979

LSQ FIT

Residuals at each vertex after LSQ fit

Vertex No.	Coordinate x	y	Magnitude
1	0.494	-0.266	0.561
2	-0.076	0.038	0.085
3	0.532	1.179	1.293
4	-0.951	-0.951	1.344

Angle about z axis = -74.62°

Scale factor = 0.3885

$d^2 = 3.80 \text{ mm}^2$

Table 5.3 Three dimensional test example of least squares (LSQ) fitting of a rotated, scaled and translated orthorhombic figure (green) onto the original orthorhombic figure (red), illustrated in Figure 5.8.

	Red brick				Green brick		
Vertex No.	Coordinate x	y	z	Vertex No.	Coordinate x	y	z
1	0.000	0.000	0.000	1	1.055	-4.393	9.771
2	20.000	0.000	0.000	2	8.759	4.080	0.083
3	0.000	40.000	0.000	3	-23.951	10.820	3.189
4	0.000	0.000	30.000	4	5.635	10.256	26.224
5	20.000	40.000	0.000	5	-16.247	19.292	-6.499
6	0.000	40.000	30.000	6	-19.370	25.465	19.643
7	20.000	40.000	30.000	7	-11.666	33.940	9.955
8	20.000	0.000	30.000	8	13.340	18.728	16.536

LSQ FIT

Residuals at each vertex after LSQ fit

Vertex No.	Coordinate x	y	z	Magnitude
1	0.000	0.000	0.000	0.000
2	0.000	0.001	0.000	0.001
3	0.000	-0.001	0.000	0.001
4	0.000	0.000	0.000	0.001
5	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000

Angle about z axis = 16.70°   Scale factor = 1.333

Angle about y axis = -40.23° $d^2 = 1.7 \times 10^{-6} \text{ mm}^2$

Angle about x axis = -47.72°

Table 5.4   Three dimensional test example of least squares (LSQ) fitting of a rotated, scaled, translated and deformed orthorhombic figure (green) onto the original orthorhombic figure (red), illustrated in Figure 5.9.

	Red brick				Green brick		
Vertex No.	Coordinate x	y	z	Vertex No.	Coordinate x	y	z
1	0.000	0.000	0.000	1	1.054	-4.393	9.771
2	20.000	0.000	0.000	2	8.759	4.080	0.083
3	0.000	40.000	0.000	3	-23.951	10.819	3.189
4	0.000	0.000	30.000	4	5.635	10.255	26.224
5	20.000	40.000	0.000	5	-16.247	19.292	-6.499
6	0.000	40.000	30.000	6	-19.370	25.467	19.642
7	20.000	40.000	30.000	7	-12.103	40.401	9.452
8	20.000	0.000	30.000	8	12.903	25.176	6.034

LSQ FIT

Residuals at each vertex after LSQ fit

Vertex No.	Coordinate x	y	z	Magnitude
1	0.812	-0.638	1.087	1.499
2	1.938	-0.184	0.760	2.090
3	-0.077	1.623	0.011	1.625
4	1.320	0.156	2.780	3.081
5	1.049	2.077	-0.316	2.348
6	0.432	2.419	1.704	2.990
7	-3.186	-1.599	-3.557	5.036
8	-2.289	-3.854	-2.470	5.117

Angle about z axis = 17.45°   Scale factor = 1.2588

Angle about y axis = -41.60° $d^2 = 84.75 \text{ mm}^2$

Angle about x axis = -49.05°

Table 5.5 (a) Comparison of least squares (LSQ) and repeated median (RM)
fitting of a rotated, scaled, translated and deformed two
dimensional figure (green hexagon) onto the original (red
hexagon), illustrated in Figures 5.10 (a) to (c).

Red hexagon			Green hexagon		
Vertex	Coordinate		Vertex	Coordinate	
No.	x	y	No.	x	y
1	20.000	40.000	1	80.000	-40.000
2	0.000	30.000	2	60.000	0.000
3	0.000	10.000	3	20.000	0.000
4	20.000	0.000	4	0.000	-40.000
5	40.000	10.000	5	20.000	-120.000
6	40.000	30.000	6	60.000	-120.000

LSQ FIT			RM FIT		
Residuals at each vertex after LSQ fit			Residuals at each vertex after RM fit		
Vertex	Coordinate	Magnitude	Vertex	Coordinate	Magnitude
No.	x	y	No.	x	y
1	4.865	5.405	7.272	1	0.000	0.000	0.000
2	-0.541	2.703	2.756	2	0.000	0.000	0.000
3	-0.541	-2.703	2.756	3	0.000	0.000	0.000
4	4.865	-5.405	7.272	4	0.000	0.000	0.000
5	-4.324	-2.703	5.099	5	20.000	0.000	20.000
6	-4.324	2.703	5.099	6	20.000	0.000	20.000

Angle about z axis = 450.00°

Scale factor = 0.3649

d^2 = 172.95 mm^2

Median angle about z axis = 90.00°

Median scale factor = 0.5000

Median translation vector between

centroids = (6.67, 0.00)

Table 5.5 (b)　Comparison of least squares (LSQ) and repeated median (RM) fitting of a rotated, scaled, translated and deformed two dimensional figure (green decagon) onto the original (red decagon), illustrated in Figure 5.10 (d) to (f).

Red decagon			Green decagon		
Vertex No.	Coordinate x	y	Vertex No.	Coordinate x	y
1	0.000	40.000	1	-40.000	40.000
2	0.000	60.000	2	-60.000	60.000
3	10.000	50.000	3	-40.000	60.000
4	20.000	40.000	4	-20.000	60.000
5	30.000	50.000	5	-20.000	80.000
6	40.000	60.000	6	-20.000	100.000
7	40.000	40.000	7	0.000	80.000
8	30.000	30.000	8	10.000	50.000
9	20.000	20.000	9	20.000	20.000
10	10.000	30.000	10	-10.000	30.000

LSQ FIT			RM FIT		

Residuals at each vertex after LSQ fit			Residuals at each vertex after RM fit		
Vertex No.	Coordinate x	y　　Magnitude	Vertex No.	Coordinate x	y　　Magnitude
1	-4.179	-3.582　5.504	1	0.000	0.000　0.000
2	-4.179	0.597　4.222	2	0.000	0.000　0.000
3	-2.090	-1.493　2.568	3	0.000	0.000　0.000
4	0.000	-3.582　3.582	4	0.000	0.000　0.000
5	2.089	-1.492　2.568	5	0.000	0.000　0.000
6	4.179	0.597　4.221	6	0.000	0.000　0.000
7	4.179	-3.582　5.504	7	0.000	0.000　0.000
8	2.090	2.239　3.063	8	0.000	-10.000　10.000
9	0.001	8.060　8.060	9	0.000	-20.000　20.000
10	-2.089	2.239　3.062	10	0.000	-10.000　10.000

Angle about z axis = -45.00°

Scale factor = 0.5594

d^2 = 205.97 mm^2

Median angle about z axis = -45.00°

Median scale factor = 0.7071

Median translation vector between centroids = (0.00, -4.00)

Table 5.6 Comparison of least squares (LSQ) and repeated median (RM)
fitting of a rotated, scaled, translated and deformed three
dimensional figure (green brick) onto the original orthorhombic
figure (red brick), illustrated in Figure 5.11.

	Red brick				Green brick		
Vertex No.	x	Coordinate y	z	Vertex No.	x	Coordinate y	z
1	0.000	0.000	0.000	1	1.054	-4.393	9.771
2	20.000	0.000	0.000	2	8.759	4.080	0.083
3	0.000	40.000	0.000	3	-23.951	10.819	3.189
4	0.000	0.000	30.000	4	5.635	10.255	26.224
5	20.000	40.000	0.000	5	-16.247	19.292	-6.499
6	0.000	40.000	30.000	6	-19.370	25.467	19.642
7	20.000	40.000	30.000	7	-12.103	40.401	9.452
8	20.000	0.000	30.000	8	12.903	25.176	16.034

LSQ FIT   RM FIT

Residuals at each vertex after LSQ fit   Residuals at each vertex after RM fit

Vertex No.	x	Coordinate y	z	Magnt	Vertex No.	x	Coordinate y	z	Magnt
1	0.812	-0.638	1.087	1.499	1	0.000	0.000	0.000	0.000
2	1.938	-0.184	0.760	2.090	2	0.000	-0.001	0.000	0.001
3	-0.077	1.623	0.011	1.625	3	0.000	0.000	0.000	0.000
4	1.320	0.156	2.780	3.081	4	0.000	0.000	-0.001	0.001
5	1.049	2.077	-0.316	2.348	5	0.000	0.000	0.000	0.000
6	0.432	2.419	1.704	2.990	6	0.000	-0.001	0.000	0.001
7	-3.186	-1.599	-3.557	5.036	7	4.999	5.000	5.000	8.659
8	-2.289	-3.854	-2.470	5.117	8	4.990	4.991	4.988	8.643

	LSQ Angle			Median Angle		
z-axis	y-axis	x-axis	Iteration	z-axis	y-axis	x-axis
17.45°	-41.60°	-49.05°	1	-59.28°	-41.82°	9.60°
			2	8.65°	-0.77°	-0.40°
			3	0.19°	0.27°	-0.06°
			4	0.00°	0.03°	0.00°
			5	0.00°	0.00°	0.00°
			6	0.00°	0.00°	0.00°
			7	0.00°	0.00°	0.00°

Scale factor = 1.2588

$d^2 = 84.75 \text{ mm}^2$

Median scale factor = 1.33
Median translation vector between
centroids = (1.25,1.25,1.25)

Table 5.7   Least squares alignment of a rotated, scaled and translated distorted rectangle (green) with the original rectangle (red) in three dimensions, illustrated in Figure 5.13 (b).

	Red rectangle				Green rectangle		
Vertex No.	Coordinate			Vertex No.	Coordinate		
	x	y	z		x	y	z
1	32.853	40.402	-31.439	1	33.691	51.916	-51.669
2	28.781	27.381	-46.064	2	38.216	27.164	-38.751
3	2.036	6.510	7.313	3	-7.399	6.728	0.000
4	-2.036	-6.510	-7.313	4	7.399	-6.728	0.000

LSQ FIT

Residuals at each vertex after LSQ fit

Vertex No.	Coordinate			Magnitude
	x	y	z	
1	-3.742	-4.103	4.695	7.272
2	3.965	3.272	-7.498	9.091
3	0.405	1.688	2.362	2.932
4	-0.628	-0.857	0.440	1.150

Angle about z axis = 53.81°   Scale factor = 0.8371

Angle about y axis = 17.40° $d^2 = 145.45 \text{ mm}^2$

Angle about x axis = -58.68°

Table 5.8   Repeated median alignment of a rotated, scaled and translated distorted rectangle (green) with the original rectangle (red) in three dimensions, illustrated in Figure 5.13 (c).

Red rectangle				Green rectangle			
Vertex No.	Coordinate			Vertex No.	Coordinate		
	x	y	z		x	y	z
1	32.853	40.402	-31.439	1	33.691	51.916	-51.669
2	28.781	27.381	-46.064	2	38.216	27.164	-38.751
3	2.036	6.510	7.313	3	-7.399	6.728	0.000
4	-2.036	-6.510	-7.313	4	7.399	-6.728	0.000

RM FIT

Residuals at each vertex after RM fit

Vertex No.	Coordinate			Magnitude
	x	y	z	
1	9.874	11.585	-12.696	19.821
2	-0.053	0.092	0.173	0.203
3	-0.256	-0.092	-0.004	0.272
4	0.053	-0.194	0.004	0.201

Iteration	Median angle		
	z-axis	y-axis	x-axis
1	-6.2456°	3.0372°	10.5084°
2	-6.5982°	8.1136°	5.7514°
3	-6.8231°	6.2694°	5.5667°
4	-5.6644°	5.5628°	4.8250°
5	-4.8588°	4.8379°	3.9985°
6	-2.6510°	3.3214°	2.3210°
7	-2.5790°	2.5504°	1.9696°
8	-2.5387°	2.3588°	1.8712°
9	-2.3848°	2.2161°	1.2658°
10	-1.9979°	1.6973°	0.6379°
11	-1.2102°	0.9546°	0.3529°
12	-0.6300°	0.5014°	0.1772°
13	-0.3812°	0.2858°	0.1024°
14	-0.3144°	0.2157°	0.0805°
15	-0.2412°	0.1656°	0.0611°

Median scale factor = 1.000

Median translation vector between centroids = (2.40, 2.85, -3.13)

Table 5.9   Least squares alignment followed by repeated median alignment
of a rotated, scaled and translated distorted rectangle (green) with
the original rectangle (red) in three dimensions, illustrated in
Figure 5.13 (d).

	Red rectangle				Green rectangle		
Vertex	Coordinate			Vertex	Coordinate		
No.	x	y	z	No.	x	y	z
1	32.853	40.402	-31.439	1	36.595	44.505	-36.134
2	28.781	27.381	-46.064	2	24.816	24.109	-38.566
3	2.036	6.510	7.313	3	1.631	4.822	4.951
4	-2.036	-6.510	-7.313	4	-1.408	-5.653	-7.753

RM FIT

Residuals at each vertex after RM fit

Vertex	Coordinate			Magnitude
No.	x	y	z	
1	10.271	11.297	-12.915	19.998
2	0.000	0.000	0.001	0.001
3	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000

	Median angle		
Iteration	z-axis	y-axis	x-axis
1	-0.8961°	1.5745°	-1.7709°
2	0.4299°	-0.2378°	-0.2862°
3	-0.0132°	-0.0649°	-0.0150°
4	-0.0092°	-0.0002°	0.0012°
5	-0.0010°	0.0010°	0.0003°
6	-0.0009°	-0.0004°	0.0001°
7	0.0001°	0.0001°	0.0000°
8	0.0000°	0.0000°	0.0000°
9	0.0000°	0.0000°	0.0000°
10	0.0000°	0.0000°	0.0000°
11	0.0000°	0.0000°	0.0000°
12	0.0000°	0.0000°	0.0000°
13	0.0000°	0.0000°	0.0000°
14	0.0000°	0.0000°	0.0000°
15	0.0000°	0.0000°	0.0000°

Median scale factor = 1.1945

Median translation vector between centroids = (2.57, 2.82, -3.23)

Table 5.10 (a)   Comparison of a triangle (green) deformed simply by stretching along the X and Y axes, with the initial triangle (red) using strain analysis, illustrated in Figures 5.15 (a) and (b).

Red triangle			Green triangle		
Vertex No.	Coordinate x	y	Vertex No.	Coordinate x	y
1	0.000	0.000	1	0.000	0.000
2	40.000	30.000	2	50.000	32.000
3	40.000	0.000	3	50.000	0.000

STRAIN ANALYSIS

	Minor	Major
Principal Strain	0.0689	0.2813
Principal Stretch Ratios	1.0667	1.2500

	Homologue 1 X	Y	Homologue 2 X	Y
Minor Principal Strain Dns	0.000	1.000	0.000	1.000
Major Principal Strain Dns	-1.000	0.000	-1.000	0.000
Area	600.00 mm^2		800.00 mm^2	

Percentage Area Change   33.33%

Table 5.10 (b) Comparison of a deformed triangle (green), with the initial triangle (red) using strain analysis, illustrated in Figures 5.15 (c) and (d).

	Red triangle			Green triangle	
Vertex No.	Coordinate x	y	Vertex No.	Coordinate x	y
1	0.000	0.000	1	0.000	0.000
2	40.000	30.000	2	48.000	32.000
3	40.000	0.000	3	50.000	0.000

STRAIN ANALYSIS

	Minor	Major
Principal Strain	0.0632	0.2892
Principal Stretch Ratios	1.0613	1.2564

	Homologue 1 X	Y	Homologue 2 X	Y
Minor Principal Strain Dns	-0.1877	-0.9822	-0.1593	-0.9872
Major Principal Strain Dns	-0.9822	0.1877	-0.9872	0.1593
Area	600.00 mm^2		800.00 mm^2	

Percentage Area Change	33.33%

Table 5.11   Comparison of a deformed tetrahedron (green), with the initial tetrahedron (red) using strain analysis, illustrated in Figure 5.16.

	Red tetrahedron				Green tetrahedron		
Vertex No.	Coordinate x	y	z	Vertex No.	Coordinate x	y	z
1	0.000	0.000	0.000	1	0.000	0.000	0.000
2	40.000	30.000	0.000	2	50.000	30.000	0.000
3	40.000	0.000	0.000	3	50.000	0.000	0.000
4	40.000	0.000	25.000	4	50.000	0.000	25.000

STRAIN ANALYSIS

	Minor	Semi	Major
Principal Strain	0.0000	0.0000	0.2812
Principal Stretch Ratios	1.0000	1.0000	1.2500

	Homologue 1			Homologue 2		
	X	Y	Z	X	Y	Z
Minor Principal Strain Dns	0.000	0.000	-1.000	0.000	0.000	-1.000
Semi Principal Strain Dns	0.000	-1.000	0.000	0.000	1.000	0.000
Major Principal Strain Dns	-1.000	0.000	0.000	-1.000	0.000	0.000

Volume	5000.00 mm^3	6250.00 mm^3

Percentage Volume Change	25.00%

Table 6.1 (a) The experimental reference distance and angle standard statistics for the mandible generated from the coordinate data of the osseous landmarks of the four female dried skulls.

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
1	cdr-gor	4	58.86	56.40	62.14	5.75	2.61	2.07
2	gor-gn	4	82.03	74.91	93.70	18.79	8.15	1.38
3	gn-pg	4	10.87	9.78	12.33	2.55	1.21	1.69
4	pg-id	4	19.89	17.71	21.12	3.42	1.55	1.59
5	gn-gol	4	83.37	77.15	92.41	15.26	6.45	1.94
6	gol-cdl	4	56.49	50.93	60.92	9.99	4.16	2.98
7	cdl-cnl	4	25.74	23.02	28.14	5.11	2.21	2.67
8	cnl-ctl	4	15.65	13.46	17.81	4.35	1.92	2.09
9	ctl-eoll	4	28.05	23.82	33.90	10.08	4.42	3.59
10	eoll-mll	2	28.52	27.07	29.97	2.90	2.05	3.27
11	mll-id	2	40.36	38.69	42.02	3.33	2.35	1.01
12	id-mlr	3	40.45	39.02	41.49	2.48	1.28	0.95
13	mlr-eolr	3	28.03	24.92	32.83	7.90	4.21	1.38
14	eolr-ctr	4	30.33	23.65	34.15	10.50	4.62	1.43
15	ctr-cnr	4	13.70	12.08	15.98	3.90	1.66	0.98
16	cnr-cdr	4	27.03	23.71	29.44	5.72	2.41	1.77
17	cnr-gor	4	44.94	39.86	51.01	11.15	4.59	1.23
18	ctr-gor	4	55.30	50.12	60.79	10.67	4.39	1.46
19	cdr-ctr	4	35.52	29.98	41.27	11.29	4.62	1.94
20	eolr-id	4	66.95	64.10	72.26	8.16	3.66	1.23
21	cdr-gn	4	118.37	109.83	126.51	16.68	6.82	1.88
22	cdr-pg	4	118.62	110.60	124.32	13.72	5.77	2.28
23	cnl-gol	4	42.34	37.92	48.58	10.66	4.60	2.15
24	ctl-gol	4	54.37	51.30	59.29	7.99	3.84	2.48
25	cdl-ctl	4	34.85	30.02	39.83	9.81	4.01	2.94
26	eoll-id	4	65.95	63.22	70.88	7.66	3.38	3.19
27	cdl-gn	4	116.13	111.20	124.11	12.91	5.65	2.51
28	cdl-pg	4	118.45	113.12	128.58	15.45	6.96	2.83
29	gor-pg	4	86.48	80.51	95.25	14.74	6.26	1.90
30	gol-pg	4	90.05	83.99	101.38	17.39	7.73	2.33
31	gor-gol	4	82.16	74.75	88.08	13.32	5.52	2.13
32	cdr-cdl	4	101.94	99.51	106.89	7.38	3.35	2.95
33	cnr-cnl	4	84.65	81.19	87.44	6.25	3.26	1.27
34	ctr-ctl	4	83.61	79.63	88.75	9.12	4.68	1.93
35	eolr-eoll	4	77.99	74.63	80.65	6.02	2.77	3.35
36	mlr-mll	2	55.44	53.21	57.67	4.46	3.16	1.18
37	cdr-gor-gn	4	113.55	106.79	117.72	10.93	5.00	1.33
38	cdl-gol-gn	4	110.98	106.26	114.33	8.07	3.39	2.09

Table 6.1 (a) (continued)

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
40	gor-cdr-cnr	4	46.79	41.03	51.81	10.78	4.78	2.32
41	gol-cdl-cnl	4	44.57	40.59	47.86	7.27	3.52	3.69
42	cdr-cnr-ctr	4	117.27	109.42	128.13	18.71	7.84	2.84
43	cdl-cnl-ctl	4	112.19	107.85	118.46	10.61	4.48	5.00
44	cnr-ctr-eolr	4	65.01	62.10	69.44	7.34	3.20	2.51
45	cnl-ctl-eoll	4	66.79	62.94	73.01	10.06	4.35	6.05
46	ctr-eolr-mlr	3	108.28	103.95	115.88	11.93	6.61	2.34
47	ctl-eoll-mll	2	112.66	109.57	115.75	6.17	4.36	5.54
48	eolr-id-eoll	4	71.99	67.77	76.51	8.74	3.80	1.74
49	mlr-id-mll	2	86.88	86.42	87.34	0.93	0.65	1.22
50	cdr-gor-pg	4	108.08	102.29	112.16	9.86	4.62	1.40
51	cdl-gol-pg	4	105.72	101.87	109.11	7.23	2.98	2.13
52	gor-pg-gol	4	55.58	51.63	60.13	8.50	3.91	1.15
53	ML(l)/NSL	4	37.36	33.50	40.51	7.01	2.97	1.48
54	ML(r)/NSL	4	38.56	36.35	40.75	4.40	2.12	1.39
55	NL/ML(l)	4	34.86	30.93	41.48	10.55	4.68	1.62
56	NL/ML(r)	4	34.52	30.98	37.37	6.39	2.66	1.53
57	CL/ML(l)	4	83.64	72.26	94.41	22.15	9.19	3.07
58	CL/ML(r)	4	89.48	82.34	92.84	10.50	4.90	3.02

[+] Expected standard deviation (see Section 6.3.2)

Table 6.1 (b)   The experimental reference distance and angle standard statistics for the maxilla generated from the coordinate data of the osseous landmarks of the four female dried skulls.

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
1	n-morr	4	13.18	11.06	16.62	5.56	2.47	1.72
2	morr-orr	4	25.24	23.41	27.79	4.38	1.94	2.60
3	orr-zmr	4	28.78	24.74	30.63	5.89	2.72	2.37
4	zmr-mur	4	29.20	26.30	33.36	7.06	3.00	1.34
5	mur-pr	4	43.04	41.29	45.07	3.78	1.59	2.12
6	pr-mul	4	43.40	40.85	45.27	4.43	1.91	2.00
7	mul-zml	4	27.31	24.72	31.93	7.21	3.35	1.49
8	zml-orl	4	27.24	22.24	29.70	7.46	3.45	3.25
9	orl-morl	4	24.77	23.94	25.61	1.67	0.77	3.28
10	morl-n	4	13.40	11.52	15.09	3.57	1.81	1.72
11	n-na	4	17.60	14.18	20.43	6.24	2.58	1.36
12	na-nabr	4	27.39	23.27	30.97	7.70	3.85	1.70
13	na-nabl	4	24.79	22.67	29.51	6.84	3.20	2.77
14	nabr-ans	4	15.63	13.12	17.34	4.22	1.78	1.80
15	nabl-ans	4	14.91	8.50	18.31	9.81	4.56	2.83
16	ans-pr	4	15.72	12.97	18.29	5.32	2.18	2.17
17	ans-pns	4	51.60	42.09	56.18	14.08	6.44	2.41
18	pns-scr	3	15.56	13.27	19.31	6.05	3.28	3.20
19	pns-scl	3	16.00	13.70	19.67	5.98	3.22	3.35
20	mur-orr	4	41.88	35.49	47.02	11.53	4.91	2.42
21	mul-orl	4	41.30	34.68	45.51	10.83	4.68	3.06
22	mur-iofr	4	31.95	27.55	34.44	6.89	3.14	3.13
23	mul-iofl	4	29.55	24.42	34.26	9.84	4.22	2.61
24	n-pr	4	58.83	52.17	66.87	14.70	6.14	2.12
25	n-ans	4	44.07	39.22	48.82	9.60	3.92	1.49
26	na-ans	4	27.85	25.92	31.45	5.53	2.46	1.42
27	nabr-zmr	4	40.80	39.26	43.52	4.26	1.87	1.68
28	nabl-zml	4	40.01	38.49	41.14	2.65	1.22	2.92
29	nabr-nabl	4	25.76	21.72	29.10	7.38	3.04	2.98
30	zmr-zml	4	91.68	90.21	93.65	3.44	1.44	1.57
31	mur-mul	4	58.31	56.84	59.57	2.73	1.36	1.24
32	scr-scl	3	26.59	24.35	30.12	5.77	3.09	3.51
33	iofr-iofl	4	53.51	52.68	54.58	1.90	0.81	3.88
34	orr-orl	4	59.27	56.34	61.47	5.14	2.49	3.70
35	morr-morl	4	22.98	19.63	26.62	6.99	3.05	1.97
36	ans-scr	3	63.48	58.82	68.04	9.21	4.61	2.62
37	ans-scl	3	63.86	57.49	69.49	12.00	6.03	2.80

Table 6.1 (b) (continued)

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
38	n-pns	4	62.10	55.66	66.28	10.62	4.53	2.37
39	pns-ba	4	44.09	38.60	54.86	16.26	7.38	3.42
40	morl-n-morr	4	120.68	114.08	135.10	21.02	9.78	5.76
41	n-morr-orr	4	162.19	153.67	174.03	20.36	8.54	5.29
42	morr-orr-zmr	4	157.80	153.32	169.44	16.11	7.78	4.06
43	orr-zmr-mur	4	92.29	84.27	100.77	16.50	7.42	3.03
44	mur-pr-mul	4	84.94	81.83	88.77	6.94	3.33	2.23
45	n-morl-orl	4	162.07	155.77	170.28	14.51	7.10	5.89
46	morl-orl-zml	4	155.57	152.87	158.16	5.29	2.83	5.77
47	orl-zml-mul	4	97.94	87.40	104.61	17.21	7.39	4.17
48	zmr-ans-zml	4	117.27	112.79	127.09	14.30	6.61	1.32
49	s-n-na	4	109.05	99.62	123.73	24.12	10.50	2.84
50	n-na-nabr	4	134.90	118.80	142.73	23.92	11.01	3.15
51	n-na-nabl	4	127.07	116.52	139.11	22.59	10.24	4.78
52	na-nabr-ans	4	74.41	63.39	80.19	16.80	7.61	4.90
53	na-nabl-ans	4	85.61	78.77	93.51	14.74	6.48	6.52
54	nabr-ans-nabl	4	114.82	110.61	121.24	10.63	4.60	6.84
55	NL/NSL	4	7.01	2.19	11.62	9.44	4.58	1.90
56	n-s-pns	4	68.29	64.87	73.02	8.15	3.79	3.25
57	pns-s-ba	4	64.29	59.50	68.41	8.90	3.66	4.10
58	pns-ans-pr	4	116.18	109.89	128.62	18.73	8.44	5.70
59	na-n-g	4	138.39	136.79	142.00	5.21	2.43	4.64
60	sorr-n-g	4	72.55	62.19	84.37	22.18	9.35	4.49
61	sorl-n-g	4	83.92	76.56	96.14	19.59	8.60	5.16
62	sorr-n-na	4	104.26	102.43	106.19	3.76	1.58	3.40
63	sorl-n-na	4	110.88	108.80	113.55	4.75	2.05	4.25

[+] Expected standard deviation (see Section 6.3.2)

Table 6.1 (c) The experimental reference distance and angle standard statistics for the orbit generated from the coordinate data of the osseous landmarks of the four female dried skulls.

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
1	n-na	4	17.60	14.18	20.43	6.24	2.58	1.36
2	n-morr	4	13.18	11.06	16.62	5.56	2.47	1.72
3	morr-sorr	4	22.81	20.76	26.59	5.82	2.58	2.30
4	sorr-lorr	4	28.12	25.27	31.10	5.83	2.38	2.00
5	lorr-oorr	4	10.35	8.71	12.59	3.88	1.62	1.65
6	oorr-orr	4	18.00	17.78	18.65	0.87	0.43	2.63
7	orr-morr	4	25.24	23.41	27.79	4.38	1.94	2.60
8	morr-ofr	2	48.54	48.52	48.56	0.03	0.00	1.59
9	sorr-ofr	2	49.06	48.63	49.48	0.84	0.60	1.98
10	lorr-ofr	2	48.68	48.43	48.94	0.50	0.36	1.11
11	oorr-ofr	2	52.34	50.89	53.78	2.89	2.04	1.63
12	orr-ofr	2	50.67	49.08	52.26	3.18	2.25	2.33
13	orr-iofr	4	11.00	8.29	13.71	5.42	2.95	3.69
14	n-morl	4	13.40	11.52	15.09	3.57	1.81	1.72
15	morl-sorl	4	23.10	22.12	24.53	2.42	1.05	3.58
16	sorl-lorl	4	26.94	26.18	28.68	2.50	1.17	5.37
17	lorl-oorl	4	12.60	11.63	13.52	1.88	0.92	4.54
18	oorl-orl	4	15.41	14.73	16.95	2.22	1.05	3.40
19	orl-morl	4	24.77	23.94	25.61	1.67	0.77	3.28
20	morl-ofl	2	47.93	44.94	50.92	5.98	4.22	1.73
21	sorl-ofl	2	49.13	48.16	50.10	1.94	1.37	3.46
22	lorl-ofl	2	49.96	47.55	52.37	4.82	3.41	4.36
23	oorl-ofl	2	54.65	49.22	60.08	10.86	7.68	1.94
24	orl-ofl	2	52.38	47.44	57.31	9.87	6.98	3.14
25	orl-iofl	4	13.15	12.24	14.98	2.74	1.24	3.89
26	morr-lorr	4	39.59	39.29	40.03	0.74	0.31	1.61
27	sorr-orr	4	30.56	28.97	33.95	4.99	2.29	2.86
28	morl-lorl	4	38.91	38.37	39.63	1.27	0.61	4.46
29	sorl-orl	4	30.16	28.94	32.29	3.34	1.47	4.44
30	morr-morl	4	22.98	19.63	26.62	6.99	3.05	1.97
31	sorr-sorl	4	59.31	57.73	60.32	2.59	1.17	3.77
32	lorr-lorl	4	95.96	93.32	98.48	5.17	2.12	4.31
33	oorr-oorl	4	89.40	85.06	95.07	10.01	4.17	2.19
34	orr-orl	4	59.27	56.34	61.47	5.14	2.49	3.70
35	iofr-iofl	4	53.51	52.68	54.58	1.90	0.81	3.88
36	ofr-ofl	2	25.81	24.74	26.88	2.14	1.51	1.28
37	oorr-zcr	4	17.57	14.93	19.28	4.35	1.95	1.64
38	oorl-zcl	4	19.32	16.98	21.22	4.23	2.08	2.03

Table 6.1 (c) (continued)

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
39	morl-n-morr	4	120.68	114.08	135.10	21.02	9.78	5.76
40	morr-sorr-lorr	4	101.44	95.23	106.86	11.63	4.81	4.09
41	sorr-lorr-oorr	4	104.36	97.12	113.54	16.42	8.04	6.62
42	lorr-oorr-orr	4	121.17	113.97	129.50	15.53	6.88	7.95
43	oorr-orr-morr	4	123.64	117.29	128.54	11.26	4.71	5.78
44	orr-morr-sorr	4	79.04	69.07	85.64	16.58	7.20	4.68
45	sorr-ofr-orr	2	37.14	35.41	38.87	3.47	2.45	1.98
46	morr-ofr-lorr	2	47.97	47.86	48.07	0.21	0.15	1.32
47	morl-sorl-lorl	4	101.83	99.14	104.54	5.40	2.21	8.26
48	sorl-lorl-oorl	4	99.51	98.03	102.57	4.54	2.09	12.99
49	lorl-oorl-orl	4	122.82	116.24	130.86	14.62	7.55	13.49
50	oorl-orl-morl	4	127.71	122.80	140.19	17.39	8.34	8.84
51	orl-morl-sorl	4	78.02	72.66	83.94	11.28	4.67	6.58
52	sorl-ofl-orl	2	34.70	34.16	35.24	1.08	0.77	3.23
53	morl-ofl-lorl	2	47.61	44.58	50.65	6.07	4.29	3.29
54	ofr-n-ofl	2	28.05	27.09	29.02	1.93	1.36	1.20
55	ofr-s-ofl	2	79.99	75.30	84.68	9.38	6.63	6.16

[+] Expected standard deviation (see Section 6.3.2)

Table 6.1 (d)   The experimental reference distance and angle standard statistics for the zygoma generated from the coordinate data of the osseous landmarks of the four female dried skulls.

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
1	lorr-zcr	4	16.38	14.99	17.69	2.70	1.17	1.12
2	zcr-eamr	4	58.49	56.81	60.19	3.38	1.53	1.89
3	eamr-aer	4	24.12	22.64	27.54	4.90	2.33	2.45
4	aer-zmr	4	43.08	40.45	47.08	6.64	2.87	1.96
5	zmr-orr	4	28.78	24.74	30.63	5.89	2.72	2.37
6	orr-oorr	4	18.00	17.78	18.65	0.87	0.43	2.63
7	oorr-lorr	4	10.35	8.71	12.59	3.88	1.62	1.65
8	lorl-zcl	4	18.52	16.14	22.04	5.90	2.50	4.40
9	zcl-eaml	4	59.11	56.68	61.83	5.16	2.50	2.65
10	eaml-ael	4	24.38	21.97	27.89	5.92	2.61	3.96
11	ael-zml	4	45.04	42.83	49.84	7.01	3.23	3.43
12	zml-orl	4	27.24	22.24	29.70	7.46	3.45	3.25
13	orl-oorl	4	15.41	14.73	16.95	2.22	1.05	3.40
14	oorl-lorl	4	12.60	11.63	13.52	1.88	0.92	4.54
15	zmr-oorr	4	22.28	17.34	27.91	10.57	4.36	1.69
16	zmr-zcr	4	22.65	17.72	29.15	11.43	4.77	1.18
17	zmr-eamr	4	65.07	61.99	69.90	7.91	3.47	1.94
18	zcr-oorr	4	17.57	14.93	19.28	4.35	1.95	1.64
19	zml-oorl	4	23.16	16.32	28.88	12.56	5.27	2.10
20	zml-zcl	4	24.56	18.66	29.98	11.32	4.97	1.76
21	zml-eaml	4	67.71	63.20	71.69	8.49	3.48	2.70
22	zcl-oorl	4	19.32	16.98	21.22	4.23	2.08	2.03
23	zmr-zml	4	91.68	90.21	93.65	3.44	1.44	1.57
24	aer-ael	4	107.43	103.29	114.52	11.23	5.18	3.62
25	eamr-eaml	4	94.98	94.44	95.91	1.47	0.68	2.93
26	zcr-zcl	4	111.24	109.45	113.97	4.52	1.94	1.41
27	lorr-lorl	4	95.96	93.32	98.48	5.17	2.12	4.31
28	oorr-oorl	4	89.40	85.06	95.07	10.01	4.17	2.19
29	orr-orl	4	59.27	56.34	61.47	5.14	2.49	3.70
30	lorr-oorr-eamr	4	73.78	60.89	80.87	19.98	9.32	6.36
31	lorl-oorl-eaml	4	77.69	57.08	99.08	42.00	18.71	11.20
32	lorr-zcr-eamr	4	125.79	120.51	133.15	12.64	5.86	2.54
33	zcr-eamr-zmr	4	20.05	16.52	23.85	7.33	3.07	1.46
34	eamr-zmr-orr	4	112.46	95.52	119.89	24.36	11.40	2.81
35	zmr-orr-oorr	4	50.41	44.48	63.64	19.16	9.01	5.54
36	orr-oorr-lorr	4	121.17	113.97	129.50	15.53	6.88	7.95
37	oorr-lorr-zcr	4	78.50	69.76	83.61	13.85	6.03	6.69
38	lorl-zcl-eaml	4	129.59	120.88	143.08	22.20	9.47	8.25

Table 6.1 (d) (continued)

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
39	zcl-eaml-zml	4	20.75	16.80	23.69	6.89	3.40	1.94
40	eaml-zml-orl	4	109.70	98.45	118.18	19.73	9.17	3.89
41	zml-orl-oorl	4	57.56	47.21	70.56	23.35	9.80	8.46
42	orl-oorl-lorl	4	122.82	116.24	130.86	14.62	7.55	13.49
43	oorl-lorl-zcl	4	74.05	63.72	82.53	18.80	8.69	13.78

[+] Expected standard deviation (see Section 6.3.2)

Table 6.1 (e) The experimental reference distance and angle standard statistics for the cranium generated from the coordinate data of the osseous landmarks of the four female dried skulls.

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
1	s-n	4	64.18	59.90	68.99	9.09	3.73	2.46
2	n-g	4	17.42	12.70	21.08	8.38	3.83	2.34
3	g-br	1	90.15	90.15	90.15	0.00	0.00	2.20
4	g-zfr	4	53.85	49.18	58.43	9.25	4.64	3.31
5	g-zfl	4	57.92	55.66	61.76	6.10	2.88	3.36
6	zfr-br	1	79.49	79.49	79.49	0.00	0.00	2.62
7	zfl-br	1	77.67	77.67	77.67	0.00	0.00	2.68
8	br-v	1	22.87	22.87	22.87	0.00	0.00	2.83
9	v-op	3	124.24	111.91	130.70	18.79	10.68	2.89
10	op-o	3	71.16	64.30	75.73	11.43	6.05	0.96
11	op-mtr	4	106.47	94.86	115.80	20.94	9.03	1.67
12	op-mtl	4	107.42	97.61	116.27	18.66	7.99	1.82
13	o-fmbr	2	23.26	20.78	25.74	4.96	3.51	1.91
14	o-fmbl	2	24.55	23.92	25.18	1.26	0.89	1.30
15	fmbr-ba	2	25.18	24.66	25.69	1.03	0.73	3.25
16	fmbl-ba	2	23.59	23.48	23.70	0.23	0.16	2.93
17	ba-s	4	41.58	36.58	50.97	14.39	6.56	3.48
18	mtr-eamr	4	25.06	21.38	29.59	8.21	3.40	2.25
19	eamr-zfr	4	81.54	76.94	87.17	10.23	4.51	3.08
20	eamr-v	3	118.38	113.29	123.09	9.81	4.91	3.25
21	mtl-eaml	4	24.67	19.76	29.67	9.91	4.90	2.86
22	eaml-zfl	4	80.84	75.83	87.03	11.20	5.82	3.53
23	eaml-v	3	119.78	112.67	125.66	12.99	6.58	3.64
24	mtr-mtl	4	95.08	89.46	98.88	9.42	4.12	2.16
25	eamr-eaml	4	94.98	94.44	95.91	1.47	0.68	2.93
26	zfr-zfl	4	94.81	91.15	98.50	7.35	4.08	3.65
27	fmbr-fmbl	2	30.36	30.35	30.37	0.02	0.01	2.22
28	o-ba	3	36.81	35.60	37.61	2.01	1.07	2.70
29	n-ba	4	97.15	88.03	108.83	20.81	9.18	2.85
30	s-g	4	72.41	68.96	74.34	5.38	2.51	3.08
31	s-o	3	69.83	66.30	73.69	7.40	3.71	2.28
32	g-o	3	141.43	134.53	147.34	12.81	6.46	2.16
33	g-op	4	182.83	167.76	193.70	25.94	10.99	2.27
34	ba-br	1	118.10	118.10	118.10	0.00	0.00	2.73
35	s-v	3	92.71	90.49	95.78	5.29	2.75	3.55
36	s-br	1	85.42	85.42	85.42	0.00	0.00	2.32
37	ba-v	3	125.17	120.19	133.17	12.98	7.00	3.83

Table 6.1 (e) (continued)

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
38	ba-s-n	4	132.53	128.98	141.42	12.45	5.95	3.07
39	s-n-g	4	110.81	99.47	118.39	18.93	8.04	4.08
40	n-g-br	1	110.46	110.46	110.46	0.00	0.00	3.97
41	g-br-v	1	144.98	144.98	144.98	0.00	0.00	3.60
42	br-v-op	1	126.46	126.46	126.46	0.00	0.00	3.59
43	v-op-o	2	83.25	77.61	88.89	11.29	7.98	0.84
44	op-o-ba	3	128.09	125.23	130.39	5.16	2.62	2.54
45	o-ba-s	3	136.90	126.63	147.60	20.98	10.50	3.76
46	op-mtr-eamr	4	87.78	83.99	92.98	9.00	3.76	3.09
47	op-mtl-eaml	4	85.33	82.69	92.33	9.64	4.67	4.50
48	o-fmbr-ba	2	98.00	96.53	99.47	2.94	2.08	5.17
49	o-fmbl-ba	2	99.23	93.43	105.02	11.59	8.19	4.43
50	fmbr-o-fmbl	2	78.69	75.25	82.12	6.87	4.85	3.49
51	fmbr-ba-fmbl	2	76.94	75.76	78.13	2.37	1.68	5.85
52	g-v-op	3	102.09	98.41	104.30	5.89	3.21	1.24

[+] Expected standard deviation (see Section 6.3.2)

Table 6.2 (a)   Bilateral comparison of the distance and angle experimental reference standard statistics for the mandible.

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
1	cdr-gor	4	58.86	56.40	62.14	5.75	2.61	2.07
6	cdl-gol	4	56.49	50.93	60.92	9.99	4.16	2.98
	difference		2.37	5.47*	1.22	-4.24		
2	gor-gn	4	82.03	74.91	93.70	18.79	8.15	1.38
5	gol-gn	4	83.37	77.15	92.41	15.26	6.45	1.94
	difference		-1.34	-2.24	1.29	3.53		
7	cdl-cnl	4	25.74	23.02	28.14	5.11	2.21	2.67
16	cdr-cnr	4	27.03	23.71	29.44	5.72	2.41	1.77
	difference		-1.29	-0.69	-1.30	-0.61		
8	cnl-ctl	4	15.65	13.46	17.81	4.35	1.92	2.09
15	cnr-ctr	4	13.70	12.08	15.98	3.90	1.66	0.98
	difference		1.95	1.38	1.83	0.45		
9	ctl-eoll	4	28.05	23.82	33.90	10.08	4.42	3.59
14	ctr-eolr	4	30.33	23.65	34.15	10.50	4.62	1.43
	difference		-2.28	0.17	-0.25	-0.42		
10	eoll-mll	2	28.52	27.07	29.97	2.90	2.05	3.27
13	eolr-mlr	3	28.03	24.92	32.83	7.90	4.21	1.38
	difference		0.49	2.15	-2.86	-5.00		
11	mll-id	2	40.36	38.69	42.02	3.33	2.35	1.01
12	mlr-id	3	40.45	39.02	41.49	2.48	1.28	0.95
	difference		-0.09	-0.33	0.53	0.85		
17	cnr-gor	4	44.94	39.86	51.01	11.15	4.59	1.23
23	cnl-gol	4	42.34	37.92	48.58	10.66	4.60	2.15
	difference		2.60	1.94	2.43	0.49		
18	ctr-gor	4	55.30	50.12	60.79	10.67	4.39	1.46
24	ctl-gol	4	54.37	51.30	59.29	7.99	3.84	2.48
	difference		0.93	-1.18	1.50	2.68		
19	cdr-ctr	4	35.52	29.98	41.27	11.29	4.62	1.94
25	cdl-ctl	4	34.85	30.02	39.83	9.81	4.01	2.94
	difference		0.67	-0.04	1.44	1.48		

Table 6.2 (a) (continued)

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
20	eolr-id	4	66.95	64.10	72.26	8.16	3.66	1.23
26	eoll-id	4	65.95	63.22	70.88	7.66	3.38	3.19
	difference		1.00	0.88	1.38	0.50		
21	cdr-gn	4	118.37	109.83	126.51	16.68	6.82	1.88
27	cdl-gn	4	116.13	111.20	124.11	12.91	5.65	2.51
	difference		2.24	-1.37	2.40	3.77		
22	cdr-pg	4	118.62	110.60	124.32	13.72	5.77	2.28
28	cdl-pg	4	118.45	113.12	128.58	15.45	6.96	2.83
	difference		0.17	-2.52	-4.26	-1.73		
29	gor-pg	4	86.48	80.51	95.25	14.74	6.26	1.90
30	gol-pg	4	90.05	83.99	101.38	17.39	7.73	2.33
	difference		-3.57	-3.48	-6.13*	-2.65		
37	cdr-gor-gn	4	113.55	106.79	117.72	10.93	5.00	1.33
38	cdl-gol-gn	4	110.98	106.26	114.33	8.07	3.39	2.09
	difference		2.57	0.53	3.39	2.86		
40	gor-cdr-cnr	4	46.79	41.03	51.81	10.78	4.78	2.32
41	gol-cdl-cnl	4	44.57	40.59	47.86	7.27	3.52	3.69
	difference		2.22	0.44	3.95	3.51		
42	cdr-cnr-ctr	4	117.27	109.42	128.13	18.71	7.84	2.84
43	cdl-cnl-ctl	4	112.19	107.85	118.46	10.61	4.48	5.00
	difference		5.08	1.57	9.67*	8.10		
44	cnr-ctr-eolr	4	65.01	62.10	69.44	7.34	3.20	2.51
45	cnl-ctl-eoll	4	66.79	62.94	73.01	10.06	4.35	6.05
	difference		-1.78	-0.84	-3.57	-2.72		
46	ctr-eolr-mlr	3	108.28	103.95	115.88	11.93	6.61	2.34
47	ctl-eoll-mll	2	112.66	109.57	115.75	6.17	4.36	5.54
	difference		-4.38	-5.62	0.13	5.76		
50	cdr-gor-pg	4	108.08	102.29	112.16	9.86	4.62	1.40
51	cdl-gol-pg	4	105.72	101.87	109.11	7.23	2.98	2.13
	difference		2.36	0.42	3.05	2.63		

Table 6.2 (a) (continued)

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
53	ML(l)/NSL	4	37.36	33.50	40.51	7.01	2.97	1.48
54	ML(r)/NSL	4	38.56	36.35	40.75	4.40	2.12	1.39
	difference		-1.20	-2.85	-0.24	2.61		
55	NL/ML(l)	4	34.86	30.93	41.48	10.55	4.68	1.62
56	NL/ML(r)	4	34.52	30.98	37.37	6.39	2.66	1.53
	difference		0.34	-0.05	4.11	4.16		
57	CL/ML(l)	4	83.64	72.26	94.41	22.15	9.19	3.07
58	CL/ML(r)	4	89.48	82.34	92.84	10.50	4.90	3.02
	difference		-5.84	-10.08*	1.57	11.65		

[+] Expected standard deviation (see Section 6.3.2)

* significant asymmetry

Table 6.2 (b)   Bilateral comparison of the distance and angle experimental reference standard statistics for the maxilla.

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
1	n-morr	4	13.18	11.06	16.62	5.56	2.47	1.72
10	n-morl	4	13.40	11.52	15.09	3.57	1.81	1.72
	difference		-0.22	-0.46	1.53	1.99		
2	morr-orr	4	25.24	23.41	27.79	4.38	1.94	2.60
9	morl-orl	4	24.77	23.94	25.61	1.67	0.77	3.28
	difference		0.47	-0.53	2.18	2.71		
3	orr-zmr	4	28.78	24.74	30.63	5.89	2.72	2.37
8	orl-zml	4	27.24	22.24	29.70	7.46	3.45	3.25
	difference		1.54	2.50	0.93	-1.57		
4	zmr-mur	4	29.20	26.30	33.36	7.06	3.00	1.34
7	zml-mul	4	27.31	24.72	31.93	7.21	3.35	1.49
	difference		1.89	1.58	1.43	-0.15		
5	mur-pr	4	43.04	41.29	45.07	3.78	1.59	2.12
6	pr-mul	4	43.40	40.85	45.27	4.43	1.91	2.00
	difference		-0.36	0.44	-0.20	-0.65		
12	na-nabr	4	27.39	23.27	30.97	7.70	3.85	1.70
13	na-nabl	4	24.79	22.67	29.51	6.84	3.20	2.77
	difference		2.60	0.60	1.46	0.86		
14	nabr-ans	4	15.63	13.12	17.34	4.22	1.78	1.80
15	nabl-ans	4	14.91	8.50	18.31	9.81	4.56	2.83
	difference		0.72	4.62	-0.97	-5.59		
18	pns-scr	3	15.56	13.27	19.31	6.05	3.28	3.20
19	pns-scl	3	16.00	13.70	19.67	5.98	3.22	3.35
	difference		-0.44	-0.43	-0.36	0.07		
20	mur-orr	4	41.88	35.49	47.02	11.53	4.91	2.42
21	mul-orl	4	41.30	34.68	45.51	10.83	4.68	3.06
	difference		0.58	0.81	1.51	0.70		
22	mur-iofr	4	31.95	27.55	34.44	6.89	3.14	3.13
23	mul-iofl	4	29.55	24.42	34.26	9.84	4.22	2.61
	difference		2.40	3.13	0.18	-2.95		

Table 6.2 (b) (continued)

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
27	nabr-zmr	4	40.80	39.26	43.52	4.26	1.87	1.68
28	nabl-zml	4	40.01	38.49	41.14	2.65	1.22	2.92
	difference		0.79	0.77	2.38	1.61		
36	ans-scr	3	63.48	58.82	68.04	9.21	4.61	2.62
37	ans-scl	3	63.86	57.49	69.49	12.00	6.03	2.80
	difference		-0.38	1.33	-1.45	-2.79		
41	n-morr-orr	4	162.19	153.67	174.03	20.36	8.54	5.29
45	n-morl-orl	4	162.07	155.77	170.28	14.51	7.10	5.89
	difference		0.12	-2.10	3.75	5.85		
42	morr-orr-zmr	4	157.80	153.32	169.44	16.11	7.78	4.06
46	morl-orl-zml	4	155.57	152.87	158.16	5.29	2.83	5.77
	difference		2.23	0.45	11.28*	10.82		
43	orr-zmr-mur	4	92.29	84.27	100.77	16.50	7.42	3.03
47	orl-zml-mul	4	97.94	87.40	104.61	17.21	7.39	4.17
	difference		-5.65	-3.13	-3.84	-0.71		
50	n-na-nabr	4	134.90	118.80	142.73	23.92	11.01	3.15
51	n-na-nabl	4	127.07	116.52	139.11	22.59	10.24	4.78
	difference		7.83*	2.28	3.62	1.33		
52	na-nabr-ans	4	74.41	63.39	80.19	16.80	7.61	4.90
53	na-nabl-ans	4	85.61	78.77	93.51	14.74	6.48	6.52
	difference		-11.20*	-15.38*	-13.32*	2.06		

[+] Expected standard deviation (see Section 6.3.2)

* significant asymmetry

Table 6.2 (c)   Bilateral comparison of the distance and angle experimental reference standard statistics for the orbit.

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
2	n-morr	4	13.18	11.06	16.62	5.56	2.47	1.72
14	n-morl	4	13.40	11.52	15.09	3.57	1.81	1.72
	difference		-0.22	-0.46	1.53	1.99		
3	morr-sorr	4	22.81	20.76	26.59	5.82	2.58	2.30
15	morl-sorl	4	23.10	22.12	24.53	2.42	1.05	3.58
	difference		-0.29	-1.36	2.06	3.40		
4	sorr-lorr	4	28.12	25.27	31.10	5.83	2.38	2.00
16	sorl-lorl	4	26.94	26.18	28.68	2.50	1.17	5.37
	difference		1.18	-0.91	2.42	3.33		
5	lorr-oorr	4	10.35	8.71	12.59	3.88	1.62	1.65
17	lorl-oorl	4	12.60	11.63	13.52	1.88	0.92	4.54
	difference		-2.25	-2.92	-0.93	2.00		
6	oorr-orr	4	18.00	17.78	18.65	0.87	0.43	2.63
18	oorl-orl	4	15.41	14.73	16.95	2.22	1.05	3.40
	difference		2.59	3.05	1.70	-1.35		
7	orr-morr	4	25.24	23.41	27.79	4.38	1.94	2.60
19	orl-morl	4	24.77	23.94	25.61	1.67	0.77	3.28
	difference		0.47	-0.53	2.18	2.71		
8	morr-ofr	2	48.54	48.52	48.56	0.03	0.00	1.59
20	morl-ofl	2	47.93	44.94	50.92	5.98	4.22	1.73
	difference		0.61	3.58	-2.36	-5.95		
9	sorr-ofr	2	49.06	48.63	49.48	0.84	0.60	1.98
21	sorl-ofl	2	49.13	48.16	50.10	1.94	1.37	3.46
	difference		-0.07	0.47	-0.62	-1.10		
10	lorr-ofr	2	48.68	48.43	48.94	0.50	0.36	1.11
22	lorl-ofl	2	49.96	47.55	52.37	4.82	3.41	4.36
	difference		-1.28	0.88	-3.43	-4.32		
11	oorr-ofr	2	52.34	50.89	53.78	2.89	2.04	1.63
23	oorl-ofl	2	54.65	49.22	60.08	10.86	7.68	1.94
	difference		-2.31	1.67	-6.30*	-7.97		

Table 6.2 (c) (continued)

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
12	orr-ofr	2	50.67	49.08	52.26	3.18	2.25	2.33
24	orl-ofl	2	52.38	47.44	57.31	9.87	6.98	3.14
	difference		-1.71	1.64	-5.05*	-6.69		
13	orr-iofr	4	11.00	8.29	13.71	5.42	2.95	3.69
25	orl-iofl	4	13.15	12.24	14.98	2.74	1.24	3.89
	difference		-2.15	-3.95	-1.27	2.68		
26	morr-lorr	4	39.59	39.29	40.03	0.74	0.31	1.61
28	morl-lorl	4	38.91	38.37	39.63	1.27	0.61	4.46
	difference		0.68	0.92	0.40	-0.53		
27	sorr-orr	4	30.56	28.97	33.95	4.99	2.29	2.86
29	sorl-orl	4	30.16	28.94	32.29	3.34	1.47	4.44
	difference		0.40	0.03	1.66	1.65		
37	oorr-zcr	4	17.57	14.93	19.28	4.35	1.95	1.64
38	oorl-zcl	4	19.32	16.98	21.22	4.23	2.08	2.03
	difference		-1.75	-2.05	-1.94	0.12		
40	morr-sorr-lorr	4	101.44	95.23	106.86	11.63	4.81	4.09
47	morl-sorl-lorl	4	101.83	99.14	104.54	5.40	2.21	8.26
	difference		-0.39	-3.91	2.32	6.23		
41	sorr-lorr-oorr	4	104.36	97.12	113.54	16.42	8.04	6.62
48	sorl-lorl-oorl	4	99.51	98.03	102.57	4.54	2.09	12.99
	difference		4.85	-0.91	10.97*	11.88		
42	lorr-oorr-orr	4	121.17	113.97	129.50	15.53	6.88	7.95
49	lorl-oorl-orl	4	122.82	116.24	130.86	14.62	7.55	13.49
	difference		-1.65	-2.27	-1.36	0.91		
43	oorr-orr-morr	4	123.64	117.29	128.54	11.26	4.71	5.78
50	oorl-orl-morl	4	127.71	122.80	140.19	17.39	8.34	8.84
	difference		-4.07	-5.51	-11.65*	-6.13		
44	orr-morr-sorr	4	79.04	69.07	85.64	16.58	7.20	4.68
51	orl-morl-sorl	4	78.02	72.66	83.94	11.28	4.67	6.58
	difference		1.02	-3.59	1.70	5.30		

Table 6.2 (c) (continued)

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
45	sorr-ofr-orr	2	37.14	35.41	38.87	3.47	2.45	1.98
52	sorl-ofl-orl	2	34.70	34.16	35.24	1.08	0.77	3.23
difference			2.44	1.25	3.63	2.39		
46	morr-ofr-lorr	2	47.97	47.86	48.07	0.21	0.15	1.32
53	morl-ofl-lorl	2	47.61	44.58	50.65	6.07	4.29	3.29
difference			0.36	3.28	-2.58	-5.86		

[+] Expected standard deviation (see Section 6.3.2)

* significant asymmetry

Table 6.2 (d)   Bilateral comparison of the distance and angle experimental
reference standard statistics for the zygoma.

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
1	lorr-zcr	4	16.38	14.99	17.69	2.70	1.17	1.12
8	lorl-zcl	4	18.52	16.14	22.04	5.90	2.50	4.40
	difference		-2.14	-1.15	-4.35	-3.20		
2	zcr-eamr	4	58.49	56.81	60.19	3.38	1.53	1.89
9	zcl-eaml	4	59.11	56.68	61.83	5.16	2.50	2.65
	difference		-0.62	0.13	-1.64	-1.78		
3	eamr-aer	4	24.12	22.64	27.54	4.90	2.33	2.45
10	eaml-ael	4	24.38	21.97	27.89	5.92	2.61	3.96
	difference		-0.26	0.67	-0.35	-1.02		
4	aer-zmr	4	43.08	40.45	47.08	6.64	2.87	1.96
11	ael-zml	4	45.04	42.83	49.84	7.01	3.23	3.43
	difference		-1.96	-2.38	-2.76	-0.37		
5	zmr-orr	4	28.78	24.74	30.63	5.89	2.72	2.37
12	zml-orl	4	27.24	22.24	29.70	7.46	3.45	3.25
	difference		1.54	2.50	0.93	-1.57		
6	orr-oorr	4	18.00	17.78	18.65	0.87	0.43	2.63
13	orl-oorl	4	15.41	14.73	16.95	2.22	1.05	3.40
	difference		2.59	3.05	1.70	-1.35		
7	oorr-lorr	4	10.35	8.71	12.59	3.88	1.62	1.65
14	oorl-lorl	4	12.60	11.63	13.52	1.88	0.92	4.54
	difference		-2.25	-2.92	-0.93	2.00		
15	zmr-oorr	4	22.28	17.34	27.91	10.57	4.36	1.69
19	zml-oorl	4	23.16	16.32	28.88	12.56	5.27	2.10
	difference		-0.88	1.02	-0.97	-1.99		
16	zmr-zcr	4	22.65	17.72	29.15	11.43	4.77	1.18
20	zml-zcl	4	24.56	18.66	29.98	11.32	4.97	1.76
	difference		-1.91	-0.94	-0.83	0.11		
17	zmr-eamr	4	65.07	61.99	69.90	7.91	3.47	1.94
21	zml-eaml	4	67.71	63.20	71.69	8.49	3.48	2.70
	difference		-2.64	-1.21	-1.79	-0.58		

Table 6.2 (d) (continued)

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
18	zcr-oorr	4	17.57	14.93	19.28	4.35	1.95	1.64
22	zcl-oorl	4	19.32	16.98	21.22	4.23	2.08	2.03
	difference		-1.75	-2.05	-1.94	0.12		
30	lorr-oorr-eamr	4	73.78	60.89	80.87	19.98	9.32	6.36
31	lorl-oorl-eaml	4	77.69	57.08	99.08	42.00	18.71	11.20
	difference		-3.91	3.81	-18.21*	-22.02		
32	lorr-zcr-eamr	4	125.79	120.51	133.15	12.64	5.86	2.54
38	lorl-zcl-eaml	4	129.59	120.88	143.08	22.20	9.47	8.25
	difference		-3.80	-0.37	-9.93*	-9.56		
33	zcr-eamr-zmr	4	20.05	16.52	23.85	7.33	3.07	1.46
39	zcl-eaml-zml	4	20.75	16.80	23.69	6.89	3.40	1.94
	difference		-0.70	-0.28	0.16	0.44		
34	eamr-zmr-orr	4	112.46	95.52	119.89	24.36	11.40	2.81
40	eaml-zml-orl	4	109.70	98.45	118.18	19.73	9.17	3.89
	difference		2.76	-2.93	1.71	4.63		
35	zmr-orr-oorr	4	50.41	44.48	63.64	19.16	9.01	5.54
41	zml-orl-oorl	4	57.56	47.21	70.56	23.35	9.80	8.46
	difference		-7.15	-2.73	-6.92	-4.19		
36	orr-oorr-lorr	4	121.17	113.97	129.50	15.53	6.88	7.95
42	orl-oorl-lorl	4	122.82	116.24	130.86	14.62	7.55	13.49
	difference		-1.65	-2.27	-1.36	0.91		
37	oorr-lorr-zcr	4	78.50	69.76	83.61	13.85	6.03	6.69
43	oorl-lorl-zcl	4	74.05	63.72	82.53	18.80	8.69	13.78
	difference		4.45	6.04	1.08	-4.95		

[+] Expected standard deviation (see Section 6.3.2)

* significant asymmetry

Table 6.2 (e)   Bilateral comparison of the distance and angle experimental reference standard statistics for the cranium.

N	Name	Obs	Mean	Min	Max	Range	SD	Exp.SD[+]
4	g-zfr	4	53.85	49.18	58.43	9.25	4.64	3.31
5	g-zfl	4	57.92	55.66	61.76	6.10	2.88	3.36
	difference		-4.07	-6.48*	-3.33	3.15		
6	zfr-br	1	79.49	79.49	79.49	0.00	0.00	2.62
7	zfl-br	1	77.67	77.67	77.67	0.00	0.00	2.68
	difference		1.82	1.82	1.82	0.00		
11	op-mtr	4	106.47	94.86	115.80	20.94	9.03	1.67
12	op-mtl	4	107.42	97.61	116.27	18.66	7.99	1.82
	difference		-0.95	-2.75	-0.47	2.28		
13	o-fmbr	2	23.26	20.78	25.74	4.96	3.51	1.91
14	o-fmbl	2	24.55	23.92	25.18	1.26	0.89	1.30
	difference		-1.29	-3.14	0.56	3.70		
15	fmbr-ba	2	25.18	24.66	25.69	1.03	0.73	3.25
16	fmbl-ba	2	23.59	23.48	23.70	0.23	0.16	2.93
	difference		1.59	1.18	1.99	0.80		
18	mtr-eamr	4	25.06	21.38	29.59	8.21	3.40	2.25
21	mtl-eaml	4	24.67	19.76	29.67	9.91	4.90	2.86
	difference		0.39	1.62	-0.08	-1.70		
19	eamr-zfr	4	81.54	76.94	87.17	10.23	4.51	3.08
22	eaml-zfl	4	80.84	75.83	87.03	11.20	5.82	3.53
	difference		0.70	1.11	0.14	-0.97		
20	eamr-v	3	118.38	113.29	123.09	9.81	4.91	3.25
23	eaml-v	3	119.78	112.67	125.66	12.99	6.58	3.64
	difference		-1.40	0.62	-2.57	-3.18		
46	op-mtr-eamr	4	87.78	83.99	92.98	9.00	3.76	3.09
47	op-mtl-eaml	4	85.33	82.69	92.33	9.64	4.67	4.50
	difference		2.45	1.30	0.65	-0.64		
48	o-fmbr-ba	2	98.00	96.53	99.47	2.94	2.08	5.17
49	o-fmbl-ba	2	99.23	93.43	105.02	11.59	8.19	4.43
	difference		-1.23	3.10	-5.55	-8.65		

[+] Expected standard deviation (see Section 6.3.2)
* significant asymmetry

Table 6.3 (a) The individual distance and angle measurements used for the creation of the distance and angle experimental reference standard where significant bilateral asymmetry was detected for the mandible.

N	Name	Obs	A90	A13184	A38778	A57590	SD	Exp.SD[+]
1	cdr-gor	4	57.20	59.72	56.40	62.14	2.61	2.07
6	cdl-gol	4	50.93	57.61	56.48	60.92	4.16	2.98
	difference		6.27*	2.11	-0.08	1.22		
29	gor-pg	4	85.83	84.31	80.51	95.25	6.26	1.90
30	gol-pg	4	87.60	87.23	83.99	101.38	7.73	2.33
	difference		-1.77	-2.92	-3.48	-6.13*		
42	cdr-cnr-ctr	4	128.13	115.98	115.55	109.42	7.84	2.84
43	cdl-cnl-ctl	4	118.46	110.87	111.58	107.85	4.48	5.00
	difference		9.67*	5.11	3.97	1.57		
57	CL/ML(l)	4	94.41	81.96	85.92	72.26	9.19	3.07
58	CL/ML(r)	4	92.53	82.34	90.19	92.84	4.90	3.02
	difference		1.88	-0.38	-4.27	-20.58*		

Table 6.3 (b) The individual distance and angle measurements used for the creation of the distance and angle experimental reference standard where significant bilateral asymmetry was detected for the maxilla.

N	Name	Obs	A90	A13184	A38778	A57590	SD	Exp.SD[+]
42	morr-orr-zmr	4	154.68	153.74	153.32	169.44	7.78	4.06
46	morl-orl-zml	4	152.87	158.16	153.40	157.88	2.83	5.77
	difference		1.81	-4.42	-0.08	11.56*		
50	n-na-nabr	4	142.73	136.91	141.14	118.80	11.01	3.15
51	n-na-nabl	4	120.99	131.69	139.11	116.52	10.24	4.78
	difference		21.74*	5.22	2.03	2.28		
52	na-nabr-ans	4	63.39	78.64	80.19	75.42	7.61	4.90
53	na-nabl-ans	4	42.24	87.93	93.51	78.77	6.48	6.52
	difference		21.15*	-9.29*	-13.32*	-3.35		

[+] Expected standard deviation (see Section 6.3.2)

* significant asymmetry

Table 6.3 (c)   The individual distance and angle measurements used for the creation of the distance and angle experimental reference standard where significant bilateral asymmetry was detected for the orbit.

N	Name	Obs	A90	A13184	A38778	A57590	SD	Exp.SD[+]
11	oorr-ofr	2	50.89	999.99	999.99	53.78	2.04	1.63
23	oorl-ofl	2	49.22	999.99	999.99	60.08	7.68	1.94
	difference		1.67	999.99	999.99	-6.30*		
12	orr-ofr	2	52.26	999.99	999.99	49.08	2.25	2.33
24	orl-ofl	2	47.44	999.99	999.99	57.31	6.98	3.14
	difference		4.82	999.99	999.99	-8.23*		
41	sorr-lorr-oorr	4	113.54	98.15	108.66	97.12	8.04	6.62
48	sorl-lorl-oorl	4	102.57	98.03	98.32	99.09	2.09	12.99
	difference		10.97*	0.12	10.34*	-1.97		
43	oorr-orr-morr	4	117.29	125.10	128.54	123.63	4.71	5.78
50	oorl-orl-morl	4	140.19	123.60	124.25	122.80	8.34	8.84
	difference		-22.90*	1.50	4.29	0.83		

Table 6.3 (d)   The individual distance and angle measurements used for the creation of the distance and angle experimental reference standard where significant bilateral asymmetry was detected for the zygoma.

N	Name	Obs	A90	A13184	A38778	A57590	SD	Exp.SD[+]
30	lorr-oorr-eamr	4	80.87	80.38	72.96	60.89	9.32	6.36
31	lorl-oorl-eaml	4	86.45	99.08	68.16	57.08	18.71	11.20
	difference		-5.58	-18.70*	4.80	3.81		
32	lorr-zcr-eamr	4	120.51	133.15	121.68	127.83	5.86	2.54
38	lorl-zcl-eaml	4	126.97	143.08	120.88	127.44	9.47	8.25
	difference		-6.46	-9.93*	0.80	0.39		

[+] Expected standard deviation (see Section 6.3.2)
* significant asymmetry

Table 6.3 (e)   The individual distance and angle measurements used for the creation of the distance and angle experimental reference standard where significant bilateral asymmetry was detected for the cranium.

N	Name	Obs	A90	A13184	A38778	A57590	SD	Exp.SD[+]
4	g-zfr	4	58.43	50.60	49.18	57.20	4.64	3.31
5	g-zfl	4	61.76	55.76	58.50	55.66	2.88	3.36
	difference		-3.33	-5.16*	-9.32*	1.54		

[+] Expected standard deviation (see Section 6.3.2)
* significant asymmetry

Table 6.4 (a)   The coordinates of the least squares skull standard generated using the four female dried skulls.

Landmark No.	Coordinate (mm)			n	Landmark Name
	x	y	z		
1	3.226	9.650	22.037	4	sella
2	5.763	-54.315	23.667	4	nasion
3	3.544	-60.466	39.626	4	glabella
4	0.212	21.117	113.600	3	vertex
5	-4.030	121.812	42.215	4	opisthocranion
6	-0.305	71.623	-11.103	3	opisthion
7	49.503	48.973	-14.941	4	mastoid tip (L)
8	-45.389	43.855	-16.607	4	mastoid tip (R)
9	3.454	36.762	-9.065	4	basion
10	-45.546	29.798	3.897	4	ext auditory meatus (R)
11	49.207	35.572	5.486	4	ext auditory meatus (L)
12	-49.330	17.829	4.365	4	condylion (R)
13	52.411	23.069	4.463	4	condylion (L)
16	-37.047	20.832	-52.843	4	gonion (R)
17	44.842	26.197	-51.265	4	gonion (L)
20	7.420	-42.135	-80.105	4	gnathion
21	5.412	-50.836	-74.897	4	pogonion
22	7.614	-56.985	-56.473	4	infradentale
23	6.049	-63.433	-34.197	4	prosthion
24	6.773	-57.511	-19.944	4	ant nasal spine
25	4.128	-6.523	-15.420	4	post nasal spine
26	-24.413	-33.576	-38.690	4	upper molar (R)
27	33.590	-30.009	-35.254	4	upper molar (L)
28	-22.434	-30.731	-49.701	3	lower molar (R)
29	33.489	-27.148	-48.371	2	lower molar (L)
30	-41.477	-32.036	-15.102	4	zygomaxillare (R)
31	50.104	-29.127	-13.619	4	zygomaxillare (L)
32	-38.008	-12.882	-9.369	4	coronoid tip (R)
33	45.301	-8.008	-9.413	4	coronoid tip (L)
36	-8.899	0.703	-13.730	3	palatine tubercle (R)
37	17.028	1.647	-13.379	3	palatine tubercle (L)
40	-9.266	-5.827	23.686	2	optic foramen (R)
41	14.959	-4.198	28.180	2	optic foramen (L)
42	5.646	-60.573	7.534	4	nasale
43	2.682	0.622	109.385	1	bregma
46	-5.697	-52.064	17.828	4	medial orbitale (R)
47	16.930	-49.599	18.525	4	medial orbitale (L)
48	-24.407	-51.530	30.860	4	superior orbitale (R)
49	34.680	-48.222	33.114	4	superior orbitale (L)
50	-42.580	-38.635	14.041	4	lateral orbitale (R)

Table 6.4 (a) (continued)

Landmark No.	Coordinate (mm)			n	Landmark Name
	x	y	z		
51	53.007	-35.328	18.260	4	lateral orbitale (L)
52	-39.861	-41.499	4.660	4	opposite orbitale (R)
53	49.326	-38.206	7.278	4	opposite orbitale (L)
54	-23.380	-47.110	0.689	4	orbitale (R)
55	35.573	-43.709	3.437	4	orbitale (L)
56	-21.268	-46.426	-9.824	4	infraorbital foramen (R)
57	31.754	-40.427	-8.093	4	infraorbital foramen (L)
58	-51.685	7.181	-1.291	4	articular eminence (R)
59	55.577	13.306	-0.871	4	articular eminence (L)
62	-51.004	-28.366	4.814	4	zygomatic corner (R)
63	59.984	-22.354	7.488	4	zygomatic corner (L)
64	-43.106	-36.593	51.019	4	zygomatic frontal (R)
65	51.356	-30.299	52.060	4	zygomatic frontal (L)
66	-7.392	-54.009	-15.423	4	nasal breadth (R)
67	17.443	-51.526	-12.014	4	nasal breadth (L)
68	-39.048	0.146	-13.239	4	coronoid notch (R)
69	45.219	6.909	-13.953	4	coronoid notch (L)
70	-34.942	-8.594	-38.970	4	ext oblique line (R)
71	42.893	-5.006	-36.884	4	ext oblique line (L)
72	-17.049	13.474	4.891	3	medial foramen ovale (R)
73	23.934	15.055	5.912	3	medial foramen ovale (L)
78	-13.723	53.980	-10.409	2	foramen mag breadth (R)
79	17.361	54.952	-9.157	2	foramen mag breadth (L)
91	15.542	5.719	22.899	3	anterior clinoid (L)
92	-9.805	4.046	21.270	2	anterior clinoid (R)
93	34.686	-8.075	28.460	2	lesser wing of sphenoid (L)
94	-29.918	-9.384	28.267	2	lesser wing of sphenoid (R)
95	32.905	43.845	20.332	2	
96	-32.107	45.008	11.190	2	
97	15.805	24.077	19.193	3	
98	-10.246	22.764	17.927	2	
99	15.697	14.803	20.588	3	
100	-10.031	13.404	19.602	2	
101	33.835	18.027	24.695	2	
102	-30.996	18.087	20.346	2	
103	9.777	1.621	22.909	3	medial anterior clinoid (L)
104	-3.667	0.601	22.993	2	medial anterior clinoid (R)
105	9.094	16.764	23.027	3	posterior clinoid (L)
106	-2.723	16.240	22.919	3	posterior clinoid (R)

Table 6.4 (b)   The standard deviations of the osseous landmarks for the least squares skull standard.

Landmk No.	Standard deviation (mm) x	y	z	Magnt	LE[+]	n	Landmark Name
1	0.679	2.175	2.509	3.389	2.239	4	sella
2	0.350	1.515	1.684	2.292	1.007	4	nasion
3	2.189	3.494	2.568	4.857	2.110	4	glabella
4	0.999	4.389	2.219	5.019	2.758	3	vertex
5	0.869	4.805	3.766	6.167	0.847	4	opisthocranion
6	1.966	1.234	0.573	2.391	0.453	3	opisthion
7	3.542	2.975	2.887	5.453	1.610	4	mastoid tip (L)
8	1.745	2.476	2.361	3.840	1.439	4	mastoid tip (R)
9	0.912	4.406	4.197	6.153	2.663	4	basion
10	2.789	2.390	2.668	4.540	1.724	4	ext auditory meatus (R)
11	1.742	2.186	3.274	4.305	2.369	4	ext auditory meatus (L)
12	2.637	1.788	1.888	3.704	1.719	4	condylion (R)
13	2.744	2.395	3.243	4.877	2.392	4	condylion (L)
16	2.185	2.896	2.558	4.439	1.157	4	gonion (R)
17	3.692	0.940	2.025	4.314	1.784	4	gonion (L)
20	1.364	2.675	2.087	3.657	0.760	4	gnathion
21	2.865	2.262	2.695	4.538	1.504	4	pogonion
22	1.211	0.749	2.958	3.283	0.508	4	infradentale
23	1.159	2.850	2.105	3.728	1.870	4	prosthion
24	2.318	4.048	0.839	4.740	1.094	4	ant nasal spine
25	0.520	2.775	3.603	4.577	2.142	4	post nasal spine
26	1.332	2.457	2.520	3.763	1.003	4	upper molar (R)
27	0.827	2.611	2.913	3.999	0.723	4	upper molar (L)
28	1.110	2.464	1.073	2.908	0.799	3	lower molar (R)
29	0.309	1.370	1.341	1.942	0.868	2	lower molar (L)
30	2.001	2.137	4.020	4.973	0.886	4	zygomaxillare (R)
31	1.441	1.347	4.237	4.673	1.301	4	zygomaxillare (L)
32	1.165	2.495	3.458	4.421	0.893	4	coronoid tip (R)
33	2.348	1.669	3.812	4.778	1.716	4	coronoid tip (L)
36	1.513	1.483	2.817	3.525	2.381	3	palatine tubercle (R)
37	1.155	2.659	4.305	5.190	2.578	3	palatine tubercle (L)
40	0.940	0.201	1.786	2.028	0.766	2	optic foramen (R)
41	1.247	2.329	3.917	4.725	1.023	2	optic foramen (L)
42	0.501	3.250	1.868	3.782	0.913	4	nasale
43	0.000	0.000	0.000	0.000	0.616	1	bregma
46	1.686	1.229	1.084	2.352	1.397	4	medial orbitale (R)
47	0.722	1.341	0.459	1.590	1.390	4	medial orbitale (L)
48	2.958	2.037	0.725	3.664	1.827	4	superior orbitale (R)
49	1.264	2.559	1.081	3.052	3.303	4	superior orbitale (L)
50	1.691	0.876	3.126	3.661	0.805	4	lateral orbitale (R)

Table 6.4 (b) (continued)

Landmk No.	Standard deviation (mm)				LE[+]	n	Landmark Name
	x	y	z	Magnt			
51	1.226	3.470	2.051	4.213	4.235	4	lateral orbitale (L)
52	2.492	2.048	2.480	4.068	1.443	4	opposite orbitale (R)
53	1.768	1.669	1.414	2.813	1.649	4	opposite orbitale (L)
54	1.606	0.819	2.565	3.136	2.197	4	orbitale (R)
55	1.222	0.973	2.354	2.826	2.973	4	orbitale (L)
56	3.225	1.036	0.609	3.441	2.961	4	infraorbital foramen (L)
58	4.289	1.304	0.936	4.579	1.744	4	articular eminence (R)
59	4.715	1.656	3.027	5.843	3.174	4	articular eminence (L)
62	2.068	1.804	1.713	3.235	0.773	4	zygomatic corner (R)
63	2.171	0.747	1.297	2.637	1.179	4	zygomatic corner (L)
64	2.205	3.025	2.282	4.384	2.550	4	zygomatic frontal (R)
65	1.098	2.785	3.405	4.534	2.611	4	zygomatic frontal (L)
66	1.441	1.750	2.985	3.748	1.431	4	nasal breadth (R)
67	0.910	2.113	2.279	3.238	2.614	4	nasal breadth (L)
68	0.969	0.905	3.512	3.754	0.411	4	coronoid notch (R)
69	3.076	0.636	3.557	4.746	1.197	4	coronoid notch (L)
70	1.581	1.412	2.089	2.976	1.121	4	ext oblique line (R)
71	2.234	1.671	1.799	3.320	3.154	4	ext oblique line (L)
72	0.261	1.079	0.732	1.330	2.805	3	medial foramen ovale (R)
73	0.470	1.713	1.362	2.239	2.971	3	medial foramen ovale (L)
78	1.373	3.633	8.262	9.129	1.858	2	foramen mag breadth (R)
79	0.192	3.021	8.205	8.746	1.222	2	foramen mag breadth (L)
91	0.809	2.396	2.438	3.513	1.842	3	anterior clinoid (L)
92	0.176	0.277	1.957	1.984	0.462	2	anterior clinoid (R)
93	3.455	3.505	1.332	5.098	2.331	2	lesser wing of sphenoid (L)
94	0.437	3.713	1.268	3.948	2.385	2	lesser wing of sphenoid (R)
95	4.290	3.584	0.971	5.674	3.544	2	
96	0.842	1.407	0.065	1.641	3.915	2	
97	1.210	1.644	3.927	4.426	1.140	3	
98	0.463	0.657	1.338	1.561	1.483	2	
99	0.946	1.654	2.118	2.849	0.529	3	
100	0.092	0.557	0.274	0.627	0.820	2	
101	3.887	3.599	1.146	5.420	3.009	2	
102	0.181	2.113	0.000	2.121	3.279	2	
103	1.066	2.141	0.716	2.497	2.725	3	medial anterior clinoid (L)
104	0.653	2.653	0.114	2.734	3.370	2	medial anterior clinoid (R)
105	1.270	2.412	1.338	3.036	5.165	3	posterior clinoid (L)
106	1.583	2.017	1.855	3.165	3.500	3	posterior clinoid (R)

[+] landmark relocation error

Table 6.5 (a)   The individual osseous landmarks used to represent the mandible.

Landmark No.	Landmark Abbrev.	Landmark Name
12	cdr	condylion (R)
13	cdl	condylion (L)
16	gor	gonion (R)
17	gol	gonion (L)
20	gn	gnathion
21	pg	pogonion
22	id	infradentale
28	lmr	lower molar (R)
29	lml	lower molar (L)
32	ctr	coronoid tip (R)
33	ctl	coronoid tip (L)
68	cnr	coronoid notch (R)
69	cnl	coronoid notch (L)
70	eolr	ext oblique line (R)
71	eoll	ext oblique line (L)

Table 6.5 (b)   The individual osseous landmarks used to represent the maxilla.

Landmark No.	Landmark Abbrev.	Landmark Name
2	n	nasion
23	pr	prosthion
24	ans	ant nasal spine
25	pns	post nasal spine
26	umr	upper molar (R)
27	uml	upper molar (L)
30	zmr	zygomaxillare (R)
31	zml	zygomaxillare (L)
36	scr	palatine tubercle (R)
37	scl	palatine tubercle (L)
42	na	nasale
46	morr	medial orbitale (R)
47	morl	medial orbitale (L)
54	orr	orbitale (R)
55	orl	orbitale (L)
56	iofr	infraorbital foramen (R)
57	iofl	infraorbital foramen (L)
66	nabr	nasal breadth (R)
67	nabl	nasal breadth (L)

Table 6.5 (c)   The individual osseous landmarks used to represent the orbits.

Landmark No.	Landmark Abbrev.	Landmark Name
2	n	nasion
40	ofr	optic foramen (R)
41	ofl	optic foramen (L)
42	na	nasale
46	morr	medial orbitale (R)
47	morl	medial orbitale (L)
48	sorr	superior orbitale (R)
49	sorl	superior orbitale (L)
50	lorr	lateral orbitale (R)
51	lorl	lateral orbitale (L)
52	oorr	opposite orbitale (R)
53	oorl	opposite orbitale (L)
54	orr	orbitale (R)
55	orl	orbitale (L)
56	iofr	infraorbital foramen (R)
57	iofl	infraorbital foramen (L)
62	zcr	zygomatic corner (R)
63	zcl	zygomatic corner (L)

Table 6.5 (d)   The individual osseous landmarks used to represent the zygomas.

Landmark No.	Landmark Abbrev.	Landmark Name
7	mtl	mastoid tip (L)
8	mtr	mastoid tip (R)
10	eamr	ext auditory meatus (R)
11	eaml	ext auditory meatus (L)
30	zmr	zygomaxillare (R)
31	zml	zygomaxillare (L)
50	lorr	lateral orbitale (R)
51	lorl	lateral orbitale (L)
52	oorr	opposite orbitale (R)
53	oorl	opposite orbitale (L)
54	orr	orbitale (R)
55	orl	orbitale (L)
56	iofr	infraorbital foramen (R)
57	iofl	infraorbital foramen (L)
58	aer	articular eminence (R)
59	ael	articular eminence (L)
62	zcr	zygomatic corner (R)
63	zcl	zygomatic corner (L)

Table 6.5 (e)   The individual osseous landmarks used to represent the cranium.

Landmark No.	Landmark Abbrev.	Landmark Name
1	s	sella
2	n	nasion
3	g	glabella
4	v	vertex
5	op	opisthocranion
6	o	opisthion
7	mtl	mastoid tip (L)
8	mtr	mastoid tip (R)
9	ba	basion
10	eamr	ext auditory meatus (R)
11	eaml	ext auditory meatus (L)
43	br	bregma
64	zfr	zygomatic frontal (R)
65	zfl	zygomatic frontal (L)
78	fmbr	foramen mag breadth (R)
79	fmbl	foramen mag breadth (L)

Table 6.6 (a)   The coordinates and standard deviations of the osseous landmarks for the least squares mandible experimental reference standard generated using the four female dried skulls.

Landmark No.	Coordinate (mm) x	y	z	n	Landmark Name
12	-49.638	17.021	4.323	4	condylion (R)
13	52.102	22.997	2.720	4	condylion (L)
16	-38.348	20.711	-53.069	4	gonion (R)
17	43.466	26.730	-52.796	4	gonion (L)
20	6.093	-41.550	-81.739	4	gnathion
21	4.301	-50.361	-76.618	4	pogonion
22	6.828	-56.722	-58.337	4	infradentale
28	-23.055	-30.979	-51.062	3	lower molar (R)
29	31.721	-26.386	-50.910	2	lower molar (L)
32	-38.322	-13.469	-9.987	4	coronoid tip (R)
33	44.922	-7.984	-11.462	4	coronoid tip (L)
68	-39.529	-0.383	-13.668	4	coronoid notch (R)
69	44.664	7.020	-15.807	4	coronoid notch (L)
70	-35.784	-8.844	-39.572	4	ext oblique line (R)
71	42.035	-4.713	-38.759	4	ext oblique line (L)

Landmark No.	Standard deviation (mm) x	y	z	Magnt	n	Landmark Name
12	3.069	2.094	0.744	3.789	4	condylion (R)
13	3.235	1.891	1.667	4.101	4	condylion (L)
16	2.220	1.892	1.325	3.204	4	gonion (R)
17	2.974	0.673	1.770	3.526	4	gonion (L)
20	1.192	2.576	1.564	3.241	4	gnathion
21	2.858	1.753	1.998	3.903	4	pogonion
22	0.765	0.455	2.150	2.327	4	infradentale
28	1.267	2.081	1.062	2.657	3	lower molar (R)
29	0.040	0.916	0.990	1.349	2	lower molar (L)
32	1.143	2.821	2.643	4.031	4	coronoid tip (R)
33	1.869	2.476	2.394	3.918	4	coronoid tip (L)
68	1.137	0.742	2.423	2.777	4	coronoid notch (R)
69	2.736	0.379	1.948	3.380	4	coronoid notch (L)
70	1.676	1.293	1.669	2.696	4	ext oblique line (R)
71	2.325	1.844	1.270	3.227	4	ext oblique line (L)

Table 6.6 (b)   The coordinates and standard deviations of the osseous landmarks for the least squares maxilla experimental reference standard generated using the four female dried skulls.

Landmark No.	Coordinate (mm)			n	Landmark Name
	x	y	z		
2	4.985	-55.783	23.341	4	nasion
23	6.700	-62.565	-34.823	4	prosthion
24	7.168	-57.282	-20.371	4	ant nasal spine
25	4.916	-6.418	-13.944	4	post nasal spine
26	-23.321	-32.254	-38.925	4	upper molar (R)
27	34.630	-29.513	-33.881	4	upper molar (L)
30	-40.993	-31.295	-15.721	4	zygomaxillare (R)
31	50.530	-29.617	-11.755	4	zygomaxillare (L)
36	-8.649	0.973	-11.543	3	palatine tubercle (R)
37	17.176	1.927	-10.456	3	palatine tubercle (L)
42	5.245	-61.389	6.876	4	nasale
46	-6.278	-53.137	17.305	4	medial orbitale (R)
47	16.344	-50.962	18.669	4	medial orbitale (L)
54	-23.494	-47.339	-0.032	4	orbitale (R)
55	35.438	-44.733	4.290	4	orbitale (L)
56	-21.084	-46.193	-10.452	4	infraorbital foramen (R)
57	32.011	-40.967	-7.159	4	infraorbital foramen (L)
66	-7.146	-53.833	-16.046	4	nasal breadth (R)
67	17.661	-51.706	-11.911	4	nasal breadth (L)

Table 6.6 (b) (continued)

Landmark No.	Standard deviation (mm) x	y	z	Magnt	n	Landmark Name
2	0.436	1.123	1.348	1.808	4	nasion
23	1.159	0.705	2.372	2.733	4	prosthion
24	2.315	2.419	0.738	3.429	4	ant nasal spine
25	0.990	2.491	2.223	3.483	4	post nasal spine
26	1.507	0.899	2.398	2.971	4	upper molar (R)
27	1.486	1.557	1.943	2.900	4	upper molar (L)
30	2.186	0.739	2.674	3.532	4	zygomaxillare (R)
31	2.129	1.704	3.623	4.535	4	zygomaxillare (L)
36	1.191	1.675	0.546	2.126	3	palatine tubercle (R)
37	1.138	2.934	0.539	3.192	3	palatine tubercle (L)
42	0.334	2.782	1.050	2.992	4	nasale
46	1.525	1.088	1.355	2.312	4	medial orbitale (R)
47	0.830	1.122	0.900	1.660	4	medial orbitale (L)
54	1.602	1.023	2.498	3.139	4	orbitale (R)
55	1.319	1.002	2.191	2.747	4	orbitale (L)
56	3.346	1.515	0.444	3.700	4	infraorbital foramen (R)
57	0.646	3.490	0.831	3.645	4	infraorbital foramen (L)
66	1.252	0.668	2.591	2.954	4	nasal breadth (R)
67	0.934	1.422	2.235	2.809	4	nasal breadth (L)

Table 6.6 (c)   The coordinates and standard deviations of the osseous landmarks for the least squares orbit experimental reference standard generated using the four female dried skulls.

Landmark No.	Coordinate (mm)			n	Landmark Name
	x	y	z		
2	5.761	-54.563	23.705	4	nasion
40	-9.184	-6.204	23.571	2	optic foramen (R)
41	14.922	-4.678	28.776	2	optic foramen (L)
42	6.393	-61.165	7.625	4	nasale
46	-5.428	-52.388	17.313	4	medial orbitale (R)
47	17.201	-49.946	19.010	4	medial orbitale (L)
48	-24.695	-51.493	29.439	4	superior orbitale (R)
49	34.280	-48.334	34.418	4	superior orbitale (L)
50	-42.102	-38.941	11.532	4	lateral orbitale (R)
51	53.335	-35.769	20.243	4	lateral orbitale (L)
52	-38.927	-41.972	2.333	4	opposite orbitale (R)
53	50.077	-38.833	9.086	4	opposite orbitale (L)
54	-22.288	-47.693	-0.705	4	orbitale (R)
55	36.556	-44.398	4.708	4	orbitale (L)
56	-19.619	-47.206	-11.204	4	infraorbital foramen (R)
57	33.339	-41.342	-7.096	4	infraorbital foramen (L)
62	-50.043	-28.837	1.749	4	zygomatic corner (R)
63	60.737	-22.954	9.512	4	zygomatic corner (L)

Table 6.6 (c) (continued)

Landmark No.	Standard deviation (mm)				n	Landmark Name
	x	y	z	Magnt		
2	0.226	1.677	1.180	2.063	4	nasion
40	0.699	0.262	2.409	2.521	2	optic foramen (R)
41	1.171	2.079	4.247	4.871	2	optic foramen (L)
42	0.877	3.281	1.759	3.825	4	nasale
46	1.864	1.251	0.889	2.415	4	medial orbitale (R)
47	0.666	0.947	0.518	1.268	4	medial orbitale (L)
48	1.934	1.147	1.186	2.542	4	superior orbitale (R)
49	1.282	1.396	0.462	1.951	4	superior orbitale (L)
50	0.904	0.793	1.420	1.861	4	lateral orbitale (R)
51	0.888	2.163	0.870	2.495	4	lateral orbitale (L)
52	0.829	1.976	0.780	2.281	4	opposite orbitale (R)
53	1.654	2.188	0.536	2.795	4	opposite orbitale (L)
54	0.526	1.034	1.316	1.755	4	orbitale (R)
55	0.724	0.814	1.453	1.816	4	orbitale (L)
56	2.010	0.859	1.659	2.744	4	infraorbital foramen (R)
57	0.793	3.143	1.004	3.393	4	infraorbital foramen (L)
62	1.902	1.371	0.806	2.480	4	zygomatic corner (R)
63	1.718	2.598	0.288	3.128	4	zygomatic corner (L)

Table 6.6 (d)   The coordinates and standard deviations of the osseous landmarks for the least squares zygoma experimental reference standard generated using the four female dried skulls.

Landmark No.	Coordinate (mm) x	y	z	n	Landmark Name
7	49.833	48.785	-16.850	4	mastoid tip (L)
8	-44.999	43.166	-20.074	4	mastoid tip (R)
10	-45.440	29.581	0.788	4	ext auditory meatus (R)
11	49.234	35.823	3.880	4	ext auditory meatus (L)
30	-40.787	-32.699	-16.704	4	zygomaxillare (R)
31	50.752	-29.347	-13.737	4	zygomaxillare (L)
50	-42.405	-38.588	12.599	4	lateral orbitale (R)
51	53.164	-34.813	18.376	4	lateral orbitale (L)
52	-39.495	-41.698	3.354	4	opposite orbitale (R)
53	49.687	-37.987	7.449	4	opposite orbitale (L)
54	-22.920	-47.314	-0.207	4	orbitale (R)
55	36.025	-43.658	3.475	4	orbitale (L)
56	-20.586	-46.870	-10.729	4	infraorbital foramen (R)
57	32.392	-40.652	-8.293	4	infraorbital foramen (L)
58	-51.354	6.787	-3.980	4	articular eminence (R)
59	55.807	13.421	-1.885	4	articular eminence (L)
62	-50.693	-28.584	3.002	4	zygomatic corner (R)
63	60.242	-22.056	7.441	4	zygomatic corner (L)

Table 6.6 (d) (continued)

Landmark No.	Standard deviation (mm)				n	Landmark Name
	x	y	z	Magnt		
7	3.513	3.762	1.603	5.391	4	mastoid tip (L)
8	0.782	2.608	1.751	3.237	4	mastoid tip (R)
10	1.447	1.172	2.010	2.740	4	ext auditory meatus (R)
11	1.426	1.017	2.231	2.837	4	ext auditory meatus (L)
30	1.178	2.259	3.701	4.493	4	zygomaxillare (R)
31	0.811	1.240	4.150	4.406	4	zygomaxillare (L)
50	1.531	0.891	2.274	2.883	4	lateral orbitale (R)
51	0.734	3.828	2.237	4.494	4	lateral orbitale (L)
52	2.228	1.893	1.617	3.341	4	opposite orbitale (R)
53	1.836	1.400	1.278	2.639	4	opposite orbitale (L)
54	1.348	0.690	1.918	2.444	4	orbitale (R)
55	1.052	1.098	2.179	2.657	4	orbitale (L)
56	2.326	0.733	1.029	2.647	4	infraorbital foramen (R)
57	0.879	4.352	0.543	4.473	4	infraorbital foramen (L)
58	2.869	1.187	1.813	3.595	4	articular eminence (R)
59	4.637	0.946	2.376	5.296	4	articular eminence (L)
62	1.188	1.500	0.788	2.069	4	zygomatic corner (R)
63	1.478	1.262	1.327	2.353	4	zygomatic corner (L)

Table 6.6 (e)   The coordinates and standard deviations of the osseous landmarks for the least squares cranium experimental reference standard generated using the four female dried skulls.

Landmark No.	Coordinate (mm) x	y	z	n	Landmark Name
1	2.658	9.953	22.375	4	sella
2	5.127	-54.008	25.236	4	nasion
3	3.054	-59.846	41.277	4	glabella
4	-0.077	23.005	114.065	3	vertex
5	-4.318	122.515	40.473	4	opisthocranion
6	-0.988	71.375	-11.340	3	opisthion
7	48.712	48.439	-15.737	4	mastoid tip (L)
8	-46.225	43.409	-16.565	4	mastoid tip (R)
9	2.687	36.416	-9.312	4	basion
10	-46.231	29.756	4.244	4	ext auditory meatus (R)
11	48.550	35.455	5.016	4	ext auditory meatus (L)
43	2.678	3.133	109.956	1	bregma
64	-43.520	-35.732	52.560	4	zygomatic frontal (R)
65	50.984	-29.534	52.795	4	zygomatic frontal (L)
78	-13.924	54.188	-9.974	2	foramen mag breadth (R)
79	16.928	55.189	-8.806	2	foramen mag breadth (L)

Landmark No.	Standard deviation (mm) x	y	z	Magnt	n	Landmark Name
1	1.003	2.081	2.406	3.336	4	sella
2	0.255	1.838	2.854	3.404	4	nasion
3	1.836	2.536	2.025	3.729	4	glabella
4	1.167	3.581	1.480	4.047	3	vertex
5	0.899	4.336	2.398	5.036	4	opisthocranion
6	2.263	2.103	0.403	3.116	3	opisthion
7	3.312	2.467	3.863	5.655	4	mastoid tip (L)
8	2.004	2.377	3.007	4.326	4	mastoid tip (R)
9	1.163	3.604	4.394	5.801	4	basion
10	1.979	2.856	2.793	4.458	4	ext auditory meatus (R)
11	1.538	2.772	3.261	4.548	4	ext auditory meatus (L)
64	2.187	2.072	0.964	3.163	4	zygomatic frontal (R)
65	1.027	2.414	2.025	3.314	4	zygomatic frontal (L)
78	1.795	2.624	7.634	8.269	2	foramen mag breadth (R)
79	0.166	1.966	7.675	7.924	2	foramen mag breadth (L)

Table 6.7 (a)   Non-scaled least squares comparison of the least squares mandible standard with the least squares skull standard.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
12	0.070	0.019	3.70	1.72	condylion (R)
13	0.098	0.020	4.88	2.39	condylion (L)
16	0.076	0.017	4.44	1.16	gonion (R)
17	0.099	0.023	4.31	1.78	gonion (L)
20	0.150	0.041	3.66	0.76	gnathion
21	0.169	0.037	4.54	1.50	pogonion
22	0.124	0.038	3.28	0.51	infradentale
28	0.454	0.156	2.91	0.80	lower molar (R)
29	1.019	0.525	1.94	0.87	lower molar (L)
32	0.034	0.008	4.42	0.89	coronoid tip (R)
33	0.029	0.006	4.78	1.72	coronoid tip (L)
68	0.059	0.016	3.75	0.41	coronoid notch (R)
69	0.034	0.007	4.75	1.20	coronoid notch (L)
70	0.056	0.019	2.98	1.12	ext oblique line (R)
71	0.124	0.037	3.32	3.15	ext oblique line (L)

Table 6.7 (b)   Non-scaled least squares comparison of the least squares maxilla
standard with the least squares skull standard.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	0.073	0.032	2.29	1.01	nasion
23	0.322	0.086	3.73	1.87	prosthion
24	0.278	0.059	4.74	1.09	ant nasal spine
25	0.238	0.052	4.58	2.14	post nasal spine
26	0.374	0.100	3.76	1.00	upper molar (R)
27	0.327	0.082	4.00	0.72	upper molar (L)
30	0.380	0.076	4.97	0.89	zygomaxillare (R)
31	0.296	0.063	4.67	1.30	zygomaxillare (L)
36	0.773	0.219	3.52	2.38	palatine tubercle (R)
37	1.078	0.208	5.19	2.58	palatine tubercle (L)
42	0.174	0.046	3.78	0.91	nasale
46	0.113	0.048	2.35	1.40	medial orbitale (R)
47	0.029	0.018	1.59	1.39	medial orbitale (L)
54	0.164	0.052	3.14	2.20	orbitale (R)
55	0.126	0.042	2.83	2.97	orbitale (L)
56	0.227	0.066	3.44	2.96	infraorbital foramen (R)
57	0.229	0.051	4.51	2.50	infraorbital foramen (L)
66	0.207	0.055	3.75	1.43	nasal breadth (R)
67	0.195	0.060	3.24	2.61	nasal breadth (L)
81	1.365	0.804	0.00	1.70	incision superius (L)
85	1.639	2.787	0.00	0.59	

Table 6.7 (c)   Non-scaled least squares comparison of the least squares orbit standard with the least squares skull standard.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	0.176	0.077	2.29	1.01	nasion
40	0.832	0.410	2.03	0.77	optic foramen (R)
41	0.449	0.095	4.72	1.02	optic foramen (L)
42	0.128	0.034	3.78	0.91	nasale
46	0.109	0.046	2.35	1.40	medial orbitale (R)
47	0.111	0.070	1.59	1.39	medial orbitale (L)
48	0.357	0.097	3.66	1.83	superior orbitale (R)
49	0.311	0.094	3.05	3.30	superior orbitale (L)
50	0.217	0.059	3.66	0.81	lateral orbitale (R)
51	0.136	0.032	4.21	4.24	lateral orbitale (L)
52	0.177	0.043	4.07	1.44	opposite orbitale (R)
53	0.126	0.045	2.81	1.65	opposite orbitale (L)
54	0.123	0.039	3.14	2.20	orbitale (R)
55	0.140	0.047	2.83	2.97	orbitale (L)
56	0.286	0.083	3.44	2.96	infraorbital foramen (R)
57	0.350	0.078	4.51	2.50	infraorbital foramen (L)
62	0.338	0.105	3.24	0.77	zygomatic corner (R)
63	0.312	0.118	2.64	1.18	zygomatic corner (L)

Table 6.7 (d)   Non-scaled least squares comparison of the least squares zygoma standard with the least squares skull standard.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
7	0.089	0.016	5.45	1.61	mastoid tip (L)
8	0.063	0.016	3.84	1.44	mastoid tip (R)
10	0.033	0.007	4.54	1.72	ext auditory meatus (R)
11	0.051	0.012	4.30	2.37	ext auditory meatus (L)
30	0.026	0.005	4.97	0.89	zygomaxillare (R)
31	0.044	0.009	4.67	1.30	zygomaxillare (L)
50	0.052	0.014	3.66	0.81	lateral orbitale (R)
51	0.050	0.012	4.21	4.24	lateral orbitale (L)
52	0.042	0.010	4.07	1.44	opposite orbitale (R)
53	0.087	0.031	2.81	1.65	opposite orbitale (L)
54	0.030	0.010	3.14	2.20	orbitale (R)
55	0.086	0.029	2.83	2.97	orbitale (L)
56	0.026	0.008	3.44	2.96	infraorbital foramen (R)
57	0.104	0.023	4.51	2.50	infraorbital foramen (L)
58	0.032	0.007	4.58	1.74	articular eminence (R)
59	0.043	0.007	5.84	3.17	articular eminence (L)
62	0.040	0.012	3.24	0.77	zygomatic corner (R)
63	0.035	0.013	2.64	1.18	zygomatic corner (L)

Table 6.7 (e)   Non-scaled least squares comparison of the least squares cranium standard with the least squares skull standard.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	0.172	0.051	3.39	2.24	sella
2	0.111	0.049	2.29	1.01	nasion
3	0.112	0.023	4.86	2.11	glabella
4	0.347	0.069	5.02	2.76	vertex
5	0.293	0.047	6.17	0.85	opisthocranion
6	0.344	0.144	2.39	0.45	opisthion
7	0.400	0.073	5.45	1.61	mastoid tip (L)
8	0.271	0.070	3.84	1.44	mastoid tip (R)
9	0.326	0.053	6.15	2.66	basion
10	0.190	0.042	4.54	1.72	ext auditory meatus (R)
11	0.287	0.067	4.30	2.37	ext auditory meatus (L)
43	0.601	0.976	0.00	0.62	bregma
64	0.102	0.023	4.38	2.55	zygomatic frontal (R)
65	0.208	0.046	4.53	2.61	zygomatic frontal (L)
78	0.868	0.095	9.13	1.86	foramen mag breadth (R)
79	0.882	0.101	8.75	1.22	foramen mag breadth (L)

Table 6.8 (a)　The coordinates of the repeated median skull standard
generated using the four female dried skulls.

Landmark No.	Coordinate (mm)			n	Landmark Name
	x	y	z		
1	3.431	9.535	22.701	4	sella
2	5.784	-55.138	23.979	4	nasion
3	3.505	-61.440	40.077	4	glabella
4	0.388	20.946	115.163	3	vertex
5	-3.568	122.818	43.747	4	opisthocranion
6	0.102	72.434	-10.582	3	opisthion
7	50.379	49.368	-14.398	4	mastoid tip (L)
8	-45.573	44.523	-16.207	4	mastoid tip (R)
9	3.769	37.130	-8.582	4	basion
10	-45.793	30.184	4.430	4	ext auditory meatus (R)
11	50.011	35.689	6.153	4	ext auditory meatus (L)
12	-49.658	18.088	4.820	4	condylion (R)
13	53.209	23.051	5.041	4	condylion (L)
16	-37.182	21.417	-52.974	4	gonion (R)
17	45.625	26.562	-51.275	4	gonion (L)
20	7.587	-42.217	-80.877	4	gnathion
21	5.520	-51.032	-75.656	4	pogonion
22	7.713	-57.363	-57.055	4	infradentale
23	6.092	-64.007	-34.585	4	prosthion
24	6.836	-58.111	-20.149	4	ant nasal spine
25	4.319	-6.575	-15.267	4	post nasal spine
26	-24.603	-33.697	-38.971	4	upper molar (R)
27	34.048	-30.296	-35.433	4	upper molar (L)
28	-22.580	-30.933	-50.123	3	lower molar (R)
29	34.068	-27.602	-48.759	2	lower molar (L)
30	-41.876	-32.223	-15.134	4	zygomaxillare (R)
31	50.719	-29.586	-13.537	4	zygomaxillare (L)
32	-38.298	-12.923	-9.216	4	coronoid tip (R)
33	45.938	-8.274	-9.156	4	coronoid tip (L)
36	-8.896	0.753	-13.503	3	palatine tubercle (R)
37	17.305	1.641	-13.135	3	palatine tubercle (L)
40	-9.274	-6.188	24.119	2	optic foramen (R)
41	15.215	-4.620	28.674	2	optic foramen (L)
42	5.660	-61.367	7.618	4	nasale
43	2.787	1.315	111.056	1	bregma
46	-5.790	-52.794	18.080	4	medial orbitale (R)
47	17.089	-50.373	18.803	4	medial orbitale (L)
48	-24.721	-52.261	31.245	4	superior orbitale (R)
49	35.024	-49.122	33.572	4	superior orbitale (L)

Table 6.8 (a) (continued)

Landmark No.	Coordinate (mm) x	y	z	n	Landmark Name
50	-43.038	-39.075	14.295	4	lateral orbitale (R)
51	53.607	-36.062	18.643	4	lateral orbitale (L)
52	-40.292	-41.928	4.792	4	opposite orbitale (R)
53	49.888	-38.903	7.526	4	opposite orbitale (L)
54	-23.641	-47.633	0.765	4	orbitale (R)
55	35.970	-44.395	3.598	4	orbitale (L)
56	-21.492	-46.868	-9.859	4	infraorbital foramen (R)
57	32.132	-40.988	-8.056	4	infraorbital foramen (L)
58	-52.071	7.371	-0.963	4	articular eminence (R)
59	56.383	13.210	-0.401	4	articular eminence (L)
62	-51.507	-28.612	5.026	4	zygomatic corner (R)
63	60.716	-22.910	7.853	4	zygomatic corner (L)
64	-43.595	-37.209	51.690	4	zygomatic frontal (R)
65	51.919	-31.167	52.848	4	zygomatic frontal (L)
66	-7.484	-54.556	-15.557	4	nasal breadth (R)
67	17.631	-52.146	-12.088	4	nasal breadth (L)
68	-39.304	0.271	-13.064	4	coronoid notch (R)
69	45.907	6.830	-13.665	4	coronoid notch (L)
70	-35.160	-8.412	-39.117	4	ext oblique line (R)
71	43.537	-5.047	-36.921	4	ext oblique line (L)
72	-17.099	13.494	5.439	3	medial foramen ovale (R)
73	24.319	14.975	6.507	3	medial foramen ovale (L)
78	-13.563	54.617	-10.376	2	foramen mag breadth (R)
79	17.855	55.535	-9.088	2	foramen mag breadth (L)
81	10.636	-61.998	-45.883	1	incision superius (L)
85	33.783	-30.126	-36.926	1	disto-molare superius (L)
91	15.807	5.392	23.583	3	anterior clinoid (L)
92	-9.806	3.807	21.753	2	anterior clinoid (R)
93	35.281	-8.579	29.130	2	lesser wing of sphenoid (L)
94	-30.135	-9.622	28.861	2	lesser wing of sphenoid (R)
95	33.711	44.025	21.077	2	
96	-32.098	45.522	11.741	2	
97	16.121	23.990	20.003	3	
98	-10.232	22.738	18.519	2	
99	15.987	14.599	21.329	3	
100	-10.025	13.272	20.140	2	
101	34.536	17.866	25.408	2	
102	-31.099	18.230	20.924	2	
103	9.972	1.277	23.550	3	medial anterior clinoid (L)
104	-3.602	0.301	23.476	2	medial anterior clinoid (R)
105	9.318	16.573	23.812	3	posterior clinoid (L)
106	-2.621	16.085	23.690	3	posterior clinoid (R)

Table 6.8 (b)   The standard deviations of the osseous landmarks for the
                 repeated median skull standard.

Landmk No.	Standard deviation (mm)				LE+	n	Landmark Name
	x	y	z	Magnt			
1	0.588	1.890	2.706	3.353	2.239	4	sella
2	0.215	1.272	1.395	1.900	1.007	4	nasion
3	2.212	3.068	2.376	4.467	2.110	4	glabella
4	1.032	5.649	2.058	6.101	2.758	3	vertex
5	1.007	4.588	4.703	6.647	0.847	4	opisthocranion
6	2.237	1.275	1.499	2.979	0.453	3	opisthion
7	3.913	2.964	2.661	5.584	1.610	4	mastoid tip (L)
8	1.582	2.640	1.978	3.659	1.439	4	mastoid tip (R)
9	0.843	4.388	4.397	6.269	2.663	4	basion
10	2.755	2.624	2.518	4.562	1.724	4	ext auditory meatus (R)
11	1.999	2.357	3.546	4.704	2.369	4	ext auditory meatus (L)
12	2.638	2.032	1.798	3.784	1.719	4	condylion (R)
13	2.876	2.709	3.313	5.156	2.392	4	condylion (L)
16	2.206	2.821	2.576	4.411	1.157	4	gonion (R)
17	3.824	1.101	1.927	4.422	1.784	4	gonion (L)
20	1.313	2.390	2.425	3.649	0.760	4	gnathion
21	2.947	2.187	3.134	4.826	1.504	4	pogonion
22	1.147	1.059	3.426	3.765	0.508	4	infradentale
23	1.210	3.014	2.596	4.158	1.870	4	prosthion
24	2.429	4.097	1.172	4.905	1.094	4	ant nasal spine
25	0.468	2.946	3.638	4.704	2.142	4	post nasal spine
26	1.248	2.673	2.647	3.964	1.003	4	upper molar (R)
27	0.968	2.716	3.068	4.211	0.723	4	upper molar (L)
28	0.998	2.370	1.326	2.894	0.799	3	lower molar (R)
29	0.102	1.035	1.808	2.085	0.868	2	lower molar (L)
30	1.939	2.283	4.258	5.206	0.886	4	zygomaxillare (R)
31	1.537	1.453	4.617	5.079	1.301	4	zygomaxillare (L)
32	1.207	2.419	3.422	4.361	0.893	4	coronoid tip (R)
33	2.511	1.423	3.819	4.787	1.716	4	coronoid tip (L)
36	1.513	1.451	2.967	3.633	2.381	3	palatine tubercle (R)
37	1.176	2.664	4.430	5.301	2.578	3	palatine tubercle (L)
40	0.947	0.663	1.740	2.089	0.766	2	optic foramen (R)
41	1.184	1.747	4.075	4.589	1.023	2	optic foramen (L)
42	0.502	3.523	1.767	3.973	0.913	4	nasale
43	0.000	0.000	0.000	0.000	0.616	1	bregma
46	1.677	1.129	0.766	2.162	1.397	4	medial orbitale (R)
47	0.726	1.548	0.347	1.744	1.390	4	medial orbitale (L)
48	2.970	1.635	0.756	3.473	1.827	4	superior orbitale (R)
49	1.228	2.753	0.890	3.143	3.303	4	superior orbitale (L)

Table 6.8 (b) (continued)

Landmk No.	Standard deviation (mm)				LE[+]	n	Landmark Name
	x	y	z	Magnt			
50	1.743	0.670	3.114	3.631	0.805	4	lateral orbitale (R)
51	1.235	3.660	1.906	4.308	4.235	4	lateral orbitale (L)
52	2.530	2.218	2.423	4.147	1.443	4	opposite orbitale (R)
53	1.922	2.055	1.247	3.077	1.649	4	opposite orbitale (L)
54	1.575	0.642	2.436	2.972	2.197	4	orbitale (R)
55	1.323	1.216	2.243	2.874	2.973	4	orbitale (L)
56	3.225	1.016	0.892	3.497	2.961	4	infraorbital foramen (R)
57	0.832	4.361	0.548	4.473	2.503	4	infraorbital foramen (L)
58	4.251	1.505	0.784	4.577	1.744	4	articular eminence (R)
59	4.744	1.697	3.164	5.949	3.174	4	articular eminence (L)
62	2.016	1.656	1.720	3.125	0.773	4	zygomatic corner (R)
63	2.264	0.392	1.245	2.614	1.179	4	zygomatic corner (L)
64	2.081	2.732	2.427	4.205	2.550	4	zygomatic frontal (R)
65	1.228	3.043	3.532	4.821	2.611	4	zygomatic frontal (L)
66	1.563	1.881	3.026	3.891	1.431	4	nasal breadth (R)
67	0.869	2.264	2.278	3.327	2.614	4	nasal breadth (L)
68	0.877	0.857	3.537	3.744	0.411	4	coronoid notch (R)
69	3.298	0.818	3.538	4.906	1.197	4	coronoid notch (L)
70	1.516	1.437	1.969	2.870	1.121	4	ext oblique line (R)
71	2.344	1.455	1.804	3.296	3.154	4	ext oblique line (L)
72	0.245	0.958	0.710	1.217	2.805	3	medial foramen ovale (R)
73	0.494	1.464	1.189	1.950	2.971	3	medial foramen ovale (L)
78	0.955	3.543	8.628	9.376	1.858	2	foramen mag breadth (R)
79	0.710	3.056	8.499	9.060	1.222	2	foramen mag breadth (L)
91	0.755	2.048	2.776	3.531	1.842	3	anterior clinoid (L)
92	0.212	0.135	1.847	1.864	0.462	2	anterior clinoid (R)
93	3.564	2.922	1.151	4.750	2.331	2	lesser wing of sphenoid (L)
94	0.376	3.040	1.201	3.290	2.385	2	lesser wing of sphenoid (R)
95	4.490	3.108	1.455	5.651	3.544	2	
96	1.027	0.929	0.545	1.489	3.915	2	
97	1.142	1.593	4.017	4.470	1.140	3	
98	0.371	0.300	1.613	1.682	1.483	2	
99	0.861	1.415	2.410	2.924	0.529	3	
100	0.026	0.173	0.080	0.192	0.820	2	
101	4.042	3.066	1.299	5.237	3.009	2	
102	0.305	1.525	0.268	1.578	3.279	2	
103	1.031	1.809	0.785	2.225	2.725	3	medial anterior clinoid (L)
104	0.703	2.210	0.019	2.319	3.370	2	medial anterior clinoid (R)
105	1.193	2.141	1.709	2.988	5.165	3	posterior clinoid (L)
106	1.553	1.775	1.734	2.927	3.500	3	posterior clinoid (R)

[+]landmark relocation error

Table 6.9 (a)   The coordinates and standard deviations of the osseous landmarks for the repeated median mandible experimental reference standard generated using the four female dried skulls.

Landmark No.	Coordinate (mm) x	y	z	n	Landmark Name
12	-50.000	16.768	3.797	4	condylion (R)
13	50.773	23.240	3.153	4	condylion (L)
16	-38.275	20.368	-52.969	4	gonion (R)
17	42.725	26.738	-51.925	4	gonion (L)
20	6.313	-41.156	-80.821	4	gnathion
21	4.538	-49.859	-75.741	4	pogonion
22	6.905	-56.119	-57.593	4	infradentale
28	-22.890	-30.588	-50.849	3	lower molar (R)
29	31.433	-25.928	-50.195	2	lower molar (L)
32	-38.469	-13.418	-10.198	4	coronoid tip (R)
33	43.974	-7.523	-10.906	4	coronoid tip (L)
68	-39.703	-0.467	-13.892	4	coronoid notch (R)
69	43.669	7.338	-15.247	4	coronoid notch (L)
70	-35.734	-8.878	-39.513	4	ext oblique line (R)
71	41.329	-4.375	-37.975	4	ext oblique line (L)

Landmark No.	Standard deviation (mm) x	y	z	Magnt	n	Landmark Name
12	3.338	1.909	1.126	4.006	4	condylion (R)
13	2.838	2.049	1.164	3.689	4	condylion (L)
16	1.823	2.278	2.017	3.547	4	gonion (R)
17	3.459	0.505	2.186	4.123	4	gonion (L)
20	0.860	2.637	1.592	3.198	4	gnathion
21	2.926	1.779	1.912	3.922	4	pogonion
22	0.668	0.456	1.868	2.035	4	infradentale
28	1.168	2.016	0.301	2.350	3	lower molar (R)
29	0.151	1.475	0.557	1.584	2	lower molar (L)
32	1.066	2.820	3.499	4.619	4	coronoid tip (R)
33	1.749	2.207	2.361	3.675	4	coronoid tip (L)
68	1.382	0.824	3.374	3.738	4	coronoid notch (R)
69	2.420	0.411	2.047	3.196	4	coronoid notch (L)
70	1.759	1.114	1.162	2.385	4	ext oblique line (R)
71	2.377	2.011	0.950	3.256	4	ext oblique line (L)

Table 6.9 (b)   The coordinates and standard deviations of the osseous
landmarks for the repeated median maxilla experimental
reference standard generated using the four female dried skulls.

Landmark No.	Coordinate (mm)			n	Landmark Name
	x	y	z		
2	5.245	-55.622	24.031	4	nasion
23	6.834	-63.677	-34.464	4	prosthion
24	7.389	-58.036	-20.046	4	ant nasal spine
25	5.296	-6.629	-14.573	4	post nasal spine
26	-23.352	-33.042	-39.166	4	upper molar (R)
27	35.148	-30.450	-34.276	4	upper molar (L)
30	-41.115	-31.506	-15.731	4	zygomaxillare (R)
31	51.262	-30.140	-11.990	4	zygomaxillare (L)
36	-8.439	0.675	-12.168	3	palatine tubercle (R)
37	17.465	1.645	-11.005	3	palatine tubercle (L)
42	5.463	-61.594	7.547	4	nasale
46	-6.111	-53.040	17.906	4	medial orbitale (R)
47	16.723	-50.885	19.209	4	medial orbitale (L)
54	-23.514	-47.448	0.351	4	orbitale (R)
55	35.974	-45.011	4.527	4	orbitale (L)
56	-21.108	-46.520	-10.162	4	infraorbital foramen (R)
57	32.527	-41.392	-7.104	4	infraorbital foramen (L)
66	-7.039	-54.391	-15.712	4	nasal breadth (R)
67	17.968	-52.294	-11.616	4	nasal breadth (L)

Table 6.9 (b) (continued)

Landmark No.	Standard deviation				n	Landmark Name
	x	y	z	Magnt		
2	0.290	1.160	0.873	1.480	4	nasion
23	1.229	1.147	2.056	2.656	4	prosthion
24	2.214	2.161	0.426	3.122	4	ant nasal spine
25	1.257	2.370	2.538	3.693	4	post nasal spine
26	2.075	0.500	2.145	3.026	4	upper molar (R)
27	1.676	1.505	1.721	2.835	4	upper molar (L)
30	2.760	0.981	3.148	4.300	4	zygomaxillare (R)
31	2.711	1.885	3.353	4.706	4	zygomaxillare (L)
36	0.939	2.003	0.026	2.212	3	palatine tubercle (R)
37	1.266	3.153	0.973	3.534	3	palatine tubercle (L)
42	0.328	2.641	0.891	2.807	4	nasale
46	1.547	1.002	1.184	2.190	4	medial orbitale (R)
47	0.582	1.087	0.979	1.575	4	medial orbitale (L)
54	1.880	1.038	2.447	3.256	4	orbitale (R)
55	1.635	1.224	2.461	3.198	4	orbitale (L)
56	3.727	1.391	0.290	3.989	4	infraorbital foramen (R)
57	0.569	3.409	1.111	3.630	4	infraorbital foramen (L)
66	0.965	0.626	2.783	3.012	4	nasal breadth (R)
67	0.967	1.646	2.267	2.964	4	nasal breadth (L)

Table 6.9 (c)   The coordinates and standard deviations of the osseous
landmarks for the repeated median orbit experimental reference
standard generated using the four female dried skulls.

Landmark No.	Coordinate (mm) x	y	z	n	Landmark Name
2	5.771	-54.249	23.470	4	nasion
40	-8.949	-6.038	24.487	2	optic foramen (R)
41	15.070	-4.681	29.490	2	optic foramen (L)
42	6.155	-60.366	7.243	4	nasale
46	-5.456	-51.830	17.304	4	medial orbitale (R)
47	17.141	-49.594	18.768	4	medial orbitale (L)
48	-24.522	-51.152	29.677	4	superior orbitale (R)
49	34.378	-48.548	33.947	4	superior orbitale (L)
50	-42.006	-38.021	12.413	4	lateral orbitale (R)
51	53.276	-35.745	19.910	4	lateral orbitale (L)
52	-38.988	-40.795	3.109	4	opposite orbitale (R)
53	49.871	-38.451	8.751	4	opposite orbitale (L)
54	-22.471	-46.527	-0.305	4	orbitale (R)
55	36.282	-43.771	4.409	4	orbitale (L)
56	-19.956	-45.732	-10.781	4	infraorbital foramen (R)
57	32.963	-40.367	-7.213	4	infraorbital foramen (L)
62	-49.989	-27.601	3.046	4	zygomatic corner (R)
63	60.629	-22.715	9.503	4	zygomatic corner (L)

Table 6.9 (c) (continued)

Landmark No.	Standard deviation				n	Landmark Name
	x	y	z	Magnt		
2	0.227	1.335	1.418	1.961	4	nasion
40	0.563	0.643	1.275	1.535	2	optic foramen (R)
41	0.886	1.444	5.089	5.364	2	optic foramen (L)
42	0.735	3.317	2.092	3.990	4	nasale
46	1.691	1.100	0.511	2.081	4	medial orbitale (R)
47	0.694	1.110	0.425	1.376	4	medial orbitale (L)
48	2.128	0.894	0.584	2.381	4	superior orbitale (R)
49	1.173	1.697	0.182	2.071	4	superior orbitale (L)
50	1.033	0.657	2.177	2.497	4	lateral orbitale (R)
51	1.086	2.617	0.892	2.970	4	lateral orbitale (L)
52	1.067	2.026	1.199	2.584	4	opposite orbitale (R)
53	1.535	2.376	0.353	2.851	4	opposite orbitale (L)
54	0.480	0.799	1.636	1.882	4	orbitale (R)
55	0.692	1.041	1.384	1.865	4	orbitale (L)
56	2.235	0.701	1.760	2.930	4	infraorbital foramen (R)
57	0.700	3.168	1.126	3.434	4	infraorbital foramen (L)
62	1.766	1.088	0.918	2.268	4	zygomatic corner (R)
63	1.977	2.472	0.159	3.170	4	zygomatic corner (L)

Table 6.9 (d)   The coordinates and standard deviations of the osseous landmarks for the repeated median zygoma experimental reference standard generated using the four female dried skulls.

Landmark No.	Coordinate (mm)			n	Landmark Name
	x	y	z		
7	50.276	49.302	-16.680	4	mastoid tip (L)
8	-45.357	43.594	-19.725	4	mastoid tip (R)
10	-45.747	29.953	1.353	4	ext auditory meatus (R)
11	49.707	36.287	4.262	4	ext auditory meatus (L)
30	-41.077	-32.888	-16.071	4	zygomaxillare (R)
31	51.222	-29.458	-13.278	4	zygomaxillare (L)
50	-42.645	-38.748	13.514	4	lateral orbitale (R)
51	53.727	-34.878	19.116	4	lateral orbitale (L)
52	-39.728	-41.911	4.184	4	opposite orbitale (R)
53	50.195	-38.112	8.104	4	opposite orbitale (L)
54	-23.019	-47.581	0.593	4	orbitale (R)
55	36.416	-43.842	4.149	4	orbitale (L)
56	-20.687	-47.155	-10.033	4	infraorbital foramen (R)
57	32.729	-40.862	-7.708	4	infraorbital foramen (L)
58	-51.717	6.952	-3.362	4	articular eminence (R)
59	56.313	13.688	-1.488	4	articular eminence (L)
62	-51.018	-28.685	3.821	4	zygomatic corner (R)
63	60.839	-22.037	8.033	4	zygomatic corner (L)

Table 6.9 (d) (continued)

Landmark No.	Standard deviation				n	Landmark Name
	x	y	z	Magnt		
7	3.995	3.727	1.978	5.811	4	mastoid tip (L)
8	0.767	2.679	1.646	3.237	4	mastoid tip (R)
10	1.504	1.326	1.957	2.802	4	ext auditory meatus (R)
11	1.702	1.076	2.764	3.420	4	ext auditory meatus (L)
30	1.113	2.244	4.247	4.931	4	zygomaxillare (R)
31	0.919	1.142	4.814	5.032	4	zygomaxillare (L)
50	1.256	1.024	2.222	2.750	4	lateral orbitale (R)
51	0.575	4.192	1.691	4.556	4	lateral orbitale (L)
52	1.846	2.151	1.536	3.224	4	opposite orbitale (R)
53	2.037	1.901	0.654	2.862	4	opposite orbitale (L)
54	0.909	0.824	1.719	2.111	4	orbitale (R)
55	1.120	1.549	1.852	2.662	4	orbitale (L)
56	2.185	0.434	1.477	2.673	4	infraorbital foramen (R)
57	0.764	4.568	0.800	4.700	4	infraorbital foramen (L)
58	3.089	1.248	1.509	3.657	4	articular eminence (R)
59	4.447	0.836	2.814	5.329	4	articular eminence (L)
62	0.947	1.299	0.588	1.712	4	zygomatic corner (R)
63	1.469	0.921	0.862	1.936	4	zygomatic corner (L)

Table 6.9 (e)   The coordinates and standard deviations of the osseous landmarks for the repeated median cranium experimental reference standard generated using the four female dried skulls.

Landmark No.	Coordinate (mm)			n	Landmark Name
	x	y	z		
1	2.835	9.879	22.176	4	sella
2	5.468	-54.574	26.182	4	nasion
3	3.193	-60.163	42.439	4	glabella
4	-0.847	24.440	114.091	3	vertex
5	-4.761	123.701	38.418	4	opisthocranion
6	-0.672	70.824	-12.582	3	opisthion
7	49.736	48.196	-16.288	4	mastoid tip (L)
8	-45.952	42.814	-18.406	4	mastoid tip (R)
9	3.277	36.071	-10.252	4	basion
10	-46.214	29.378	2.844	4	ext auditory meatus (R)
11	49.280	35.414	4.851	4	ext auditory meatus (L)
64	-43.998	-35.783	52.716	4	zygomatic frontal (R)
65	51.263	-29.267	54.161	4	zygomatic frontal (L)
78	-13.746	53.209	-10.855	2	foramen mag breadth (R)
79	17.062	54.253	-9.636	2	foramen mag breadth (L)

Landmark No.	Standard deviation				n	Landmark Name
	x	y	z	Magnt		
1	0.838	2.070	2.026	3.015	4	sella
2	0.094	2.508	2.059	3.246	4	nasion
3	1.863	2.084	2.181	3.546	4	glabella
4	1.873	3.829	0.293	4.272	3	vertex
5	0.436	5.792	2.450	6.303	4	opisthocranion
6	2.200	0.988	0.394	2.444	3	opisthion
7	3.751	2.913	4.054	6.244	4	mastoid tip (L)
8	1.333	2.503	3.944	4.858	4	mastoid tip (R)
9	0.627	4.065	5.182	6.616	4	basion
10	1.520	2.728	2.645	4.092	4	ext auditory meatus (R)
11	1.311	2.430	3.470	4.434	4	ext auditory meatus (L)
64	2.267	1.629	1.930	3.394	4	zygomatic frontal (R)
65	1.000	2.149	2.602	3.519	4	zygomatic frontal (L)
78	1.074	3.793	7.473	8.449	2	foramen mag breadth (R)
79	0.121	3.154	7.335	7.985	2	foramen mag breadth (L)

Table 6.10 (a)   Non-scaled repeated median comparison of the repeated median mandible standard relative to the repeated median skull standard.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
12	1.403	0.371	3.78	1.72	condylion (R)
13	1.271	0.247	5.16	2.39	condylion (L)
16	1.178	0.267	4.41	1.16	gonion (R)
17	1.147	0.259	4.42	1.78	gonion (L)
20	1.288	0.353	3.65	0.76	gnathion
21	1.287	0.267	4.83	1.50	pogonion
22	1.102	0.293	3.76	0.51	infradentale
28	1.031	0.356	2.89	0.80	lower molar (R)
29	1.760	0.844	2.09	0.87	lower molar (L)
32	1.035	0.237	4.36	0.89	coronoid tip (R)
33	0.935	0.195	4.79	1.72	coronoid tip (L)
68	1.010	0.270	3.74	0.41	coronoid notch (R)
69	0.901	0.184	4.91	1.20	coronoid notch (L)
70	0.864	0.301	2.87	1.12	ext oblique line (R)
71	0.759	0.230	3.30	3.15	ext oblique line (L)

Table 6.10 (b) Non-scaled repeated median comparison of the repeated median maxilla standard relative to the repeated median skull standard.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	0.104	0.055	1.90	1.01	nasion
23	0.086	0.021	4.16	1.87	prosthion
24	0.091	0.019	4.91	1.09	ant nasal spine
25	0.134	0.029	4.70	2.14	post nasal spine
26	0.079	0.020	3.96	1.00	upper molar (R)
27	0.110	0.026	4.21	0.72	upper molar (L)
30	0.149	0.029	5.21	0.89	zygomaxillare (R)
31	0.100	0.020	5.08	1.30	zygomaxillare (L)
36	0.960	0.264	3.63	2.38	palatine tubercle (R)
37	1.269	0.239	5.30	2.58	palatine tubercle (L)
42	0.146	0.037	3.97	0.91	nasale
46	0.102	0.047	2.16	1.40	medial orbitale (R)
47	0.097	0.056	1.74	1.39	medial orbitale (L)
54	0.025	0.008	2.97	2.20	orbitale (R)
55	0.097	0.033	2.87	2.97	orbitale (L)
56	0.084	0.024	3.50	2.96	infraorbital foramen (R)
57	0.009	0.002	4.47	2.50	infraorbital foramen (L)
66	0.043	0.011	3.89	1.43	nasal breadth (R)
67	0.024	0.007	3.33	2.61	nasal breadth (L)
81	1.086	0.640	0.00	1.70	incision superius (L)
85	1.540	2.619	0.00	0.59	disto-molare superius (L)

Table 6.10 (c) Non-scaled repeated median comparison of the repeated median orbit standard relative to the repeated median skull standard.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	0.261	0.137	1.90	1.01	nasion
40	1.151	0.551	2.09	0.77	optic foramen (R)
41	0.953	0.208	4.59	1.02	optic foramen (L)
42	0.197	0.050	3.97	0.91	nasale
46	0.210	0.097	2.16	1.40	medial orbitale (R)
47	0.213	0.122	1.74	1.39	medial orbitale (L)
48	0.536	0.154	3.47	1.83	superior orbitale (R)
49	0.470	0.142	3.14	3.30	superior orbitale (L)
50	0.596	0.164	3.63	0.81	lateral orbitale (R)
51	0.615	0.143	4.31	4.24	lateral orbitale (L)
52	0.573	0.138	4.15	1.44	opposite orbitale (R)
53	0.633	0.206	3.08	1.65	opposite orbitale (L)
54	0.386	0.130	2.97	2.20	orbitale (R)
55	0.405	0.136	2.87	2.97	orbitale (L)
56	0.426	0.122	3.50	2.96	infraorbital foramen (R)
57	0.356	0.080	4.47	2.50	infraorbital foramen (L)
62	0.728	0.233	3.12	0.77	zygomatic corner (R)
63	0.826	0.316	2.61	1.18	zygomatic corner (L)

Table 6.10 (d) Non-scaled repeated median comparison of the repeated median zygoma standard relative to the repeated median skull standard.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
7	0.194	0.035	5.58	1.61	mastoid tip (L)
8	0.157	0.043	3.66	1.44	mastoid tip (R)
10	0.159	0.035	4.56	1.72	ext auditory meatus (R)
11	0.202	0.043	4.70	2.37	ext auditory meatus (L)
30	0.109	0.021	5.21	0.89	zygomaxillare (R)
31	0.141	0.028	5.08	1.30	zygomaxillare (L)
50	0.094	0.026	3.63	0.81	lateral orbitale (R)
51	0.110	0.026	4.31	4.24	lateral orbitale (L)
52	0.093	0.022	4.15	1.44	opposite orbitale (R)
53	0.094	0.031	3.08	1.65	opposite orbitale (L)
54	0.078	0.026	2.97	2.20	orbitale (R)
55	0.055	0.019	2.87	2.97	orbitale (L)
56	0.100	0.029	3.50	2.96	infraorbital foramen (R)
57	0.070	0.016	4.47	2.50	infraorbital foramen (L)
58	0.188	0.041	4.58	1.74	articular eminence (R)
59	0.214	0.036	5.95	3.17	articular eminence (L)
62	0.118	0.038	3.12	0.77	zygomatic corner (R)
63	0.155	0.059	2.61	1.18	zygomatic corner (L)

Table 6.10 (e) Non-scaled repeated median comparison of the repeated median cranium standard relative to the repeated median skull standard.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	0.157	0.047	3.35	2.24	sella
2	0.261	0.137	1.90	1.01	nasion
3	0.311	0.070	4.47	2.11	glabella
4	0.509	0.084	6.10	2.76	vertex
5	0.080	0.012	6.65	0.85	opisthocranion
6	1.171	0.393	2.98	0.45	opisthion
7	0.083	0.015	5.58	1.61	mastoid tip (L)
8	0.150	0.041	3.66	1.44	mastoid tip (R)
9	0.090	0.014	6.27	2.66	basion
10	0.156	0.034	4.56	1.72	ext auditory meatus (R)
11	0.130	0.028	4.70	2.37	ext auditory meatus (L)
43	1.910	3.100	0.00	0.62	bregma
64	0.280	0.067	4.21	2.55	zygomatic frontal (R)
65	0.232	0.048	4.82	2.61	zygomatic frontal (L)
78	2.017	0.215	9.38	1.86	foramen mag breadth (R)
79	1.793	0.198	9.06	1.22	foramen mag breadth (L)

Table 6.11 (a)   Comparison of the least squares and repeated median skull standards following repeated median alignment without scaling.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	0.281	0.084	3.35	2.24	sella
2	0.554	0.291	1.90	1.01	nasion
3	0.699	0.156	4.47	2.11	glabella
4	1.235	0.203	6.10	2.76	vertex
5	1.473	0.222	6.65	0.85	opisthocranion
6	0.957	0.321	2.98	0.45	opisthion
7	0.825	0.148	5.58	1.61	mastoid tip (L)
8	0.831	0.227	3.66	1.44	mastoid tip (R)
9	0.508	0.081	6.27	2.66	basion
10	0.692	0.152	4.56	1.72	ext auditory meatus (R)
11	0.679	0.144	4.70	2.37	ext auditory meatus (L)
12	0.655	0.173	3.78	1.72	condylion (R)
13	0.622	0.121	5.16	2.39	condylion (L)
14	0.699	0.243	2.88	0.00	articulare (R)
15	0.646	0.392	1.65	0.00	articulare (L)
16	0.831	0.188	4.41	1.16	gonion (R)
17	0.836	0.189	4.42	1.78	gonion (L)
20	0.999	0.274	3.65	0.76	gnathion
21	0.976	0.202	4.83	1.50	pogonion
22	0.836	0.222	3.76	0.51	infradentale
23	0.726	0.175	4.16	1.87	prosthion
24	0.598	0.122	4.91	1.09	ant nasal spine
25	0.212	0.045	4.70	2.14	post nasal spine
26	0.621	0.157	3.96	1.00	upper molar (R)
27	0.578	0.137	4.21	0.72	upper molar (L)
28	0.797	0.276	2.89	0.80	lower molar (R)
29	0.907	0.435	2.09	0.87	lower molar (L)
30	0.607	0.117	5.21	0.89	zygomaxillare (R)
31	0.567	0.112	5.08	1.30	zygomaxillare (L)
32	0.486	0.111	4.36	0.89	coronoid tip (R)
33	0.467	0.098	4.79	1.72	coronoid tip (L)
36	0.293	0.081	3.63	2.38	palatine tubercle (R)
37	0.228	0.043	5.30	2.58	palatine tubercle (L)
40	0.211	0.101	2.09	0.77	optic foramen (R)
41	0.148	0.032	4.59	1.02	optic foramen (L)
42	0.571	0.144	3.97	0.91	nasale
43	1.972	3.202	0.00	0.62	bregma
46	0.523	0.242	2.16	1.40	medial orbitale (R)
47	0.493	0.283	1.74	1.39	medial orbitale (L)
48	0.650	0.187	3.47	1.83	superior orbitale (R)

Table 6.11 (a) (continued)

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
49	0.624	0.189	3.14	3.30	superior orbitale (L)
50	0.636	0.175	3.63	0.81	lateral orbitale (R)
51	0.619	0.144	4.31	4.24	lateral orbitale (L)
52	0.621	0.150	4.15	1.44	opposite orbitale (R)
53	0.589	0.191	3.08	1.65	opposite orbitale (L)
54	0.536	0.180	2.97	2.20	orbitale (R)
55	0.513	0.173	2.87	2.97	orbitale (L)
56	0.519	0.148	3.50	2.96	infraorbital foramen (R)
57	0.477	0.107	4.47	2.50	infraorbital foramen (L)
58	0.646	0.141	4.58	1.74	articular eminence (R)
59	0.609	0.102	5.95	3.17	articular eminence (L)
62	0.653	0.209	3.12	0.77	zygomatic corner (R)
63	0.626	0.240	2.61	1.18	zygomatic corner (L)
64	0.805	0.192	4.21	2.55	zygomatic frontal (R)
65	0.763	0.158	4.82	2.61	zygomatic frontal (L)
66	0.559	0.144	3.89	1.43	nasal breadth (R)
67	0.525	0.158	3.33	2.61	nasal breadth (L)
68	0.518	0.138	3.74	0.41	coronoid notch (R)
69	0.508	0.103	4.91	1.20	coronoid notch (L)
70	0.633	0.221	2.87	1.12	ext oblique line (R)
71	0.612	0.186	3.30	3.15	ext oblique line (L)
72	0.346	0.123	1.22	2.81	med foramen ovale (R)
73	0.254	0.085	1.95	2.97	med foramen ovale (L)
78	0.993	0.106	9.38	1.86	foramen mag breadth (R)
79	1.008	0.111	9.06	1.22	foramen mag breadth (L)
81	0.588	0.347	0.00	1.70	incision superius (L)
85	0.519	0.883	0.00	0.59	disto-molare superius (L)
91	0.249	0.071	3.53	1.84	anterior clinoid (L)
92	0.215	0.115	1.86	0.46	anterior clinoid (R)
93	0.531	0.112	4.75	2.33	less wing of sphenoid (L)
94	0.462	0.140	3.29	2.38	less wing of sphenoid (R)
95	0.746	0.132	5.65	3.54	
96	0.727	0.186	1.49	3.91	
97	0.356	0.080	4.47	1.14	
98	0.334	0.198	1.68	1.48	
99	0.282	0.097	2.92	0.53	
100	0.263	0.321	0.19	0.82	
101	0.556	0.106	5.24	3.01	
102	0.489	0.149	1.58	3.28	
103	0.228	0.083	2.23	2.72	medial ant clinoid (L)
104	0.151	0.045	2.32	3.37	medial ant clinoid (R)
105	0.314	0.061	2.99	5.16	posterior clinoid (L)
106	0.340	0.097	2.93	3.50	posterior clinoid (R)

Table 6.11 (b) Comparison of the least squares and repeated median mandible standards following repeated median alignment without scaling.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
12	0.702	0.175	4.01	1.72	condylion (R)
13	0.614	0.167	3.69	2.39	condylion (L)
16	0.545	0.154	3.55	1.16	gonion (R)
17	0.504	0.122	4.12	1.78	gonion (L)
20	0.501	0.157	3.20	0.76	gnathion
21	0.541	0.138	3.92	1.50	pogonion
22	0.488	0.240	2.04	0.51	infradentale
28	0.481	0.205	2.35	0.80	lower molar (R)
29	0.204	0.129	1.58	0.87	lower molar (L)
32	0.517	0.112	4.62	0.89	coronoid tip (R)
33	0.404	0.110	3.67	1.72	coronoid tip (L)
68	0.519	0.139	3.74	0.41	coronoid notch (R)
69	0.409	0.128	3.20	1.20	coronoid notch (L)
70	0.401	0.168	2.38	1.12	ext oblique line (R)
71	0.325	0.100	3.26	3.15	ext oblique line (L)

Table 6.11 (c) Comparison of the least squares and repeated median maxilla standards following repeated median alignment without scaling.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	0.307	0.208	1.48	1.01	nasion
23	0.267	0.101	2.66	1.87	prosthion
24	0.168	0.054	3.12	1.09	ant nasal spine
25	0.297	0.081	3.69	2.14	post nasal spine
26	0.370	0.122	3.03	1.00	upper molar (R)
27	0.351	0.124	2.83	0.72	upper molar (L)
30	0.434	0.101	4.30	0.89	zygomaxillare (R)
31	0.446	0.095	4.71	1.30	zygomaxillare (L)
36	0.246	0.104	2.21	2.38	palatine tubercle (R)
37	0.329	0.093	3.53	2.58	palatine tubercle (L)
42	0.204	0.073	2.81	0.91	nasale
46	0.267	0.122	2.19	1.40	medial orbitale (R)
47	0.282	0.179	1.57	1.39	medial orbitale (L)
54	0.293	0.090	3.26	2.20	orbitale (R)
55	0.286	0.090	3.20	2.97	orbitale (L)
56	0.265	0.067	3.99	2.96	infraorbital foramen (R)
57	0.253	0.070	3.63	2.50	infraorbital foramen (L)
66	0.127	0.042	3.01	1.43	nasal breadth (R)
67	0.125	0.042	2.96	2.61	nasal breadth (L)
81	0.969	0.571	0.00	1.70	incision superius (L)
85	0.995	1.692	0.00	0.59	disto-molare superius (L)

Table 6.11 (d) Comparison of the least squares and repeated median orbit standards following repeated median alignment without scaling.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	0.049	0.025	1.96	1.01	nasion
40	0.509	0.331	1.53	0.77	optic foramen (R)
41	0.466	0.087	5.36	1.02	optic foramen (L)
42	0.065	0.016	3.99	0.91	nasale
46	0.056	0.027	2.08	1.40	medial orbitale (R)
47	0.032	0.023	1.38	1.39	medial orbitale (L)
48	0.097	0.041	2.38	1.83	superior orbitale (R)
49	0.095	0.029	2.07	3.30	superior orbitale (L)
50	0.150	0.060	2.50	0.81	lateral orbitale (R)
51	0.140	0.033	2.97	4.24	lateral orbitale (L)
52	0.135	0.052	2.58	1.44	opposite orbitale (R)
53	0.114	0.040	2.85	1.65	opposite orbitale (L)
54	0.096	0.044	1.88	2.20	orbitale (R)
55	0.086	0.029	1.86	2.97	orbitale (L)
56	0.101	0.034	2.93	2.96	infraorbital foramen (R)
57	0.081	0.023	3.43	2.50	infraorbital foramen (L)
62	0.168	0.074	2.27	0.77	zygomatic corner (R)
63	0.147	0.047	3.17	1.18	zygomatic corner (L)

Table 6.11 (e)   Comparison of the least squares and repeated median zygoma standards following repeated median alignment without scaling.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
7	0.773	0.133	5.81	1.61	mastoid tip (L)
8	0.769	0.237	3.24	1.44	mastoid tip (R)
10	0.645	0.230	2.80	1.72	ext auditory meatus (R)
11	0.646	0.189	3.42	2.37	ext auditory meatus (L)
30	0.415	0.084	4.93	0.89	zygomaxillare (R)
31	0.385	0.077	5.03	1.30	zygomaxillare (L)
50	0.426	0.155	2.75	0.81	lateral orbitale (R)
51	0.421	0.092	4.56	4.24	lateral orbitale (L)
52	0.392	0.122	3.22	1.44	opposite orbitale (R)
53	0.366	0.128	2.86	1.65	opposite orbitale (L)
54	0.283	0.129	2.11	2.20	orbitale (R)
55	0.268	0.090	2.66	2.97	orbitale (L)
56	0.272	0.092	2.67	2.96	infraorbital foramen (R)
57	0.245	0.052	4.70	2.50	infraorbital foramen (L)
58	0.564	0.154	3.66	1.74	articular eminence (R)
59	0.532	0.100	5.33	3.17	articular eminence (L)
62	0.465	0.271	1.71	0.77	zygomatic corner (R)
63	0.462	0.239	1.94	1.18	zygomatic corner (L)

Table 6.11 (f)   Comparison of the least squares and repeated median cranium standards following repeated median alignment without scaling.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	0.059	0.020	3.02	2.24	sella
2	0.612	0.189	3.25	1.01	nasion
3	0.649	0.183	3.55	2.11	glabella
4	0.575	0.135	4.27	2.76	vertex
5	0.949	0.151	6.30	0.85	opisthocranion
6	0.167	0.068	2.44	0.45	opisthion
7	0.622	0.100	6.24	1.61	mastoid tip (L)
8	0.616	0.127	4.86	1.44	mastoid tip (R)
9	0.386	0.058	6.62	2.66	basion
10	0.446	0.109	4.09	1.72	ext auditory meatus (R)
11	0.440	0.099	4.43	2.37	ext auditory meatus (L)
43	1.035	1.680	0.00	0.62	bregma
64	0.599	0.177	3.39	2.55	zygomatic frontal (R)
65	0.596	0.169	3.52	2.61	zygomatic frontal (L)
78	0.550	0.065	8.45	1.86	foramen mag breadth (R)
79	0.556	0.070	7.99	1.22	foramen mag breadth (L)

Table 6.12 (a)   Definition of the triangular finite elements used for strain analysis of the mandible.

Triangle Vertices						Area of Representation
Landmk no.			Landmk abbrev.			
12	16	68	cdr	gor	cnr	Right posterior ramus
16	68	70	gor	cnr	eolr	Right middle ramus
68	70	32	cnr	eolr	ctr	Right anterior ramus
16	70	28	gor	eolr	mlr	Junction of right ramus to right body
16	28	20	gor	mlr	gn	Lower body element right
28	20	22	mlr	gn	id	Upper body element right
20	22	21	gn	id	pg	Chin
13	17	69	cdl	gol	cnl	Left posterior ramus
17	69	71	gol	cnl	eoll	Left middle ramus
69	71	33	cnl	eoll	ctl	Left anterior ramus
17	71	29	gol	eoll	mll	Junction of left ramus to left body
17	29	20	gol	mll	gn	Lower body element left
29	20	22	mll	gn	id	Upper body element left

Table 6.12 (b) Definition of the triangular finite elements used for strain analysis of the maxilla.

Triangle Vertices						Area of Representation
Landmk no.			Landmk abbrev.			
2	42	46	n	na	morr	Right nasal bone
42	46	66	na	morr	nabr	Right lateral aspect of the nasal aperture
46	66	54	morr	nabr	orr	Supero-medial anterior maxillary sinus right
66	24	26	nabr	ans	mur	Superior maxillary dental alveolar right
24	26	23	ans	mur	pr	Inferior maxillary dental alveolar right
66	42	24	nabr	na	ans	Anterior right nasal aperture
26	30	36	mur	zmr	scr	Right infero-lateral surface
36	25	23	scr	pns	ans	Right hard palate
26	54	66	mur	orr	nabr	Infero-medial anterior maxillary sinus right
26	54	30	mur	orr	zmr	Lateral anterior maxillary sinus right
24	2	25	ans	n	pns	Nasal septum
2	42	47	n	na	morl	Left nasal bone
42	47	67	na	morl	nabl	Left lateral aspect of the nasal aperture
47	67	55	morl	nabl	orl	Supero-medial anterior maxillary sinus left
67	24	27	nabl	ans	mul	Superior maxillary dental alveolar left
24	27	23	ans	mul	pr	Inferior maxillary dental alveolar left
67	42	24	nabl	na	ans	Anterior left nasal aperture
27	31	37	mul	zml	scl	Left infero-lateral surface
37	25	24	scl	pns	ans	Left hard palate
27	55	67	mul	orl	nabl	Infero-medial anterior maxillary sinus left
27	55	31	mul	orl	zml	Lateral anterior maxillary sinus left

Table 6.12 (c) Definition of the triangular finite elements used for strain
analysis of the orbit.

| Triangle Vertices | | | | | | Area of Representation |
Landmk no.			Landmk abbrev.			
48	50	52	sorr	lorr	oorr	Right lateral anterior border
52	48	54	oorr	sorr	orr	Right central anterior border
48	54	46	sorr	orr	morr	Right medial anterior border
46	48	40	morr	sorr	ofr	Right supero-medial orbital wall and roof
40	48	50	ofr	sorr	lorr	Right supero-lateral orbital roof and wall
40	50	52	ofr	lorr	oorr	Right infero-lateral orbital wall
40	52	54	ofr	oorr	orr	Right lateral orbital floor
54	40	46	orr	ofr	morr	Right infero-medial orbital wall and floor
49	51	53	sorl	lorl	oorl	Left lateral anterior border
53	49	55	oorl	sorl	orl	Left central anterior border
49	55	47	sorl	orl	morl	Left medial anterior border
47	49	41	morl	sorl	ofl	Left supero-medial orbital wall and roof
41	49	51	ofl	sorl	lorl	Left supero-lateral orbital roof and wall
41	51	53	ofl	lorl	oorl	Left infero-lateral orbital wall
41	53	55	ofl	oorl	orl	Left lateral orbital floor
55	41	47	orl	ofl	morl	Left infero-medial orbital wall and floor

Table 6.12 (d) Definition of the tetrahedral finite elements used for strain
analysis of the orbit.

Tetrahedron Vertices								Area of Representation
Landmk no.				Landmk abbrev.				
40	46	48	54	ofr	morr	sorr	orr	Medial orbital cavity right
40	48	50	54	ofr	sorr	lorr	orr	Lateral orbital cavity right
41	47	49	55	ofl	morl	sorl	orl	Medial orbital cavity left
41	49	51	55	ofl	sorl	lorl	orl	Lateral orbital cavity left

Table 6.12 (e) Definition of the triangular finite elements used for strain
analysis of the zygoma.

Triangle Vertices						Area of Representation
Landmk no.			Landmk abbrev.			
30	54	52	zmr	orr	oorr	Medial body of zygoma right
52	30	62	oorr	zmr	zcr	Lateral body of zygoma right
52	50	62	oorr	lorr	zcr	Frontal process of zygoma right
30	62	10	zmr	zcr	eamr	Zygomatic arch right
31	55	53	zml	orl	oorl	Medial body of zygoma left
53	31	63	oorl	zml	zcl	Lateral body of zygoma left
53	51	63	oorl	lorl	zcl	Frontal process of zygoma left
31	63	11	zml	zcl	eaml	Zygomatic arch left

Table 6.12 (f)   Definition of the triangular finite elements used for strain analysis of the calvaria and the cranial base.

Triangle Vertices Landmk no.			Landmk abbrev.			Area of Representation
3	4	64	g	v	zfr	Right frontal
4	8	64	v	mtr	zfr	Right anterior temporal parietal
4	8	5	v	mtr	op	Right posterior temporal parietal
5	8	6	op	mtr	o	Right occipital
3	4	65	g	v	zfl	Left frontal
4	7	65	v	mtl	zfl	Left anterior temporal parietal
4	7	5	v	mtl	op	Left posterior temporal parietal
5	7	6	op	mtl	o	Left occipital
1	8	64	s	mtr	zfr	Right middle cranial base
1	8	6	s	mtr	o	Right posterior cranial base
1	7	65	s	mtl	zfl	Left middle cranial base
1	7	6	s	mtl	o	Left posterior cranial base

Table 6.13 (a)   Principle stretch ratios and area changes for each of the four female dried skulls relative to the repeated median mandible standard.

Triangle	Parameter	A90	A13184	A38778	A57590
12 16 68	% Stretch minor	-1.99	-1.77	-12.75	-11.83
	% Stretch major	15.03	3.12	3.92	15.89
	% Area Change	12.73	1.29	-9.34	2.18
16 68 70	% Stretch minor	-1.11	-9.82	-23.35	13.98
	% Stretch major	17.88	3.67	-4.79	16.25
	% Area Change	16.58	-6.51	-27.02	32.50
68 70 32	% Stretch minor	8.53	-5.42	-23.38	-12.11
	% Stretch major	21.27	4.58	1.38	15.67
	% Area Change	31.62	-1.09	-22.32	1.65
16 70 28	% Stretch minor	-15.48	999.99	-7.35	12.31
	% Stretch major	3.30	999.99	4.14	19.08
	% Area Change	-12.70	999.99	-3.51	33.73
16 28 20	% Stretch minor	-5.12	999.99	-7.79	9.55
	% Stretch major	-0.15	999.99	-1.62	18.67
	% Area Change	-5.26	999.99	-9.28	30.00
28 20 22	% Stretch minor	-5.90	999.99	-4.58	-6.18
	% Stretch major	3.25	999.99	7.51	10.47
	% Area Change	-2.83	999.99	2.59	3.65
20 22 21	% Stretch minor	-35.22	-3.84	-5.16	-3.11
	% Stretch major	-2.27	11.51	11.34	90.01
	% Area Change	-36.70	7.23	5.59	84.10
13 17 69	% Stretch minor	-10.27	-3.91	-5.34	-10.20
	% Stretch major	19.17	3.47	5.62	17.82
	% Area Change	6.94	-0.58	-0.02	5.80
17 69 71	% Stretch minor	-9.16	1.16	-18.33	5.09
	% Stretch major	13.60	3.70	-2.54	22.55
	% Area Change	3.19	4.90	-20.40	28.79
69 71 33	% Stretch minor	-6.43	3.21	-16.04	-14.80
	% Stretch major	19.53	7.35	-4.41	25.31
	% Area Change	11.84	10.79	-19.74	6.76
17 71 29	% Stretch minor	999.99	999.99	-6.18	0.86
	% Stretch major	999.99	999.99	10.22	12.62
	% Area Change	999.99	999.99	3.41	13.59
17 29 20	% Stretch minor	999.99	999.99	-6.37	6.24
	% Stretch major	999.99	999.99	0.40	12.31
	% Area Change	999.99	999.99	-6.00	19.32
29 20 22	% Stretch minor	999.99	999.99	-4.02	-4.49
	% Stretch major	999.99	999.99	7.07	10.45
	% Area Change	999.99	999.99	2.77	5.49

Table 6.13 (b)   Principle stretch ratios and area changes for each of the four female dried skulls relative to the repeated median maxilla standard.

Triangle	Parameter	A90	A13184	A38778	A57590
2 42 46	% Stretch minor	-0.57	-10.50	-25.13	16.51
	% Stretch major	3.61	5.25	-14.03	27.87
	% Area Change	3.02	-5.80	-35.63	48.97
42 46 66	% Stretch minor	-2.55	-11.73	-25.39	0.19
	% Stretch major	15.12	4.83	-14.91	35.21
	% Area Change	12.19	-7.47	-36.52	35.46
46 66 54	% Stretch minor	0.05	-10.11	-17.70	-5.00
	% Stretch major	15.32	0.75	9.41	3.20
	% Area Change	15.38	-9.44	-9.95	-1.96
26 54 66	% Stretch minor	-2.52	-8.14	-15.93	-0.31
	% Stretch major	6.77	11.79	0.53	4.98
	% Area Change	4.08	2.69	-15.48	4.66
26 54 30	% Stretch minor	-3.11	3.20	-17.22	-13.64
	% Stretch major	6.29	14.01	-1.17	8.63
	% Area Change	2.98	17.66	-18.19	-6.18
66 24 26	% Stretch minor	-38.20	-2.26	-8.18	0.59
	% Stretch major	4.07	18.05	4.87	17.56
	% Area Change	35.69	15.39	-3.70	18.26
24 26 23	% Stretch minor	-18.94	-3.02	-6.14	0.63
	% Stretch major	4.23	2.57	3.96	19.59
	% Area Change	-15.51	-0.53	-2.43	20.34
66 42 24	% Stretch minor	-22.53	-8.86	-15.14	11.83
	% Stretch major	11.91	4.53	5.59	13.13
	% Area Change	-13.31	-4.73	-10.40	26.52
26 30 36	% Stretch minor	-1.30	-5.29	999.99	-10.68
	% Stretch major	5.37	13.38	999.99	5.90
	% Area Change	4.00	7.38	999.99	-5.42
36 25 23	% Stretch minor	-10.88	-16.16	999.99	-4.49
	% Stretch major	11.19	10.30	999.99	22.80
	% Area Change	-0.91	-7.52	999.99	17.28
24 2 25	% Stretch minor	-1.86	-0.25	-20.02	5.33
	% Stretch major	9.05	3.03	-8.72	10.64
	% Area Change	7.01	2.77	-26.99	16.54
2 42 47	% Stretch minor	0.53	-13.54	-19.33	10.47
	% Stretch major	12.26	3.94	-8.46	17.75
	% Area Change	12.86	-10.14	-26.15	30.08

Table 6.13 (b) (continued)

Triangle	Parameter	A90	A13184	A38778	A57590
42 47 67	% Stretch minor	-12.14	-13.40	-17.11	4.65
	% Stretch major	9.89	5.82	-1.55	25.05
	% Area Change	-3.45	-8.36	-18.40	30.87
47 67 55	% Stretch minor	11.52	-6.35	-7.71	-1.46
	% Stretch major	9.27	4.65	1.25	6.99
	% Area Change	-3.32	-2.00	-6.55	5.43
27 55 67	% Stretch minor	-0.79	-1.19	-16.33	-0.57
	% Stretch major	5.62	10.33	-4.60	4.57
	% Area Change	4.78	9.01	-20.18	3.97
27 55 31	% Stretch minor	-10.49	2.48	-20.61	-11.40
	% Stretch major	8.76	16.16	5.59	10.49
	% Area Change	-2.65	19.04	-16.17	-2.10
67 24 27	% Stretch minor	-0.58	-1.25	-42.66	-0.29
	% Stretch major	26.20	12.26	-11.57	23.10
	% Area Change	25.47	10.85	-49.30	22.75
24 27 23	% Stretch minor	-16.78	-1.23	-21.85	2.23
	% Stretch major	2.43	5.47	8.26	23.77
	% Area Change	-14.76	4.17	-15.39	26.54
67 42 24	% Stretch minor	-8.96	-7.12	-42.58	12.34
	% Stretch major	24.74	0.83	-2.17	28.39
	% Area Change	13.56	-6.35	-43.83	44.24
85 23 81	% Stretch minor	0.42	999.99	999.99	999.99
	% Stretch major	21.82	999.99	999.99	999.99
	% Area Change	22.34	999.99	999.99	999.99
27 31 37	% Stretch minor	-10.81	-8.40	999.99	-9.58
	% Stretch major	2.06	16.63	999.99	7.29
	% Area Change	-8.98	6.83	999.99	-2.99
37 25 23	% Stretch minor	-4.21	-14.31	999.99	-1.84
	% Stretch major	11.30	24.92	999.99	30.70
	% Area Change	6.62	7.05	999.99	28.29

Table 6.13 (c)   Principle stretch ratios and area changes for each of the four female dried skulls relative to the repeated median orbit standard.

Triangle	Parameter	A90	A13184	A38778	A57590
48 50 52	% Stretch minor	-19.07	-5.77	-11.49	0.05
	% Stretch major	12.01	6.16	0.71	28.10
	% Area Change	-9.36	0.04	-10.86	28.17
52 48 54	% Stretch minor	-0.04	-4.74	-5.93	-2.34
	% Stretch major	12.31	0.04	1.58	5.33
	% Area Change	12.27	-4.70	-4.45	2.86
48 54 46	% Stretch minor	-5.71	-6.58	-4.68	-9.65
	% Stretch major	14.27	-2.54	19.47	-1.68
	% Area Change	7.75	-8.95	13.88	-11.16
46 48 40	% Stretch minor	-4.52	999.99	999.99	-9.31
	% Stretch major	4.44	999.99	999.99	4.47
	% Area Change	-0.28	999.99	999.99	-5.25
40 48 50	% Stretch minor	2.14	999.99	999.99	0.70
	% Stretch major	11.64	999.99	999.99	1.88
	% Area Change	14.03	999.99	999.99	2.60
40 50 52	% Stretch minor	-14.46	999.99	999.99	-1.66
	% Stretch major	4.39	999.99	999.99	24.31
	% Area Change	-10.70	999.99	999.99	22.25
40 52 54	% Stretch minor	-6.04	999.99	999.99	-7.01
	% Stretch major	9.80	999.99	999.99	12.25
	% Area Change	3.17	999.99	999.99	4.38
54 40 46	% Stretch minor	4.38	999.99	999.99	-6.00
	% Stretch major	11.00	999.99	999.99	5.40
	% Area Change	15.86	999.99	999.99	-0.92
49 51 53	% Stretch minor	-1.90	-3.11	-3.78	6.85
	% Stretch major	12.89	1.64	-0.01	11.15
	% Area Change	10.75	-1.52	-3.79	18.76
53 49 55	% Stretch minor	-9.85	-5.19	-3.02	6.94
	% Stretch major	5.15	0.63	0.83	11.56
	% Area Change	-5.21	-4.59	-2.22	19.31
49 55 47	% Stretch minor	-4.71	-2.79	-4.23	-4.14
	% Stretch major	7.95	1.14	2.35	8.20
	% Area Change	2.87	-1.68	-1.97	3.72
47 49 41	% Stretch minor	-2.80	999.99	999.99	-4.75
	% Stretch major	7.19	999.99	999.99	11.13
	% Area Change	4.18	999.99	999.99	5.85

Table 6.13 (c) (continued)

Triangle	Parameter	A90	A13184	A38778	A57590
41 49 51	% Stretch minor	-6.78	999.99	999.99	3.99
	% Stretch major	3.44	999.99	999.99	7.04
	% Area Change	-3.58	999.99	999.99	11.30
41 51 53	% Stretch minor	-6.69	999.99	999.99	-19.89
	% Stretch major	15.23	999.99	999.99	25.56
	% Area Change	7.52	999.99	999.99	0.58
41 53 55	% Stretch minor	-7.09	999.99	999.99	8.67
	% Stretch major	-3.18	999.99	999.99	15.02
	% Area Change	-10.04	999.99	999.99	25.00
55 41 47	% Stretch minor	-7.71	999.99	999.99	2.24
	% Stretch major	2.82	999.99	999.99	12.25
	% Area Change	-5.10	999.99	999.99	14.76

Table 6.13 (d) Principle stretch ratios and area changes for each of the four female dried skulls relative to the repeated median zygoma standard.

Triangle	Parameter	A90	A13184	A38778	A57590
30 54 52	% Stretch minor	-10.44	-4.63	-21.96	-1.09
	% Stretch major	4.79	4.49	-1.25	29.36
	% Area Change	-6.15	-0.34	-22.94	27.95
52 30 62	% Stretch minor	-4.05	-5.78	-23.28	10.43
	% Stretch major	0.59	9.73	-14.13	30.17
	% Area Change	-3.48	3.38	-34.13	43.75
52 50 62	% Stretch minor	-15.84	-3.67	-14.15	3.83
	% Stretch major	0.12	9.48	2.06	23.33
	% Area Change	-15.75	5.46	-12.38	28.05
30 62 10	% Stretch minor	-5.50	-6.12	-21.74	-6.50
	% Stretch major	6.03	3.01	-2.02	29.54
	% Area Change	0.20	-3.29	-23.32	21.12
31 55 53	% Stretch minor	-5.75	-9.49	-29.40	2.82
	% Stretch major	9.64	2.62	-1.11	29.71
	% Area Change	3.33	-7.11	-30.18	33.37
53 31 63	% Stretch minor	-12.36	-9.23	-31.74	8.49
	% Stretch major	12.86	11.07	-5.82	26.58
	% Area Change	-1.09	0.82	-35.71	37.32
53 51 63	% Stretch minor	-12.01	-3.11	-12.77	-3.60
	% Stretch major	15.20	20.01	-0.94	14.73
	% Area Change	1.37	16.28	-13.58	10.60
31 63 11	% Stretch minor	-1.02	-8.00	-24.46	-6.40
	% Stretch major	17.25	1.92	-4.74	22.61
	% Area Change	16.05	-6.23	-28.04	14.77

Table 6.13 (e)   Principle stretch ratios and area changes for each of the four female dried skulls relative to the repeated median cranium standard.

Triangle	Parameter	A90	A13184	A38778	A57590
3 4 64	% Stretch minor	-0.57	999.99	-9.81	-3.47
	% Stretch major	8.22	999.99	-0.63	8.15
	% Area Change	7.59	999.99	-10.38	4.40
4 8 64	% Stretch minor	-0.65	999.99	-8.26	-4.30
	% Stretch major	0.72	999.99	-0.04	2.47
	% Area Change	0.06	999.99	-8.30	-1.93
4 8 5	% Stretch minor	0.41	999.99	-13.02	2.09
	% Stretch major	6.14	999.99	-7.40	8.76
	% Area Change	6.57	999.99	-19.45	11.04
5 8 6	% Stretch minor	-5.10	-6.75	-13.45	999.99
	% Stretch major	3.69	0.05	8.79	999.99
	% Area Change	-1.60	-6.71	-5.85	999.99
3 4 65	% Stretch minor	0.57	999.99	-3.57	-6.17
	% Stretch major	6.08	999.99	0.71	2.16
	% Area Change	6.68	999.99	-2.89	-4.15
4 7 65	% Stretch minor	0.15	999.99	-10.63	-3.72
	% Stretch major	0.73	999.99	-2.99	3.73
	% Area Change	0.88	999.99	-13.30	-0.13
4 7 5	% Stretch minor	-0.11	999.99	-11.08	3.07
	% Stretch major	5.82	999.99	-8.21	7.91
	% Area Change	5.70	999.99	-18.38	11.22
5 7 6	% Stretch minor	-8.84	-2.74	-12.65	999.99
	% Stretch major	3.44	7.56	-2.11	999.99
	% Area Change	-5.70	4.61	-14.50	999.99
1 8 64	% Stretch minor	0.10	-4.27	-10.17	-1.55
	% Stretch major	1.79	5.46	-1.81	4.20
	% Area Change	1.89	0.95	-11.79	2.59
1 8 6	% Stretch minor	-2.35	-9.04	-10.70	999.99
	% Stretch major	3.45	3.87	2.09	999.99
	% Area Change	1.02	-5.51	-8.84	999.99
1 7 65	% Stretch minor	-6.71	0.16	-11.35	-2.21
	% Stretch major	0.08	8.40	-0.72	6.34
	% Area Change	-6.64	8.57	-11.99	3.99
1 7 6	% Stretch minor	-7.89	-4.51	-9.29	999.99
	% Stretch major	3.70	7.06	-2.95	999.99
	% Area Change	-4.49	2.22	-11.96	999.99

Table 6.14 (a) Statistics of the strain analysis of the four female dried skulls relative to the repeated median mandible standard.

Triangle	Parameter	Obs	Mean	Min	Max	Range	SD
12 16 68	% Stretch minor	4	-7.08	-12.75	-1.77	10.98	6.02
	% Stretch major	4	9.49	3.12	15.89	12.77	6.91
	% Area Change	4	1.71	-9.34	12.73	22.07	9.02
16 68 70	% Stretch minor	4	-5.08	-23.35	13.98	37.33	15.66
	% Stretch major	4	8.25	-4.79	17.88	22.67	10.77
	% Area Change	4	3.89	-27.02	32.50	59.52	26.10
68 70 32	% Stretch minor	4	-8.09	-23.38	8.53	31.91	13.33
	% Stretch major	4	10.72	1.38	21.27	19.89	9.32
	% Area Change	4	2.47	-22.32	31.62	53.94	22.19
16 70 28	% Stretch minor	3	-3.51	-15.48	12.31	27.79	14.29
	% Stretch major	3	8.84	3.30	19.08	15.78	8.88
	% Area Change	3	5.84	-12.70	33.73	46.43	24.59
16 28 20	% Stretch minor	3	-1.12	-7.79	9.55	17.34	9.34
	% Stretch major	3	5.63	-1.62	18.67	20.29	11.31
	% Area Change	3	5.15	-9.28	30.00	39.28	21.61
28 20 22	% Stretch minor	3	-5.55	-6.18	-4.58	1.60	0.85
	% Stretch major	3	7.08	3.25	10.47	7.22	3.63
	% Area Change	3	1.14	-2.83	3.65	6.48	3.48
20 22 21	% Stretch minor	4	-11.83	-35.22	-3.11	32.11	15.61
	% Stretch major	4	27.65	-2.27	90.01	92.28	42.07
	% Area Change	4	15.06	-36.70	84.10	120.80	50.32
13 17 69	% Stretch minor	4	-7.43	-10.27	-3.91	6.36	3.29
	% Stretch major	4	11.52	3.47	19.17	15.70	8.12
	% Area Change	4	3.04	-0.58	6.94	7.52	3.89
17 69 71	% Stretch minor	4	-5.31	-18.33	5.09	23.42	10.56
	% Stretch major	4	9.33	-2.54	22.55	25.09	11.04
	% Area Change	4	4.12	-20.40	28.79	49.19	20.09
69 71 33	% Stretch minor	4	-8.52	-16.04	3.21	19.25	8.91
	% Stretch major	4	11.95	-4.41	25.31	29.72	13.23
	% Area Change	4	2.41	-19.74	11.84	31.58	14.93
17 71 29	% Stretch minor	2	-2.66	-6.18	0.86	7.04	4.98
	% Stretch major	2	11.42	10.22	12.62	2.40	1.70
	% Area Change	2	8.50	3.41	13.59	10.18	7.20
17 29 20	% Stretch minor	2	-0.06	-6.37	6.24	12.61	8.92
	% Stretch major	2	6.36	0.40	12.31	11.91	8.42
	% Area Change	2	6.66	-6.00	19.32	25.32	17.90
29 20 22	% Stretch minor	2	-4.26	-4.49	-4.02	0.47	0.33
	% Stretch major	2	8.76	7.07	10.45	3.38	2.39
	% Area Change	2	4.13	2.77	5.49	2.72	1.92

Table 6.14 (b) Statistics of the strain analysis of the four female dried skulls relative to the repeated median maxilla standard.

Triangle	Parameter	Obs	Mean	Min	Max	Range	SD
2 42 46	% Stretch minor	4	-4.92	-25.13	16.51	41.64	17.49
	% Stretch major	4	5.68	-14.03	27.87	41.90	17.18
	% Area Change	4	2.64	-35.63	48.97	84.60	35.04
42 46 66	% Stretch minor	4	-9.87	-25.39	0.19	25.58	11.53
	% Stretch major	4	10.06	-14.91	35.21	50.12	20.89
	% Area Change	4	0.91	-36.52	35.46	71.98	30.51
46 66 54	% Stretch minor	4	-8.19	-17.70	0.05	17.75	7.58
	% Stretch major	4	7.17	0.75	15.32	14.57	6.54
	% Area Change	4	-1.49	-9.95	15.38	25.33	11.83
26 54 66	% Stretch minor	4	-6.72	-15.93	-0.31	15.62	6.97
	% Stretch major	4	6.02	0.53	11.79	11.26	4.66
	% Area Change	4	-1.01	-15.48	4.66	20.14	9.68
26 54 30	% Stretch minor	4	-7.69	-17.22	3.20	20.42	9.41
	% Stretch major	4	6.94	-1.17	14.01	15.18	6.30
	% Area Change	4	-0.93	-18.19	17.66	35.85	15.13
66 24 26	% Stretch minor	4	-12.01	-38.20	0.59	38.79	17.84
	% Stretch major	4	11.14	4.07	18.05	13.98	7.71
	% Area Change	4	-1.43	-35.69	18.26	53.95	24.83
24 26 23	% Stretch minor	4	-6.87	-18.94	0.63	19.57	8.51
	% Stretch major	4	7.59	2.57	19.59	17.02	8.03
	% Area Change	4	0.47	-15.51	20.34	35.85	14.83
66 42 24	% Stretch minor	4	-8.68	-22.53	11.83	34.36	14.77
	% Stretch major	4	8.79	4.53	13.13	8.60	4.36
	% Area Change	4	-0.48	-13.31	26.52	39.83	18.35
26 30 36	% Stretch minor	3	-5.76	-10.68	-1.30	9.38	4.71
	% Stretch major	3	8.22	5.37	13.38	8.01	4.48
	% Area Change	3	1.99	-5.42	7.3	12.80	6.63
36 25 23	% Stretch minor	3	-10.51	-16.16	-4.49	11.67	5.84
	% Stretch major	3	14.76	10.30	22.80	12.50	6.97
	% Area Change	3	2.95	-7.52	17.28	24.80	12.84
24 2 25	% Stretch minor	4	-4.20	-20.02	5.33	25.35	10.99
	% Stretch major	4	3.50	-8.72	10.64	19.36	8.78
	% Area Change	4	-0.17	-26.99	16.54	43.53	18.79
2 42 47	% Stretch minor	4	-5.47	-19.33	10.47	29.80	13.51
	% Stretch major	4	6.37	-8.46	17.75	26.21	11.40
	% Area Change	4	1.66	-26.15	30.08	56.23	24.80

Table 6.14 (b) (continued)

Triangle	Parameter	Obs	Mean	Min	Max	Range	SD
42 47 67	% Stretch minor	4	-9.50	-17.11	4.65	21.76	9.67
	% Stretch major	4	9.80	-1.55	25.05	26.60	11.21
	% Area Change	4	0.17	-18.40	30.87	49.27	21.39
47 67 55	% Stretch minor	4	-6.76	-11.52	-1.46	10.06	4.16
	% Stretch major	4	5.54	1.25	9.27	8.02	3.43
	% Area Change	4	-1.61	-6.55	5.43	11.98	5.07
27 55 67	% Stretch minor	4	-4.72	-16.33	-0.57	15.76	7.74
	% Stretch major	4	3.98	-4.60	10.33	14.93	6.24
	% Area Change	4	-0.61	-20.18	9.01	29.19	13.24
27 55 31	% Stretch minor	4	-10.00	-20.61	2.48	23.09	9.50
	% Stretch major	4	10.25	5.59	16.16	10.57	4.43
	% Area Change	4	-0.47	-16.17	19.04	35.21	14.54
67 24 27	% Stretch minor	4	-11.20	-42.66	-0.29	42.37	20.98
	% Stretch major	4	12.50	-11.57	26.20	37.77	17.12
	% Area Change	4	2.44	-49.30	25.47	74.77	35.07
24 27 23	% Stretch minor	4	-9.41	-21.85	2.23	24.08	11.71
	% Stretch major	4	9.98	2.43	23.77	21.34	9.50
	% Area Change	4	0.14	-15.39	26.54	41.93	19.80
67 42 24	% Stretch minor	4	-11.58	-42.58	12.34	54.92	22.80
	% Stretch major	4	12.95	-2.17	28.39	30.56	15.84
	% Area Change	4	1.91	-43.83	44.24	88.07	36.91
85 23 81	% Stretch minor	1	0.42	0.42	0.42	0.00	999.90
	% Stretch major	1	21.82	21.82	21.82	0.00	999.90
	% Area Change	1	22.34	22.34	22.34	0.00	999.90
27 31 37	% Stretch minor	3	-9.60	-10.81	-8.40	2.41	1.21
	% Stretch major	3	8.66	2.06	16.63	14.57	7.38
	% Area Change	3	-1.71	-8.98	6.83	15.81	7.98
37 25 23	% Stretch minor	3	-6.79	-14.31	-1.84	12.47	6.62
	% Stretch major	3	22.31	11.30	30.70	19.40	9.96
	% Area Change	3	13.99	6.62	28.29	21.67	12.39

Table 6.14 (c) Statistics of the strain analysis of the four female dried skulls relative to the repeated median orbit standard.

Triangle	Parameter	Obs	Mean	Min	Max	Range	SD
48 50 52	% Stretch minor	4	-9.07	-19.07	0.05	19.12	8.16
	% Stretch major	4	11.75	0.71	28.10	27.39	11.84
	% Area Change	4	2.00	-10.86	28.17	39.03	18.10
52 48 54	% Stretch minor	4	-3.26	-5.93	-0.04	5.89	2.62
	% Stretch major	4	4.81	0.04	12.31	12.27	5.47
	% Area Change	4	1.49	-4.70	12.27	16.97	7.99
48 54 46	% Stretch minor	4	-6.65	-9.65	-4.68	4.97	2.14
	% Stretch major	4	7.38	-2.54	19.47	22.01	11.17
	% Area Change	4	0.38	-11.16	13.88	25.04	12.34
46 48 40	% Stretch minor	2	-6.92	-9.31	-4.52	4.79	3.39
	% Stretch major	2	4.46	4.44	4.47	0.03	0.02
	% Area Change	2	-2.77	-5.25	-0.28	4.97	3.51
40 48 50	% Stretch minor	2	1.42	0.70	2.14	1.44	1.02
	% Stretch major	2	6.76	1.88	11.64	9.76	6.90
	% Area Change	2	8.32	2.60	14.03	11.43	8.08
40 50 52	% Stretch minor	2	-8.06	-14.46	-1.66	12.80	9.05
	% Stretch major	2	14.35	4.39	24.31	19.92	14.09
	% Area Change	2	5.78	-10.70	22.25	32.95	23.30
40 52 54	% Stretch minor	2	-6.53	-7.01	-6.04	0.97	0.69
	% Stretch major	2	11.03	9.80	12.25	2.45	1.73
	% Area Change	2	3.78	3.17	4.38	1.21	0.86
54 40 46	% Stretch minor	2	-0.81	-6.00	4.38	10.38	7.34
	% Stretch major	2	8.20	5.40	11.00	5.60	3.96
	% Area Change	2	7.47	-0.92	15.86	16.78	11.87
49 51 53	% Stretch minor	4	-0.48	-3.78	6.85	10.63	4.95
	% Stretch major	4	6.42	-0.01	12.89	12.90	6.54
	% Area Change	4	6.05	-3.79	18.76	22.55	10.61
53 49 55	% Stretch minor	4	-2.78	-9.85	6.94	16.79	7.08
	% Stretch major	4	4.54	0.63	11.56	10.93	5.12
	% Area Change	4	1.82	-5.21	19.31	24.52	11.73
49 55 47	% Stretch minor	4	-3.97	-4.71	-2.79	1.92	0.82
	% Stretch major	4	4.91	1.14	8.20	7.06	3.69
	% Area Change	4	0.74	-1.97	3.72	5.69	2.98
47 49 41	% Stretch minor	2	-3.78	-4.75	-2.80	1.95	1.38
	% Stretch major	2	9.16	7.19	11.13	3.94	2.79
	% Area Change	2	5.02	4.18	5.85	1.67	1.18

Table 6.14 (c) (continued)

Triangle	Parameter	Obs	Mean	Min	Max	Range	SD
41 49 51	% Stretch minor	2	-1.40	-6.78	3.99	10.77	7.62
	% Stretch major	2	5.24	3.44	7.04	3.60	2.55
	% Area Change	2	3.86	-3.58	11.30	14.88	10.52
41 51 53	% Stretch minor	2	-13.29	-19.89	-6.69	13.20	9.33
	% Stretch major	2	20.40	15.23	25.56	10.33	7.30
	% Area Change	2	4.05	0.58	7.52	6.94	4.91
41 53 55	% Stretch minor	2	0.79	-7.09	8.67	15.76	11.14
	% Stretch major	2	5.92	-3.18	15.02	18.20	12.87
	% Area Change	2	7.48	-10.04	25.00	35.04	24.78
55 41 47	% Stretch minor	2	-2.74	-7.71	2.24	9.95	7.04
	% Stretch major	2	7.54	2.82	12.25	9.43	6.67
	% Area Change	2	4.83	-5.10	14.76	19.86	14.04

Table 6.14 (d) Statistics of the strain analysis of the four female dried skulls relative to the repeated median zygoma standard.

Triangle	Parameter	Obs	Mean	Min	Max	Range	SD
30 54 52	% Stretch minor	4	-9.53	-21.96	-1.09	20.87	9.14
	% Stretch major	4	9.35	-1.25	29.36	30.61	13.63
	% Area Change	4	-0.37	-22.94	27.95	50.89	21.17
52 30 62	% Stretch minor	4	-5.67	-23.28	10.43	33.71	13.81
	% Stretch major	4	6.59	-14.13	30.17	44.30	18.54
	% Area Change	4	2.38	-34.13	43.75	77.88	32.04
52 50 62	% Stretch minor	4	-7.46	-15.84	3.83	19.67	9.25
	% Stretch major	4	8.75	0.12	23.33	23.21	10.53
	% Area Change	4	1.34	-15.75	28.05	43.80	20.09
30 62 10	% Stretch minor	4	-9.97	-21.74	-5.50	16.24	7.86
	% Stretch major	4	9.14	-2.02	29.54	31.56	14.00
	% Area Change	4	-1.32	-23.32	21.12	44.44	18.20
31 55 53	% Stretch minor	4	-10.46	-29.40	2.82	32.22	13.64
	% Stretch major	4	10.22	-1.11	29.71	30.82	13.74
	% Area Change	4	-0.15	-30.18	33.37	63.55	26.37
53 31 63	% Stretch minor	4	-11.21	-31.74	8.49	40.23	16.48
	% Stretch major	4	11.17	-5.82	26.58	32.40	13.28
	% Area Change	4	0.33	-35.71	37.32	73.03	29.83
53 51 63	% Stretch minor	4	-7.87	-12.77	-3.11	9.66	5.23
	% Stretch major	4	12.25	-0.94	20.01	20.95	9.11
	% Area Change	4	3.67	-13.58	16.28	29.86	13.04
31 63 11	% Stretch minor	4	-9.97	-24.46	-1.02	23.44	10.11
	% Stretch major	4	9.26	-4.74	22.61	27.35	12.81
	% Area Change	4	-0.86	-28.04	16.05	44.09	20.80

Table 6.14 (e) Statistics of the strain analysis of the four female dried skulls relative to the repeated median cranium standard.

Triangle	Parameter	Obs	Mean	Min	Max	Range	SD
3 4 64	% Stretch minor	3	-4.62	-9.81	-0.57	9.24	4.73
	% Stretch major	3	5.25	-0.63	8.22	8.85	5.09
	% Area Change	3	0.54	-10.38	7.59	17.97	9.59
4 8 64	% Stretch minor	3	-4.40	-8.26	-0.65	7.61	3.81
	% Stretch major	3	1.05	-0.04	2.47	2.51	1.29
	% Area Change	3	-3.39	-8.30	0.06	8.36	4.37
4 8 5	% Stretch minor	3	-3.51	-13.02	2.09	15.11	8.28
	% Stretch major	3	2.50	-7.40	8.76	16.16	8.67
	% Area Change	3	-0.61	-19.45	11.04	30.49	16.47
5 8 6	% Stretch minor	3	-8.43	-13.45	-5.10	8.35	4.42
	% Stretch major	3	4.18	0.05	8.79	8.74	4.39
	% Area Change	3	-4.72	-6.71	-1.60	5.11	2.74
3 4 65	% Stretch minor	3	-3.06	-6.17	0.57	6.74	3.40
	% Stretch major	3	2.98	0.71	6.08	5.37	2.78
	% Area Change	3	-0.12	-4.15	6.68	10.83	5.92
4 7 65	% Stretch minor	3	-4.73	-10.63	0.15	10.78	5.46
	% Stretch major	3	0.49	-2.99	3.73	6.72	3.37
	% Area Change	3	-4.18	-13.30	0.88	14.18	7.91
4 7 5	% Stretch minor	3	-2.71	-11.08	3.07	14.15	7.42
	% Stretch major	3	1.84	-8.21	7.91	16.12	8.77
	% Area Change	3	-0.49	-18.38	11.22	29.60	15.74
5 7 6	% Stretch minor	3	-8.08	-12.65	-2.74	9.91	5.00
	% Stretch major	3	2.96	-2.11	7.56	9.67	4.85
	% Area Change	3	-5.20	-14.50	4.61	19.11	9.56
1 8 64	% Stretch minor	4	-3.97	-10.17	0.10	10.27	4.51
	% Stretch major	4	2.41	-1.81	5.46	7.27	3.20
	% Area Change	4	-1.59	-11.79	2.59	14.38	6.83
1 8 6	% Stretch minor	3	-7.36	-10.70	-2.35	8.35	4.42
	% Stretch major	3	3.14	2.09	3.87	1.78	0.93
	% Area Change	3	-4.44	-8.84	1.02	9.86	5.02
1 7 65	% Stretch minor	4	-5.03	-11.35	0.16	11.51	5.09
	% Stretch major	4	3.53	-0.72	8.40	9.12	4.53
	% Area Change	4	-1.52	-11.99	8.57	20.56	9.45
1 7 6	% Stretch minor	3	-7.23	-9.29	-4.51	4.78	2.46
	% Stretch major	3	2.60	-2.95	7.06	10.01	5.09
	% Area Change	3	-4.74	-11.96	2.22	14.18	7.09

Table 6.15 (a) Scaled least squares comparison of the male mandible with the least squares experimental reference mandible standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
12	1.970	0.520	3.79	1.72	condylion (R)
13	2.117	0.516	4.10	2.39	condylion (L)
16	4.455	1.391	3.20	1.16	gonion (R)
17	1.905	0.540	3.53	1.78	gonion (L)
20	1.904	0.588	3.24	0.76	gnathion
21	4.428	1.135	3.90	1.50	pogonion
22	0.761	0.327	2.33	0.51	infradentale
28	2.351	0.885	2.66	0.80	lower molar (R)
29	3.399	2.519*	1.35	0.87	lower molar (L)
32	2.002	0.497	4.03	0.89	coronoid tip (R)
33	2.957	0.755	3.92	1.72	coronoid tip (L)
68	0.567	0.204	2.78	0.41	coronoid notch (R)
69	2.498	0.739	3.38	1.20	coronoid notch (L)
70	2.735	1.014	2.70	1.12	ext oblique line (R)
71	2.517	0.780	3.23	3.15	ext oblique line (L)

Male is 5.3% larger than the standard with scale factor Z-score = 1.055
Scale factor standard deviation for this standard = 0.0501

* significant at the 5% level

Table 6.15 (b)   Scaled repeated median comparison of the male mandible with the repeated median experimental reference mandible standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
12	1.655	0.413	4.01	1.72	condylion (R)
13	2.033	0.551	3.69	2.39	condylion (L)
16	4.663	1.315	3.55	1.16	gonion (R)
17	1.832	0.444	4.12	1.78	gonion (L)
20	1.754	0.549	3.20	0.76	gnathion
21	4.588	1.170	3.92	1.50	pogonion
22	1.394	0.685	2.04	0.51	infradentale
28	2.033	0.865	2.35	0.80	lower molar (R)
29	3.269	2.064*	1.58	0.87	lower molar (L)
32	2.002	0.433	4.62	0.89	coronoid tip (R)
33	3.131	0.852	3.67	1.72	coronoid tip (L)
68	0.000	0.000	3.74	0.41	coronoid notch (R)
69	2.581	0.807	3.20	1.20	coronoid notch (L)
70	2.878	1.207	2.38	1.12	ext oblique line (R)
71	2.522	0.775	3.26	3.15	ext oblique line (L)

Male is 5.8% larger than the standard with scale factor Z-score = 1.185
Scale factor standard deviation for this standard = 0.0493

* significant at the 5% level

Table 6.15 (c)   Non-scaled least squares comparison of the male mandible with the least squares experimental reference mandible standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
12	5.292	1.397	3.79	1.72	condylion (R)
13	2.877	0.701	4.10	2.39	condylion (L)
16	7.469	2.331*	3.20	1.16	gonion (R)
17	4.775	1.354	3.53	1.78	gonion (L)
20	3.914	1.208	3.24	0.76	gnathion
21	4.933	1.264	3.90	1.50	pogonion
22	3.643	1.566	2.33	0.51	infradentale
28	2.904	1.093	2.66	0.80	lower molar (R)
29	3.741	2.772*	1.35	0.87	lower molar (L)
32	0.951	0.236	4.03	0.89	coronoid tip (R)
33	2.350	0.600	3.92	1.72	coronoid tip (L)
68	2.783	1.002	2.78	0.41	coronoid notch (R)
69	3.432	1.015	3.38	1.20	coronoid notch (L)
70	3.042	1.128	2.70	1.12	ext oblique line (R)
71	2.601	0.806	3.23	3.15	ext oblique line (L)

* significant at the 5% level

Table 6.15 (d) Non-scaled repeated median comparison of the male mandible with the repeated median experimental reference mandible standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
12	6.439	1.607	4.01	1.72	condylion (R)
13	3.340	0.905	3.69	2.39	condylion (L)
16	8.809	2.484*	3.55	1.16	gonion (R)
17	4.938	1.198	4.12	1.78	gonion (L)
20	4.146	1.296	3.20	0.76	gnathion
21	5.057	1.289	3.92	1.50	pogonion
22	3.984	1.957*	2.04	0.51	infradentale
28	3.615	1.539	2.35	0.80	lower molar (R)
29	3.572	2.255*	1.58	0.87	lower molar (L)
32	1.976	0.428	4.62	0.89	coronoid tip (R)
33	1.920	0.522	3.67	1.72	coronoid tip (L)
68	3.799	1.016	3.74	0.41	coronoid notch (R)
69	2.955	0.925	3.20	1.20	coronoid notch (L)
70	3.544	1.486	2.38	1.12	ext oblique line (R)
71	2.052	0.630	3.26	3.15	ext oblique line (L)

* significant at the 5% level

Table 6.16 Distance and angle comparison of the male mandible with the
experimental reference mandible standard using Z-scores.

N	Name	Value	Z-score	Mean	SD	Exp.SD
1	cdr-gor	59.82	0.37	58.86	2.61	2.07
2	gor-gn	90.96	1.10	82.03	8.15	1.38
3	gn-pg	6.91	-2.35*	10.87	1.21	1.69
4	pg-id	21.67	1.12	19.89	1.55	1.59
5	gn-gol	90.38	1.09	83.37	6.45	1.94
6	gol-cdl	56.72	0.06	56.49	4.16	2.98
7	cdl-cnl	27.39	0.62	25.74	2.21	2.67
8	cnl-ctl	15.30	-0.17	15.65	1.92	2.09
9	ctl-eoll	27.33	-0.16	28.05	4.42	3.59
10	eoll-mll	22.31	-1.90	28.52	2.05	3.27
11	mll-id	46.02	2.41*	40.36	2.35	1.01
12	id-mlr	44.71	3.33*	40.45	1.28	0.95
13	mlr-eolr	26.57	-0.35	28.03	4.21	1.38
14	eolr-ctr	27.85	-0.54	30.33	4.62	1.43
15	ctr-cnr	14.46	0.46	13.70	1.66	0.98
16	cnr-cdr	29.13	0.87	27.03	2.41	1.77
17	cnr-gor	47.21	0.49	44.94	4.59	1.23
18	ctr-gor	57.43	0.48	55.30	4.39	1.46
19	cdr-ctr	39.74	0.91	35.52	4.62	1.94
20	eolr-id	69.96	0.82	66.95	3.66	1.23
21	cdr-gn	125.48	1.04	118.37	6.82	1.88
22	cdr-pg	126.72	1.40	118.62	5.77	2.28
23	cnl-gol	45.45	0.68	42.34	4.60	2.15
24	ctl-gol	56.36	0.52	54.37	3.84	2.48
25	cdl-ctl	39.16	1.08	34.85	4.01	2.94
26	eoll-id	67.39	0.43	65.95	3.38	3.19
27	cdl-gn	121.44	0.94	116.13	5.65	2.51
28	cdl-pg	120.84	0.34	118.45	6.96	2.83
29	gor-pg	95.11	1.38	86.48	6.26	1.90
30	gol-pg	92.36	0.30	90.05	7.73	2.33
31	gor-gol	92.75	1.92	82.16	5.52	2.13
32	cdr-cdl	107.41	1.63	101.94	3.35	2.95
33	cnr-cnl	89.18	1.39	84.65	3.26	1.27
34	ctr-ctl	85.56	0.42	83.61	4.68	1.93
35	eolr-eoll	80.72	0.81	77.99	2.77	3.35
36	mlr-mll	60.88	1.72	55.44	3.16	1.18
37	cdr-gor-gn	110.97	-0.52	113.55	5.00	1.33
38	cdl-gol-gn	109.15	-0.54	110.98	3.39	2.09
39	gor-gn-gol	61.52	0.37	59.79	4.69	0.96

Table 6.16 (continued)

N	Name	Value	Z-score	Mean	SD	Exp.SD
40	gor-cdr-cnr	50.90	0.86	46.79	4.78	2.32
41	gol-cdl-cnl	52.27	2.09*	44.57	3.52	3.69
42	cdr-cnr-ctr	128.24	1.40	117.27	7.84	2.84
43	cdl-cnl-ctl	131.01	3.76*	112.19	4.48	5.00
44	cnr-ctr-eolr	76.34	3.54*	65.01	3.20	2.51
45	cnl-ctl-eoll	76.83	1.66	66.79	4.35	6.05
46	ctr-eolr-mlr	114.19	0.89	108.28	6.61	2.34
47	ctl-eoll-mll	116.11	0.62	112.66	4.36	5.54
48	eolr-id-eoll	71.95	-0.01	71.99	3.80	1.74
49	mlr-id-mll	84.28	-2.13*	86.88	0.65	1.22
50	cdr-gor-pg	107.57	-0.11	108.08	4.62	1.40
51	cdl-gol-pg	105.82	0.03	105.72	2.98	2.13
52	gor-pg-gol	59.28	0.95	55.58	3.91	1.15
53	ML(l)/NSL	37.63	0.09	37.36	2.97	1.48
54	ML(r)/NSL	37.64	-0.44	38.56	2.12	1.39
55	NL/ML(l)	33.00	-0.40	34.86	4.68	1.62
56	NL/ML(r)	34.12	-0.15	34.52	2.66	1.53
57	CL/ML(l)	95.18	1.26	83.64	9.19	3.07
58	CL/ML(r)	90.85	0.28	89.48	4.90	3.02

Mean Z-score = 0.66   SD Z-score = 1.14   RMS Z-score = 1.31

* significant at the 5% level

Table 6.17 Stretch ratio and area change comparison between the male mandible and the experimental reference mandible standard using strain analysis.

Triangle	Parameter	Value[+]	"Z-score"[+]	Mean	SD	Obs
12 16 68	% Stretch minor	2.89	1.66	-7.08	6.02	4
	% Stretch major	15.93	0.93	9.49	6.91	4
	% Area Change	19.27	1.95	1.71	9.02	4
16 68 70	% Stretch minor	0.96	0.39	-5.08	15.66	4
	% Stretch major	23.90	1.45	8.25	10.77	4
	% Area Change	25.09	0.81	3.89	26.10	4
68 70 32	% Stretch minor	-8.44	-0.03	-8.09	13.33	4
	% Stretch major	16.13	0.58	10.72	9.32	4
	% Area Change	6.33	0.17	2.47	22.19	4
16 70 28	% Stretch minor	-7.50	-0.28	-3.51	14.29	3
	% Stretch major	22.51	1.54	8.84	8.88	3
	% Area Change	13.32	0.30	5.84	24.59	3
16 28 20	% Stretch minor	6.81	0.85	-1.12	9.34	3
	% Stretch major	12.53	0.61	5.63	11.31	3
	% Area Change	20.20	0.70	5.15	21.61	3
28 20 22	% Stretch minor	-0.13	6.38	-5.55	0.85	3
	% Stretch major	13.22	1.69	7.08	3.63	3
	% Area Change	13.07	3.43	1.14	3.48	3
20 22 21	% Stretch minor	-47.60	-2.29	-11.83	15.61	4
	% Stretch major	19.44	-0.20	27.65	42.07	4
	% Area Change	-37.42	-1.04	15.06	50.32	4
13 17 69	% Stretch minor	0.71	2.47	-7.43	3.29	4
	% Stretch major	24.09	1.55	11.52	8.12	4
	% Area Change	24.97	5.64	3.04	3.89	4
17 69 71	% Stretch minor	8.04	1.26	-5.31	10.56	4
	% Stretch major	14.74	0.49	9.33	11.04	4
	% Area Change	23.97	0.99	4.12	20.09	4
69 71 33	% Stretch minor	-6.66	0.21	-8.52	8.91	4
	% Stretch major	11.69	-0.02	11.95	13.23	4
	% Area Change	4.25	0.12	2.41	14.93	4
17 71 29	% Stretch minor	-20.57	-3.60	-2.66	4.98	2
	% Stretch major	16.13	2.77	11.42	1.70	2
	% Area Change	-7.76	-2.26	8.50	7.20	2
17 29 20	% Stretch minor	-1.79	-0.19	-0.06	8.92	2
	% Stretch major	14.70	0.99	6.36	8.42	2
	% Area Change	12.65	0.33	6.66	17.90	2
29 20 22	% Stretch minor	-0.11	12.58	-4.26	0.33	2
	% Stretch major	17.36	3.60	8.76	2.39	2
	% Area Change	17.23	6.82	4.13	1.92	2

[+] See Section 6.6.1 for discussion on criteria for identification of significant stretch ratios and area changes.

Table 6.18 (a) Scaled least squares comparison of the male maxilla with the least squares experimental reference maxilla standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	0.697	0.386	1.81	1.01	nasion
23	3.111	1.138	2.73	1.87	prosthion
24	3.205	0.935	3.43	1.09	ant nasal spine
25	1.741	0.500	3.48	2.14	post nasal spine
26	4.754	1.600	2.97	1.00	upper molar (R)
27	3.807	1.313	2.90	0.72	upper molar (L)
30	2.239	0.634	3.53	0.89	zygomaxillare (R)
31	3.477	0.767	4.53	1.30	zygomaxillare (L)
36	2.116	0.889	2.13	2.38	palatine tubercle (R)
37	0.616	0.193	3.19	2.58	palatine tubercle (L)
42	2.580	0.862	2.99	0.91	nasale
46	1.963	0.849	2.31	1.40	medial orbitale (R)
47	2.552	1.537	1.66	1.39	medial orbitale (L)
54	2.349	0.748	3.14	2.20	orbitale (R)
55	1.066	0.359	2.75	2.97	orbitale (L)
56	1.941	0.525	3.70	2.96	infraorbital foramen (R)
57	3.379	0.927	3.65	2.50	infraorbital foramen (L)
66	2.041	0.691	2.95	1.43	nasal breadth (R)
67	1.260	0.449	2.81	2.61	nasal breadth (L)

Male is 4.7% larger than the standard with scale factor Z-score = 0.872
Scale factor standard deviation for this standard = 0.0542

Table 6.18 (b)   Scaled repeated median comparison of the male maxilla with the repeated median experimental reference maxilla standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	0.499	0.337	1.48	1.01	nasion
23	3.071	1.156	2.66	1.87	prosthion
24	3.134	1.003	3.12	1.09	ant nasal spine
25	1.331	0.361	3.69	2.14	post nasal spine
26	4.859	1.606	3.03	1.00	upper molar (R)
27	4.513	1.592	2.83	0.72	upper molar (L)
30	2.473	0.575	4.30	0.89	zygomaxillare (R)
31	4.049	0.861	4.71	1.30	zygomaxillare (L)
36	1.362	0.572	2.21	2.38	palatine tubercle (R)
37	0.844	0.239	3.53	2.58	palatine tubercle (L)
42	2.429	0.866	2.81	0.91	nasale
46	1.727	0.789	2.19	1.40	medial orbitale (R)
47	2.383	1.514	1.57	1.39	medial orbitale (L)
54	2.472	0.759	3.26	2.20	orbitale (R)
55	0.558	0.174	3.20	2.97	orbitale (L)
56	1.917	0.481	3.99	2.96	infraorbital foramen (R)
57	3.436	0.947	3.63	2.50	infraorbital foramen (L)
66	2.039	0.677	3.01	1.43	nasal breadth (R)
67	0.995	0.336	2.96	2.61	nasal breadth (L)

Male is 3.3% larger than the standard with scale factor Z-score = 0.499
Scale factor standard deviation for this standard = 0.0656

Table 6.18 (c)   Non-scaled least squares comparison of the male maxilla with the least squares experimental reference maxilla standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	1.542	0.853	1.81	1.01	nasion
23	3.439	1.258	2.73	1.87	prosthion
24	4.353	1.269	3.43	1.09	ant nasal spine
25	1.450	0.416	3.48	2.14	post nasal spine
26	4.827	1.624*	2.97	1.00	upper molar (R)
27	4.775	1.647*	2.90	0.72	upper molar (L)
30	3.524	0.998	3.53	0.89	zygomaxillare (R)
31	4.750	1.048	4.53	1.30	zygomaxillare (L)
36	1.662	0.698	2.13	2.38	palatine tubercle (R)
37	1.607	0.503	3.19	2.58	palatine tubercle (L)
42	2.306	0.771	2.99	0.91	nasale
46	1.506	0.651	2.31	1.40	medial orbitale (R)
47	2.882	1.736*	1.66	1.39	medial orbitale (L)
54	3.637	1.159	3.14	2.20	orbitale (R)
55	1.267	0.426	2.75	2.97	orbitale (L)
56	1.057	0.286	3.70	2.96	infraorbital foramen (R)
57	4.098	1.124	3.65	2.50	infraorbital foramen (L)
66	3.109	1.052	2.95	1.43	nasal breadth (R)
67	1.526	0.543	2.81	2.61	nasal breadth (L)

* significant at the 5% level

Table 6.18 (d) Non-scaled repeated median comparison of the male maxilla with the repeated median experimental reference maxilla standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	1.542	1.042	1.48	1.01	nasion
23	3.298	1.242	2.66	1.87	prosthion
24	4.091	1.310	3.12	1.09	ant nasal spine
25	1.483	0.402	3.69	2.14	post nasal spine
26	5.176	1.710*	3.03	1.00	upper molar (R)
27	4.719	1.665*	2.83	0.72	upper molar (L)
30	3.384	0.787	4.30	0.89	zygomaxillare (R)
31	4.654	0.989	4.71	1.30	zygomaxillare (L)
36	1.335	0.561	2.21	2.38	palatine tubercle (R)
37	1.538	0.435	3.53	2.58	palatine tubercle (L)
42	2.061	0.734	2.81	0.91	nasale
46	1.837	0.839	2.19	1.40	medial orbitale (R)
47	2.411	1.531	1.57	1.39	medial orbitale (L)
54	3.782	1.162	3.26	2.20	orbitale (R)
55	0.658	0.206	3.20	2.97	orbitale (L)
56	0.809	0.203	3.99	2.96	infraorbital foramen (R)
57	3.881	1.069	3.63	2.50	infraorbital foramen (L)
66	3.130	1.040	3.01	1.43	nasal breadth (R)
67	1.331	0.449	2.96	2.61	nasal breadth (L)

* significant at the 5% level

Table 6.19 Distance and angle comparison of the male maxilla with the experimental reference maxilla standard using Z-scores.

N	Name	Value	Z-score	Mean	SD	Exp.SD
1	n-morr	15.58	0.97	13.18	2.47	1.72
2	morr-orr	26.32	0.41	25.24	1.94	2.60
3	orr-zmr	29.20	0.15	28.78	2.72	2.37
4	zmr-mur	25.86	-1.11	29.20	3.00	1.34
5	mur-pr	49.05	2.84*	43.04	1.59	2.12
6	pr-mul	49.53	3.07*	43.40	1.91	2.00
7	mul-zml	27.27	-0.01	27.31	3.35	1.49
8	zml-orl	28.42	0.34	27.24	3.45	3.25
9	orl-morl	24.69	-0.02	24.77	0.77	3.28
10	morl-n	15.30	1.05	13.40	1.81	1.72
11	n-na	20.54	1.14	17.60	2.58	1.36
12	na-nabr	27.24	-0.04	27.39	3.85	1.70
13	na-nabl	23.63	-0.36	24.79	3.20	2.77
14	nabr-ans	16.73	0.61	15.63	1.78	1.80
15	nabl-ans	17.00	0.46	14.91	4.56	2.83
16	ans-pr	11.78	-1.81	15.72	2.18	2.17
17	ans-pns	55.19	0.56	51.60	6.44	2.41
18	pns-scr	15.36	-0.06	15.56	3.28	3.20
19	pns-scl	17.47	0.44	16.00	3.22	3.35
20	mur-orr	39.72	-0.44	41.88	4.91	2.42
21	mul-orl	40.68	-0.13	41.30	4.68	3.06
22	mur-iofr	29.81	-0.68	31.95	3.14	3.13
23	mul-iofl	30.41	0.20	29.55	4.22	2.61
24	n-pr	59.12	0.05	58.83	6.14	2.12
25	n-ans	47.99	1.00	44.07	3.92	1.49
26	na-ans	28.33	0.19	27.85	2.46	1.42
27	nabr-zmr	44.39	1.92	40.80	1.87	1.68
28	nabl-zml	44.45	1.52	40.01	1.22	2.92
29	nabr-nabl	26.72	0.32	25.76	3.04	2.98
30	zmr-zml	96.60	3.13*	91.68	1.44	1.57
31	mur-mul	65.74	5.46*	58.31	1.36	1.24
32	scr-scl	27.61	0.29	26.59	3.09	3.51
33	iofr-iofl	54.83	0.34	53.51	0.81	3.88
34	orr-orl	63.63	1.18	59.27	2.49	3.70
35	morr-morl	26.23	1.07	22.98	3.05	1.97
36	ans-scr	64.54	0.23	63.48	4.61	2.62
37	ans-scl	66.27	0.40	63.86	6.03	2.80
38	n-pns	63.79	0.37	62.10	4.53	2.37
39	pns-ba	45.91	0.25	44.09	7.38	3.42
40	morl-n-morr	116.31	-0.45	120.68	9.78	5.76

Table 6.19 (continued)

N	Name	Value	Z-score	Mean	SD	Exp.SD
41	n-morr-orr	168.87	0.78	162.19	8.54	5.29
42	morr-orr-zmr	155.63	-0.28	157.80	7.78	4.06
43	orr-zmr-mur	92.12	-0.02	92.29	7.42	3.03
44	mur-pr-mul	83.65	-0.39	84.94	3.33	2.23
45	n-morl-orl	154.02	-1.13	162.07	7.10	5.89
46	morl-orl-zml	148.62	-1.20	155.57	2.83	5.77
47	orl-zml-mul	93.83	-0.56	97.94	7.39	4.17
48	zmr-ans-zml	108.59	-1.31	117.27	6.61	1.32
49	s-n-na	107.97	-0.10	109.05	10.50	2.84
50	n-na-nabr	132.56	-0.21	134.90	11.01	3.15
51	n-na-nabl	128.77	0.17	127.07	10.24	4.78
52	na-nabr-ans	76.06	0.22	74.41	7.61	4.90
53	na-nabl-ans	86.79	0.18	85.61	6.48	6.52
54	nabr-ans-nabl	104.75	-1.47	114.82	4.60	6.84
55	NL/NSL	8.73	0.38	7.01	4.58	1.90
56	n-s-pns	67.72	-0.15	68.29	3.79	3.25
57	pns-s-ba	62.29	-0.49	64.29	3.66	4.10
58	pns-ans-pr	124.77	1.02	116.18	8.44	5.70
59	na-n-g	126.37	-2.59*	138.39	2.43	4.64
60	sorr-n-g	84.53	1.28	72.55	9.35	4.49
61	sorl-n-g	80.22	-0.43	83.92	8.60	5.16
62	sorr-n-na	107.02	0.81	104.26	1.58	3.40
63	sorl-n-na	113.50	0.62	110.88	2.05	4.25

Mean Z-score = 0.32   SD Z-score = 1.21   RMS Z-score = 1.24

* significant at the 5% level

Table 6.20   Stretch ratio and area change comparison between the male maxilla and the experimental reference maxilla standard using strain analysis.

Triangle	Parameter	Value[+]	"Z-score"[+]	Mean	SD	Obs
2 42 46	% Stretch minor	16.97	1.25	-4.92	17.49	4
	% Stretch major	19.17	0.79	5.68	17.18	4
	% Area Change	39.40	1.05	2.64	35.04	4
42 46 66	% Stretch minor	-1.22	0.75	-9.87	11.53	4
	% Stretch major	19.78	0.47	10.06	20.89	4
	% Area Change	18.32	0.57	0.91	30.51	4
46 66 54	% Stretch minor	0.42	1.14	-8.19	7.58	4
	% Stretch major	15.08	1.21	7.17	6.54	4
	% Area Change	15.56	1.44	-1.49	11.83	4
26 54 66	% Stretch minor	-5.58	0.16	6.72	6.97	4
	% Stretch major	19.62	2.92	6.02	4.66	4
	% Area Change	12.95	1.44	-1.01	9.68	4
26 54 30	% Stretch minor	-12.18	-0.48	-7.69	9.41	4
	% Stretch major	1.86	-0.81	6.94	6.30	4
	% Area Change	-10.54	-0.64	-0.93	15.13	4
66 24 26	% Stretch minor	1.98	0.78	-12.01	17.84	4
	% Stretch major	8.08	-0.40	11.14	7.71	4
	% Area Change	10.22	0.47	-1.43	24.83	4
24 26 23	% Stretch minor	-28.29	-2.52	-6.87	8.51	4
	% Stretch major	14.21	0.82	7.59	8.03	4
	% Area Change	-18.10	-1.25	0.47	14.83	4
66 42 24	% Stretch minor	-0.52	0.55	-8.68	14.77	4
	% stretch major	8.25	-0.12	8.79	4.36	4
	% Area Change	7.68	0.44	-0.48	18.35	4
26 30 36	% Stretch minor	-13.00	-1.54	-5.76	4.71	3
	% Stretch major	-2.59	-2.41	8.22	4.48	3
	% Area Change	-15.25	-2.60	1.99	6.63	3
36 25 23	% Stretch minor	-4.10	1.10	-10.51	5.84	3
	% Stretch major	3.69	-1.59	14.76	6.97	3
	% Area Change	-0.56	-0.27	2.95	12.84	3
24 2 25	% Stretch minor	2.26	0.59	-4.20	10.99	4
	% Stretch major	11.38	0.90	3.50	8.78	4
	% Area Change	13.89	0.75	-0.17	18.79	4
2 42 47	% Stretch minor	13.82	1.43	-5.47	13.51	4
	% Stretch major	19.19	1.12	6.37	11.40	4
	% Area Change	35.67	1.37	1.66	24.80	4

Table 6.20 (continued)

Triangle	Parameter	Value[+]	"Z-score"[+]	Mean	SD	Obs
42 47 67	% Stretch minor	-4.52	0.51	-9.50	9.67	4
	% Stretch major	19.47	0.86	9.80	11.21	4
	% Area Change	14.07	0.65	0.17	21.39	4
47 67 55	% Stretch minor	-2.09	1.12	-6.76	4.16	4
	% Stretch major	8.55	0.88	5.54	3.43	4
	% Area Change	6.29	1.56	-1.61	5.07	4
27 55 67	% Stretch minor	-2.83	0.24	-4.72	7.74	4
	% Stretch major	12.94	1.44	3.98	6.24	4
	% Area Change	9.74	0.78	-0.61	13.24	4
27 55 31	% Stretch minor	-2.79	0.76	-10.00	9.50	4
	% Stretch major	8.57	-0.38	10.25	4.43	4
	% Area Change	5.54	0.41	-0.47	14.54	4
67 24 27	% Stretch minor	-1.36	0.47	-11.20	20.98	4
	% Stretch major	19.24	0.39	12.50	17.12	4
	% Area Change	17.62	0.43	2.44	35.07	4
24 27 23	% Stretch minor	-24.56	-1.29	-9.41	11.71	4
	% Stretch major	14.77	0.50	9.98	9.50	4
	% Area Change	-13.42	-0.68	0.14	19.80	4
67 42 24	% Stretch minor	-4.35	0.32	-11.58	22.80	4
	% Stretch major	15.78	0.18	12.95	15.84	4
	% Area Change	10.75	0.24	1.91	36.91	4
27 31 37	% Stretch minor	-0.85	7.23	-9.60	1.21	3
	% Stretch major	-0.01	-1.17	8.66	7.38	3
	% Area Change	-0.87	0.11	-1.71	7.98	3
37 25 23	% Stretch minor	3.31	1.53	-6.79	6.62	3
	% Stretch major	18.11	-0.42	22.31	9.96	3
	% Area Change	22.02	0.65	13.99	12.39	3

[+] See Section 6.6.1 for discussion on criteria for identification of significant stretch ratios and area changes.

Table 6.21 (a) Scaled least squares comparison of the male orbit with the least squares experimental reference orbit standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	2.554	1.238	2.06	1.01	nasion
40	4.479	1.776*	2.52	0.77	optic foramen (R)
41	3.996	0.820	4.87	1.02	optic foramen (L)
42	3.628	0.949	3.82	0.91	nasale
46	1.928	0.798	2.41	1.40	medial orbitale (R)
47	1.306	0.940	1.27	1.39	medial orbitale (L)
48	3.974	1.563	2.54	1.83	superior orbitale (R)
49	2.364	0.716	1.95	3.30	superior orbitale (L)
50	1.769	0.951	1.86	0.81	lateral orbitale (R)
51	2.073	0.489	2.49	4.24	lateral orbitale (L)
52	2.107	0.924	2.28	1.44	opposite orbitale (R)
53	4.246	1.519	2.79	1.65	opposite orbitale (L)
54	1.790	0.815	1.75	2.20	orbitale (R)
55	1.752	0.589	1.82	2.97	orbitale (L)
56	1.994	0.674	2.74	2.96	infraorbital foramen (R)
57	4.057	1.196	3.39	2.50	infraorbital foramen (L)
62	3.417	1.378	2.48	0.77	zygomatic corner (R)
63	3.534	1.130	3.13	1.18	zygomatic corner (L)

Male is 5.3% larger than the standard with scale factor Z-score = 1.849
Scale factor standard deviation for this standard = 0.0285

* significant at the 5% level

Table 6.21 (b) Scaled repeated median comparison of the male orbit with the repeated median experimental reference orbit standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	1.891	0.964	1.96	1.01	nasion
40	6.126	3.991*	1.53	0.77	optic foramen (R)
41	6.376	1.189	5.36	1.02	optic foramen (L)
42	3.247	0.814	3.99	0.91	nasale
46	1.809	0.869	2.08	1.40	medial orbitale (R)
47	0.921	0.663	1.38	1.39	medial orbitale (L)
48	2.609	1.096	2.38	1.83	superior orbitale (R)
49	2.824	0.855	2.07	3.30	superior orbitale (L)
50	1.160	0.465	2.50	0.81	lateral orbitale (R)
51	2.056	0.485	2.97	4.24	lateral orbitale (L)
52	1.581	0.612	2.58	1.44	opposite orbitale (R)
53	3.677	1.290	2.85	1.65	opposite orbitale (L)
54	2.390	1.088	1.88	2.20	orbitale (R)
55	2.852	0.959	1.86	2.97	orbitale (L)
56	2.558	0.864	2.93	2.96	infraorbital foramen (R)
57	5.849	1.703*	3.43	2.50	infraorbital foramen (L)
62	2.767	1.220	2.27	0.77	zygomatic corner (R)
63	1.767	0.558	3.17	1.18	zygomatic corner (L)

Male is 5.1% larger than the standard with scale factor Z-score = 1.526
Scale factor standard deviation for this standard = 0.0336

* significant at the 5% level

Table 6.21 (c)   Non-scaled least squares comparison of the orbit mandible with
the least squares experimental reference orbit standard using the
d/σ-score.

Landmark No	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	3.437	1.666*	2.06	1.01	nasion
40	6.215	2.464*	2.52	0.77	optic foramen (R)
41	4.930	1.012	4.87	1.02	optic foramen (L)
42	4.722	1.235	3.82	0.91	nasale
46	2.581	1.069	2.41	1.40	medial orbitale (R)
47	2.174	1.564	1.27	1.39	medial orbitale (L)
48	4.191	1.648*	2.54	1.83	superior orbitale (R)
49	1.491	0.451	1.95	3.30	superior orbitale (L)
50	1.593	0.856	1.86	0.81	lateral orbitale (R)
51	1.745	0.412	2.49	4.24	lateral orbitale (L)
52	2.381	1.044	2.28	1.44	opposite orbitale (R)
53	3.126	1.119	2.79	1.65	opposite orbitale (L)
54	3.487	1.587	1.75	2.20	orbitale (R)
55	2.502	0.841	1.82	2.97	orbitale (L)
56	2.041	0.689	2.74	2.96	infraorbital foramen (R)
57	4.989	1.470	3.39	2.50	infraorbital foramen (L)
62	5.175	2.087*	2.48	0.77	zygomatic corner (R)
63	4.798	1.534	3.13	1.18	zygomatic corner (L)

* significant at the 5% level

Table 6.21 (d) Non-scaled repeated median comparison of the male orbit with the repeated median experimental reference orbit standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	2.777	1.416	1.96	1.01	nasion
40	7.587	4.943*	1.53	0.77	optic foramen (R)
41	7.057	1.316	5.36	1.02	optic foramen (L)
42	4.312	1.081	3.99	0.91	nasale
46	2.519	1.211	2.08	1.40	medial orbitale (R)
47	1.662	1.195	1.38	1.39	medial orbitale (L)
48	2.868	1.205	2.38	1.83	superior orbitale (R)
49	2.002	0.606	2.07	3.30	superior orbitale (L)
50	1.911	0.765	2.50	0.81	lateral orbitale (R)
51	1.453	0.343	2.97	4.24	lateral orbitale (L)
52	2.681	1.037	2.58	1.44	opposite orbitale (R)
53	2.389	0.838	2.85	1.65	opposite orbitale (L)
54	4.162	1.894*	1.88	2.20	orbitale (R)
55	3.230	1.086	1.86	2.97	orbitale (L)
56	2.945	0.995	2.93	2.96	infraorbital foramen (R)
57	6.481	1.887*	3.43	2.50	infraorbital foramen (L)
62	5.225	2.303*	2.27	0.77	zygomatic corner (R)
63	3.506	1.106	3.17	1.18	zygomatic corner (L)

* significant at the 5% level

Table 6.22   Distance and angle comparison of the male orbit with the experimental reference orbit standard using Z-scores.

N	Name	Value	Z-score	Mean	SD	Exp.SD
1	n-na	20.54	1.14	17.60	2.58	1.36
2	n-morr	15.58	0.97	13.18	2.47	1.72
3	morr-sorr	22.51	-0.12	22.81	2.58	2.30
4	sorr-lorr	31.29	1.33	28.12	2.38	2.00
5	lorr-oorr	10.18	-0.10	10.35	1.62	1.65
6	oorr-orr	17.43	-0.22	18.00	0.43	2.63
7	orr-morr	26.32	0.41	25.24	1.94	2.60
8	morr-ofr	54.74	3.90*	48.54	0.00	1.59
9	sorr-ofr	57.91	4.47*	49.06	0.60	1.98
10	lorr-ofr	53.68	4.51*	48.68	0.36	1.11
11	oorr-ofr	56.02	1.80	52.34	2.04	1.63
12	orr-ofr	57.28	2.84*	50.67	2.25	2.33
13	orr-iofr	13.48	0.67	11.00	2.95	3.69
14	n-morl	15.30	1.05	13.40	1.81	1.72
15	morl-sorl	21.68	-0.40	23.10	1.05	3.58
16	sorl-lorl	29.27	0.43	26.94	1.17	5.37
17	lorl-oorl	12.12	-0.11	12.60	0.92	4.54
18	oorl-orl	16.70	0.38	15.41	1.05	3.40
19	orl-morl	24.69	-0.02	24.77	0.77	3.28
20	morl-ofl	51.17	0.77	47.93	4.22	1.73
21	sorl-ofl	52.95	1.10	49.13	1.37	3.46
22	lorl-ofl	53.03	0.70	49.96	3.41	4.36
23	oorl-ofl	52.85	-0.23	54.65	7.68	1.94
24	orl-ofl	56.60	0.60	52.38	6.98	3.14
25	orl-iofl	12.10	-0.27	13.15	1.24	3.89
26	morr-lorr	39.97	0.24	39.59	0.31	1.61
27	sorr-orr	32.48	0.67	30.56	2.29	2.86
28	morl-lorl	38.68	-0.05	38.91	0.61	4.46
29	sorl-orl	32.31	0.48	30.16	1.47	4.44
30	morr-morl	26.23	1.07	22.98	3.05	1.97
31	sorr-sorl	57.76	-0.41	59.31	1.17	3.77
32	lorr-lorl	97.89	0.45	95.96	2.12	4.31
33	oorr-oorl	90.20	0.19	89.40	4.17	2.19
34	orr-orl	63.63	1.18	59.27	2.49	3.70
35	iofr-iofl	54.83	0.34	53.51	0.81	3.88
36	ofr-ofl	21.72	-2.71*	25.81	1.51	1.28
37	oorr-zcr	19.72	1.11	17.57	1.95	1.64
38	oorl-zcl	20.88	0.75	19.32	2.08	2.03
39	morl-n-morr	116.31	-0.45	120.68	9.78	5.76
40	morr-sorr-lorr	94.55	-1.43	101.44	4.81	4.09
41	sorr-lorr-oorr	107.46	0.39	104.36	8.04	6.62

Table 6.22 (continued)

N	Name	Value	Z-score	Mean	SD	Exp.SD
42	lorr-oorr-orr	121.07	-0.01	121.17	6.88	7.95
43	oorr-orr-morr	125.00	0.23	123.64	4.71	5.78
44	orr-morr-sorr	83.00	0.55	79.04	7.20	4.68
45	sorr-ofr-orr	32.75	-1.79	37.14	2.45	1.98
46	morr-ofr-lorr	43.25	-3.58*	47.97	0.15	1.32
47	morl-sorl-lorl	97.68	-0.50	101.83	2.21	8.26
48	sorl-lorl-oorl	95.81	-0.28	99.51	2.09	12.99
49	lorl-oorl-orl	134.38	0.86	122.82	7.55	13.49
50	oorl-orl-morl	113.12	-1.65	127.71	8.34	8.84
51	orl-morl-sorl	88.09	1.53	78.02	4.67	6.58
52	sorl-ofl-orl	34.10	-0.18	34.70	0.77	3.23
53	morl-ofl-lorl	43.54	-0.95	47.61	4.29	3.29
54	ofr-n-ofl	21.25	-5.00*	28.05	1.36	1.20
55	ofr-s-ofl	102.69	3.42*	79.99	6.63	6.16

Mean Z-score = 0.37   SD Z-score = 1.63   RMS Z-score = 1.66

* significant at the 5% level

Table 6.23   Stretch ratio and area change comparison between the male orbit and the experimental reference orbit standard using strain analysis.

Triangle	Parameter	Value[+]	"Z-score"[+]	Mean	SD	Obs
48 50 52	% Stretch minor	-1.32	0.95	-9.07	8.16	4
	% Stretch major	12.38	0.05	11.75	11.84	4
	% Area Change	10.90	0.49	2.00	18.10	4
52 48 54	% Stretch minor	-4.66	-0.53	-3.26	2.62	4
	% Stretch major	11.64	1.25	4.81	5.47	4
	% Area Change	6.44	0.62	1.49	7.99	4
48 54 46	% Stretch minor	-2.18	2.09	-6.65	2.14	4
	% Stretch major	7.53	0.01	7.38	11.17	4
	% Area Change	5.19	0.39	0.38	12.34	4
46 48 40	% Stretch minor	-2.14	1.41	-6.92	3.39	2
	% Stretch major	20.81	817.50	4.46	0.02	2
	% Area Change	18.22	5.98	-2.77	3.51	2
40 48 50	% Stretch minor	6.92	5.39	1.42	1.02	2
	% Stretch major	21.98	2.21	6.76	6.90	2
	% Area Change	30.42	2.74	8.32	8.08	2
40 50 52	% Stretch minor	-0.30	0.86	-8.06	9.05	2
	% Stretch major	14.87	0.04	14.35	14.09	2
	% Area Change	14.52	0.38	5.78	23.30	2
40 52 54	% Stretch minor	-5.08	2.10	-6.53	0.69	2
	% Stretch major	17.25	3.60	11.03	1.73	2
	% Area Change	11.29	8.73	3.78	0.86	2
54 40 46	% Stretch minor	5.02	0.79	-0.81	7.34	2
	% Stretch major	17.94	2.46	8.20	3.96	2
	% Area Change	23.86	1.38	7.47	11.87	2
49 51 53	% Stretch minor	0.03	0.10	-0.48	4.95	4
	% Stretch major	11.78	0.82	6.42	6.54	4
	% Area Change	11.81	0.54	6.05	10.61	4
53 49 55	% Stretch minor	4.55	1.04	-2.78	7.08	4
	% Stretch major	11.62	1.38	4.54	5.12	4
	% Area Change	16.70	1.27	1.82	11.73	4
49 55 47	% Stretch minor	-10.57	-8.05	-3.97	0.82	4
	% Stretch major	8.03	0.85	4.91	3.69	4
	% Area Change	-3.39	-1.39	0.74	2.98	4
47 49 41	% Stretch minor	-5.74	-1.42	-3.78	1.38	2
	% Stretch major	11.32	0.77	9.16	2.79	2
	% Area Change	4.93	-0.08	5.02	1.18	2

Table 6.23 (continued)

Triangle	Parameter	Value[+]	"Z-score"[+]	Mean	SD	Obs
41 49 51	% Stretch minor	4.51	0.78	-1.40	7.62	2
	% Stretch major	12.89	3.00	5.24	2.55	2
	% Area Change	17.98	1.34	3.86	10.52	2
41 51 53	% Stretch minor	-8.19	0.55	-13.29	9.33	2
	% Stretch major	16.18	-0.58	20.40	7.30	2
	% Area Change	6.66	0.53	4.05	4.91	2
41 53 55	% Stretch minor	-10.44	-1.01	0.79	11.14	2
	% Stretch major	26.48	1.60	5.92	12.87	2
	% Area Change	13.27	0.23	7.48	24.78	2
55 41 47	% Stretch minor	-0.24	0.36	-2.74	7.04	2
	% Stretch major	11.47	0.59	7.54	6.67	2
	% Area Change	11.20	0.45	4.83	14.04	2

[+] See Section 6.6.1 for discussion on criteria for identification of significant stretch ratios and area changes.

Table 6.24 (a)   Scaled least squares comparison of the male zygoma with the least squares experimental reference zygoma standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
7	2.681	0.497	5.39	1.61	mastoid tip (L)
8	1.879	0.580	3.24	1.44	mastoid tip (R)
10	2.519	0.919	2.74	1.72	ext auditory meatus (R)
11	1.017	0.359	2.84	2.37	ext auditory meatus (L)
30	0.430	0.096	4.49	0.89	zygomaxillare (R)
31	2.252	0.511	4.41	1.30	zygomaxillare (L)
50	1.582	0.549	2.88	0.81	lateral orbitale (R)
51	2.220	0.494	4.49	4.24	lateral orbitale (L)
52	1.175	0.352	3.34	1.44	opposite orbitale (R)
53	3.797	1.439	2.64	1.65	opposite orbitale (L)
54	2.117	0.866	2.44	2.20	orbitale (R)
55	2.694	0.906	2.66	2.97	orbitale (L)
56	2.764	0.934	2.65	2.96	infraorbital foramen (R)
57	5.045	1.128	4.47	2.50	infraorbital foramen (L)
58	2.424	0.674	3.60	1.74	articular eminence (R)
59	2.847	0.538	5.30	3.17	articular eminence (L)
62	2.354	1.137	2.07	0.77	zygomatic corner (R)
63	1.747	0.742	2.35	1.18	zygomatic corner (L)

Male is 4.6% larger than the standard with scale factor Z-score = 1.861
Scale factor standard deviation for this standard = 0.0246

Table 6.24 (b)   Scaled repeated median comparison of the male zygoma with
the repeated median experimental reference zygoma standard
using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
7	2.640	0.454	5.81	1.61	mastoid tip (L)
8	1.898	0.586	3.24	1.44	mastoid tip (R)
10	2.737	0.977	2.80	1.72	ext auditory meatus (R)
11	2.134	0.624	3.42	2.37	ext auditory meatus (L)
30	0.482	0.098	4.93	0.89	zygomaxillare (R)
31	2.528	0.502	5.03	1.30	zygomaxillare (L)
50	1.607	0.584	2.75	0.81	lateral orbitale (R)
51	1.725	0.379	4.56	4.24	lateral orbitale (L)
52	0.924	0.287	3.22	1.44	opposite orbitale (R)
53	3.573	1.249	2.86	1.65	opposite orbitale (L)
54	2.434	1.108	2.11	2.20	orbitale (R)
55	2.832	0.953	2.66	2.97	orbitale (L)
56	2.933	0.991	2.67	2.96	infraorbital foramen (R)
57	5.399	1.149	4.70	2.50	infraorbital foramen (L)
58	2.295	0.628	3.66	1.74	articular eminence (R)
59	3.387	0.636	5.33	3.17	articular eminence (L)
62	2.157	1.260	1.71	0.77	zygomatic corner (R)
63	2.055	1.061	1.94	1.18	zygomatic corner (L)

Male is 3.9% larger than the standard with scale factor Z-score = 1.565
Scale factor standard deviation for this standard = 0.0251

Table 6.24 (c)   Non-scaled least squares comparison of the male zygoma with the least squares experimental reference zygoma standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
7	2.820	0.523	5.39	1.61	mastoid tip (L)
8	4.293	1.326	3.24	1.44	mastoid tip (R)
10	1.536	0.560	2.74	1.72	ext auditory meatus (R)
11	3.112	1.097	2.84	2.37	ext auditory meatus (L)
30	2.406	0.535	4.49	0.89	zygomaxillare (R)
31	2.932	0.665	4.41	1.30	zygomaxillare (L)
50	2.232	0.774	2.88	0.81	lateral orbitale (R)
51	1.452	0.323	4.49	4.24	lateral orbitale (L)
52	1.640	0.491	3.34	1.44	opposite orbitale (R)
53	1.775	0.673	2.64	1.65	opposite orbitale (L)
54	4.220	1.727*	2.44	2.20	orbitale (R)
55	4.085	1.374	2.66	2.97	orbitale (L)
56	3.835	1.295	2.65	2.96	infraorbital foramen (R)
57	6.888	1.540	4.47	2.50	infraorbital foramen (L)
58	5.381	1.497	3.60	1.74	articular eminence (R)
59	5.346	1.010	5.30	3.17	articular eminence (L)
62	4.008	1.937*	2.07	0.77	zygomatic corner (R)
63	3.553	1.510	2.35	1.18	zygomatic corner (L)

* significant at the 5% level

Table 6.24 (d) Non-scaled repeated median comparison of the male zygoma with the repeated median experimental reference zygoma standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
7	1.168	0.201	5.81	1.61	mastoid tip (L)
8	2.958	0.914	3.24	1.44	mastoid tip (R)
10	0.550	0.196	2.80	1.72	ext auditory meatus (R)
11	2.596	0.759	3.42	2.37	ext auditory meatus (L)
30	2.478	0.503	4.93	0.89	zygomaxillare (R)
31	2.663	0.529	5.03	1.30	zygomaxillare (L)
50	2.671	0.971	2.75	0.81	lateral orbitale (R)
51	0.642	0.141	4.56	4.24	lateral orbitale (L)
52	1.838	0.570	3.22	1.44	opposite orbitale (R)
53	1.559	0.545	2.86	1.65	opposite orbitale (L)
54	4.704	2.141*	2.11	2.20	orbitale (R)
55	4.472	1.504	2.66	2.97	orbitale (L)
56	4.295	1.450	2.67	2.96	infraorbital foramen (R)
57	7.333	1.560	4.70	2.50	infraorbital foramen (L)
58	4.898	1.339	3.66	1.74	articular eminence (R)
59	4.840	0.908	5.33	3.17	articular eminence (L)
62	3.698	2.160*	1.71	0.77	zygomatic corner (R)
63	3.185	1.645*	1.94	1.18	zygomatic corner (L)

* significant at the 5% level

Table 6.25   Distance and angle comparison of the male zygoma with the experimental reference zygoma standard using Z-scores.

N	Name	Value	Z-score	Mean	SD	Exp.SD
1	lorr-zcr	19.06	2.29*	16.38	1.17	1.12
2	zcr-eamr	59.43	0.49	58.49	1.53	1.89
3	eamr-aer	25.91	0.73	24.12	2.33	2.45
4	aer-zmr	45.58	0.87	43.08	2.87	1.96
5	zmr-orr	29.20	0.15	28.78	2.72	2.37
6	orr-oorr	17.43	-0.22	18.00	0.43	2.63
7	oorr-lorr	10.18	-0.10	10.35	1.62	1.65
8	lorl-zcl	18.13	-0.09	18.52	2.50	4.40
9	zcl-eaml	60.29	0.44	59.11	2.50	2.65
10	eaml-ael	24.13	-0.06	24.38	2.61	3.96
11	ael-zml	46.64	0.47	45.04	3.23	3.43
12	zml-orl	28.42	0.34	27.24	3.45	3.25
13	orl-oorl	16.70	0.38	15.41	1.05	3.40
14	oorl-lorl	12.12	-0.11	12.60	0.92	4.54
15	zmr-oorr	22.96	0.16	22.28	4.36	1.69
16	zmr-zcr	25.16	0.53	22.65	4.77	1.18
17	zmr-eamr	66.92	0.53	65.07	3.47	1.94
18	zcr-oorr	19.72	1.11	17.57	1.95	1.64
19	zml-oorl	21.80	-0.26	23.16	5.27	2.10
20	zml-zcl	25.03	0.09	24.56	4.97	1.76
21	zml-eaml	68.62	0.26	67.71	3.48	2.70
22	zcl-oorl	20.88	0.75	19.32	2.08	2.03
23	zmr-zml	96.60	3.13*	91.68	1.44	1.57
24	aer-ael	116.86	1.82	107.43	5.18	3.62
25	eamr-eaml	96.85	0.64	94.98	0.68	2.93
26	zcr-zcl	117.58	3.27*	111.24	1.94	1.41
27	lorr-lorl	97.89	0.45	95.96	2.12	4.31
28	oorr-oorl	90.20	0.19	89.40	4.17	2.19
29	orr-orl	63.63	1.18	59.27	2.49	3.70
30	lorr-oorr-eamr	81.26	0.80	73.78	9.32	6.36
31	lorl-oorl-eaml	81.13	0.18	77.69	18.71	11.20
32	lorr-zcr-eamr	127.42	0.28	125.79	5.86	2.54
33	zcr-eamr-zmr	21.96	0.62	20.05	3.07	1.46
34	eamr-zmr-orr	114.89	0.21	112.46	11.40	2.81
35	zmr-orr-oorr	51.82	0.16	50.41	9.01	5.54
36	orr-oorr-lorr	121.07	-0.01	121.17	6.88	7.95

Table 6.25 (continued)

N	Name	Value	Z-score	Mean	SD	Exp.SD
37	oorr-lorr-zcr	78.42	-0.01	78.50	6.03	6.69
38	lorl-zcl-eaml	130.51	0.10	129.59	9.47	8.25
39	zcl-eaml-zml	21.14	0.12	20.75	3.40	1.94
40	eaml-zml-orl	119.10	1.02	109.70	9.17	3.89
41	zml-orl-oorl	49.92	-0.78	57.56	9.80	8.46
42	orl-oorl-lorl	134.38	0.86	122.82	7.55	13.49
43	oorl-lorl-zcl	84.82	0.78	74.05	8.69	13.78

Mean Z-score = 0.55   SD Z-score = 0.80   RMS Z-score = 0.97

* significant at the 5% level

Table 6.26 Stretch ratio and area change comparison between the male zygoma and the experimental reference zygoma standard using strain analysis.

Triangle	Parameter	Value[+]	"Z-score"[+]	Mean	SD	Obs
30 54 52	% Stretch minor	-3.43	0.67	-9.53	9.14	4
	% Stretch major	3.58	-0.42	9.35	13.63	4
	% Area Change	0.03	0.02	-0.37	21.17	4
52 30 62	% Stretch minor	3.23	0.64	-5.67	13.81	4
	% Stretch major	15.96	0.51	6.59	18.54	4
	% Area Change	19.71	0.54	2.38	32.04	4
52 50 62	% Stretch minor	-1.02	0.70	-7.46	9.25	4
	% Stretch major	17.27	0.81	8.75	10.53	4
	% Area Change	16.07	0.73	1.34	20.09	4
30 62 10	% Stretch minor	0.84	1.38	-9.97	7.86	4
	% Stretch major	11.23	0.15	9.14	14.00	4
	% Area Change	12.16	0.74	-1.32	18.20	4
31 55 53	% Stretch minor	-8.12	0.17	-10.46	13.64	4
	% Stretch major	11.03	0.06	10.22	13.74	4
	% Area Change	2.01	0.08	-0.15	26.37	4
53 31 63	% Stretch minor	-5.63	0.34	-11.21	16.48	4
	% Stretch major	9.47	-0.13	11.17	13.28	4
	% Area Change	3.31	0.10	0.33	29.83	4
53 51 63	% Stretch minor	-6.94	0.18	-7.87	5.23	4
	% Stretch major	10.03	-0.24	12.25	9.11	4
	% Area Change	2.40	-0.10	3.67	13.04	4
31 63 11	% Stretch minor	0.75	1.06	-9.97	10.11	4
	% Stretch major	2.95	-0.49	9.26	12.81	4
	% Area Change	3.73	0.22	-0.86	20.80	4

[+] See Section 6.6.1 for discussion on criteria for identification of significant stretch ratios and area changes.

Table 6.27 (a) Scaled least squares comparison of the male cranium with the least squares experimental reference cranium standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	2.387	0.716	3.34	2.24	sella
2	1.449	0.426	3.40	1.01	nasion
3	8.417	2.257*	3.73	2.11	glabella
4	3.236	0.800	4.05	2.76	vertex
5	6.218	1.235	5.04	0.85	opisthocranion
6	3.168	1.017	3.12	0.45	opisthion
7	2.889	0.511	5.65	1.61	mastoid tip (L)
8	3.525	0.815	4.33	1.44	mastoid tip (R)
9	1.938	0.334	5.80	2.66	basion
10	2.427	0.545	4.46	1.72	ext auditory meatus (R)
11	2.770	0.609	4.55	2.37	ext auditory meatus (L)
43	7.256	11.779*	0.00	0.62	bregma
64	3.268	1.033	3.16	2.55	zygomatic frontal (R)
65	3.804	1.148	3.31	2.61	zygomatic frontal (L)
78	4.635	0.561	8.27	1.86	foramen mag breadth (R)
79	6.699	0.845	7.92	1.22	foramen mag breadth (L)

Male is 4.8% larger than the standard with scale factor Z-score = 1.276
Scale factor standard deviation for the standard = 0.0378

* significant at the 5% level

Table 6.27 (b) Scaled repeated median comparison of the male cranium with the repeated median experimental reference cranium standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	1.596	0.529	3.02	2.24	sella
2	2.062	0.635	3.25	1.01	nasion
3	9.080	2.561*	3.55	2.11	glabella
4	4.199	0.983	4.27	2.76	vertex
5	5.602	0.889	6.30	0.85	opisthocranion
6	2.125	0.869	2.44	0.45	opisthion
7	3.759	0.602	6.24	1.61	mastoid tip (L)
8	3.482	0.717	4.86	1.44	mastoid tip (R)
9	2.066	0.312	6.62	2.66	basion
10	2.487	0.608	4.09	1.72	ext auditory meatus (R)
11	3.642	0.821	4.43	2.37	ext auditory meatus (L)
43	8.460	13.733*	0.00	0.62	bregma
64	3.573	1.053	3.39	2.55	zygomatic frontal (R)
65	3.324	0.944	3.52	2.61	zygomatic frontal (L)
78	4.934	0.584	8.45	1.86	foramen mag breadth (R)
79	5.972	0.748	7.99	1.22	foramen mag breadth (L)

Male is 4.0% larger than the standard with scale factor Z-score = 1.569
Scale factor standard deviation for this standard = 0.0253

* significant at the 5% level

Table 6.27 (c) Non-scaled least squares comparison of the male cranium with the least squares experimental reference cranium standard using the d/σ-score.

Landmark No.	Residual	d/σ- Score	SD	Exp.SD	Landmark Name
1	2.939	0.881	3.34	2.24	sella
2	4.851	1.425	3.40	1.01	nasion
3	9.879	2.649*	3.73	2.11	glabella
4	5.426	1.341	4.05	2.76	vertex
5	7.982	1.585	5.04	0.85	opisthocranion
6	1.703	0.546	3.12	0.45	opisthion
7	2.901	0.513	5.65	1.61	mastoid tip (L)
8	5.066	1.171	4.33	1.44	mastoid tip (R)
9	3.486	0.601	5.80	2.66	basion
10	2.088	0.468	4.46	1.72	ext auditory meatus (R)
11	2.968	0.653	4.55	2.37	ext auditory meatus (L)
43	8.817	14.314*	0.00	0.62	bregma
64	6.175	1.952*	3.16	2.55	zygomatic frontal (R)
65	5.088	1.535	3.31	2.61	zygomatic frontal (L)
78	5.884	0.712	8.27	1.86	foramen mag breadth (R)
79	7.198	0.908	7.92	1.22	foramen mag breadth (L)

* significant at the 5% level

Table 6.27 (d)   Non-scaled repeated median comparison of the male cranium
with the repeated median experimental reference cranium
standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	2.958	0.981	3.02	2.24	sella
2	4.856	1.496	3.25	1.01	nasion
3	10.278	2.899*	3.55	2.11	glabella
4	5.082	1.189	4.27	2.76	vertex
5	7.208	1.143	6.30	0.85	opisthocranion
6	1.423	0.582	2.44	0.45	opisthion
7	2.780	0.445	6.24	1.61	mastoid tip (L)
8	3.623	0.746	4.86	1.44	mastoid tip (R)
9	3.067	0.464	6.62	2.66	basion
10	1.126	0.275	4.09	1.72	ext auditory meatus (R)
11	3.263	0.736	4.43	2.37	ext auditory meatus (L)
43	9.390	15.244*	0.00	0.62	bregma
64	6.466	1.905*	3.39	2.55	zygomatic frontal (R)
65	4.641	1.319	3.52	2.61	zygomatic frontal (L)
78	6.124	0.725	8.45	1.86	foramen mag breadth (R)
79	6.861	0.859	7.99	1.22	foramen mag breadth (L)

* significant at the 5% level

Table 6.28 Distance and angle comparison of the male cranium with the experimental reference cranium standard using Z-scores.

N	Name	Value	Z-score	Mean	SD	Exp.SD
1	s-n	66.30	0.57	64.18	3.73	2.46
2	n-g	12.43	-1.30	17.42	3.83	2.34
3	g-br	111.18	9.56*	90.15	0.00	2.20
4	g-zfr	61.48	1.64	53.85	4.64	3.31
5	g-zfl	59.21	0.38	57.92	2.88	3.36
6	zfr-br	89.89	3.97*	79.49	0.00	2.62
7	zfl-br	87.67	3.73*	77.67	0.00	2.68
8	br-v	17.03	-2.06*	22.87	0.00	2.83
9	v-op	122.45	-0.17	124.24	10.68	2.89
10	op-o	79.17	1.32	71.16	6.05	0.96
11	op-mtr	111.47	0.55	106.47	9.03	1.67
12	op-mtl	111.85	0.55	107.42	7.99	1.82
13	o-fmbr	24.91	0.47	23.26	3.51	1.91
14	o-fmbl	26.34	1.38	24.55	0.89	1.30
15	fmbr-ba	23.41	-0.55	25.18	0.73	3.25
16	fmbl-ba	21.11	-0.85	23.59	0.16	2.93
17	ba-s	46.00	0.67	41.58	6.56	3.48
18	mtr-eamr	27.25	0.64	25.06	3.40	2.25
19	eamr-zfr	89.52	1.77	81.54	4.51	3.08
20	eamr-v	124.49	1.24	118.38	4.91	3.25
21	mtl-eaml	27.25	0.53	24.67	4.90	2.86
22	eaml-zfl	86.39	0.95	80.84	5.82	3.53
23	eaml-v	122.84	0.46	119.78	6.58	3.64
24	mtr-mtl	95.68	0.14	95.08	4.12	2.16
25	eamr-eaml	96.85	0.64	94.98	0.68	2.93
26	zfr-zfl	95.20	0.09	94.81	4.08	3.65
27	fmbr-fmbl	30.67	0.14	30.36	0.01	2.22
28	o-ba	35.95	-0.32	36.81	1.07	2.70
29	n-ba	102.06	0.53	97.15	9.18	2.85
30	s-g	74.22	0.59	72.41	2.51	3.08
31	s-o	73.01	0.86	69.83	3.71	2.28
32	g-o	145.24	0.59	141.43	6.46	2.16
33	g-op	192.57	0.89	182.83	10.99	2.27
34	ba-br	131.39	4.87*	118.10	0.00	2.73
35	s-v	97.12	1.24	92.71	2.75	3.55
36	s-br	92.92	3.23*	85.42	0.00	2.32
37	ba-v	131.35	0.88	125.17	7.00	3.83
38	ba-s-n	129.81	-0.46	132.53	5.95	3.07
39	s-n-g	125.59	1.84	110.81	8.04	4.08

Table 6.28 (continued)

N	Name	Value	Z-score	Mean	SD	Exp.SD
40	n-g-br	102.50	-2.00*	110.46	0.00	3.97
41	g-br-v	140.67	-1.20	144.98	0.00	3.60
42	br-v-op	136.67	2.84*	126.46	0.00	3.59
43	v-op-o	82.41	-0.11	83.25	7.98	0.84
44	op-o-ba	136.40	3.17*	128.09	2.62	2.54
45	o-ba-s	125.56	-1.08	136.90	10.50	3.76
46	op-mtr-eamr	86.48	-0.34	87.78	3.76	3.09
47	op-mtl-eaml	81.73	-0.77	85.33	4.67	4.50
48	o-fmbr-ba	96.09	-0.37	98.00	2.08	5.17
49	o-fmbl-ba	97.89	-0.16	99.23	8.19	4.43
50	fmbr-o-fmbl	73.46	-1.08	78.69	4.85	3.49
51	fmbr-ba-fmbl	86.94	1.71	76.94	1.68	5.85
52	g-v-op	102.30	0.06	102.09	3.21	1.24

Mean Z-score = 0.81   SD Z-score = 1.89   RMS Z-score = 2.04

* significant at the 5% level

Table 6.29 Stretch ratio and area change comparison between the male cranium and the experimental reference cranium standard using strain analysis.

Triangle	Parameter	Value[+]	"Z-score"[+]	Mean	SD	Obs
3 4 64	% Stretch minor	1.72	1.34	-4.62	4.73	3
	% Stretch major	16.65	2.24	5.25	5.09	3
	% Area Change	18.66	1.89	0.54	9.59	3
4 8 64	% Stretch minor	3.03	1.95	-4.40	3.81	3
	% Stretch major	11.25	7.91	1.05	1.29	3
	% Area Change	14.62	4.12	-3.39	4.37	3
4 8 5	% Stretch minor	-2.36	0.14	-3.51	8.28	3
	% Stretch major	5.88	0.39	2.50	8.67	3
	% Area Change	3.37	0.24	-0.61	16.47	3
5 8 6	% Stretch minor	0.67	2.06	-8.43	4.42	3
	% Stretch major	8.78	1.05	4.18	4.39	3
	% Area Change	9.51	5.19	-4.72	2.74	3
3 4 65	% Stretch minor	-9.59	-1.92	-3.06	3.40	3
	% Stretch major	13.42	3.76	2.98	2.78	3
	% Area Change	2.55	0.45	-0.12	5.92	3
4 7 65	% Stretch minor	1.96	1.23	-4.73	5.46	3
	% Stretch major	7.64	2.12	0.49	3.37	3
	% Area Change	9.75	1.76	-4.18	7.91	3
4 7 5	% Stretch minor	-2.15	0.08	-2.71	7.42	3
	% Stretch major	4.79	0.34	1.84	8.77	3
	% Area Change	2.53	0.19	-0.49	15.74	3
5 7 6	% Stretch minor	-4.79	0.66	-8.08	5.00	3
	% Stretch major	7.84	1.01	2.96	4.85	3
	% Area Change	2.68	0.82	-5.20	9.56	3
1 8 64	% Stretch minor	-2.68	0.29	-3.97	4.51	4
	% Stretch major	9.30	2.15	2.41	3.20	4
	% Area Change	6.37	1.17	-1.59	6.83	4
1 8 6	% Stretch minor	-0.77	1.49	-7.36	4.42	3
	% Stretch major	5.50	2.54	3.14	0.93	3
	% Area Change	4.69	1.82	-4.44	5.02	3
1 7 65	% Stretch minor	0.54	1.09	-5.03	5.09	4
	% Stretch major	6.69	0.70	3.53	4.53	4
	% Area Change	7.27	0.93	-1.52	9.45	4
1 7 6	% Stretch minor	-4.52	1.10	-7.23	2.46	3
	% Stretch major	5.64	0.60	2.60	5.09	3
	% Area Change	0.86	0.79	-4.74	7.09	3

[+] See Section 6.6.1 for discussion on criteria for identification of significant stretch ratios and area changes.

Table 6.30 (a) Scaled least squares comparison of the male skull with the least squares experimental reference skull standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	2.172	0.641	3.39	2.24	sella
2	1.612	0.703	2.29	1.01	nasion
3	8.404	1.730*	4.86	2.11	glabella
4	4.105	0.818	5.02	2.76	vertex
5	4.850	0.787	6.17	0.85	opisthocranion
6	2.799	1.171	2.39	0.45	opisthion
7	2.513	0.461	5.45	1.61	mastoid tip (L)
8	3.464	0.902	3.84	1.44	mastoid tip (R)
9	2.932	0.476	6.15	2.66	basion
10	2.558	0.563	4.54	1.72	ext auditory meatus (R)
11	1.515	0.352	4.30	2.37	ext auditory meatus (L)
12	2.979	0.805	3.70	1.72	condylion (R)
13	2.057	0.422	4.88	2.39	condylion (L)
16	4.475	1.008	4.44	1.16	gonion (R)
17	2.985	0.692	4.31	1.78	gonion (L)
20	2.589	0.708	3.66	0.76	gnathion
21	5.624	1.240	4.54	1.50	pogonion
22	2.129	0.648	3.28	0.51	infradentale
23	1.782	0.478	3.73	1.87	prosthion
24	4.235	0.893	4.74	1.09	ant nasal spine
25	2.312	0.505	4.58	2.14	post nasal spine
26	5.097	1.354	3.76	1.00	upper molar (R)
27	3.477	0.870	4.00	0.72	upper molar (L)
28	1.240	0.427	2.91	0.80	lower molar (R)
29	3.431	1.767*	1.94	0.87	lower molar (L)
30	2.058	0.414	4.97	0.89	zygomaxillare (R)
31	3.257	0.697	4.67	1.30	zygomaxillare (L)
32	2.361	0.534	4.42	0.89	coronoid tip (R)
33	2.651	0.555	4.78	1.72	coronoid tip (L)
36	2.633	0.747	3.52	2.38	palatine tubercle (R)
37	2.278	0.439	5.19	2.58	palatine tubercle (L)
40	5.848	2.883*	2.03	0.77	optic foramen (R)
41	5.802	1.228	4.72	1.02	optic foramen (L)
42	3.845	1.017	3.78	0.91	nasale
43	8.506	13.809*	0.00	0.62	bregma
46	2.320	0.987	2.35	1.40	medial orbitale (R)
47	1.808	1.136	1.59	1.39	medial orbitale (L)
48	2.503	0.683	3.66	1.83	superior orbitale (R)
49	3.058	0.926	3.05	3.30	superior orbitale (L)

Table 6.30 (a) (continued)

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
50	1.407	0.384	3.66	0.81	lateral orbitale (R)
51	3.312	0.782	4.21	4.24	lateral orbitale (L)
52	2.558	0.629	4.07	1.44	opposite orbitale (R)
53	5.045	1.794*	2.81	1.65	opposite orbitale (L)
54	2.558	0.816	3.14	2.20	orbitale (R)
55	2.114	0.711	2.83	2.97	orbitale (L)
56	1.788	0.520	3.44	2.96	infraorbital foramen (R)
57	3.806	0.845	4.51	2.50	infraorbital foramen (L)
58	3.729	0.814	4.58	1.74	articular eminence (R)
59	3.485	0.597	5.84	3.17	articular eminence (L)
62	3.943	1.219	3.24	0.77	zygomatic corner (R)
63	2.781	1.055	2.64	1.18	zygomatic corner (L)
64	3.334	0.761	4.38	2.55	zygomatic frontal (R)
65	3.265	0.720	4.53	2.61	zygomatic frontal (L)
66	2.862	0.764	3.75	1.43	nasal breadth (R)
67	2.384	0.736	3.24	2.61	nasal breadth (L)
68	1.191	0.317	3.75	0.41	coronoid notch (R)
69	3.279	0.691	4.75	1.20	coronoid notch (L)
70	3.315	1.114	2.98	1.12	ext oblique line (R)
71	2.762	0.832	3.32	3.15	ext oblique line (L)
78	4.781	0.524	9.13	1.86	foramen mag breadth (R)
79	6.610	0.756	8.75	1.22	foramen mag breadth (L)
91	3.171	0.903	3.51	1.84	anterior clinoid (L)
92	2.752	1.387	1.98	0.46	anterior clinoid (R)
93	4.112	0.806	5.10	2.33	less wing of sphenoid (L)
94	5.472	1.386	3.95	2.38	less wing of sphenoid (R)
95	3.267	0.576	5.67	3.54	
96	13.153	3.360*	1.64	3.91	
97	3.502	0.791	4.43	1.14	
98	1.819	1.165	1.56	1.48	
99	0.914	0.321	2.85	0.53	
100	1.169	1.426	0.63	0.82	
101	2.474	0.456	5.42	3.01	
102	8.326	2.539*	2.12	3.28	
103	1.236	0.453	2.50	2.72	med anterior clinoid (L)
104	2.379	0.706	2.73	3.37	med anterior clinoid (R)
105	6.188	1.198	3.04	5.16	posterior clinoid (L)
106	7.194	2.055*	3.16	3.50	posterior clinoid (R)

Male is 3.1% larger than the standard with scale factor Z-score = 1.001
Scale factor standard deviation for the standard = 0.0446

* significant at the 5% level

Table 6.30 (b)   Scaled repeated median comparison of the male skull with the repeated median experimental reference skull standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	1.957	0.584	3.35	2.24	sella
2	1.428	0.751	1.90	1.01	nasion
3	8.215	1.839*	4.47	2.11	glabella
4	4.211	0.690	6.10	2.76	vertex
5	5.054	0.760	6.65	0.85	opisthocranion
6	3.008	1.010	2.98	0.45	opisthion
7	2.166	0.388	5.58	1.61	mastoid tip (L)
8	3.984	1.089	3.66	1.44	mastoid tip (R)
9	2.892	0.461	6.27	2.66	basion
10	2.969	0.651	4.56	1.72	ext auditory meatus (R)
11	1.541	0.328	4.70	2.37	ext auditory meatus (L)
12	2.981	0.788	3.78	1.72	condylion (R)
13	1.795	0.348	5.16	2.39	condylion (L)
16	4.361	0.989	4.41	1.16	gonion (R)
17	3.264	0.738	4.42	1.78	gonion (L)
20	2.750	0.754	3.65	0.76	gnathion
21	5.682	1.177	4.83	1.50	pogonion
22	2.186	0.581	3.76	0.51	infradentale
23	1.914	0.460	4.16	1.87	prosthion
24	4.233	0.863	4.91	1.09	ant nasal spine
25	2.195	0.467	4.70	2.14	post nasal spine
26	5.201	1.312	3.96	1.00	upper molar (R)
27	3.525	0.837	4.21	0.72	upper molar (L)
28	1.164	0.402	2.89	0.80	lower molar (R)
29	3.647	1.749*	2.09	0.87	lower molar (L)
30	2.334	0.448	5.21	0.89	zygomaxillare (R)
31	3.233	0.637	5.08	1.30	zygomaxillare (L)
32	2.277	0.522	4.36	0.89	coronoid tip (R)
33	2.647	0.553	4.79	1.72	coronoid tip (L)
36	2.413	0.664	3.63	2.38	palatine tubercle (R)
37	2.166	0.409	5.30	2.58	palatine tubercle (L)
40	6.246	2.990*	2.09	0.77	optic foramen (R)
41	5.807	1.265	4.59	1.02	optic foramen (L)
42	3.688	0.928	3.97	0.91	nasale
43	7.606	12.347*	0.00	0.62	bregma
46	2.300	1.064	2.16	1.40	medial orbitale (R)
47	1.681	0.963	1.74	1.39	medial orbitale (L)
48	2.233	0.643	3.47	1.83	superior orbitale (R)
49	3.082	0.933	3.14	3.30	superior orbitale (L)

Table 6.30 (b) (continued)

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
50	1.673	0.461	3.63	0.81	lateral orbitale (R)
51	3.168	0.735	4.31	4.24	lateral orbitale (L)
52	2.875	0.693	4.15	1.44	opposite orbitale (R)
53	4.989	1.621*	3.08	1.65	opposite orbitale (L)
54	2.739	0.922	2.97	2.20	orbitale (R)
55	2.007	0.675	2.87	2.97	orbitale (L)
56	1.680	0.480	3.50	2.96	infraorbital foramen (R)
57	3.866	0.864	4.47	2.50	infraorbital foramen (L)
58	3.998	0.873	4.58	1.74	articular eminence (R)
59	3.659	0.615	5.95	3.17	articular eminence (L)
62	4.336	1.387	3.12	0.77	zygomatic corner (R)
63	2.787	1.066	2.61	1.18	zygomatic corner (L)
64	3.301	0.785	4.21	2.55	zygomatic frontal (R)
65	3.477	0.721	4.82	2.61	zygomatic frontal (L)
66	2.863	0.736	3.89	1.43	nasal breadth (R)
67	2.327	0.699	3.33	2.61	nasal breadth (L)
68	0.996	0.266	3.74	0.41	coronoid notch (R)
69	3.406	0.694	4.91	1.20	coronoid notch (L)
70	3.148	1.097	2.87	1.12	ext oblique line (R)
71	2.907	0.882	3.30	3.15	ext oblique line (L)
78	4.443	0.474	9.38	1.86	foramen mag breadth (R)
79	6.239	0.689	9.06	1.22	foramen mag breadth (L)
91	3.103	0.879	3.53	1.84	anterior clinoid (L)
92	2.837	1.522	1.86	0.46	anterior clinoid (R)
93	4.298	0.905	4.75	2.33	less wing of sphenoid (L)
94	5.477	1.665*	3.29	2.38	less wing of sphenoid (R)
95	3.532	0.625	5.65	3.54	
96	13.279	3.392*	1.49	3.91	
97	3.831	0.857	4.47	1.14	
98	1.875	1.115	1.68	1.48	
99	1.267	0.433	2.92	0.53	
100	1.174	1.431	0.19	0.82	
101	2.703	0.516	5.24	3.01	
102	8.355	2.548*	1.58	3.28	
103	1.528	0.561	2.23	2.72	med anterior clinoid (L)
104	2.613	0.775	2.32	3.37	med anterior clinoid (R)
105	5.928	1.148	2.99	5.16	posterior clinoid (L)
106	6.872	1.963*	2.93	3.50	posterior clinoid (R)

Male is 3.3% larger than the standard with scale factor Z-score = 0.712
Scale factor standard deviation for this standard = 0.0457

* significant at the 5% level

Table 6.30 (c) Non-scaled least squares comparison of the male skull with the least squares experimental reference skull standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	1.948	0.575	3.39	2.24	sella
2	3.350	1.461	2.29	1.01	nasion
3	8.266	1.702*	4.86	2.11	glabella
4	7.375	1.470	5.02	2.76	vertex
5	8.405	1.363	6.17	0.85	opisthocranion
6	2.791	1.167	2.39	0.45	opisthion
7	3.681	0.675	5.45	1.61	mastoid tip (L)
8	5.983	1.558	3.84	1.44	mastoid tip (R)
9	3.608	0.586	6.15	2.66	basion
10	3.172	0.699	4.54	1.72	ext auditory meatus (R)
11	3.734	0.867	4.30	2.37	ext auditory meatus (L)
12	5.582	1.507	3.70	1.72	condylion (R)
13	1.877	0.385	4.88	2.39	condylion (L)
16	7.339	1.653*	4.44	1.16	gonion (R)
17	4.636	1.075	4.31	1.78	gonion (L)
20	5.296	1.448	3.66	0.76	gnathion
21	7.189	1.584	4.54	1.50	pogonion
22	5.440	1.657*	3.28	0.51	infradentale
23	4.203	1.127	3.73	1.87	prosthion
24	6.678	1.409	4.74	1.09	ant nasal spine
25	2.528	0.552	4.58	2.14	post nasal spine
26	4.854	1.290	3.76	1.00	upper molar (R)
27	3.576	0.894	4.00	0.72	upper molar (L)
28	2.772	0.953	2.91	0.80	lower molar (R)
29	3.466	1.785*	1.94	0.87	lower molar (L)
30	3.078	0.619	4.97	0.89	zygomaxillare (R)
31	2.970	0.636	4.67	1.30	zygomaxillare (L)
32	3.340	0.756	4.42	0.89	coronoid tip (R)
33	2.845	0.595	4.78	1.72	coronoid tip (L)
36	2.931	0.832	3.52	2.38	palatine tubercle (R)
37	1.438	0.277	5.19	2.58	palatine tubercle (L)
40	6.006	2.961*	2.03	0.77	optic foramen (R)
41	5.264	1.114	4.72	1.02	optic foramen (L)
42	5.081	1.343	3.78	0.91	nasale
43	11.254	18.269*	0.00	0.62	bregma
46	2.965	1.261	2.35	1.40	medial orbitale (R)
47	1.961	1.233	1.59	1.39	medial orbitale (L)
48	3.829	1.045	3.66	1.83	superior orbitale (R)

Table 6.30 (c) (continued)

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
49	1.141	0.345	3.05	3.30	superior orbitale (L)
50	1.715	0.468	3.66	0.81	lateral orbitale (R)
51	1.618	0.382	4.21	4.24	lateral orbitale (L)
52	2.377	0.584	4.07	1.44	opposite orbitale (R)
53	2.883	1.025	2.81	1.65	opposite orbitale (L)
54	4.135	1.319	3.14	2.20	orbitale (R)
55	3.147	1.058	2.83	2.97	orbitale (L)
56	2.846	0.827	3.44	2.96	infraorbital foramen (R)
57	5.836	1.295	4.51	2.50	infraorbital foramen (L)
58	6.399	1.397	4.58	1.74	articular eminence (R)
59	5.597	0.958	5.84	3.17	articular eminence (L)
62	5.013	1.550	3.24	0.77	zygomatic corner (R)
63	3.462	1.313	2.64	1.18	zygomatic corner (L)
64	5.926	1.352	4.38	2.55	zygomatic frontal (R)
65	4.765	1.051	4.53	2.61	zygomatic frontal (L)
66	5.319	1.419	3.75	1.43	nasal breadth (R)
67	3.866	1.194	3.24	2.61	nasal breadth (L)
68	3.095	0.824	3.75	0.41	coronoid notch (R)
69	3.143	0.662	4.75	1.20	coronoid notch (L)
70	3.573	1.201	2.98	1.12	ext oblique line (R)
71	3.135	0.944	3.32	3.15	ext oblique line (L)
78	4.913	0.538	9.13	1.86	foramen mag breadth (R)
79	5.823	0.666	8.75	1.22	foramen mag breadth (L)
91	3.690	1.050	3.51	1.84	anterior clinoid (L)
92	3.910	1.970*	1.98	0.46	anterior clinoid (R)
93	5.719	1.122	5.10	2.33	less wing of sphenoid (L)
94	4.212	1.067	3.95	2.38	less wing of sphenoid (R)
95	6.294	1.109	5.67	3.54	
96	11.807	3.016*	1.64	3.91	
97	4.555	1.029	4.43	1.14	
98	2.828	1.812*	1.56	1.48	
99	2.183	0.766	2.85	0.53	
100	2.420	2.951*	0.63	0.82	
101	4.594	0.848	5.42	3.01	
102	7.308	2.229*	2.12	3.28	
103	1.841	0.676	2.50	2.72	med anterior clinoid (L)
104	2.971	0.881	2.73	3.37	med anterior clinoid (R)
105	5.181	1.003	3.04	5.16	posterior clinoid (L)
106	7.269	2.077*	3.16	3.50	posterior clinoid (R)

* significant at the 5% level

Table 6.30 (d)   Non-scaled repeated median comparison of the male skull with
the repeated median experimental reference mandible skull
using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	1.938	0.578	3.35	2.24	sella
2	2.857	1.504	1.90	1.01	nasion
3	8.029	1.798*	4.47	2.11	glabella
4	6.393	1.048	6.10	2.76	vertex
5	7.414	1.115	6.65	0.85	opisthocranion
6	2.663	0.894	2.98	0.45	opisthion
7	2.772	0.496	5.58	1.61	mastoid tip (L)
8	5.419	1.481	3.66	1.44	mastoid tip (R)
9	3.242	0.517	6.27	2.66	basion
10	3.002	0.658	4.56	1.72	ext auditory meatus (R)
11	3.101	0.659	4.70	2.37	ext auditory meatus (L)
12	4.824	1.275	3.78	1.72	condylion (R)
13	1.342	0.260	5.16	2.39	condylion (L)
16	6.376	1.445	4.41	1.16	gonion (R)
17	4.226	0.956	4.42	1.78	gonion (L)
20	4.586	1.257	3.65	0.76	gnathion
21	6.576	1.363	4.83	1.50	pogonion
22	4.635	1.231	3.76	0.51	infradentale
23	3.687	0.887	4.16	1.87	prosthion
24	6.079	1.239	4.91	1.09	ant nasal spine
25	2.417	0.514	4.70	2.14	post nasal spine
26	4.896	1.235	3.96	1.00	upper molar (R)
27	3.378	0.802	4.21	0.72	upper molar (L)
28	1.999	0.691	2.89	0.80	lower molar (R)
29	3.229	1.548	2.09	0.87	lower molar (L)
30	2.682	0.515	5.21	0.89	zygomaxillare (R)
31	2.788	0.549	5.08	1.30	zygomaxillare (L)
32	2.895	0.664	4.36	0.89	coronoid tip (R)
33	2.863	0.598	4.79	1.72	coronoid tip (L)
36	2.713	0.747	3.63	2.38	palatine tubercle (R)
37	1.606	0.303	5.30	2.58	palatine tubercle (L)
40	6.180	2.958*	2.09	0.77	optic foramen (R)
41	5.249	1.144	4.59	1.02	optic foramen (L)
42	4.568	1.150	3.97	0.91	nasale
43	9.486	15.399*	0.00	0.62	bregma
46	2.642	1.222	2.16	1.40	medial orbitale (R)
47	1.566	0.898	1.74	1.39	medial orbitale (L)
48	3.279	0.944	3.47	1.83	superior orbitale (R)

Table 6.30 (d) (continued)

Landmark No.	Residual	d/σ- Score	SD	Exp.SD	Landmark Name
49	1.566	0.474	3.14	3.30	superior orbitale (L)
50	1.369	0.377	3.63	0.81	lateral orbitale (R)
51	1.521	0.353	4.31	4.24	lateral orbitale (L)
52	2.345	0.566	4.15	1.44	opposite orbitale (R)
53	3.220	1.046	3.08	1.65	opposite orbitale (L)
54	3.769	1.268	2.97	2.20	orbitale (R)
55	2.768	0.931	2.87	2.97	orbitale (L)
56	2.331	0.666	3.50	2.96	infraorbital foramen (R)
57	5.481	1.225	4.47	2.50	infraorbital foramen (L)
58	5.750	1.256	4.58	1.74	articular eminence (R)
59	5.111	0.859	5.95	3.17	articular eminence (L)
62	4.823	1.543	3.12	0.77	zygomatic corner (R)
63	3.105	1.188	2.61	1.18	zygomatic corner (L)
64	5.279	1.255	4.21	2.55	zygomatic frontal (R)
65	4.571	0.948	4.82	2.61	zygomatic frontal (L)
66	4.766	1.225	3.89	1.43	nasal breadth (R)
67	3.395	1.020	3.33	2.61	nasal breadth (L)
68	2.446	0.653	3.74	0.41	coronoid notch (R)
69	3.436	0.700	4.91	1.20	coronoid notch (L)
70	3.305	1.151	2.87	1.12	ext oblique line (R)
71	3.196	0.970	3.30	3.15	ext oblique line (L)
78	4.291	0.458	9.38	1.86	foramen mag breadth (R)
79	5.517	0.609	9.06	1.22	foramen mag breadth (L)
91	3.681	1.042	3.53	1.84	anterior clinoid (L)
92	3.776	2.026*	1.86	0.46	anterior clinoid (R)
93	5.516	1.161	4.75	2.33	less wing of sphenoid (L)
94	4.552	1.384	3.29	2.38	less wing of sphenoid (R)
95	5.603	0.991	5.65	3.54	
96	12.436	3.177*	1.49	3.91	
97	4.395	0.983	4.47	1.14	
98	2.465	1.466	1.68	1.48	
99	2.075	0.709	2.92	0.53	
100	2.119	2.585*	0.19	0.82	
101	4.174	0.797	5.24	3.01	
102	7.727	2.356*	1.58	3.28	
103	1.798	0.660	2.23	2.72	med anterior clinoid (L)
104	2.897	0.860	2.32	3.37	med anterior clinoid (R)
105	5.358	1.037	2.99	5.16	posterior clinoid (L)
106	7.081	2.023*	2.93	3.50	posterior clinoid (R)

* significant at the 5% level

Table 6.31   Total number of distances and angles measured.

Bone	Distances	Angles	Total
Mandible	36	22	58
Maxilla	39	24	63
Orbits	38	17	55
Zygoma	29	14	43
Cranium	37	15	52

FEMALE

Axis values: 5300 | 5350 | 5400 | 5450 | 5500 | 5550 | 5600 | 5650 | 5700 | 5750 | 5800 | 5850 | 5900 | 5950 | 6000 | 6050 | 6100 | 6150 | 6200 | 6250 | 6300 | 6350 | 6400 | 6450 | 6500 | 6550

FEMALE side (above the axis), listed bottom-to-top within each column:

Value	Skull numbers
5350	38262, 25552
5400	100, 76, 69
5450	72
5500	57749, 38778, 187, 57
5550	38525, 25971, 25505, 11521
5600	116
5650	38897, 38697, 38626, 25511, 25510
5700	57798, 57590, 38991, 38634, 15269, 123
5750	57942, 42199, 38977, 38506, 25505, 13184, 451, 89, 55, 46
5800	57903, 38835, 38696, 38211, 25504, 20609, 568, 110, 105, 63
5850	38863, 38824, 38767, 38056, 16521, 13142, 90, 47, 43
5900	304
5950	57695, 11406, 68, 49
6000	25498, 20628, 16508, 112
6050	38896, 113, 92, 41

MALE side (below the axis), listed top-to-bottom within each column:

Value	Skull numbers
5950	480, 452, 97, 77, 65
6000	57795, 38911, 38865, 38727, 132, 66
6050	57592, 25507, 25449, 11529, 481, 104, 74
6100	11527, 106, 78, 62, 60, 42, 38
6150	25925, 25516, 768, 450, 108, 91, 50
6200	57892, 38913, 38287, 25479, 13167, 569, 484, 306, 126, 40
6250	38524, 25501, 20584, 13171, 117, 115, 101, 61, 37
6300	57807, 38780, 38769, 25553, 11436, 114, 102, 99
6350	38893, 38250, 11438, 125, 98
6400	38799, 20629, 129
6450	38636, 38433
6500	38756, 38556
6550	25899

MALE

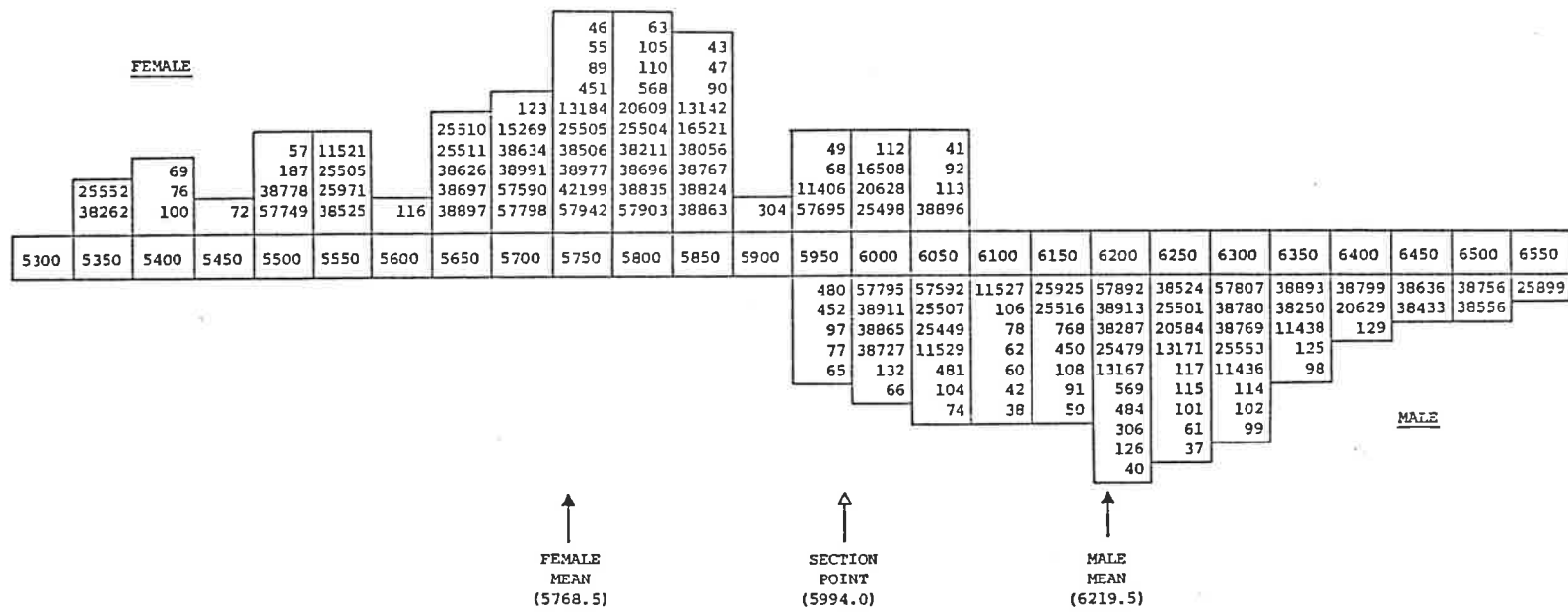FEMALE MEAN (5768.5) — SECTION POINT (5994.0) — MALE MEAN (6219.5)

Table 6.32 Sex distribution of the Narrinyeri skulls, including the five test skulls (from Richards, 1983).

Table 7.1 (a)   Scaled least squares comparison of the patient's mandible with the least squares experimental reference mandible standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
12	9.906	2.614*	3.79	1.72	condylion (R)
13	10.219	2.492*	4.10	2.39	condylion (L)
16	13.027	4.066*	3.20	1.16	gonion (R)
17	11.061	3.137*	3.53	1.78	gonion (L)
20	6.470	1.996*	3.24	0.76	gnathion
21	7.997	2.049*	3.90	1.50	pogonion
22	5.109	2.196*	2.33	0.51	infradentale
28	7.635	2.873*	2.66	0.80	lower molar (R)
29	7.033	5.212*	1.35	0.87	lower molar (L)
32	6.811	1.690*	4.03	0.89	coronoid tip (R)
33	9.874	2.520*	3.92	1.72	coronoid tip (L)
69	4.721	1.397	3.38	1.20	coronoid notch (L)
71	5.520	1.710*	3.23	3.15	ext oblique line (L)

Patient is 5.8% smaller than the standard with scale factor Z-score = -1.166
Scale factor standard deviation for this standard = 0.0501

* significant at the 5% level

Table 7.1 (b)   Scaled repeated median comparison of the patient's mandible
with the repeated median experimental reference mandible
standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
12	11.425	2.852*	4.01	1.72	condylion (R)
13	8.369	2.269*	3.69	2.39	condylion (L)
16	14.542	4.100*	3.55	1.16	gonion (R)
17	11.139	2.702*	4.12	1.78	gonion (L)
20	6.578	2.057*	3.20	0.76	gnathion
21	8.325	2.123*	3.92	1.50	pogonion
22	3.044	1.495	2.04	0.51	infradentale
28	5.883	2.504*	2.35	0.80	lower molar (R)
29	6.486	4.095*	1.58	0.87	lower molar (L)
32	9.940	2.152*	4.62	0.89	coronoid tip (R)
33	10.631	2.893*	3.67	1.72	coronoid tip (L)
69	5.658	1.770*	3.20	1.20	coronoid notch (L)
71	6.662	2.047*	3.26	3.15	ext oblique line (L)

Patient is 8.4% smaller than the standard with scale factor Z-score = -1.713
Scale factor standard deviation for this standard = 0.0493

* significant at the 5% level

Table 7.1 (c)   Non-scaled least squares comparison of the patient's mandible
with the least squares experimental reference mandible standard
using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
12	11.612	3.065*	3.79	1.72	condylion (R)
13	12.170	2.967*	4.10	2.39	condylion (L)
16	13.256	4.138*	3.20	1.16	gonion (R)
17	11.761	3.336*	3.53	1.78	gonion (L)
20	8.000	2.469*	3.24	0.76	gnathion
21	9.452	2.422*	3.90	1.50	pogonion
22	7.584	3.259*	2.33	0.51	infradentale
28	8.474	3.188*	2.66	0.80	lower molar (R)
29	8.166	6.052*	1.35	0.87	lower molar (L)
32	3.661	0.908	4.03	0.89	coronoid tip (R)
33	7.005	1.788*	3.92	1.72	coronoid tip (L)
69	2.026	0.599	3.38	1.20	coronoid notch (L)
71	5.006	1.551	3.23	3.15	ext oblique line (L)

* significant at the 5% level

Table 7.1 (d) Non-scaled repeated median comparison of the patient's mandible with the repeated median experimental reference mandible standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
12	12.397	3.094*	4.01	1.72	condylion (R)
13	11.238	3.046*	3.69	2.39	condylion (L)
16	12.873	3.629*	3.55	1.16	gonion (R)
17	10.763	2.611*	4.12	1.78	gonion (L)
20	8.991	2.811*	3.20	0.76	gnathion
21	10.770	2.746*	3.92	1.50	pogonion
22	7.509	3.689*	2.04	0.51	infradentale
28	6.892	2.934*	2.35	0.80	lower molar (R)
29	8.419	5.315*	1.58	0.87	lower molar (L)
32	5.157	1.116	4.62	0.89	coronoid tip (R)
33	6.420	1.747*	3.67	1.72	coronoid tip (L)
69	1.848	0.578	3.20	1.20	coronoid notch (L)
71	4.795	1.473	3.26	3.15	ext oblique line (L)

* significant at the 5% level

Table 7.2   Distance and angle comparison of the patient's mandible with the experimental reference mandible standard using Z-scores.

N	Name	Value	Z-score	Mean	SD	Exp.SD
1	cdr-gor	46.23	-4.84*	58.86	2.61	2.07
2	gor-gn	67.89	-1.73	82.03	8.15	1.38
3	gn-pg	7.82	-1.81	10.87	1.21	1.69
4	pg-id	22.29	1.51	19.89	1.55	1.59
5	gn-gol	70.24	-2.04*	83.37	6.45	1.94
6	gol-cdl	43.48	-3.13*	56.49	4.16	2.98
7	cdl-cnl	13.98	-4.40*	25.74	2.21	2.67
8	cnl-ctl	15.51	-0.07	15.65	1.92	2.09
9	ctl-eoll	27.11	-0.21	28.05	4.42	3.59
10	eoll-mll	28.14	-0.12	28.52	2.05	3.27
11	mll-id	32.56	-3.32*	40.36	2.35	1.01
12	id-mlr	39.04	-1.11	40.45	1.28	0.95
13	mlr-eolr	999.99	999.99	28.03	4.21	1.38
14	eolr-ctr	999.99	999.99	30.33	4.62	1.43
15	ctr-cnr	999.99	999.99	13.70	1.66	0.98
16	cnr-cdr	999.99	999.99	27.03	2.41	1.77
17	cnr-gor	999.99	999.99	44.94	4.59	1.23
18	ctr-gor	46.33	-2.04*	55.30	4.39	1.46
19	cdr-ctr	26.86	-1.87	35.52	4.62	1.94
20	eolr-id	999.99	999.99	66.95	3.66	1.23
21	cdr-gn	102.35	-2.35*	118.37	6.82	1.88
22	cdr-pg	104.10	-2.52*	118.62	5.77	2.28
23	cnl-gol	37.38	-1.08	42.34	4.60	2.15
24	ctl-gol	48.07	-1.64	54.37	3.84	2.48
25	cdl-ctl	24.66	-2.54*	34.85	4.01	2.94
26	eoll-id	58.98	-2.06*	65.95	3.38	3.19
27	cdl-gn	100.03	-2.85*	116.13	5.65	2.51
28	cdl-pg	101.50	-2.43*	118.45	6.96	2.83
29	gor-pg	71.87	-2.33*	86.48	6.26	1.90
30	gol-pg	73.87	-2.09*	90.05	7.73	2.33
31	gor-gol	87.43	0.95	82.16	5.52	2.13
32	cdr-cdl	101.22	-0.21	101.94	3.35	2.95
33	cnr-cnl	999.99	999.99	84.65	3.26	1.27
34	ctr-ctl	93.33	2.08*	83.61	4.68	1.93
35	eolr-eoll	999.99	999.99	77.99	2.77	3.35
36	mlr-mll	46.95	-2.69*	55.44	3.16	1.18
37	cdr-gor-gn	126.44	2.58*	113.55	5.00	1.33
38	cdl-gol-gn	121.40	3.07*	110.98	3.39	2.09

Table 7.2 (continued)

N	Name	Value	Z-score	Mean	SD	Exp.SD
39	gor-gn-gol	78.51	3.99*	59.79	4.69	0.96
40	gor-cdr-cnr	999.99	999.99	46.79	4.78	2.32
41	gol-cdl-cnl	55.50	2.96*	44.57	3.52	3.69
42	cdr-cnr-ctr	999.99	999.99	117.27	7.84	2.84
43	cdl-cnl-ctl	113.39	0.24	112.19	4.48	5.00
44	cnr-ctr-eolr	999.99	999.99	65.01	3.20	2.51
45	cnl-ctl-eoll	64.21	-0.43	66.79	4.35	6.05
46	ctr-eolr-mlr	999.99	999.99	108.28	6.61	2.34
47	ctl-eoll-mll	139.02	4.76*	112.66	4.36	5.54
48	eolr-id-eoll	999.99	999.99	71.99	3.80	1.74
49	mlr-id-mll	81.42	-4.48*	86.88	0.65	1.22
50	cdr-gor-pg	122.11	3.04*	108.08	4.62	1.40
51	cdl-gol-pg	117.39	3.92*	105.72	2.98	2.13
52	gor-pg-gol	73.71	4.64*	55.58	3.91	1.15
53	ML(l)/NSL	57.82	6.89*	37.36	2.97	1.48
54	ML(r)/NSL	55.63	8.05*	38.56	2.12	1.39
55	NL/ML(l)	52.13	3.69*	34.86	4.68	1.62
56	NL/ML(r)	50.03	5.83*	34.52	2.66	1.53
57	CL/ML(l)	82.00	-0.18	83.64	9.19	3.07
58	CL/ML(r)	83.86	-1.15	89.48	4.90	3.02

Mean Z-score = 0.01   SD Z-score = 3.16   RMS Z-score = 3.12

* significant at the 5% level

Table 7.3   Stretch ratio and area change comparison between the patient's mandible and the experimental reference mandible standard using strain analysis.

Triangle	Parameter	Value[+]	"Z-score"[+]	Mean	SD	Obs
16 28 20	% Stretch minor	-25.49	-2.61	-1.12	9.34	3
	% Stretch major	10.23	0.41	5.63	11.31	3
	% Area Change	-17.86	-1.06	5.15	21.61	3
28 20 22	% Stretch minor	-4.07	1.74	-5.55	0.85	3
	% Stretch major	6.93	-0.04	7.08	3.63	3
	% Area Change	2.58	0.41	1.14	3.48	3
20 22 21	% Stretch minor	-29.94	-1.16	-11.83	15.61	4
	% Stretch major	26.04	-0.04	27.65	42.07	4
	% Area Change	-11.71	-0.53	15.06	50.32	4
13 17 69	% Stretch minor	-45.02	-11.43	-7.43	3.29	4
	% Stretch major	-7.30	-2.32	11.52	8.12	4
	% Area Change	-49.04	-13.39	3.04	3.89	4
17 69 71	% Stretch minor	-15.75	-0.99	-5.31	10.56	4
	% Stretch major	-3.62	-1.17	9.33	11.04	4
	% Area Change	-18.80	-1.14	4.12	20.09	4
69 71 33	% Stretch minor	-4.29	0.47	-8.52	8.91	4
	% Stretch major	1.28	-0.81	11.95	13.23	4
	% Area Change	-3.06	-0.37	2.41	14.93	4
17 71 29	% Stretch minor	-20.31	-3.54	-2.66	4.98	2
	% Stretch major	32.81	12.58	11.42	1.70	2
	% Area Change	5.84	-0.37	8.50	7.20	2
17 29 20	% Stretch minor	-20.64	-2.31	-0.06	8.92	2
	% Stretch major	-12.07	-2.19	6.36	8.42	2
	% Area Change	-30.23	-2.06	6.66	17.90	2
29 20 22	% Stretch minor	-18.26	-42.42	-4.26	0.33	2
	% Stretch major	3.07	-2.38	8.76	2.39	2
	% Area Change	-15.74	-10.35	4.13	1.92	2

[+] See Section 6.6.1 for discussion on criteria for identification of significant stretch ratios and area changes.

Table 7.4 (a)   Scaled least squares comparison of the patient's maxilla with the
least squares experimental reference maxilla standard using the
d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	2.356	1.303	1.81	1.01	nasion
23	1.297	0.475	2.73	1.87	prosthion
24	5.082	1.482	3.43	1.09	ant nasal spine
25	10.120	2.906*	3.48	2.14	post nasal spine
26	12.017	4.044*	2.97	1.00	upper molar (R)
27	7.812	2.694*	2.90	0.72	upper molar (L)
42	5.565	1.860*	2.99	0.91	nasale
46	5.065	2.191*	2.31	1.40	medial orbitale (R)
54	7.714	2.457*	3.14	2.20	orbitale (R)
55	6.846	2.303*	2.75	2.97	orbitale (L)
66	4.384	1.484	2.95	1.43	nasal breadth (R)
67	2.692	0.958	2.81	2.61	nasal breadth (L)
81	6.145	3.621*	0.00	1.70	incision superius (L)

Patient is 8.4% smaller than the standard with scale factor Z-score = -1.547
Scale factor standard deviation for this standard = 0.0542

* significant at the 5% level

Table 7.4 (b)   Scaled repeated median comparison of the patient's maxilla with the repeated median experimental reference maxilla standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	0.908	0.613	1.48	1.01	nasion
23	0.558	0.210	2.66	1.87	prosthion
24	5.254	1.682*	3.12	1.09	ant nasal spine
25	12.865	3.484*	3.69	2.14	post nasal spine
26	11.979	3.959*	3.03	1.00	upper molar (R)
27	10.733	3.786*	2.83	0.72	upper molar (L)
42	5.099	1.817*	2.81	0.91	nasale
46	4.836	2.208*	2.19	1.40	medial orbitale (R)
54	5.831	1.791*	3.26	2.20	orbitale (R)
55	8.735	2.731*	3.20	2.97	orbitale (L)
66	4.553	1.512	3.01	1.43	nasal breadth (R)
67	1.592	0.537	2.96	2.61	nasal breadth (L)
81	3.829	2.256*	0.00	1.70	incision superius (L)

Patient is 4.7% smaller than the standard with scale factor Z-score = -0.717
Scale factor standard deviation for this standard = 0.0656

* significant at the 5% level

Table 7.4 (c)   Non-scaled least squares comparison of the patient's maxilla with the least squares experimental reference maxilla standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	1.065	0.589	1.81	1.01	nasion
23	1.862	0.681	2.73	1.87	prosthion
24	4.191	1.222	3.43	1.09	ant nasal spine
25	11.876	3.410*	3.48	2.14	post nasal spine
26	13.885	4.673*	2.97	1.00	upper molar (R)
27	9.869	3.403*	2.90	0.72	upper molar (L)
42	4.262	1.424	2.99	0.91	nasale
46	4.261	1.843*	2.31	1.40	medial orbitale (R)
54	7.755	2.471*	3.14	2.20	orbitale (R)
55	7.011	2.358*	2.75	2.97	orbitale (L)
66	5.126	1.735*	2.95	1.43	nasal breadth (R)
67	1.603	0.571	2.81	2.61	nasal breadth (L)
81	3.689	2.174*	0.00	1.70	incision superius (L)

* significant at the 5% level

Table 7.4 (d) Non-scaled repeated median comparison of the patient's maxilla with the repeated median experimental reference maxilla standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	0.237	0.160	1.48	1.01	nasion
23	2.133	0.803	2.66	1.87	prosthion
24	5.390	1.726*	3.12	1.09	ant nasal spine
25	13.715	3.714*	3.69	2.14	post nasal spine
26	13.821	4.567*	3.03	1.00	upper molar (R)
27	12.462	4.396*	2.83	0.72	upper molar (L)
42	4.511	1.607	2.81	0.91	nasale
46	4.473	2.042*	2.19	1.40	medial orbitale (R)
54	5.203	1.598	3.26	2.20	orbitale (R)
55	8.564	2.678*	3.20	2.97	orbitale (L)
66	5.030	1.670*	3.01	1.43	nasal breadth (R)
67	1.300	0.439	2.96	2.61	nasal breadth (L)
81	1.418	0.836	0.00	1.70	incision superius (L)

* significant at the 5% level

Table 7.5   Distance and angle comparison of the patient's maxilla with the experimental reference maxilla standard using Z-scores.

N	Name	Value	Z-score	Mean	SD	Exp.SD
1	n-morr	17.43	1.72	13.18	2.47	1.72
2	morr-orr	25.70	0.18	25.24	1.94	2.60
3	orr-zmr	999.99	999.99	28.78	2.72	2.37
4	zmr-mur	999.99	999.99	29.20	3.00	1.34
5	mur-pr	36.84	-2.92*	43.04	1.59	2.12
6	pr-mul	38.19	-2.61*	43.40	1.91	2.00
7	mul-zml	999.99	999.99	27.31	3.35	1.49
8	zml-orl	999.99	999.99	27.24	3.45	3.25
9	orl-morl	999.99	999.99	24.77	0.77	3.28
10	morl-n	999.99	999.99	13.40	1.81	1.72
11	n-na	19.81	0.86	17.60	2.58	1.36
12	na-nabr	24.94	-0.64	27.39	3.85	1.70
13	na-nabl	25.87	0.34	24.79	3.20	2.77
14	nabr-ans	13.15	-1.38	15.63	1.78	1.80
15	nabl-ans	15.96	0.23	14.91	4.56	2.83
16	ans-pr	15.41	-0.14	15.72	2.18	2.17
17	ans-pns	44.48	-1.11	51.60	6.44	2.41
18	pns-scr	999.99	999.99	15.56	3.28	3.20
19	pns-scl	999.99	999.99	16.00	3.22	3.35
20	mur-orr	25.65	-3.30*	41.88	4.91	2.42
21	mul-orl	30.35	-2.34*	41.30	4.68	3.06
22	mur-iofr	999.99	999.99	31.95	3.14	3.13
23	mul-iofl	999.99	999.99	29.55	4.22	2.61
24	n-pr	57.03	-0.29	58.83	6.14	2.12
25	n-ans	41.74	-0.59	44.07	3.92	1.49
26	na-ans	24.75	-1.26	27.85	2.46	1.42
27	nabr-zmr	999.99	999.99	40.80	1.87	1.68
28	nabl-zml	999.99	999.99	40.01	1.22	2.92
29	nabr-nabl	21.20	-1.50	25.76	3.04	2.98
30	zmr-zml	999.99	999.99	91.68	1.44	1.57
31	mur-mul	42.43	-11.68*	58.31	1.36	1.24
32	scr-scl	999.99	999.99	26.59	3.09	3.51
33	iofr-iofl	999.99	999.99	53.51	0.81	3.88
34	orr-orl	55.92	-0.90	59.27	2.49	3.70
35	morr-morl	999.99	999.99	22.98	3.05	1.97
36	ans-scr	999.99	999.99	63.48	4.61	2.62
37	ans-scl	999.99	999.99	63.86	6.03	2.80
38	n-pns	57.49	-1.02	62.10	4.53	2.37

Table 7.5 (continued)

N	Name	Value	Z-score	Mean	SD	Exp.SD
39	pns-ba	42.70	-0.19	44.09	7.38	3.42
40	morl-n-morr	999.99	999.99	120.68	9.78	5.76
41	n-morr-orr	145.14	-2.00*	162.19	8.54	5.29
42	morr-orr-zmr	999.99	999.99	157.80	7.78	4.06
43	orr-zmr-mur	999.99	999.99	92.29	7.42	3.03
44	mur-pr-mul	68.85	-4.83*	84.94	3.33	2.23
45	n-morl-orl	999.99	999.99	162.07	7.10	5.89
46	morl-orl-zml	999.99	999.99	155.57	2.83	5.77
47	orl-zml-mul	999.99	999.99	97.94	7.39	4.17
48	zmr-ans-zml	999.99	999.99	117.27	6.61	1.32
49	s-n-na	109.68	0.06	109.05	10.50	2.84
50	n-na-nabr	116.17	-1.70	134.90	11.01	3.15
51	n-na-nabl	108.80	-1.78	127.07	10.24	4.78
52	na-nabr-ans	73.87	-0.07	74.41	7.61	4.90
53	na-nabl-ans	67.87	-2.72*	85.61	6.48	6.52
54	nabr-ans-nabl	92.93	-3.20*	114.82	4.60	6.84
55	NL/NSL	9.11	0.46	7.01	4.58	1.90
56	n-s-pns	63.81	-1.18	68.29	3.79	3.25
57	pns-s-ba	65.17	0.22	64.29	3.66	4.10
58	pns-ans-pr	87.92	-3.35*	116.18	8.44	5.70
59	na-n-g	155.57	3.70*	138.39	2.43	4.64
60	sorr-n-g	83.18	1.14	72.55	9.35	4.49
61	sorl-n-g	69.55	-1.67	83.92	8.60	5.16
62	sorr-n-na	104.38	0.03	104.26	1.58	3.40
63	sorl-n-na	117.21	1.49	110.88	2.05	4.25

Mean Z-score = -1.16   SD Z-score = 2.41   RMS Z-score = 2.64

* significant at the 5% level

Table 7.6   Stretch ratio and area change comparison between the patient's maxilla and the experimental reference maxilla standard using strain analysis.

Triangle	Parameter	Value[+]	"Z-score"[+]	Mean	SD	Obs
2 42 46	% Stretch minor	12.82	1.01	-4.92	17.49	4
	% Stretch major	36.55	1.80	5.68	17.18	4
	% Area Change	54.05	1.47	2.64	35.04	4
42 46 66	% Stretch minor	-12.25	-0.21	-9.87	11.53	4
	% Stretch major	30.29	0.97	10.06	20.89	4
	% Area Change	14.34	0.44	0.91	30.51	4
46 66 54	% Stretch minor	-7.87	0.04	-8.19	7.58	4
	% Stretch major	9.38	0.34	7.17	6.54	4
	% Area Change	0.78	0.19	-1.49	11.83	4
26 54 66	% Stretch minor	-39.34	-4.68	-6.72	6.97	4
	% Stretch major	11.17	1.11	6.02	4.66	4
	% Area Change	-32.57	-3.26	-1.01	9.68	4
66 24 26	% Stretch minor	-40.08	-1.57	-12.01	17.84	4
	% Stretch major	-10.68	-2.83	11.14	7.71	4
	% Area Change	-46.48	-1.81	-1.43	24.83	4
24 26 23	% Stretch minor	-15.29	-0.99	-6.87	8.51	4
	% Stretch major	-0.49	-1.01	7.59	8.03	4
	% Area Change	-15.70	-1.09	0.47	14.83	4
66 42 24	% Stretch minor	-15.84	-0.48	-8.68	14.77	4
	% Stretch major	-8.86	-4.05	8.79	4.36	4
	% Area Change	-23.29	-1.24	-0.48	18.35	4
24 2 25	% Stretch minor	-14.31	-0.92	-4.20	10.99	4
	% Stretch major	-4.58	-0.92	3.50	8.78	4
	% Area Change	-18.24	-0.96	-0.17	18.79	4
27 55 67	% Stretch minor	-26.94	-2.87	-4.72	7.74	4
	% Stretch major	-0.70	-0.75	3.98	6.24	4
	% Area Change	-27.45	-2.03	-0.61	13.24	4
67 24 27	% Stretch minor	-24.17	-0.62	-11.20	20.98	4
	% Stretch major	9.50	-0.18	12.50	17.12	4
	% Area Change	-16.96	-0.55	2.44	35.07	4
24 27 23	% Stretch minor	-14.01	-0.39	-9.41	11.71	4
	% Stretch major	4.78	-0.55	9.98	9.50	4
	% Area Change	-9.90	-0.51	0.14	19.80	4
67 42 24	% Stretch minor	-12.95	-0.06	-11.58	22.80	4
	% Stretch major	21.30	0.53	12.95	15.84	4
	% Area Change	5.60	0.10	1.91	36.91	4

[+] See Section 6.6.1 for discussion on criteria for identification of significant stretch ratios and area changes.

Table 7.7 (a)   Scaled least squares comparison of the patient's orbit with the least squares experimental reference orbit standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	8.488	4.115*	2.06	1.01	nasion
40	3.091	1.225	2.52	0.77	optic foramen (R)
41	2.732	0.561	4.87	1.02	optic foramen (L)
42	8.356	2.185*	3.82	0.91	nasale
46	6.973	2.888*	2.41	1.40	medial orbitale (R)
48	6.809	2.678*	2.54	1.83	superior orbitale (R)
49	8.051	2.437*	1.95	3.30	superior orbitale (L)
50	4.854	2.609*	1.86	0.81	lateral orbitale (R)
51	5.665	1.338	2.49	4.24	lateral orbitale (L)
52	7.191	3.153*	2.28	1.44	opposite orbitale (R)
53	4.566	1.634*	2.79	1.65	opposite orbitale (L)
54	5.239	2.384*	1.75	2.20	orbitale (R)
55	4.468	1.503	1.82	2.97	orbitale (L)
62	10.234	4.128*	2.48	0.77	zygomatic corner (R)
63	7.394	2.364*	3.13	1.18	zygomatic corner (L)

Patient is 5.6% smaller than the standard with scale factor Z-score = -1.960*
Scale factor standard deviation for this standard = 0.0285

* significant at the 5% level

Table 7.7 (b)   Scaled repeated median comparison of the patient's orbit with the repeated median experimental reference orbit standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	10.610	5.411*	1.96	1.01	nasion
40	2.625	1.710*	1.53	0.77	optic foramen (R)
41	3.067	0.572	5.36	1.02	optic foramen (L)
42	10.682	2.677*	3.99	0.91	nasale
46	8.916	4.284*	2.08	1.40	medial orbitale (R)
48	7.990	3.356*	2.38	1.83	superior orbitale (R)
49	9.145	2.769*	2.07	3.30	superior orbitale (L)
50	3.363	1.346	2.50	0.81	lateral orbitale (R)
51	4.846	1.144	2.97	4.24	lateral orbitale (L)
52	4.753	1.839*	2.58	1.44	opposite orbitale (R)
53	3.778	1.325	2.85	1.65	opposite orbitale (L)
54	2.782	1.266	1.88	2.20	orbitale (R)
55	3.642	1.225	1.86	2.97	orbitale (L)
62	10.398	4.584*	2.27	0.77	zygomatic corner (R)
63	7.284	2.298*	3.17	1.18	zygomatic corner (L)

Patient is 7.0% smaller than the standard with scale factor Z-score = -2.073*
Scale factor standard deviation for this standard = 0.0336

* significant at the 5% level

Table 7.7 (c)   Non-scaled least squares comparison of the patient's orbit with the least squares experimental reference orbit standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	7.078	3.431*	2.06	1.01	nasion
40	1.384	0.549	2.52	0.77	optic foramen (R)
41	3.121	0.641	4.87	1.02	optic foramen (L)
42	6.755	1.766*	3.82	0.91	nasale
46	5.755	2.384*	2.41	1.40	medial orbitale (R)
48	7.313	2.877*	2.54	1.83	superior orbitale (R)
49	8.504	2.575*	1.95	3.30	superior orbitale (L)
50	5.042	2.710*	1.86	0.81	lateral orbitale (R)
51	6.076	1.435	2.49	4.24	lateral orbitale (L)
52	7.894	3.461*	2.28	1.44	opposite orbitale (R)
53	4.877	1.745*	2.79	1.65	opposite orbitale (L)
54	5.971	2.718*	1.75	2.20	orbitale (R)
55	5.071	1.706*	1.82	2.97	orbitale (L)
62	12.421	5.010*	2.48	0.77	zygomatic corner (R)
63	9.415	3.010*	3.13	1.18	zygomatic corner (L)

* significant at the 5% level

Table 7.7 (d) Non-scaled repeated median comparison of the patient's orbit with the repeated median experimental reference orbit standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
2	6.778	3.457*	1.96	1.01	nasion
40	1.570	1.023	1.53	0.77	optic foramen (R)
41	3.412	0.636	5.36	1.02	optic foramen (L)
42	6.423	1.610	3.99	0.91	nasale
46	5.436	2.612*	2.08	1.40	medial orbitale (R)
48	7.422	3.117*	2.38	1.83	superior orbitale (R)
49	7.961	2.410*	2.07	3.30	superior orbitale (L)
50	4.704	1.883*	2.50	0.81	lateral orbitale (R)
51	7.070	1.669*	2.97	4.24	lateral orbitale (L)
52	7.550	2.921*	2.58	1.44	opposite orbitale (R)
53	5.921	2.077*	2.85	1.65	opposite orbitale (L)
54	5.684	2.587*	1.88	2.20	orbitale (R)
55	5.627	1.893*	1.86	2.97	orbitale (L)
62	12.379	5.457*	2.27	0.77	zygomatic corner (R)
63	9.412	2.970*	3.17	1.18	zygomatic corner (L)

* significant at the 5% level

Table 7.8   Distance and angle comparison of the patient's orbits with the experimental reference orbit standard using Z-scores.

N	Name	Value	Z-score	Mean	SD	Exp.SD
1	n-na	19.81	0.86	17.60	2.58	1.36
2	n-morr	17.43	1.72	13.18	2.47	1.72
3	morr-sorr	14.78	-3.11*	22.81	2.58	2.30
4	sorr-lorr	36.15	3.37*	28.12	2.38	2.00
5	lorr-oorr	10.15	-0.12	10.35	1.62	1.65
6	oorr-orr	15.39	-0.99	18.00	0.43	2.63
7	orr-morr	25.70	0.18	25.24	1.94	2.60
8	morr-ofr	50.98	1.54	48.54	0.00	1.59
9	sorr-ofr	49.50	0.22	49.06	0.60	1.98
10	lorr-ofr	45.66	-2.72*	48.68	0.36	1.11
11	oorr-ofr	46.23	-2.99*	52.34	2.04	1.63
12	orr-ofr	45.22	-2.34*	50.67	2.25	2.33
13	orr-iofr	999.99	999.99	11.00	2.95	3.69
14	n-morl	999.99	999.99	13.40	1.81	1.72
15	morl-sorl	999.99	999.99	23.10	1.05	3.58
16	sorl-lorl	36.26	1.74	26.94	1.17	5.37
17	lorl-oorl	10.70	-0.42	12.60	0.92	4.54
18	oorl-orl	14.04	-0.40	15.41	1.05	3.40
19	orl-morl	999.00	999.00	24.77	0.77	3.28
20	morl-ofl	999.99	999.99	47.93	4.22	1.73
21	sorl-ofl	50.23	0.32	49.13	1.37	3.46
22	lorl-ofl	47.45	-0.57	49.96	3.41	4.36
23	oorl-ofl	50.26	-0.57	54.65	7.68	1.94
24	orl-ofl	46.56	-0.83	52.38	6.98	3.14
25	orl-iofl	999.99	999.99	13.15	1.24	3.89
26	morr-lorr	39.06	-0.33	39.59	0.31	1.61
27	sorr-orr	31.78	0.42	30.56	2.29	2.86
28	morl-lorl	999.99	999.99	38.91	0.61	4.46
29	sorl-orl	29.98	-0.04	30.16	1.47	4.44
30	morr-morl	999.99	999.99	22.98	3.05	1.97
31	sorr-sorl	45.01	-3.79*	59.31	1.17	3.77
32	lorr-lorl	90.82	-1.19	95.96	2.12	4.31
33	oorr-oorl	82.20	-1.73	89.40	4.17	2.19
34	orr-orl	55.92	-0.90	59.27	2.49	3.70
35	iofr-iofl	999.99	999.99	53.51	0.81	3.88
36	ofr-ofl	20.97	-3.21*	25.81	1.51	1.28
37	oorr-zcr	5.48	-6.20*	17.57	1.95	1.64
38	oorl-zcl	11.66	-3.68*	19.32	2.08	2.03
39	morl-n-morr	999.99	999.99	120.68	9.78	5.76

Table 7.8 (continued)

N	Name	Value	Z-score	Mean	SD	Exp.SD
40	morr-sorr-lorr	90.03	-2.37*	101.44	4.81	4.09
41	sorr-lorr-oorr	97.78	-0.82	104.36	8.04	6.62
42	lorr-oorr-orr	119.08	-0.26	121.17	6.88	7.95
43	oorr-orr-morr	132.43	1.52	123.64	4.71	5.78
44	orr-morr-sorr	99.93	2.90*	79.04	7.20	4.68
45	sorr-ofr-orr	38.87	0.71	37.14	2.45	1.98
46	morr-ofr-lorr	47.28	-0.52	47.97	0.15	1.32
47	morl-sorl-lorl	999.99	999.99	101.83	2.21	8.26
48	sorl-lorl-oorl	93.38	-0.47	99.51	2.09	12.99
49	lorl-oorl-orl	110.48	-0.91	122.82	7.55	13.49
50	oorl-orl-morl	999.99	999.99	127.71	8.34	8.84
51	orl-morl-sorl	999.99	999.99	78.02	4.67	6.58
52	sorl-ofl-orl	35.83	0.35	34.70	0.77	3.23
53	morl-ofl-lorl	999.99	999.99	47.61	4.29	3.29
54	ofr-n-ofl	21.19	-5.04*	28.05	1.36	1.20
55	ofr-s-ofl	111.32	4.72*	79.99	6.63	6.16

Mean Z-score = -0.63   SD Z-score = 2.16   RMS Z-score = 2.23

* significant at the 5% level

Table 7.9 Stretch ratio and area change comparison between the patient's orbit and the experimental reference orbit standard using strain analysis.

Triangle	Parameter	Value[+]	"Z-score"[+]	Mean	SD	Obs
48 50 52	% Stretch minor	-0.58	1.04	-9.07	8.16	4
	% Stretch major	33.37	1.83	11.75	11.84	4
	% Area Change	32.60	1.69	2.00	18.10	4
52 48 54	% Stretch minor	-27.22	-9.15	-3.26	2.62	4
	% Stretch major	22.07	3.16	4.81	5.47	4
	% Area Change	-11.15	-1.58	1.49	7.99	4
48 54 46	% Stretch minor	-39.08	-15.15	-6.65	2.14	4
	% Stretch major	9.84	0.22	7.38	11.17	4
	% Area Change	-33.08	-2.71	0.38	12.34	4
46 48 40	% Stretch minor	-36.01	-8.58	-6.92	3.39	2
	% Stretch major	9.77	265.50	4.46	0.02	2
	% Area Change	-29.76	-7.69	-2.77	3.51	2
40 48 50	% Stretch minor	-4.71	-6.01	1.42	1.02	2
	% Stretch major	30.40	3.43	6.76	6.90	2
	% Area Change	24.26	1.97	8.32	8.08	2
40 50 52	% Stretch minor	-13.56	-0.61	-8.06	9.05	2
	% Stretch major	13.23	-0.08	14.35	14.09	2
	% Area Change	-2.13	-0.34	5.78	23.30	2
40 52 54	% Stretch minor	-13.58	-10.22	-6.53	0.69	2
	% Stretch major	-8.36	-11.21	11.03	1.73	2
	% Area Change	-20.81	-28.59	3.78	0.86	2
54 40 46	% Stretch minor	-16.00	-2.07	-0.81	7.34	2
	% Stretch major	20.03	2.99	8.20	3.96	2
	% Area Change	0.83	-0.56	7.47	11.87	2
49 51 53	% Stretch minor	-10.94	-2.11	-0.48	4.95	4
	% Stretch major	37.72	4.79	6.42	6.54	4
	% Area Change	22.65	1.56	6.05	10.61	4
53 49 55	% Stretch minor	-34.26	-4.45	-2.78	7.08	4
	% Stretch major	27.16	4.42	4.54	5.12	4
	% Area Change	-16.41	-1.55	1.82	11.73	4
41 49 51	% Stretch minor	-5.81	-0.58	-1.40	7.62	2
	% Stretch major	37.77	12.76	5.24	2.55	2
	% Area Change	29.76	2.46	3.86	10.52	2
41 51 53	% Stretch minor	-12.06	0.13	-13.29	9.33	2
	% Stretch major	-4.61	-3.43	20.40	7.30	2
	% Area Change	-16.12	-4.11	4.05	4.91	2
41 53 55	% Stretch minor	-15.68	-1.48	0.79	11.14	2
	% Stretch major	-0.94	-0.53	5.92	12.87	2
	% Area Change	-16.47	-0.97	7.48	24.78	2

+ See Section 6.6.1 for discussion on criteria for identification of significant stretch ratios and area changes.

Table 7.10   Stretch ratio and volume change comparison between the patient's orbit and the experimental reference orbit standard using three dimensional strain analysis.

Tetrahedron	Parameter	Value[+]
40 48 50 54	% Stretch minor	-17.88
	% Stretch semi	-4.59
	% Stretch major	30.41
	% Volume Change	2.17
40 46 48 54	% Stretch minor	-45.60
	% Stretch semi	-8.24
	% Stretch major	23.84
	% Volume Change	-38.18
41 49 51 55	% Stretch minor	-27.11
	% Stretch semi	-5.79
	% Stretch major	38.02
	% Volume Change	-5.23

+ See Section 6.6.1 for discussion on criteria for identification of significant stretch ratios and volume changes.

Table 7.11 (a)   Scaled least squares comparison of the patient's zygoma with the least squares experimental reference zygoma standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
7	10.780	2.000*	5.39	1.61	mastoid tip (L)
8	11.654	3.600*	3.24	1.44	mastoid tip (R)
10	8.207	2.995*	2.74	1.72	ext auditory meatus (R)
11	10.250	3.614*	2.84	2.37	ext auditory meatus (L)
50	5.386	1.869*	2.88	0.81	lateral orbitale (R)
51	5.919	1.317	4.49	4.24	lateral orbitale (L)
52	5.857	1.753*	3.34	1.44	opposite orbitale (R)
53	3.853	1.460	2.64	1.65	opposite orbitale (L)
54	4.889	2.000*	2.44	2.20	orbitale (R)
55	5.446	1.832*	2.66	2.97	orbitale (L)
62	8.782	4.244*	2.07	0.77	zygomatic corner (R)
63	6.828	2.902*	2.35	1.18	zygomatic corner (L)

Patient is 9.1% smaller than the standard with scale factor Z-score = -3.702*
Scale factor standard deviation for this standard = 0.0246

* significant at the 5% level

Table 7.11 (b) Scaled repeated median comparison of the patient's zygoma
with the repeated median experimental reference zygoma
standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
7	12.367	2.128*	5.81	1.61	mastoid tip (L)
8	11.415	3.527*	3.24	1.44	mastoid tip (R)
10	9.117	3.254*	2.80	1.72	ext auditory meatus (R)
11	12.982	3.796*	3.42	2.37	ext auditory meatus (L)
50	6.041	2.197*	2.75	0.81	lateral orbitale (R)
51	5.638	1.237	4.56	4.24	lateral orbitale (L)
52	6.687	2.074*	3.22	1.44	opposite orbitale (R)
53	4.297	1.502	2.86	1.65	opposite orbitale (L)
54	4.966	2.260*	2.11	2.20	orbitale (R)
55	2.355	0.792	2.66	2.97	orbitale (L)
62	7.605	4.443*	1.71	0.77	zygomatic corner (R)
63	8.946	4.620*	1.94	1.18	zygomatic corner (L)

Patient is 11.2% smaller than the standard with scale factor Z-score = -4.468*
Scale factor standard deviation for this standard = 0.0251

* significant at the 5% level

Table 7.11 (c) Non-scaled least squares comparison of the patient's zygoma with the least squares experimental reference zygoma standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
7	12.520	2.322*	5.39	1.61	mastoid tip (L)
8	11.341	3.503*	3.24	1.44	mastoid tip (R)
10	6.785	2.476*	2.74	1.72	ext auditory meatus (R)
11	9.690	3.416*	2.84	2.37	ext auditory meatus (L)
50	6.934	2.406*	2.88	0.81	lateral orbitale (R)
51	8.474	1.886*	4.49	4.24	lateral orbitale (L)
52	8.780	2.628*	3.34	1.44	opposite orbitale (R)
53	6.516	2.469*	2.64	1.65	opposite orbitale (L)
54	7.187	2.941*	2.44	2.20	orbitale (R)
55	6.947	2.337*	2.66	2.97	orbitale (L)
62	11.870	5.736*	2.07	0.77	zygomatic corner (R)
63	10.181	4.326*	2.35	1.18	zygomatic corner (L)

* significant at the 5% level

Table 7.11 (d) Non-scaled repeated median comparison of the patient's zygoma with the repeated median experimental reference zygoma standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
7	15.768	2.714*	5.81	1.61	mastoid tip (L)
8	12.632	3.903*	3.24	1.44	mastoid tip (R)
10	9.066	3.236*	2.80	1.72	ext auditory meatus (R)
11	13.761	4.024*	3.42	2.37	ext auditory meatus (L)
50	6.079	2.210*	2.75	0.81	lateral orbitale (R)
51	7.491	1.644*	4.56	4.24	lateral orbitale (L)
52	8.238	2.555*	3.22	1.44	opposite orbitale (R)
53	5.869	2.051*	2.86	1.65	opposite orbitale (L)
54	6.021	2.740*	2.11	2.20	orbitale (R)
55	4.080	1.372	2.66	2.97	orbitale (L)
62	12.004	7.013*	1.71	0.77	zygomatic corner (R)
63	12.191	6.296*	1.94	1.18	zygomatic corner (L)

* significant at the 5% level

Table 7.12   Distance and angle comparison of the patient's zygoma with the experimental reference zygoma standard using Z-scores.

N	Name	Value	Z-score	Mean	SD	Exp.SD
1	lorr-zcr	10.05	-5.41*	16.38	1.17	1.12
2	zcr-eamr	54.96	-1.87	58.49	1.53	1.89
3	eamr-aer	999.99	999.99	24.12	2.33	2.45
4	aer-zmr	999.99	999.99	43.08	2.87	1.96
5	zmr-orr	999.99	999.99	28.78	2.72	2.37
6	orr-oorr	15.39	-0.99	18.00	0.43	2.63
7	oorr-lorr	10.15	-0.12	10.35	1.62	1.65
8	lorl-zcl	13.83	-1.07	18.52	2.50	4.40
9	zcl-eaml	50.13	-3.39*	59.11	2.50	2.65
10	eaml-ael	999.99	999.99	24.38	2.61	3.96
11	ael-zml	999.99	999.99	45.04	3.23	3.43
12	zml-orl	999.99	999.99	27.24	3.45	3.25
13	orl-oorl	14.04	-0.40	15.41	1.05	3.40
14	oorl-lorl	10.70	-0.42	12.60	0.92	4.54
15	zmr-oorr	999.99	999.99	22.28	4.36	1.69
16	zmr-zcr	999.99	999.99	22.65	4.77	1.18
17	zmr-eamr	999.99	999.99	65.07	3.47	1.94
18	zcr-oorr	5.48	-6.20*	17.57	1.95	1.64
19	zml-oorl	999.99	999.99	23.16	5.27	2.10
20	zml-zcl	999.99	999.99	24.56	4.97	1.76
21	zml-eaml	999.99	999.99	67.71	3.48	2.70
22	zcl-oorl	11.66	-3.68*	19.32	2.08	2.03
23	zmr-zml	999.99	999.99	91.68	1.44	1.57
24	aer-ael	999.99	999.99	107.43	5.18	3.62
25	eamr-eaml	101.40	2.19*	94.98	0.68	2.93
26	zcr-zcl	91.06	-10.40*	111.24	1.94	1.41
27	lorr-lorl	90.82	-1.19	95.96	2.12	4.31
28	oorr-oorl	82.20	-1.73	89.40	4.17	2.19
29	orr-orl	55.92	-0.90	59.27	2.49	3.70
30	lorr-oorr-eamr	72.60	-0.13	73.78	9.32	6.36
31	lorl-oorl-eaml	61.55	-0.86	77.69	18.71	11.20
32	lorr-zcr-eamr	96.73	-4.96*	125.79	5.86	2.54
33	zcr-eamr-zmr	999.99	999.99	20.05	3.07	1.46
34	eamr-zmr-orr	999.99	999.99	112.46	11.40	2.81
35	zmr-orr-oorr	999.99	999.99	50.41	9.01	5.54

Table 7.12 (continued)

N	Name	Value	Z-score	Mean	SD	Exp.SD
36	orr-oorr-lorr	119.08	-0.26	121.17	6.88	7.95
37	oorr-lorr-zcr	31.51	-7.02*	78.50	6.03	6.69
38	lorl-zcl-eaml	108.27	-2.25*	129.59	9.47	8.25
39	zcl-eaml-zml	999.99	999.99	20.75	3.40	1.94
40	eaml-zml-orl	999.99	999.99	109.70	9.17	3.89
41	zml-orl-oorl	999.99	999.99	57.56	9.80	8.46
42	orl-oorl-lorl	110.48	-0.91	122.82	7.55	13.49
43	oorl-lorl-zcl	54.98	-1.38	74.05	8.69	13.78

Mean Z-score = -2.32   SD Z-score = 2.83   RMS Z-score = 3.61

* significant at the 5% level

Table 7.13   Stretch ratio and area change comparison between the patient's zygoma and the experimental reference zygoma standard using strain analysis.

Triangle	Parameter	Value[+]	"Z-score"[+]	Mean	SD	Obs
52 50 62	% Stretch minor	-68.95	-6.65	-7.46	9.25	4
	% Stretch major	4.75	-0.38	8.75	10.53	4
	% Area Change	-67.48	-3.43	1.34	20.09	4
53 51 63	% Stretch minor	-39.56	-6.06	-7.87	5.23	4
	% Stretch major	-6.22	-2.03	12.25	9.11	4
	% Area Change	-43.31	-3.60	3.67	13.04	4

[+] See Section 6.6.1 for discussion on criteria for identification of significant stretch ratios and area changes.

Table 7.14 (a) Scaled least squares comparison of the patient's cranium with the least squares experimental reference cranium standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	4.358	1.307	3.34	2.24	sella
2	5.857	1.720*	3.40	1.01	nasion
3	13.607	3.649*	3.73	2.11	glabella
4	17.487	4.321*	4.05	2.76	vertex
5	15.847	3.147*	5.04	0.85	opisthocranion
6	6.018	1.932*	3.12	0.45	opisthion
7	9.320	1.648*	5.65	1.61	mastoid tip (L)
8	6.275	1.451	4.33	1.44	mastoid tip (R)
9	5.113	0.881	5.80	2.66	basion
10	2.647	0.594	4.46	1.72	ext auditory meatus (R)
11	7.627	1.677*	4.55	2.37	ext auditory meatus (L)
43	4.053	6.579*	0.00	0.62	bregma
64	28.322	8.954*	3.16	2.55	zygomatic frontal (R)
65	18.790	5.670*	3.31	2.61	zygomatic frontal (L)
78	4.259	0.515	8.27	1.86	foramen mag breadth (R)
79	7.163	0.904	7.92	1.22	foramen mag breadth (L)

Patient is 3.8% larger than the standard with scale factor Z-score = 1.013
Scale factor standard deviation for this standard = 0.0378

* significant at the 5% level

Table 7.14 (b)   Scaled repeated median comparison of the patient's cranium with the repeated median experimental reference cranium standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	4.684	1.553	3.02	2.24	sella
2	7.918	2.439*	3.25	1.01	nasion
3	14.728	4.154*	3.55	2.11	glabella
4	20.333	4.759*	4.27	2.76	vertex
5	14.450	2.292*	6.30	0.85	opisthocranion
6	2.938	1.202	2.44	0.45	opisthion
7	6.012	0.963	6.24	1.61	mastoid tip (L)
8	3.746	0.771	4.86	1.44	mastoid tip (R)
9	3.876	0.586	6.62	2.66	basion
10	1.042	0.255	4.09	1.72	ext auditory meatus (R)
11	4.320	0.974	4.43	2.37	ext auditory meatus (L)
43	5.099	8.277*	0.00	0.62	bregma
64	31.244	9.206*	3.39	2.55	zygomatic frontal (R)
65	21.999	6.250*	3.52	2.61	zygomatic frontal (L)
78	2.842	0.336	8.45	1.86	foramen mag breadth (R)
79	4.630	0.580	7.99	1.22	foramen mag breadth (L)

Patient is 3.3% larger than the standard with scale factor Z-score = 1.293
Scale factor standard deviation for this standard = 0.0253

* significant at the 5% level

Table 7.14 (c) Non-scaled least squares comparison of the patient's cranium
with the least squares experimental reference cranium standard
using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	4.886	1.465	3.34	2.24	sella
2	6.296	1.850*	3.40	1.01	nasion
3	14.092	3.779*	3.73	2.11	glabella
4	20.121	4.972*	4.05	2.76	vertex
5	17.588	3.493*	5.04	0.85	opisthocranion
6	4.032	1.294	3.12	0.45	opisthion
7	8.927	1.579	5.65	1.61	mastoid tip (L)
8	6.365	1.472	4.33	1.44	mastoid tip (R)
9	5.548	0.956	5.80	2.66	basion
10	3.185	0.715	4.46	1.72	ext auditory meatus (R)
11	8.138	1.789*	4.55	2.37	ext auditory meatus (L)
43	7.686	12.478*	0.00	0.62	bregma
64	27.554	8.711*	3.16	2.55	zygomatic frontal (R)
65	17.661	5.329*	3.31	2.61	zygomatic frontal (L)
78	3.496	0.423	8.27	1.86	foramen mag breadth (R)
79	6.628	0.836	7.92	1.22	foramen mag breadth (L)

* significant at the 5% level

Table 7.14 (d)   Non-scaled repeated median comparison of the patient's cranium with the repeated median experimental reference cranium standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	4.015	1.332	3.02	2.24	sella
2	6.479	1.996*	3.25	1.01	nasion
3	15.396	4.342*	3.55	2.11	glabella
4	22.385	5.239*	4.27	2.76	vertex
5	16.974	2.693*	6.30	0.85	opisthocranion
6	1.974	0.808	2.44	0.45	opisthion
7	6.830	1.094	6.24	1.61	mastoid tip (L)
8	3.827	0.788	4.86	1.44	mastoid tip (R)
9	4.308	0.651	6.62	2.66	basion
10	1.181	0.289	4.09	1.72	ext auditory meatus (R)
11	6.177	1.393	4.43	2.37	ext auditory meatus (L)
43	8.108	13.162*	0.00	0.62	bregma
64	29.730	8.760*	3.39	2.55	zygomatic frontal (R)
65	20.493	5.822*	3.52	2.61	zygomatic frontal (L)
78	3.251	0.385	8.45	1.86	foramen mag breadth (R)
79	4.302	0.539	7.99	1.22	foramen mag breadth (L)

* significant at the 5% level

Table 7.15   Distance and angle comparison of the patient's cranium with the experimental reference cranium standard using Z-scores.

N	Name	Value	Z-score	Mean	SD	Exp.SD
1	s-n	62.92	-0.34	64.18	3.73	2.46
2	n-g	35.45	4.71*	17.42	3.83	2.34
3	g-br	87.27	-1.31	90.15	0.00	2.20
4	g-zfr	69.10	3.29*	53.85	4.64	3.31
5	g-zfl	62.74	1.43	57.92	2.88	3.36
6	zfr-br	105.64	9.98*	79.49	0.00	2.62
7	zfl-br	96.51	7.03*	77.67	0.00	2.68
8	br-v	38.47	5.51*	22.87	0.00	2.83
9	v-op	111.29	-1.21	124.24	10.68	2.89
10	op-o	87.80	2.75*	71.16	6.05	0.96
11	op-mtr	121.86	1.70	106.47	9.03	1.67
12	op-mtl	126.15	2.34*	107.42	7.99	1.82
13	o-fmbr	21.25	-0.57	23.26	3.51	1.91
14	o-fmbl	26.66	1.62	24.55	0.89	1.30
15	fmbr-ba	24.84	-0.10	25.18	0.73	3.25
16	fmbl-ba	21.92	-0.57	23.59	0.16	2.93
17	ba-s	40.61	-0.15	41.58	6.56	3.48
18	mtr-eamr	22.69	-0.70	25.06	3.40	2.25
19	eamr-zfr	56.97	-5.45*	81.54	4.51	3.08
20	eamr-v	131.65	2.70*	118.38	4.91	3.25
21	mtl-eaml	23.31	-0.28	24.67	4.90	2.86
22	eaml-zfl	58.26	-3.88*	80.84	5.82	3.53
23	eaml-v	131.70	1.81	119.78	6.58	3.64
24	mtr-mtl	103.46	2.03*	95.08	4.12	2.16
25	eamr-eaml	101.40	2.19*	94.98	0.68	2.93
26	zfr-zfl	100.91	1.50	94.81	4.08	3.65
27	fmbr-fmbl	29.26	-0.50	30.36	0.01	2.22
28	o-ba	37.34	0.20	36.81	1.07	2.70
29	n-ba	93.90	-0.35	97.15	9.18	2.85
30	s-g	74.73	0.75	72.41	2.51	3.08
31	s-o	68.05	-0.48	69.83	3.71	2.28
32	g-o	142.65	0.19	141.43	6.46	2.16
33	g-op	185.59	0.25	182.83	10.99	2.27
34	ba-br	133.86	5.77*	118.10	0.00	2.73
35	s-v	111.99	5.43*	92.71	2.75	3.55
36	s-br	98.76	5.75*	85.42	0.00	2.32
37	ba-v	139.15	2.00*	125.17	7.00	3.83
38	ba-s-n	128.87	-0.61	132.53	5.95	3.07
39	s-n-g	94.74	-2.00*	110.81	8.04	4.08

Table 7.15 (continued)

N	Name	Value	Z-score	Mean	SD	Exp.SD
40	n-g-br	131.44	5.29*	110.46	0.00	3.97
41	g-br-v	146.75	0.49	144.98	0.00	3.60
42	br-v-op	129.01	0.71	126.46	0.00	3.59
43	v-op-o	86.96	0.47	83.25	7.98	0.84
44	op-o-ba	137.33	3.53*	128.09	2.62	2.54
45	o-ba-s	121.57	-1.46	136.90	10.50	3.76
46	op-mtr-eamr	80.91	-1.83	87.78	3.76	3.09
47	op-mtl-eaml	82.25	-0.66	85.33	4.67	4.50
48	o-fmbr-ba	107.97	1.93	98.00	2.08	5.17
49	o-fmbl-ba	100.01	0.10	99.23	8.19	4.43
50	fmbr-o-fmbl	74.33	-0.90	78.69	4.85	3.49
51	fmbr-ba-fmbl	77.19	0.04	76.94	1.68	5.85
52	g-v-op	105.79	1.15	102.09	3.21	1.24

Mean Z-score = 1.18   SD Z-score = 2.77   RMS Z-score = 2.98

* significant at the 5% level

Table 7.16 Stretch ratio and area change comparison between the patient's cranium and the experimental reference cranium standard using strain analysis.

Triangle	Parameter	Value[+]	"Z-score"[+]	Mean	SD	Obs
3 4 64	% Stretch minor	4.18	1.86	-4.62	4.73	3
	% Stretch major	51.07	9.00	5.25	5.09	3
	% Area Change	57.39	5.93	0.54	9.59	3
4 8 64	% Stretch minor	-27.62	-6.09	-4.40	3.81	3
	% Stretch major	31.41	23.53	1.05	1.29	3
	% Area Change	-4.89	-0.34	-3.39	4.37	3
4 8 5	% Stretch minor	-10.99	-0.90	-3.51	8.28	3
	% Stretch major	16.37	1.60	2.50	8.67	3
	% Area Change	3.57	0.25	-0.61	16.47	3
5 8 6	% Stretch minor	5.62	3.18	-8.43	4.42	3
	% Stretch major	20.32	3.68	4.18	4.39	3
	% Area Change	27.07	11.60	-4.72	2.74	3
3 4 65	% Stretch minor	1.09	1.22	-3.06	3.40	3
	% Stretch major	28.11	9.04	2.98	2.78	3
	% Area Change	29.51	5.01	-0.12	5.92	3
4 7 65	% Stretch minor	-24.35	-3.59	-4.73	5.46	3
	% Stretch major	23.73	6.90	0.49	3.37	3
	% Area Change	-6.39	-0.28	-4.18	7.91	3
4 7 5	% Stretch minor	-10.88	-1.10	-2.71	7.42	3
	% Stretch major	18.45	1.89	1.84	8.77	3
	% Area Change	5.56	0.38	-0.49	15.74	3
5 7 6	% Stretch minor	12.30	4.08	-8.08	5.00	3
	% Stretch major	19.55	3.42	2.96	4.85	3
	% Area Change	34.26	4.13	-5.20	9.56	3

[+] See Section 6.6.1 for discussion on criteria for identification of significant stretch ratios and area changes.

Table 7.17 (a) Scaled least squares comparison of the patient's skull with the least squares experimental reference skull standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	4.279	1.263	3.39	2.24	sella
2	3.983	1.738*	2.29	1.01	nasion
3	21.312	4.388*	4.86	2.11	glabella
4	28.975	5.774*	5.02	2.76	vertex
5	14.539	2.358*	6.17	0.85	opisthocranion
6	3.882	1.624*	2.39	0.45	opisthion
7	10.580	1.940*	5.45	1.61	mastoid tip (L)
8	9.029	2.351*	3.84	1.44	mastoid tip (R)
9	8.457	1.374	6.15	2.66	basion
10	5.266	1.160	4.54	1.72	ext auditory meatus (R)
11	9.063	2.105*	4.30	2.37	ext auditory meatus (L)
12	7.478	2.019*	3.70	1.72	condylion (R)
13	9.175	1.881*	4.88	2.39	condylion (L)
14	13.522	4.552*	2.97	0.00	articulare (R)
15	13.527	7.791*	1.74	0.00	articulare (L)
16	15.590	3.512*	4.44	1.16	gonion (R)
17	15.598	3.615*	4.31	1.78	gonion (L)
20	17.161	4.693*	3.66	0.76	gnathion
21	17.244	3.800*	4.54	1.50	pogonion
22	11.504	3.504*	3.28	0.51	infradentale
23	6.613	1.774*	3.73	1.87	prosthion
24	1.506	0.318	4.74	1.09	ant nasal spine
25	6.771	1.479	4.58	2.14	post nasal spine
26	17.044	4.529*	3.76	1.00	upper molar (R)
27	12.362	3.092*	4.00	0.72	upper molar (L)
28	13.961	4.801*	2.91	0.80	lower molar (R)
29	12.118	6.241*	1.94	0.87	lower molar (L)
32	10.138	2.294*	4.42	0.89	coronoid tip (R)
33	13.639	2.855*	4.78	1.72	coronoid tip (L)
40	7.218	3.559*	2.03	0.77	optic foramen (R)
41	8.631	1.827*	4.72	1.02	optic foramen (L)
42	6.531	1.727*	3.78	0.91	nasale
43	13.583	22.051*	0.00	0.62	bregma
46	4.239	1.803*	2.35	1.40	medial orbitale (R)
48	6.420	1.752*	3.66	1.83	superior orbitale (R)
49	7.378	2.234*	3.05	3.30	superior orbitale (L)
50	10.246	2.799*	3.66	0.81	lateral orbitale (R)
51	10.923	2.579*	4.21	4.24	lateral orbitale (L)

Table 7.17 (a) (continued)

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
52	11.415	2.805*	4.07	1.44	opposite orbitale (R)
53	9.015	3.205*	2.81	1.65	opposite orbitale (L)
54	7.302	2.329*	3.14	2.20	orbitale (R)
55	5.136	1.728*	2.83	2.97	orbitale (L)
62	13.504	4.174*	3.24	0.77	zygomatic corner (R)
63	12.359	4.687*	2.64	1.18	zygomatic corner (L)
64	24.163	5.512*	4.38	2.55	zygomatic frontal (R)
65	16.892	3.726*	4.53	2.61	zygomatic frontal (L)
66	6.090	1.625*	3.75	1.43	nasal breadth (R)
67	1.956	0.604	3.24	2.61	nasal breadth (L)
69	12.234	2.578*	4.75	1.20	coronoid notch (L)
71	12.438	3.747*	3.32	3.15	ext oblique line (L)
78	6.062	0.664	9.13	1.86	foramen mag breadth (R)
79	8.440	0.965	8.75	1.22	foramen mag breadth (L)
81	9.142	5.387*	0.00	1.70	incision superius (L)
91	3.650	1.039	3.51	1.84	anterior clinoid (L)
92	3.231	1.628*	1.98	0.46	anterior clinoid (R)
93	14.726	2.888*	5.10	2.33	less wing of sphenoid (L)
94	9.636	2.441*	3.95	2.38	less wing of sphenoid (R)
95	17.411	3.069*	5.67	3.54	
96	10.286	2.627*	1.64	3.91	
97	10.726	2.424*	4.43	1.14	
98	4.442	2.846*	1.56	1.48	
99	6.831	2.398*	2.85	0.53	
100	3.781	4.611*	0.63	0.82	
101	13.531	2.497*	5.42	3.01	
102	9.867	3.009*	2.12	3.28	
103	3.047	1.118	2.50	2.72	med anterior clinoid (L)
104	3.951	1.172	2.73	3.37	medl anterior clinoid (R)
105	7.673	1.486	3.04	5.16	posterior clinoid (L)
106	5.577	1.593	3.16	3.50	posterior clinoid (R)

Patient is 3.4% smaller than the standard with scale factor Z-score = -0.765
Scale factor standard deviation for this standard = 0.0446

* significant at the 5% level

Table 7.17 (b)   Scaled repeated median comparison of the patient's skull with the repeated median experimental reference skull standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	1.417	0.423	3.35	2.24	sella
2	4.809	2.531*	1.90	1.01	nasion
3	24.627	5.514*	4.47	2.11	glabella
4	35.337	5.793*	6.10	2.76	vertex
5	22.422	3.373*	6.65	0.85	opisthocranion
6	2.410	0.809	2.98	0.45	opisthion
7	10.653	1.908*	5.58	1.61	mastoid tip (L)
8	7.936	2.169*	3.66	1.44	mastoid tip (R)
9	5.970	0.952	6.27	2.66	basion
10	5.121	1.122	4.56	1.72	ext auditory meatus (R)
11	10.153	2.158*	4.70	2.37	ext auditory meatus (L)
12	6.180	1.633*	3.78	1.72	condylion (R)
13	9.174	1.779*	5.16	2.39	condylion (L)
14	11.410	3.969*	2.88	0.00	articulare (R)
15	11.795	7.157*	1.65	0.00	articulare (L)
16	14.200	3.219*	4.41	1.16	gonion (R)
17	16.101	3.642*	4.42	1.78	gonion (L)
20	18.065	4.950*	3.65	0.76	gnathion
21	18.318	3.796*	4.83	1.50	pogonion
22	11.734	3.117*	3.76	0.51	infradentale
23	6.570	1.580	4.16	1.87	prosthion
24	1.940	0.396	4.91	1.09	ant nasal spine
25	5.441	1.156	4.70	2.14	post nasal spine
26	17.415	4.394*	3.96	1.00	upper molar (R)
27	12.607	2.994*	4.21	0.72	upper molar (L)
28	14.674	5.072*	2.89	0.80	lower molar (R)
29	12.187	5.843*	2.09	0.87	lower molar (L)
32	11.621	2.665*	4.36	0.89	coronoid tip (R)
33	16.376	3.421*	4.79	1.72	coronoid tip (L)
40	7.785	3.727*	2.09	0.77	optic foramen (R)
41	7.641	1.665*	4.59	1.02	optic foramen (L)
42	6.950	1.749*	3.97	0.91	nasale
43	19.304	31.337*	0.00	0.62	bregma
46	5.204	2.407*	2.16	1.40	medial orbitale (R)
48	4.852	1.397	3.47	1.83	superior orbitale (R)
49	6.521	1.974*	3.14	3.30	superior orbitale (L)
50	10.568	2.910*	3.63	0.81	lateral orbitale (R)
51	9.556	2.219*	4.31	4.24	lateral orbitale (L)

Table 7.17 (b) (continued)

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
52	11.648	2.809*	4.15	1.44	opposite orbitale (R)
53	7.899	2.567*	3.08	1.65	opposite orbitale (L)
54	7.660	2.578*	2.97	2.20	orbitale (R)
55	4.954	1.666*	2.87	2.97	orbitale (L)
62	11.982	3.834*	3.12	0.77	zygomatic corner (R)
63	10.038	3.841*	2.61	1.18	zygomatic corner (L)
64	23.837	5.668*	4.21	2.55	zygomatic frontal (R)
65	16.223	3.365*	4.82	2.61	zygomatic frontal (L)
66	6.042	1.553	3.89	1.43	nasal breadth (R)
67	2.491	0.749	3.33	2.61	nasal breadth (L)
69	14.470	2.950*	4.91	1.20	coronoid notch (L)
71	13.442	4.078*	3.30	3.15	ext oblique line (L)
78	3.536	0.377	9.38	1.86	foramen mag breadth (R)
79	5.105	0.564	9.06	1.22	foramen mag breadth (L)
81	9.608	5.662*	0.00	1.70	incision superius (L)
91	1.522	0.431	3.53	1.84	anterior clinoid (L)
92	4.141	2.222*	1.86	0.46	anterior clinoid (R)
93	17.246	3.631*	4.75	2.33	less wing of sphenoid (L)
94	11.130	3.383*	3.29	2.38	less wing of sphenoid (R)
95	16.311	2.886*	5.65	3.54	
96	10.442	2.667*	1.49	3.91	
97	7.903	1.768*	4.47	1.14	
98	3.917	2.329*	1.68	1.48	
99	4.252	1.454	2.92	0.53	
100	3.898	4.754*	0.19	0.82	
101	14.115	2.695*	5.24	3.01	
102	10.433	3.182*	1.58	3.28	
103	3.086	1.133	2.23	2.72	med anterior clinoid (L)
104	4.025	1.194	2.32	3.37	med anterior clinoid (R)
105	6.536	1.265	2.99	5.16	posterior clinoid (L)
106	3.829	1.094	2.93	3.50	posterior clinoid (R)

Patient is 8.6% smaller than the standard with scale factor Z-score = -1.888
Scale factor standard deviation for this standard = 0.0457

* significant at the 5% level

Table 7.17 (c)　Non-scaled least squares comparison of the patient's skull with the least squares experimental reference skull standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	4.907	1.448	3.39	2.24	sella
2	2.456	1.071	2.29	1.01	nasion
3	19.738	4.064*	4.86	2.11	glabella
4	25.614	5.104*	5.02	2.76	vertex
5	10.276	1.666*	6.17	0.85	opisthocranion
6	5.596	2.341*	2.39	0.45	opisthion
7	11.074	2.031*	5.45	1.61	mastoid tip (L)
8	8.951	2.331*	3.84	1.44	mastoid tip (R)
9	8.951	1.455	6.15	2.66	basion
10	5.129	1.130	4.54	1.72	ext auditory meatus (R)
11	8.926	2.073*	4.30	2.37	ext auditory meatus (L)
12	7.918	2.138*	3.70	1.72	condylion (R)
13	9.622	1.973*	4.88	2.39	condylion (L)
14	13.608	4.581*	2.97	0.00	articulare (R)
15	13.960	8.041*	1.74	0.00	articulare (L)
16	16.771	3.778*	4.44	1.16	gonion (R)
17	16.856	3.907*	4.31	1.78	gonion (L)
20	18.632	5.095*	3.66	0.76	gnathion
21	18.520	4.082*	4.54	1.50	pogonion
22	13.292	4.049*	3.28	0.51	infradentale
23	8.161	2.189*	3.73	1.87	prosthion
24	1.011	0.213	4.74	1.09	ant nasal spine
25	6.544	1.430	4.58	2.14	post nasal spine
26	18.381	4.884*	3.76	1.00	upper molar (R)
27	13.733	3.435*	4.00	0.72	upper molar (L)
28	15.421	5.304*	2.91	0.80	lower molar (R)
29	13.549	6.977*	1.94	0.87	lower molar (L)
32	9.435	2.134*	4.42	0.89	coronoid tip (R)
33	12.859	2.691*	4.78	1.72	coronoid tip (L)
40	7.511	3.703*	2.03	0.77	optic foramen (R)
41	9.139	1.934*	4.72	1.02	optic foramen (L)
42	4.829	1.277	3.78	0.91	nasale
43	10.103	16.401*	0.00	0.62	bregma
46	3.666	1.559	2.35	1.40	medial orbitale (R)
48	7.822	2.135*	3.66	1.83	superior orbitale (R)
49	8.371	2.534*	3.05	3.30	superior orbitale (L)
50	11.067	3.023*	3.66	0.81	lateral orbitale (R)
51	11.839	2.795*	4.21	4.24	lateral orbitale (L)

Table 7.17 (c) (continued)

Landmark No.	Residual	d/σ- Score	SD	Exp.SD	Landmark Name
52	12.385	3.044*	4.07	1.44	opposite orbitale (R)
53	9.774	3.475*	2.81	1.65	opposite orbitale (L)
54	8.438	2.691*	3.14	2.20	orbitale (R)
55	6.306	2.121*	2.83	2.97	orbitale (L)
62	14.492	4.480*	3.24	0.77	zygomatic corner (R)
63	13.165	4.993*	2.64	1.18	zygomatic corner (L)
64	25.092	5.724*	4.38	2.55	zygomatic frontal (R)
65	17.471	3.853*	4.53	2.61	zygomatic frontal (L)
66	7.308	1.950*	3.75	1.43	nasal breadth (R)
67	2.171	0.670	3.24	2.61	nasal breadth (L)
69	12.198	2.571*	4.75	1.20	coronoid notch (L)
71	13.316	4.012*	3.32	3.15	ext oblique line (L)
78	7.011	0.768	9.13	1.86	foramen mag breadth (R)
79	9.427	1.078	8.75	1.22	foramen mag breadth (L)
81	9.890	5.828*	0.00	1.70	incision superius (L)
91	4.208	1.198	3.51	1.84	anterior clinoid (L)
92	2.968	1.496	1.98	0.46	anterior clinoid (R)
93	13.077	2.565*	5.10	2.33	less wing of sphenoid (L)
94	8.182	2.072*	3.95	2.38	less wing of sphenoid (R)
95	17.609	3.104*	5.67	3.54	
96	9.817	2.507*	1.64	3.91	
97	11.495	2.597*	4.43	1.14	
98	4.663	2.988*	1.56	1.48	
99	7.468	2.621*	2.85	0.53	
100	3.755	4.579*	0.63	0.82	
101	12.962	2.392*	5.42	3.01	
102	9.027	2.753*	2.12	3.28	
103	3.512	1.289	2.50	2.72	med anterior clinoid (L)
104	4.225	1.254	2.73	3.37	med anterior clinoid (R)
105	8.088	1.566	3.04	5.16	posterior clinoid (L)
106	6.019	1.720*	3.16	3.50	posterior clinoid (R)

* significant at the 5% level

Table 7.17 (d) Non-scaled repeated median comparison of the patient's skull with the repeated median experimental reference skull standard using the d/σ-score.

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
1	3.491	1.041	3.35	2.24	sella
2	0.918	0.483	1.90	1.01	nasion
3	20.543	4.599*	4.47	2.11	glabella
4	25.639	4.203*	6.10	2.76	vertex
5	11.006	1.656*	6.65	0.85	opisthocranion
6	4.905	1.646*	2.98	0.45	opisthion
7	11.483	2.056*	5.58	1.61	mastoid tip (L)
8	7.177	1.962*	3.66	1.44	mastoid tip (R)
9	7.585	1.210	6.27	2.66	basion
10	3.462	0.759	4.56	1.72	ext auditory meatus (R)
11	9.250	1.966*	4.70	2.37	ext auditory meatus (L)
12	7.391	1.953*	3.78	1.72	condylion (R)
13	10.036	1.946*	5.16	2.39	condylion (L)
14	12.008	4.177*	2.88	0.00	articulare (R)
15	13.105	7.951*	1.65	0.00	articulare (L)
16	17.481	3.963*	4.41	1.16	gonion (R)
17	19.011	4.300*	4.42	1.78	gonion (L)
20	21.010	5.757*	3.65	0.76	gnathion
21	20.817	4.314*	4.83	1.50	pogonion
22	15.572	4.136*	3.76	0.51	infradentale
23	10.038	2.414*	4.16	1.87	prosthion
24	3.035	0.619	4.91	1.09	ant nasal spine
25	5.882	1.250	4.70	2.14	post nasal spine
26	20.616	5.202*	3.96	1.00	upper molar (R)
27	15.602	3.706*	4.21	0.72	upper molar (L)
28	17.886	6.182*	2.89	0.80	lower molar (R)
29	15.308	7.339*	2.09	0.87	lower molar (L)
32	9.908	2.272*	4.36	0.89	coronoid tip (R)
33	14.510	3.031*	4.79	1.72	coronoid tip (L)
40	7.615	3.645*	2.09	0.77	optic foramen (R)
41	8.246	1.797*	4.59	1.02	optic foramen (L)
42	2.994	0.754	3.97	0.91	nasale
43	9.624	15.624*	0.00	0.62	bregma
46	3.863	1.787*	2.16	1.40	medial orbitale (R)
48	8.462	2.436*	3.47	1.83	superior orbitale (R)
49	8.531	2.583*	3.14	3.30	superior orbitale (L)
50	12.073	3.325*	3.63	0.81	lateral orbitale (R)
51	11.377	2.641*	4.31	4.24	lateral orbitale (L)

Table 7.17 (d) (continued)

Landmark No.	Residual	d/σ-Score	SD	Exp.SD	Landmark Name
52	13.642	3.290*	4.15	1.44	opposite orbitale (R)
53	9.421	3.061*	3.08	1.65	opposite orbitale (L)
54	9.953	3.350*	2.97	2.20	orbitale (R)
55	7.175	2.413*	2.87	2.97	orbitale (L)
62	14.899	4.768*	3.12	0.77	zygomatic corner (R)
63	12.108	4.633*	2.61	1.18	zygomatic corner (L)
64	25.652	6.100*	4.21	2.55	zygomatic frontal (R)
65	16.849	3.495*	4.82	2.61	zygomatic frontal (L)
66	9.069	2.331*	3.89	1.43	nasal breadth (R)
67	3.730	1.121	3.33	2.61	nasal breadth (L)
69	14.113	2.877*	4.91	1.20	coronoid notch (L)
71	15.380	4.666*	3.30	3.15	ext oblique line (L)
78	5.874	0.626	9.38	1.86	foramen mag breadth (R)
79	7.991	0.882	9.06	1.22	foramen mag breadth (L)
81	11.137	6.563*	0.00	1.70	incision superius (L)
91	2.822	0.799	3.53	1.84	anterior clinoid (L)
92	1.873	1.005	1.86	0.46	anterior clinoid (R)
93	13.322	2.805*	4.75	2.33	less wing of sphenoid (L)
94	7.138	2.169*	3.29	2.38	less wing of sphenoid (R)
95	16.775	2.968*	5.65	3.54	
96	8.214	2.098*	1.49	3.91	
97	10.431	2.334*	4.47	1.14	
98	3.120	1.855*	1.68	1.48	
99	6.315	2.159*	2.92	0.53	
100	2.222	2.709*	0.19	0.82	
101	12.630	2.412*	5.24	3.01	
102	7.642	2.331*	1.58	3.28	
103	2.692	0.988	2.23	2.72	med anterior clinoid (L)
104	3.410	1.012	2.32	3.37	med anterior clinoid (R)
105	7.644	1.480	2.99	5.16	posterior clinoid (L)
106	4.494	1.284	2.93	3.50	posterior clinoid (R)

* significant at the 5% level

Table 7.18   Comparison of analysis techniques with the qualitative description of Treacher Collins Syndrome

Skeletal Feature	Individual Osseous Landmark		Distance and Angle	Strain
Mandible	Bone Standard	Skull Standard		
Hypoplastic	Scale factor indicates patient's mandible is smaller than the standard (5.8% least squares, 8.4% repeated median) but not outside the normal population variance. Superimposed wire frame diagrams show, and residuals quantify, • smaller ramus height bilaterally • smaller mandibular body length bilaterally • less developed condylar process	Similar to bone standard comparison but includes effects of position and orientation relative to the rest of the patient's skull. The alignment of the patient relative to the standard accentuates gonial angle and chin differences.	Most distance Z-scores are negative. Fifteen of the distances are significantly smaller than those of the standard • total mandibular length (left and right)[*] • posterior ramus height (left and right) • gonion right to coronoid tip right • condylion left to coronoid notch left • condylion left to coronoid tip left • lower border of the mandible (left and right)[*] • dental arch length (left) • dental arch breadth	The external surface of the patient's mandible is 8.8cm^2 smaller than the standard based on the measured triangles in common between the patient and the standard. Individual triangles quantify the extent of hypoplasia in different parts of the mandible (seven triangles showed area decreases, two showed marginal area increases).

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[*] Both gnathion and pogonion were used to define the chin giving another set of measurements

Skeletal Feature	Individual Osseous Landmark		Distance and Angle	Strain
Mandible	Bone Standard	Skull Standard		
Angle of mandible more obtuse	Evident from plots. Landmarks defining the angle differ in position significantly.	Appears more evident than for alignment of only the patient and standard mandibles due to orientation.	Significantly more obtuse (10-14° larger).	Represented by the two triangles sharing the edge gonion left to external oblique point left. The principal directions show dilations in a direction to increase the angle of the mandible.
Ramus may be deficient	The smaller size of the rami are evident from the plots. Landmarks defining the rami differ in position significantly.	The smaller size of the rami are evident from the plots. Landmarks defining the rami differ in position significantly.	Both right and left posterior ramus heights are smaller (12.6mm and 13.0mm respectively).	Left anterior, middle and posterior ramus triangles show increasing underdevelopment from anterior to posterior (that is, 3.1% to 18.8% to 49.0% area decreases).
Coronoid and condylar processes may be flat or aplastic.	Evident from plots. Landmarks differ in position significantly.	Evident from plots. Landmarks differ in position significantly.	A smaller, flatter condylar region is indicated by: · smaller condylion left to coronoid notch left (11.8mm), · smaller condylion left to coronoid tip left (10.2mm), · increased gonion left to condylion left to coronoid notch left angle (10.9°).	The left posterior ramus triangle shows a 49.0% area reduction predominantly due to a 45.0% reduction parallel to a line joining the condylar head left to the coronoid notch left resulting in a flatter condylar process.

Skeletal Feature	Individual Osseous Landmark		Distance and Angle	Strain
Mandible	Bone Standard	Skull Standard		
Receding chin	The patient's chin has a similar shape to the standard - evident from scaled plots. The chin appears receding on non-scaled plots due to the smaller mandible size and the increased ramus to body angle.	The patient's chin is very supero-posteriorly displaced relative to the skull standard. For example, the gnathion is displaced by 21mm after repeated median alignment without scaling.	Lower face height measurements are non-significant however lower border of the mandible significantly reduced in length.	Receding chin apparent due to reduction in size of the triangles representing the body of the mandible and the ramus.
Undersurface of the body of the mandible has a concave appearance.	Not measured. Need to define suitable syndrome specific landmarks to measure the undersurface of the mandible.	Not measured. Need to define suitable syndrome specific landmarks to measure the undersurface of the mandible.	Not measured. Need to define suitable syndrome specific landmarks to measure the undersurface of the mandible.	Not measured. Need to define suitable syndrome specific landmarks to measure the undersurface of the mandible.

Skeletal Feature	Individual Osseous Landmark		Distance and Angle	Strain
Mandible	Bone Standard	Skull Standard		
Other quantified results	Plots and d/σ-scores indicate that the following are also significant relative to bone standard: • Narrower dental arch, • Coronoid tips more laterally displaced, • Larger bigonial breadth. The root mean square residual is 8.9mm indicative of considerable shape and size differences.	Plots and d/σ-scores indicate that the following are also significant relative to skull standard: • Narrower dental arch, • Coronoid tips more laterally displaced, • Larger bigonial breadth. The condylar heads are positioned more antero-superiorly and medially. The patient's mandible relative to the skull standard is rotated to move the chin posteriorly and superiorly.	Arch breadth was 8.5mm smaller and arch angle was 5.5° smaller. Left dental arch length smaller than right and significantly smaller than standard (7.8mm). Coronoid tip width was significantly increased (9.7mm). Larger bigonial breadth (5mm) but this was not significant. Lower border angle as measured from gonion right to gnathion to gonion left is significantly increased (18.7°). Angular relationship of the mandibular plane to the cranial base and the hard palate are also significantly more obtuse (16-21° larger). The angle of the left anterior border of the ramus to the dental alveolar crest in the molar region is also significantly more obtuse.	Contraction along left dental arch length of 18.3% but no significant change in right dental arch length. Area reduction of the left body of the mandible of 25.3%. Contraction along right mandible body length of 25.5%.

Skeletal Feature	Individual Osseous Landmark		Distance and Angle	Strain
Maxilla	Bone Standard	Skull Standard		
Poor Development	Scale factors indicate that the patient's maxilla is smaller than the standard (8.4% least squares and 4.7% repeated median) but not outside the population variance. Absence of landmarks due to thinner or poorer quality bone.	Similar to bone standard comparison but includes effects of position and orientation relative to the rest of the patient's skull. The orientation of the patient relative to the standard emphasises that the patient's lateral face heights are substantially reduced relative to the standard.	Of the 21 determined distances, 16 were smaller (5 significantly). Lateral maxillary height was significantly reduced (by 16.2mm, right and by 11.0mm, left).	The external surface of the patient's maxilla is $4.5cm^2$ smaller than the standard based on the measured triangles in common between the patient and the standard. The individual triangles quantify the magnitude and direction of hypoplasia in the different parts of the maxilla. Of the 7 triangles relating specifically to the maxilla, six show area decreases and one a marginal area increase. All the minor principal strain directions for the maxilla were approximately vertical indicating the smaller height of the patient's maxilla relative to the standard, and this was more so laterally.
High arched palate, cleft in 30% of cases	Not measured. Need to define suitable landmarks.	Not measured. Need to define suitable landmarks.	Not measured. Need to define suitable landmarks.	Not measured. Need to define suitable landmarks.

Skeletal Feature	Individual Osseous Landmark		Distance and Angle	Strain
Maxilla	Bone Standard	Skull Standard		
Dental Malocclusion	Superimposed wire frame diagrams show, and residuals quantify, - • reduced dental arch breadth • reduced dental arch angle	In this case the orientation of the hard palate is more closely aligned with that of the standard and thus the dental arch appears more steeply inclined. The dental arch depth, breadth and width are all reduced relative to the standard.	Significantly reduced: • dental arch length bilaterally by 6.2mm, right and by 5.2mm, left. • dental arch breadth by 15.9mm. • dental arch angle by 16.1°.	Contraction along the right dental arch length of 15.3%. Both right and left dental alveolar complexes showed area reductions of 1.7cm^2 and 0.8cm^2 respectively.
Nasofrontal angle usually obliterated and bridge of nose raised	Visible in wire frame models.	Visible in wire frame models.	Significantly more obtuse (155.6°) than standard (138.4°).	No triangles defined for this region.

	Maxilla	Bone Standard	Skull Standard

Other quantified results

The landmarks that define the anterior face height do not differ significantly in position from the standard, however the landmarks that define the lateral face heights (orbitale and upper molar point) differ significantly in a direction such that the face height is smaller.

The nasal aperture (defined by nasale, nasal breadth points, right and left, and anterior nasal spine) appears more prominent at nasale but medio-posteriorly displaced at the nasal breadth point right giving the structures defining the nasal complex a more beaked appearance.

The landmark posterior nasal spine is significantly displaced from the standard (possibly due to preferential anterior alignment due to more anterior landmarks being identified).

The angle between nasion, medial orbitale right and orbitale right appears more acute for the patient than for the standard, indicating a change in angulation of the right lower orbital rim.

The root mean square residual is 7.0mm and this is indicative of the extent of the shape and size differences.

The patient's nasal line is closely aligned with that of the standard, emphasising the reduction in lateral face height. This suggests that the nasal line is less affected, and other features of the maxilla more affected, by the syndrome than the individual bone analysis might have indicated. This is in accord with the lateral clefting/hypoplastic nature of this syndrome.

When the patient's skull is aligned with the standard's skull the position of the posterior nasal spine is virtually superimposed on that of the standard.

The height of the anterior maxilla was within normal variance, as were the nasal cavity lengths, and the nasopharynx measurements.

Triangles representing the lateral aspect of the maxilla (right and left) demonstrated contractions of 39.3% and 26.9% respectively, indicating reduced height between the orbits and the upper molar teeth.

Of the 5 triangles which specifically describe the nasal cavity, 3 show area increases and 2 decreases. The nasal aperture showed a net area decrease of 0.6cm^2.

Skeletal Feature	Individual Osseous Landmark		Distance and Angle	Strain
Orbits	Bone Standard	Skull Standard		
Lower margin of the orbit noted to be defective	The patient's left and right lower orbital rims are displaced posteriorly relative to the standard.	The orientation of the orbits after alignment shows that the lower orbital rims and the frontal processes of the zygomas (lateral orbital walls) are displaced in an infero-lateral posterior direction bilaterally relative to the standard.	The distances from optic foramen right to lateral orbitale right, opposite orbitale right and orbitale right are all significantly reduced (3.0mm, 6.1mm, 5.5mm) indicative of underdevelopment of the orbital rim.	The right lateral orbital floor triangle showed a large area reduction of 20.8% (8.4% reduction in depth and 13.6% in the width). The right lateral tetrahedron showed a contraction of 17.9% along the direction from right orbitale to the right supero-lateral orbital roof and wall indicating a lack of development in the lateral orbital wall.

Skeletal Feature	Individual Osseous Landmark		Distance and Angle	Strain
Orbits	Bone Standard	Skull Standard		
Roof inclining downward and outward	The lateral aspect of the left and right orbital roofs are longer than the standard.	The lateral aspect of the orbital roofs are longer, and in the direction from superior orbitale to lateral orbitale are more inclined infero-laterally for the patient than for the standard.	The angle at superior orbitale was significantly reduced (11.4°). The lateral orbital rim (superior orbitale to lateral orbitale right) is increased (8mm for the right and 9.3mm for the left). The measurements indicate an infero-lateral-posterior displacement of the patient's lateral orbital wall relative to the standard.	The right supero-lateral orbital roof and wall showed a 30.4% dilation across the width of the triangle and the right lateral tetrahedron showed a large dilation of 30.4% approximately in the direction from right superior orbitale to the right lateral orbital wall and this coupled with the above observation of a smaller right lateral orbital floor accounts for the observation that the lateral orbital roof in the direction from superior orbitale to lateral orbitale is more inclined infero-laterally than for the standard.

Skeletal Feature	Individual Osseous Landmark		Distance and Angle	Strain
Orbits	Bone Standard	Skull Standard		
Orbital cavity, oval shaped	The plots show that both orbits are more elongate than the standard.	The patient's orbits are more elongated in an infero-lateral posterior direction relative to the standard.	The medial orbitale to superior orbitale right is significantly reduced (by 8mm) while superior orbitale to lateral orbitale right and left were increased (by 8mm and 9.3mm).	The directions and magnitudes of the triangles defining the anterior border of the right and left orbital cavities indicate that the patient's orbital rims are skewed infero-laterally. The right lateral and medial tetrahedra showed that there was a height reduction between the supero-lateral orbital roof and wall and orbitale, a slight posterior displacement of the lateral anterior orbital plane and an increased separation of the lateral orbital wall and superior orbitale, indicating that the patient's right orbit was also skewed in a posterior direction leading to a net elongation in an infero-lateral-posterior direction.

Skeletal Feature	Individual Osseous Landmark		Distance and Angle	Strain
Orbits	Bone Standard	Skull Standard		
Other quantified results	The patient's orbits are significantly smaller than the standard (by 5.6% least squares and 7.0% repeated median). The root mean square residual was 7.4mm.	The relationship of the patient's medial orbitale to nasion is similar to that of the standard but the position of the other landmarks defining the patient's orbit become increasingly infero-laterally posteriorly displaced the more laterally the orbit is transversed.	Many of the distance Z-scores are negative. Breadth measurements revealed that the separation of the patient's orbits was reduced by approximately 5mm relative to the standard. The right and left frontal processes of the zygomas (lateral orbital walls) were significantly reduced in width (by 12.1mm on the right and by 7.7mm on the left).	The surface area and volume of the patient's right orbital cone were 91.6mm^2 and 1.5ml smaller than the standard respectively.

Zygomas	Bone Standard	Skull Standard	
Most often it is grossly and symmetrically underdeveloped	The scale factors indicate that the patient's zygomas, as defined by the selected osseous landmarks, are significantly smaller by approximately 10%. The superimposed wire frame diagrams show, and the residuals quantify: · marked narrowing of the frontal process of the zygomatic bone right and left (essentially the lateral orbital walls) as the zygomatic corners are located more anteriorly while opposite orbitales more posteriorly, more so on the right than the left. · orbitale, right and left, are located more posteriorly.	Patient's zygomas are much smaller, differently shaped and displaced in an infero-lateral direction.	All of the distances used to define the zygomas of the patient were smaller than those of the standard (Z-scores all negative). The following measurements are indicative of the extent of the underdevelopment of the patient's zygomas relative to the standard: · both the distances zygomatic corner right to lateral orbitale right and zygomatic corner right to opposite orbitale right reflect the reduced width of the right zygoma (smaller by 6.3mm and 12.1mm respectively) and therefore its underdevelopment. Consistent with these measurements is the significantly smaller angle at lateral orbitale (47° smaller). · the width of the left zygoma was also significantly smaller than the standard (by 7.7mm from opposite orbitale left to zygomatic corner left). · the separation of the zygomatic corners was reduced by 20.2mm relative, to the standard.	Only the triangles representing the left and right frontal processes of the zygomas could be determined for the patient. Both of these triangles showed large area reductions (of 67.5%, right, and 43.3%, left, leading to a total decrease of 1.2cm^2 relative to the standard).

| Skeletal Feature | Individual Osseous Landmark | | Distance and Angle | Strain |
Zygomas	Bone Standard	Skull Standard		
Non fusion of the zygomatic arches	Inspection of the patient's radiology revealed both zygomatic arches to be absent. Those landmarks associated with the zygomatic arch were accordingly absent.	Inspection of the patient's radiology revealed both zygomatic arches to be absent. Those landmarks associated with the zygomatic arch were accordingly absent.	Inspection of the patient's radiology revealed both zygomatic arches to be absent. Those landmarks associated with the zygomatic arch were accordingly absent.	Inspection of the patient's radiology revealed both zygomatic arches to be absent. Those landmarks associated with the zygomatic arch were accordingly absent.
Maybe totally absent	Zygomas not totally absent for this patient.	Zygomas not totally absent for this patient.	Zygomas not totally absent for this patient.	Zygomas not totally absent for this patient.
Other quantified results	The root mean square of the residuals for the zygomas is 9.2mm, indicative of the substantial shape and size differences between the patient and the standard.			

Skeletal Feature	Individual Osseous Landmark		Distance and Angle	Strain
Calvaria	Bone Standard	Skull Standard		
Essentially Normal	Scale factor indicates that the patient's calvaria is slightly larger than the standard (least squares 3.8%, repeated median 3.3%) but not outside the population variance. This is in contrast to the scale factor results observed for the facial components which showed the patient's face to be smaller than the standard. Many landmarks of the patient's calvaria were positioned at significantly different locations to the standard although the length dimension was not significantly different. The landmarks defining the foramen magnum were not significantly different in position.	Similar to the bone standard but includes the effects of position and orientation relative to the rest of the patient's skull. Even though the patient's calvaria was found to be larger than the standard, the smaller nature of the patient's facial regions relative to the standard dominates, and alignment with scaling results in the patient's skull being enlarged to match the standard accounting for the larger size difference between the patient's and the standard's calvaria.	The traditionally defined cranial base measurements were all non-significant. Also the distance measurements defining the perimeter of the foramen magnum were non-significant as were its length and breadth measurements. The length of the cranium was found not to differ significantly from the standard. The following distances for the patient were found to differ significantly from the standard: • n-g 18.0mm larger, • g-zfr 15.3mm larger, • op-o 16.6mm larger, • op-mtl 18.7mm larger, • eamr-v 13.3mm larger, • eamr-eaml 6.4mm larger, • mtr-mtl 8.4mm larger, • eamr-zfr 24.6mm smaller, • eaml-zfl 22.3mm smaller. These measurements indicate that the patient's calvaria is larger than the standard and also an hypoplastic condition in the region of the temporal fossae.	The external surface of the patient's calvaria was found to be 356cm^2 while that of the standard was found to be 321cm^2, and this shows that the patient's calvaria has a larger surface area by 35cm^2.

Skeletal Feature	Individual Osseous Landmark		Distance and Angle	Strain
Calvaria	Bone Standard	Skull Standard		
Supra-orbital ridges may be poorly developed	From the plots the major observed differences involve the patient's forehead giving the impression of it being more vertical in the mid-line and underdeveloped laterally.	The infero-posterior displacement of the zygomatic frontal points left and right, coupled with the infero-lateral inclination of the supra-orbital roofs from superior orbitale are indicative of lack of supra-orbital ridge development bilaterally.	Glabella to the zygomatic frontal point right was significantly increased (15.3mm). Bilaterally the distance between the landmarks external auditory meatus and the zygomatic frontal were significantly smaller (by 24.6mm on the right and 22.3mm on the left). These measurements are indicative of an hypoplastic condition in the temporal fossae.	The right and left frontal triangles showed large area increases (57.4% and 29.5% for the right and left respectively) between the patient and the standard due to displacement of the landmarks zygomatic frontal right and left infero-laterally, which reflects an hypoplastic condition in the region of the anterior temporal fossae.
May be increased digital markings on radiographs in the presence of normal sutural relationships	Not metrically assessed	Not metrically assessed	Not metrically assessed	Not metrically assessed
Other quantified results	The root mean square of the residuals for the calvaria was 12.3mm and this is indicative of the large variation in landmark positions of the patient relative to the standard.			The most striking feature of the strain analysis is the very symmetric orientation of the principal strain directions about the mid-sagittal plane.