The Long Term Outcome of Mandibular Orthognathic Surgery

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(Oral and Maxillofacial Surgery)

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Summary

A retrospective study was performed to assess the treatment outcome following mandibular orthognathic surgery at an average follow up of 12.9 years (range 7 to 24 years) in 24 patients, in the Oral and Maxillofacial Surgery Unit (OMSU), The University of Adelaide. This study shows generally a good level of outcome measured by cephalometric, study models and psychological profile assessments for this long term evaluation of dentofacial surgical patients.

The investigation in this study involved a detailed assessment of the following:

1. Cephalometric evaluation of long term skeletal relapse using a series of lateral head radiographs for twenty patients. Comparative analyses were undertaken to determine the differences in relapse between single jaw osteotomy (n=9) and bimaxillary osteotomy (n= 11). Additional examination of the data was also assessed to determine the effect of gender, surgeon's experience and postoperative time on the observed relapse.
2. The final postoperative occlusion using study models and the oral health status of all samples using the decayed, missing and filled permanent teeth (DMFT) index.
3. Patient perception, psychosocial status and satisfaction of treatment outcome.
   This was investigated using psychological and social questionnaires (IBQ, BIQ, SF-36) reflecting the patient's experience following surgery.
4. The perception of aesthetic improvement of soft tissue profiles. This involved construction of profile silhouettes from Pre- and long-term postoperative cephalograms. The facial profile changes were investigated by a panel that consisted of lay Omanis, lay Australians and professional surgeons and orthodontists.

The patients' response rate for participation in this study was low (11%). This reflected the difficulty in locating patients 7 to 24 years after treatment.

The study sample that was investigated for skeletal relapse was similar in age and type of surgery to the total group but with a greater male predominance.

The study showed that the mean horizontal long term relapse was 3.1 mm (39%, $p < 0.0009$) and 2.3 mm (32%, $p < 0.0004$) measured at pogonion and B point, respectively. The mean vertical movement of the mandible and its subsequent relapse was minimal and statistically not significant. There was no statistical difference in long term relapse between single and bimaxillary cases, or between males and females. There was a better postoperative stability for patients managed by a more experienced surgeon compared to a group of 3 less experienced surgeons. The majority of relapses occurred in the early stages following the surgery.

Analysis of study models showed that 20 out of 24 patients had satisfactory dental occlusions. The final postoperative occlusal stability was independent of the observed skeletal relapse. This reflects the need for postoperative clinical monitoring by observation of both the dental occlusion and cephalometry.

The majority of patients maintained a good standard of oral health. Eighteen out of twenty four patients (75%) were caries-free and maintained the same number of teeth before and after surgery.

Patients who demonstrated signs of abnormal illness behaviour and abnormal body image were more likely to be dissatisfied with the surgical outcome. Psychosocial functioning in the long-term review was generally similar to that of the normal population when investigated by the SF-36 health survey questionnaire.

The overall aesthetic facial profile improvement was perceived at 11.6 years following surgery by different evaluator panels ($p= 0.0048$). Significant improvement was detected following bimaxillary correction of class III malocclusions ($p< 0.0001$) and after bimaxillary correction of Class II malocclusion ($p= 0.0002$), when combined with genioplasty advancement.

This study confirms that orthognathic surgery when evaluated many years later is stable and generally with a good outcome from both the patient and the clinicians perspective.

SIGNED STATEMENT

This thesis is submitted in partial fulfilment of the requirements for the degree of Doctorate of Clinical Dentistry. I, Mohammed AlAjmi declare that the text of this thesis contains no material which has been accepted for the award of any other degree or diploma in any university, and to the best of my knowledge contains no material previously published by another person except where due reference is made in the text.

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Mohammed AlAjmi

Date......................

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I INTRODUCTION

CHAPTER 1: LONG TERM OUTCOME FOLLOWING MANDIBULAR ORTHOGNATHIC SURGERY

1.1 Overview

Orthognathic surgery is a treatment modality which can be performed to correct skeletal dentofacial deformity. This leads to an improved dentofacial harmony to enhance function and appearance but it is not without unwanted side effects. Postoperative relapse is defined as a shift towards the preoperative state (Reitzik, 1988). The background history of mandibular orthognathic surgery with particular emphasis on the most commonly discussed postoperative complications of relapse is presented in Chapter 2.

Cephalometry is often used to demonstrate the dentofacial deformity by comparison to normal values. It has also been used extensively in research to quantify postsurgical relapse. The subject of cephalometry and its associated errors is presented in Chapter 3.

The orthodontic-surgical correction of dentofacial deformity can produce an unpleasant experience for the patient. The clinician should be aware of the expectations and the psychological status of his patients to ensure a successful treatment outcome. The literature review into the psychology of orthognathic patients is discussed in Chapter 4.

The aesthetics of profile change produced by surgery is critical for both the patient and surgeon. The literature review of this subject is presented in Chapter 5.

The objectives of the study were:

1. To retrieve data from the dental records of the Oral and Maxillofacial Surgery Unit on patients who had had mandibular orthognathic surgery from 1985 to 2005.
2. To quantify the long term skeletal relapse following mandibular osteotomies.

3. To evaluate the long term occlusal stability following surgery.
4. To establish the degree of association between skeletal relapse and the final postoperative occlusal stability on orthognathic surgery patients.
5. To investigate the long term impact of orthognathic surgery on the satisfaction, psychology and quality of life of patients.
6. To evaluate the long term aesthetic profile changes following mandibular surgery and to determine which type of surgery brings about the most recognised aesthetic improvement.

The retrospective long term review study involved a detailed assessment of 24 patients at an average follow-up of 12.9 years (range 7 to 24 years). The patients and methods are outlined in Chapter 6. The methodology for the assessment of postoperative satisfaction, psychological status and quality of life is discussed in Chapter 7.

Aesthetic profile changes were investigated by a survey consisted of constructed silhouettes from pre and long term postoperative lateral head radiographs of 20 patients. This is presented in Chapter 8.

The results of the study are presented in Section IV and composed of five chapters: Chapter 9, long term relapse following mandibular orthognathic surgery; Chapter 10, Errors of the cephalometric method; Chapter 11, Assessment of study models; Chapter 12, Patient's perception and psychological status following orthognathic surgery; and Chapter 13, Perception of orthognathic surgery aesthetic outcome.

This study found that mandibular orthognathic surgery is generally a stable procedure which was confirmed after long term review of more than ten years. The aesthetic improvement in facial profile was perceivable at an average of 11.6 years following mandibular surgery. The findings are discussed in details and presented in Chapter 14.

II REVIEW OF THE LITERATURE

CHAPTER 2: ORTHOGNATHIC SURGERY

2.1 Background history of orthognathic surgery

The term orthognathic derived from two words: *orthos* which means straight and *gnathos* which means jaw so it literally means straight jaw. Orthognathic surgery can be defined as a surgical procedure performed to correct jaw deformity. The positional inter-relationship of the mandible (lower jaw) and the maxilla (upper jaw) on both horizontal and vertical planes will determine the state of skeletal functional stability as well as the aesthetic of the individual. Therefore, any deviation from this normal inter-relationship may indicate a surgical intervention to improve either function or aesthetics or both. Orthognathic procedures can be categorised into three types: maxillary surgery, mandibular surgery and bimaxillary procedures.

The most commonly performed maxillary procedure is the Le Fort I osteotomy. Drommer (1986) reviewed the history of the Le Fort I maxillary osteotomy. Historically, the first surgery was performed in 1861 by Langenbeck for excision of a benign tumour of the pterygopalatine fossa. In 1867, Cheever used similar approach for the surgical treatment of nasopharyngeal tumour. In Drommer's review, it was indicated that the introduction of the Le Fort I maxillary osteotomy to correct maxillary discrepancies was firstly performed by Wassmund in 1935. Wassmund described maxillary osteotomy according to the Le Fort I fracture lines to treat open bite cases. In his operation, he used elastic traction to achieve repositioning of the maxilla without sectioning the pterygoid plates. In 1942, Schuchardt advocated the separation of the maxilla from the pterygoid plates. This was done in double stage procedure and the maxilla was repositioned by the use of extra oral traction. In 1954, Gillies and Rowe modified the procedure to treat collapsed segments on cleft maxillae and achieved better arch form postoperatively. The Le Fort I maxillary osteotomy became a standard procedure to treat different sorts of maxillary deficiencies after the pioneer works of Obwegeser (1962, 1964, 1965, 1969). He demonstrated that the maxillary complex can be manipulated and repositioned in any favourable direction, as a whole or in segments (Drommer, 1986).The surgical procedure has been further modified and refined to correct the three-dimensional deformities of the maxillary complex (Bell, 1971; Van Sickels et al, 1986).

This versatile operation allows for manipulation and repositioning of the maxillary complex in a favourable and more aesthetically acceptable position. Different movements are possible to correct anteroposterior, transverse and vertical maxillary discrepancies. The surgical approach for the Le Fort 1 maxillary osteotomy is made entirely intraorally (Figure 2.1). After manipulating the maxilla into a new position, it is generally stabilised with miniplates and screws. The use of rigid fixation was found to give good stability with minimal relapse (Louis et al, 1993; Egbert et al, 1995; Hoffman and Brennan, 2004).

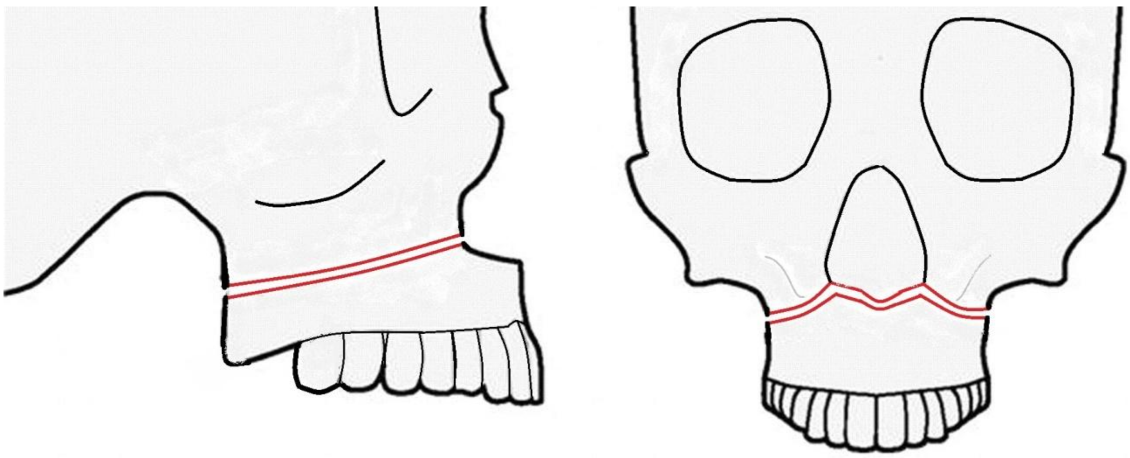


Figure 2.1 Schematic illustration of the Le Fort I Osteotomy.

Mandibular orthognathic surgery was first described by Hullihen in 1849. Subsequently, different approaches were advocated to correct mandibular deformity. However, bilateral sagittal split osteotomy (BSSO), vertical subsigmoid osteotomy (VSSO) and genioplasty are the most commonly used mandibular operations.

The bilateral sagittal split osteotomy was first employed by Schuchardt in 1942, but later refined and popularised by the work of Trauner and Obwegeser (1957). They employed splitting the ramus of the mandible into two large cancellous bone surfaces facing each other producing a "sagittal split" of the mandibular ramus (Figure 2.2). The distal segment of the mandible (tooth-bearing segment) can be then manipulated and brought forward or backward to correct mandibular retrognathia or prognathia, respectively. This procedure was later modified (Dal Pont, 1961; Bell and Schendel, 1977; Epker, 1977) to minimise postoperative complications. The most commonly encountered complications include swelling, neurosensory disturbance of the lower lip and chin, condylar displacement and relapse. The surgical modifications involved making the lateral cut more forward (Figure 2.2) thus reducing the amount of pterygomassetric muscles stripping and this has proved to reduce the degree of postoperative complications.

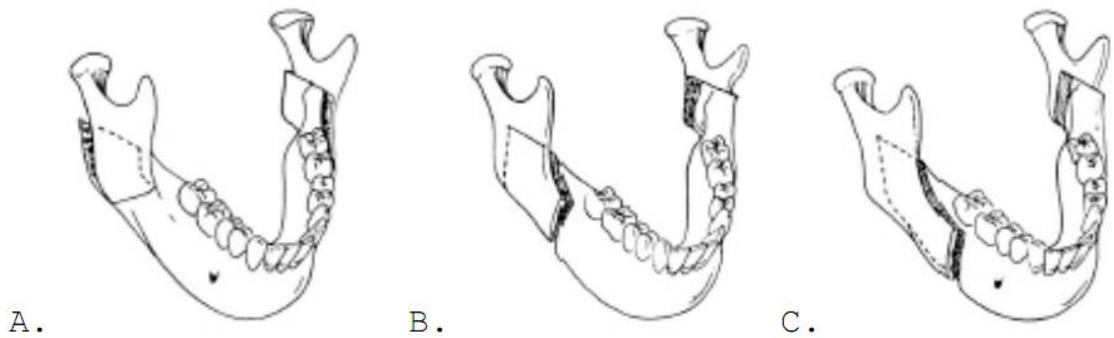


Figure 2.2 The evolution of the bilateral sagittal split osteotomy of the mandible: A. Obwegeser and Trauner technique (1957); B. Dal Pont modification (1961); C. Bell and Schendel (1977), Epker (1977) modification. (Stearns et al, 2000).

Vertical subsigmoid mandibular osteotomy was first described by Limberg in 1925 and later by Caldwell and Letterman (1954) through an extra oral approach and similarly underwent further modifications to involve less traumatic and more accepted intraoral approach (Hebert et al, 1970; Hall and McKenna 1987; Hibi and Ueda 1995). This procedure involves making a vertical cut from the sigmoid notch, posterior to the lingula where the mandibular nerve enters the bone, down to the angle of the mandible (Figure 2.3). Although good results were reported with less postoperative neurosensory disturbance of lower lip and chin, less temporomandibular dysfunction and less postsurgical relapse, it is less commonly used than the bilateral sagittal split osteotomy because it can only be used for mandibular setback to correct mandibular prognathism. Furthermore, it necessitates the need for postoperative intermaxillary fixation for a period of 4 to 8 weeks which adds discomfort to the patient and hence compromises their tolerance and acceptance.

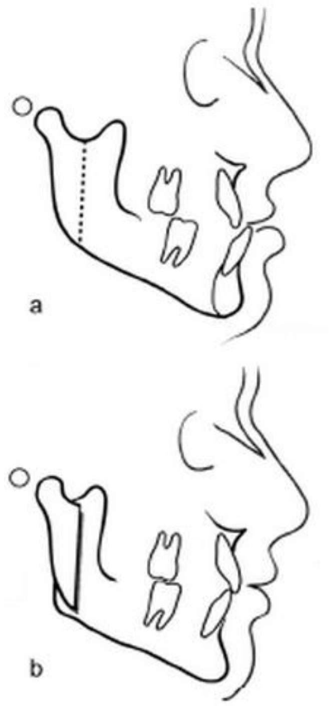


Figure 2.3 The vertical subsigmoid osteotomy used for mandibular setback (Wolford and Fields, 1999)

Genioplasty is a surgical procedure used to alter the position of the chin in all three planes of space. It was first described by Hofer in 1942. The intraoral approach was then introduced by Obwegeser in 1957. A horizontal sliding osteotomy is made inferior and anterior to the mental foramen of the mandible to prevent damage to the mental nerve and roots of the lower teeth. The osteotomised chin is then reduced or advanced to a desired position and fixed by the means of plates and/or screws (Figure 2.4). It has been recommended that the periosteal elevations, and thus muscle detachment, should be minimal to allow for accurate soft tissue repositioning (Schendel, 1985). The long term radiological evaluation of genioplasty advancement in particular was found to be a stable procedure (Schendel et al, 1976). This procedure maybe used simultaneously with a bilateral sagittal split osteotomy to produce a more harmonious lower facial profile.

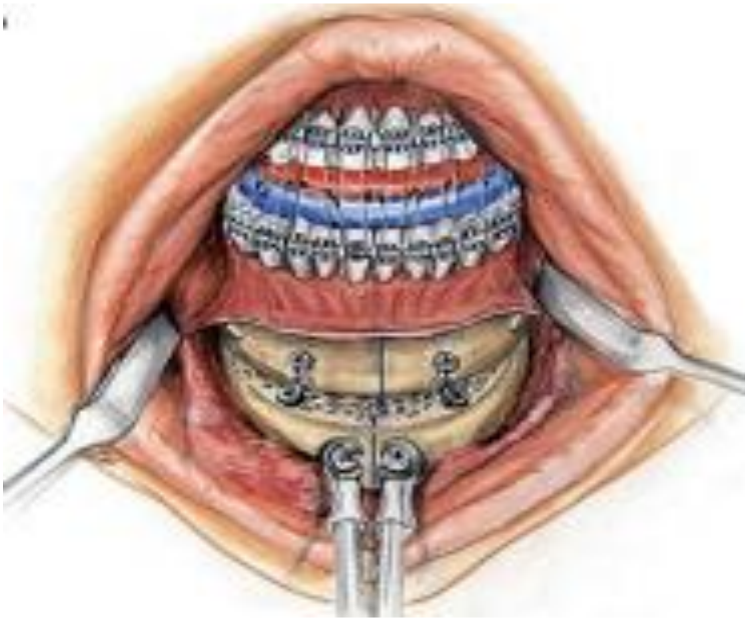


Figure 2.4 Schematic drawing of horizontal sliding osteotomy advancement (Hoenig, 2007).

2.2 Definition and causes of relapse

Comparison of relapse that has been reported in the literature is arbitrary and variable depending on the definition of relapse used in each particular study. Therefore, it is important to note the definition of postsurgical relapse is required to make clinical comparisons between studies meaningful. In the current study, the definition proposed by Reitzik (1988) as "a return to preoperative state" has been adopted to evaluate long term relapse following mandibular orthognathic surgery. It should be noted that in some instances the postoperative changes may occur in the same direction of the initial surgical shift. This is often related to growth or migration related to the micromotion at the osteotomy sites (Rosenquist and Wall, 1995).

Relapse following orthognathic surgery is one of the most commonly discussed complications. Cephalometric analysis is most commonly used to assess the postoperative stability of various orthognathic procedures. The amount of relapse attributed to mandibular orthognathic surgery varies depending upon the method of assessment. Some studies expressed relapse in a percentage of patients who showed clinical or cepahlometric postoperative changes (Schendel and Epker, 1980; Turvey et al, 1988; Gassmann et al, 1990). Others reported relapse as a percentage of changes from the initial surgical movement (Sorokolit and Nanda, 1990; Mobarak et al, 2000; Eggensperger et al, 2006).

Relapse is a complex multi-factorial phenomenon and different contributory factors have been identified in previous studies. Some of those factors were attributed for early skeletal relapse whereas others are proposed for late skeletal relapse. The condyle-ascending ramus position and paramandibular connective tissue tension was one of the first reasons proposed for early skeletal relapse following mandibular advancement (Epker and Wessberg, 1982). Others claimed that the continued resorptive process at the osteotomy cuts, osteotomy slippage, were other factors contributing to early relapse (Gassmann et al, 1990; Gomes et al, 1993). Progressive condylar resorption was the main reason addressed in the literature for late skeletal relapse especially, following mandibular advancement (Moore et al, 1991; Merkx and Damme, 1994; Mobarak et al, 2001; Hwang et al, 2004).

2.3 Skeletal relapse following mandibular advancement

Epker and Wessberg (1982) published a paper discussing the mechanism of early skeletal relapse following surgical advancement of mandible. They have reported that early skeletal relapse is a result of the interaction between the condyle-ascending ramus position and paramandibular connective tissue tension. The greatest skeletal relapse was attributed to inaccurate positioning of the condyle into the glenoid fossa and which is seen immediately following the release of intermaxillary fixation. They also demonstrated that even if the proximal segment is well controlled intra-operatively but no skeletal stabilisation is performed then skeletal relapse occurred during the period of intermaxillary fixation. The amount of relapse is directly proportional with the magnitude of mandibular advancement. This was explained by the effect of stretching the paramandibular muscles and connective tissue that exert forces on the advanced distal segment prior to bony union thus resulting in early relapse.

Van Sickels and Flanary (1985) evaluated a sample of 9 patients after bilateral sagittal split osteotomy advancement of the mandible using rigid fixation with bicortical screws. Mandibular advancements were performed on 6 patients (MA group) and mandibular advancements with concomitant genioplasty reduction were done on the remaining 3 patients (MAG group). Minimal early relapse (0.1-0.4 mm) was noted on the MA group at points B and pogonion at 6 weeks. Similarly, minimal relapse was also noted on the MAG group (0.1-0.2mm). Subsequently, Van Sickels et al (1988) published another paper with a larger patient sample including 51 patients treated with bilateral sagittal split osteotomy using rigid screw fixation. They reported again a minimal relapse (-1.3%) at 6 weeks. Those promising results gained wider acceptance for a new era of screw fixation.

Gassmann et al (1990) analysed lateral cephalogram radiographs of 50 patients at different time intervals following bilateral sagittal split osteotomy advancement of mandible. All patients had rigid fixation with three 2-mm bicortical screws. They defined relapse as “a linear change in B point (Bpt) perpendicular to the nasion A (NA) line of 25% or more”. They found that 13 patients showed relapse of 25% or more, 12 patients showed no relapse and were used as control group, and the remaining showed relapse between 0% and 25% and they were excluded from the study. They demonstrated that the majority of relapse (68%) was found within the first 6 weeks postoperatively. They have suggested that the majority of relapse occurred at the osteotomy site which was demonstrated by changes observed with both linear and angular movements. Although the proximal segment maintained its position relative to the cranial base, the distal segment had collapsed around the osteotomy site. Their results also indicated that the control group had a mean advancement of 5.5 mm at B point with no significant relapse but in the relapse group the mean advancement was 6.5 mm at B point with the resultant demonstrable relapse. Therefore, they have clearly shown that the significance of relapse was directly related to the magnitude of advancement.

Eggensperger et al (2006) published a study looking at short- and long-term relapse of 15 patients who had bilateral sagittal split advancement of mandible. In this study, the average initial movement was 4.1 mm at B point and 4.9 mm at pogonion. They have found that within the first 6 months there was a decrease of mandibular corpus length by only 0.5 mm and accordingly they have shown that there was no evidence of osteotomy slippage. They have proposed that the phenomenon of osteotomy slippage which was supported in earlier studies for early skeletal relapse did not occur after small amount of mandibular advancement (< 5mm).

Will et al (1989) evaluated cepahlometric changes in 235 patients following bilateral sagittal split osteotomy advancement of mandible. They have found that although ninety two patients (35%) experienced postoperative relapse, the majority of patients (n=66) experienced relapse within the first 3 weeks and only the remaining patients (n=26) continued to have relapse up to 6 weeks postoperatively. In this study, they have also shown that relapse was directly related to the amount of advancement and they have attributed relapse to the neuromuscular adaptation following mandibular advancement surgery.

Hing from the University of Adelaide (1989) studied postoperative skeletal relapse using selected cephalometric variables in 40 patients who underwent bilateral sagittal split osteotomy advancement of mandible. He showed a mean percentage relapse of -32% after one year. He found that more than half of the relapse (-17%) have occurred within the first 6 weeks postoperatively and the remaining relapse continued over the next 10 months. He found that the extent of surgical advancement of mandible was significantly related to skeletal relapse. However, he found no correlation between relapse and the preoperative mandibular plane, altered gonial arc radius and altered posterior facial height.

2.3.1 Wire versus screw fixation

The method of osseous fixation following sagittal split osteotomy has been an area of controversy as to which type provides superior stability. Some authors have suggested that skeletal relapse can be minimized by using rigid internal fixation (Van Sickels et al, 1986; Ellis et al, 1988; Gassman et al, 1990; Perrott et al, 1994; Dolce et al, 2002). The rigid internal fixation is thought to provide strong surgical stabilisation of the distal and proximal segments which enhance osseous healing of the osteotomy sites. Therefore, it can resist the soft-tissue tension which has been always attributed as an important factor in relapse. On the contrary, others have proposed that although stability was found to be superior for the rigid screw fixation than wire fixation at the early stages, equal stability was achieved at 1 year follow-up (Watzke et al, 1990; Politi et al, 2004). The observed early relapse in the wire fixation method was attributed to the maxillomandibular fixation that is used in conjunction with wire fixation. Watzke et al (1990) stated that “perhaps the jaw muscles do not resist soft tissue pressures that position the condyle posteriorly while there is no function, but muscular positioning again takes over after function resumes”. Despite the controversy regarding stability after using screw versus wire for skeletal fixation, the majority of authors agreed that the major advantage of screw fixation is the greater comfort to the patient because maxillomandibular fixation can be avoided and they resume some normal function shortly after surgery.

Dolce et al (2000) carried out a multisite prospective clinical trial to compare stability of rigid versus wire fixation for mandibular advancement osteotomies. A total sample of 127 patients was randomly divided into two groups according to the method of skeletal fixation. After 8 weeks review, following the release of the intermaxillary fixation, the wire group (n=49) showed a significant posterior sagittal relapse of 1.35 mm (26%) while the rigid group (n=78) demonstrated an anterior shift of 0.42 mm (8.5%). The sagittal changes recorded at 2 years following surgery showed a continuous posterior relapse for the wire group and measured 30 percent of the initial surgical advancement while the rigid group had returned back to a similar position achieved immediately after surgery ($p < 0.001$). The authors found no statistical differences between both groups in the vertical direction at any of the analysed time points (Figure 2.5). In a subsequent paper, Dolce et al (2002) published the results of a 5-year follow-up of the same earlier sample and reported a continuous relapse for the wire group which measured 2.2 mm (42%) posterior relapse while the rigid group remained unchanged from immediately after surgery. However, both groups demonstrated similar dental changes which resulted in indistinguishable occlusion between both groups at 5 years follow-up.

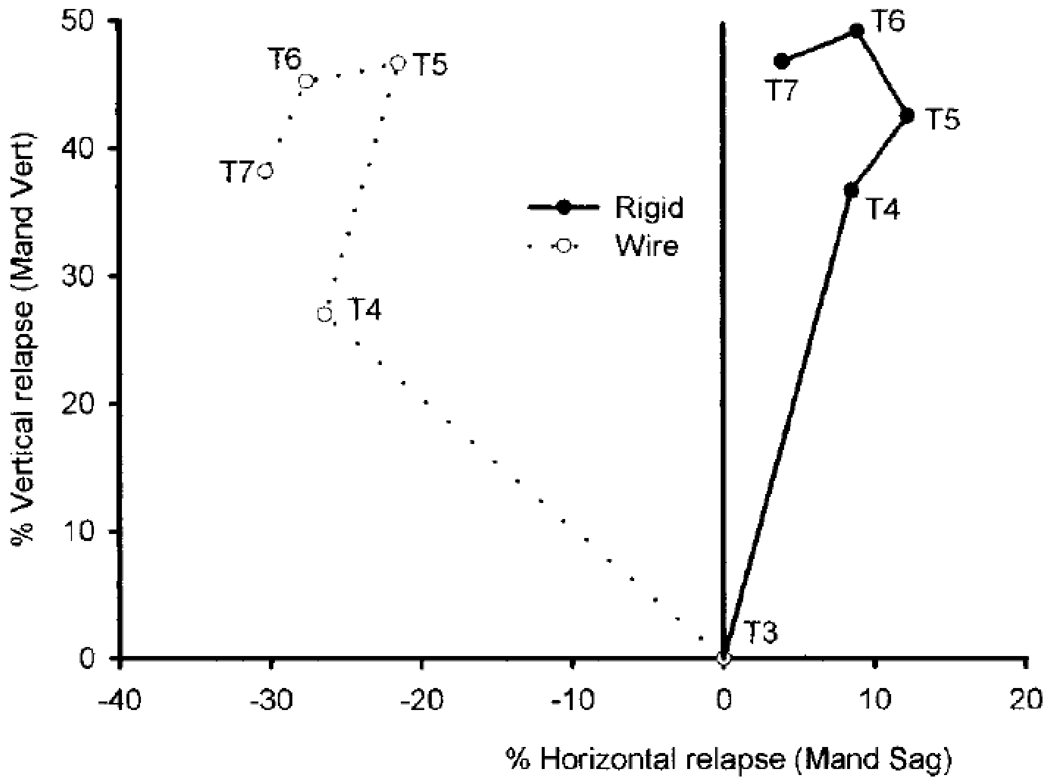


Figure 2.5 Combined sagittal and vertical changes from 8 weeks to 2 years for rigid and wire groups. T3, post-surgery; T4, 8 weeks post-surgery; T5, 6 months post-surgery; T6, 1 year post-surgery; T7, 2 years post-surgery (Dolce et al, 2000).

Mommaerts (1991) reported a significant relapse of 45 percent at 1 year after surgery for a group of patients treated with mandibular advancement osteotomy involving wire fixation, to the contrary, a rigid fixation group had a non-significant relapse of only 11 percent measured at pogonion at the one year follow-up. Similar findings were shown in a study conducted by Moenning et al (1990). The horizontal relapse measured at pogonion was 3.2 percent and 34 percent for the rigid fixation and wire osteosynthesis, respectively. Their results indicated a significantly higher horizontal stability following mandibular advancement for rigid fixation than wire osteosynthesis ($p< 0.005$) but no differences of relapse in the vertical direction. Perrott et al (1994) compared three stabilisation techniques used in sagittal split osteotomies. The authors reported that stability has improved with the use of screw fixation and a short period (14 days) of maxillomandibular fixation (group III) than screw fixation alone and screw fixation alone (group II) was better than wire fixation with 6 weeks of maxillomandibular fixation (group I). However, the only statistical difference of stability at 1 year follow-up period was found between group I and group III.

Watzke et al (1990) compared the stability of bilateral sagittal split osteotomy advancement of the mandible in patients treated with screw fixation (n=35) and another group treated with wire fixation and kept in maxillomandibular fixation for 6 weeks (n=35). They have found that significant percentage (18%) of the screw group have moved forward by 2-4 mm and no patients in the same group had posterior relapse at B point at 6 weeks. In contrast, they have shown that more than half of the patients in the wire fixation group had measurable posterior relapse of 2-4 mm at 6 weeks when the maxillomandibular fixation was removed. The researchers have suggested that forward movement after 6 weeks in the screw fixation group was probably due to the postoperative position of the proximal (condylar) segment. They have proposed that the proximal segment which has muscle attachments of medial pterygoid, temporalis and masseter muscles will rotate superiorly and anteriorly as a result of shortening of these muscles after osteotomy. They have suggested that although the seating of the condyle in the glenoid fossa was attempted prior fixation the flexibility of the wires allow for greater rotation of the proximal segment when compared with the use of more rigid screw fixation. Therefore, it was more likely that the condyle was pushed more posterior when screw fixation was used and as a result the mandible will eventually posture forward in order to avoid the stretch on the muscles after surgery. At 1 year follow-up, the authors reported equal stability between screw and wire fixation. They have found that the screw fixation group had moved slightly forward at 1 year post-surgery while the wire fixation group had significant forward movement of the mandible, recapturing its immediate postoperative position.

Politi et al (2004) investigated postoperative stability in 37 patients with class III skeletal malocclusion treated with combined Lefort I maxillary advancement and bilateral sagittal split osteotomy setback of the mandible. A comparative cephalometric analysis was undertaken to evaluate mandibular stability between a wire fixation group (group 1; n=20) and a rigid internal fixation group (group 2; n=17). The only significant difference between the groups was found at 8 weeks follow-up with group 1 exhibiting higher anterior relapse than group 2 (1.97 versus 0.38 mm). This difference was attributed to the release of the maxillomandibular fixation and splint removal in group 1 which resulted in the rotation of the mandible farther upward and forward. At an average of 1 year after surgery, the recorded sagittal relapse at pogonion was not significantly different between group 1 and group 2 and measured 2.92 mm (48% of mandibular setback) and 1.96 mm (55% of surgical setback), respectively.

2.4 Skeletal Relapse Following Mandibular Setback

In the early study by Pepersack and Chausse (1978), skeletal relapse was evaluated in 67 patients who underwent bilateral sagittal split osteotomy setback. The authors defined relapse as postoperative forward movement of mandible of more than 1.5mm. They found that relapse occurred in 8 percent of the study sample. Cephalometric analysis demonstrated a degree of rotation of the body of mandible with slight opening of the bite and forward movement of the lower incisors which accounted for the measured relapse.

Komori et al (1989) analysed the results of 15 patients who had modified sagittal split osteotomy setback of mandible with detachment of the medial pterygoid muscle, fixation with skeletal suspension wiring and adjunctive maxillomandibular fixation for 4-5 weeks. They reported that early relapse which was encountered during the period of fixation was attributed to the anteroposterior rotation of the proximal segment. In addition, they found no relationship between the magnitude of surgical movement and the amount of skeletal relapse.

Sorokolit and Nanda (1990), investigated stability of bilateral sagittal split osteotomy setback performed in 25 prognathic patients. All patients received internal rigid fixation using x3 bicortical screws on either side to stabilise the bony fragments. Skeletal relapse in the sagittal direction was measured by change of movement at B point. The results showed that 72% of the whole study sample experienced forward relapse of approximately 10% from the initial surgical advancement at a mean follow up period of 15.3 months. Data analysis suggested no significant relationship between relapse and amount of surgical movement. The authors concluded that bilateral sagittal split osteotomy was a relatively stable procedure to correct mandibular prognathism especially when presurgical orthodontic treatment allowed good intercuspation following surgery.

In a prospective, multicentre study with 2 year follow-up, Borstlap et al (2005), analysed data of 24 patients treated with bilateral sagittal split osteotomy setback using internal, rigid miniplates fixation. Cases were followed for at least 2 years. They found that the total sample experienced backward relapse of 1.1mm at 24 months. Two of the twenty four patients experienced significant clinical relapse of 1.2 mm forward movement at pogonion. The larger surgical amount of setback

(6.1 mm) was found to be related to the significant relapse seen in the relapse group when compared to the smaller surgical movement (4.7mm) in the stable group.

The postoperative stability of vertical subsigmoid osteotomy for correction of mandibular prognathism has been reported as a mostly stable procedure. Lai et al (2007) investigated skeletal changes in 41 patients who had vertical subsigmoid mandibular osteotomy. At 1 year after surgery, the researchers found that the relapse measured at menton point was minimal (0.1mm) and accounted for only 1 percent of the initial mean surgical setback. However, a more recent study (Chen et al, 2011) has shown that relapse measured at menton after 2 years follow up of 25 patients was 1.3 mm. This has accounted for a higher relapse (10.2%) than previously reported. The authors found no significant correlation between the magnitudes of setback and relapse.

Yoshika et al (2008) compared the stability of Vertical Subsigmoid Ramus Osteotomy (VSSO) and BSSO for the treatment of class III skeletal malocclusion due to mandibular prognathism. The study sample was divided equally which included 15 patients in each of the two groups. Cephalometric analysis at 1 month and 3 months after surgery demonstrated more significant posterior and inferior movement of B point and pogonion for the VSSO group than the BSSO group. On the contrary, no significant difference was found in the vertical and horizontal positions of pogonion and B point between the two groups at 1 year after surgery.

Abletins et al (2011) investigated 51 consecutive patients with class III skeletal malocclusion who were treated with bimaxillary procedures. Thirty patients underwent intraoral vertical subsigmoid mandibular osteotomy and the Le Fort I osteotomy and the remaining 21 patients had bilateral sagittal split osteotomy and the Le Fort I osteotomy to setback the mandible. At 1 year follow up, a horizontal relapse of 1.2 mm (27%) was measured at B point for the VSSO cases and 1.4 mm

(26% of the initial surgical setback shift) for the BSSO group. However, the difference between both groups did not reach statistical significance suggesting an equal degree of stability.

2.5 Long term skeletal relapse

Many studies have been published on the long term postsurgical skeletal relapse following mandibular orthognathic surgery (Van Sickels et al,1988; Scheerlinck et al,1994; Mobarak et al, 2000; Hwang et al, 2004; Borstlap et al,2004; Arpormaeklong et al,2004; Eggensperger et al, 2006). These considered one to three years was long term. However, there were only two published studies, by the same authors, on long term relapse following mandibular osteotomies with a follow-up period of more than 10 years (Joss and Thüer, 2008a; Joss and Thüer, 2008b).

In the study by Van Sickels et al (1988), several predictors for relapse of 51 patients were studied after bilateral sagittal split osteotomy of mandible. The long term follow up period ranged from 6 months to a maximum of 3 years after surgery. Magnitude of mandibular advancement was found to be the single factor related to long term relapse. They have recommended that further steps should be taken to prevent the stretch of the surrounding tissues when the mandible is to be advanced for more than 6 mm.

Scheerlinck et al (1994) reviewed the results of 103 patients treated with bilateral sagittal split osteotomy to correct mandibular retrognathia. All patients received 4-hole stainless steel miniplates and intermaxillary fixation for 1-3 days. They found that skeletal relapse over an average period of 3 years post surgery was directly related to the amount of advancement. There was a relationship between advancement and progressive condylar resorption (PCR) which accounted for the percentage of the observed relapse. There was a tendency for 5.2 more risk of PCR with advancement between 5 and 10 mm than an advancement of less than 5mm. The risk of PCR had increased more than 20 times when the advancement was greater than 10 mm.

Mobarak et al (2000) conducted a cephalometric study on 61 patients who underwent bilateral sagittal split osteotomy advancement to correct mandibular retrognathism. The researchers have investigated the relationship between postoperative skeletal relapse and the preoperative low angle versus high angle in class II cases. After 3 years a total mean relapse at Pg of 1.9 mm (39% of initial the advancement) had occurred. Most of the skeletal relapse (95%) in the low angle group was experienced during the first 2 months while the high angle group demonstrated continuous long-term relapse with significant proportion (38%) appeared at the longest follow up period. The researchers have suggested that condylar morphological changes in the high angle group accounted for the late skeletal relapse.

Hwang and his colleagues (2004) verified that long–term skeletal relapse due to condylar resorption demonstrated in "young patients with mandibular hypoplasia, a posteriorly inclined condylar neck, a high mandibular plane angle, short posterior facial height and, a small posterior-to-anterior facial height ratio". They have recommended that any patient with the above preoperative characteristics should be well informed with the possibility of condylar resorption and resultant late surgical relapse.

In a large prospective, multicentre study of 222 patients who underwent bilateral sagittal split osteotomy advancement of mandible, Borstlap et al (2004) found that the mean skeletal relapse at pogonion after 2 years was 0.9 mm. The authors further reported that 187 patients relapsed only 0.4mm or less and they were considered as the stable group. The remaining patients (n=35) experienced an average relapse of up to 3.3 mm. Skeletal relapse appeared to be strongly correlated to the initial magnitude of advancement. The authors reported that patients with high mandibular plane angle were also more prone to skeletal relapse.

Arpormaeklong et al (2004) examined the data of 29 patients who underwent bimaxillary osteotomy with the use of rigid internal fixation to correct vertical excess and mandibular deficiency. After an average follow up of 25.2 months later, they found that 34.7 percent of cases experienced posterior relapse of mandible of between 2 and 4 mm. Significant relationship was found between mandibular skeletal relapse and surgical advancement of greater than 10 mm in female patients with preoperative high mandibular plane angle.

In the study by Eggensperger et al (2006), an average skeletal relapse of 0.8 mm and 1 mm at B point and pogonion respectively was measured during the period between 1 and 12 years after mandibular advancement surgery. The results showed that relapse after 12 years measured approximately 50% of the initial amount of surgical advancement. They found that skeletal relapse ceased at 1 year after surgery in the low angle patients whereas approximately 70 percent of relapse occurred in the high angle patients between 1 and 12 years postoperatively. Therefore, they clearly demonstrated that preoperative high mandibular plane angle is a significant factor for long term skeletal relapse.

Joss and Thüer (2008a) followed up 16 patients at an average of 12.7 years following mandibular advancement. They reported a backward skeletal relapse of 2.42 mm (50 % of the initial surgical movement) at B point and 3.21 mm (60 %) at pogonion. They found that the extent of surgical advancement of the mandible was significantly correlated with relapse. Joss and Thüer (2008b) also investigated long term postoperative skeletal relapse following mandibular setback osteotomies. They analysed the data of 17 patients at an average follow up of 12.7 years postsurgery. They reported a relapse rate of 0.94 mm (15 %) and 1.46 mm (21 %) measured at B point and pogonion respectively. The long term postoperative stability was better for mandibular setback as compared to the mandibular advancement osteotomies. Joss and Thüer (2008 a,b) reported that long term relapse had no significant correlation to gender following mandibular advancement but after mandibular setback osteotomies, females demonstrated significantly better long term skeletal stability than males. The authors related the differences in relapse rate between males and females, following mandibular setback, to the differences in growth pattern.

They proposed that for males the chin and attached soft tissue grows downward and forward whereas in females tends to grow mostly downward but neither forward nor backward.

Joss and Vassalli (2009) conducted a systematic review of the literature on studies published on stability of bilateral sagittal split osteotomy advancement of mandible with rigid internal fixation. Of the 24 analysed articles, they found that long term relapse at B point ranged between 2% and 50.3%, and at pogonion measured between 6.4% and 60.2% when bicortical screws were used for fixation (Table 2.1). On the other hand, when miniplates were used for fixation the mean relapse was lower than that of screw fixation and measured at B point between 1.5% and 8.9% of the initial advancement after an average of 12.7 years (Table 2.2). They concluded that long term relapse would be expected to be higher in patients treated with screw fixation as opposed to miniplates fixation.

Study	Number of patients	Follow-up (years)	Mean surgical movement (mm)	Relapse (mm)
Joss and Thüer, 2008	16	12.7	4.81 (B) 5.33 (Pg)	2.42 (50.3%) 3.21 (60.2%)
Kahnberg et al, 2007	17	1.5	6.5 (B) 7.8 (Pg)	0.8 (12.3%) 0.5 (6.4%)
Mobarak et al, 2001	61	3	5.92 (B) 5.88 (Pg)	1.84 (31.1%) 1.94 (33%)
Van Sickels et al, 2000	62	2	5.1 (B)	0.1 (2%)
Kierl et al, 1990	19	3	6.7 (B)	1.3 (19.4%)

B= B point, Pg= Pogonion

Table 2.1 Long term relapse following bilateral sagittal split osteotomy advancement of mandible with bicortical screws fixation (modified from Joss and Vassalli, 2009).

Study	Number of patients	Follow-up (years)	Mean surgical movement (mm)	Relapse (mm)
Kahnberg et al, 2007	15	1.5	6.5 (B) 6.4 (Pg)	0.1 (1.5%) 0.1 (1.6%)
Borstlap et al, 2004	222	2	5.6 (Pg)	6.9 (16.1%)
Scheerlinck et al, 1994	103	2.5	5.9 (B)	0.5 (8.9 %)

B= B Point, Pg= Pogonion

Table 2.2 Long term relapse following bilateral sagittal split osteotomy advancement of mandible with miniplates fixation (modified from Joss and Vassalli, 2009).

2.6 Comparison of relapse between single jaw and double jaw procedures.

One-stage surgical correction of dentofacial deformities involving both jaws is often performed to achieve satisfactory functional and aesthetic results (Lindorf and Steinhauser, 1978). It has been suggested that combined double jaws surgery is preferable to single jaw surgery because it produced a better cosmetic improvement than did mandibular surgery alone, especially in severe class III skeletal malocclusions (Moser and Freihofer, 1980). Similar good aesthetic outcomes as well as functional occlusal stability were demonstrated when bimaxillary procedures are used to correct class II skeletal dentofacial deformities than did mandibular advancement alone, especially when an anterior open bite is present (Epker et al, 1982; LaBanc et al, 1982).

Kahnberg and Ridell (1988) investigated postoperative stability in bimaxillary procedures performed to correct skeletal class III deformities in ten patients. The bimaxillary procedure consisted of a Le Fort I maxillary osteotomy and vertical subsigmoid osteotomy to setback the mandible. Cephalometric measurements have demonstrated more vertical relapse in the maxilla than in the mandible whereas horizontal relapse was mainly evident in the mandible. The measured mandibular relapse in the horizontal direction was found to be similar to those reported in previous studies of vertical subsigmoid osteotomy alone to correct mandibular prognathism (Astrand et al, 1973; Astrand and Ridell, 1973; Johanson et al, 1979). However, Kahnberg and Riddel (1988) showed that the amount of horizontal mandibular relapse tend to be slightly less in the bimaxillary approach than in the single mandibular osteotomy cases. The reason for this difference in relapse was thought to be related to the initial surgical movement of the mandible. The amount of mandibular setback in the bimaxillary cases is proportioned between the maxilla and mandible, implying that the smaller the amount of setback, the smaller the relapse potential.

Franco et al (1989) published a study involving 25 patients treated with bilateral sagittal split osteotomy setback and internal rigid screw fixation. 14 patients had single lower jaw surgery and 11 patients underwent bimaxillary procedures. Horizontal relapse was measured by forward movement of Pogonion postoperatively. In the single jaw patients, the average relapse measured 2.13 mm (43.7% of the mean setback). While in the bimaxillary group, an average relapse of 2.9mm (53.4% of the mean setback) was calculated. Although the difference in relapse between single and double jaw surgery did not reach statistical significance, the authors have suggested that maxillary impaction may contribute to further relapse of mandible which was demonstrated by the greater forward movement seen at pogonion in the bimaxillary group. They reported that the position and amount of rotation of the proximal segment solely accounted for the greater relapse observed in the bimaxillary cases. This observation suggested that the stability of Lefort I maxillary procedure might further contributes to mandibular relapse. When postoperative maxillary intrusion occurred, as dictated by the decreased anterior facial height, a counter clockwise rotation of the mandible occurred and caused the mandible to move further forward which accounted for the tendency of greater mandibular relapse in the bimaxillary cases.

The stability of bimaxillary procedures to correct class II skeletal malocclusions, by the means of the Le Fort I maxillary osteotomy and bilateral sagittal split osteotomy of the mandible, has been reported extensively in the literature. Earlier studies reported less mandibular relapse but more maxillary relapse than when each of the procedures performed in one jaw alone (Brammer et al, 1980; Hiranaka and Kelly, 1987). On the other hand, other authors have reported that the amount of relapse in double jaw surgery was often similar to those found in the single jaw stability studies (Hennes et al, 1988; Turvey et al, 1988; Satrom et al, 1991).

Turvey et al (1988) investigated 53 subjects treated by bimaxillary procedures to correct class II skeletal malocclusions. Cephalometric evaluation of relapse was investigated for an average of one year follow up. The mean posterior horizontal relapse was 20%, measured at pogonion and 26%, measured at B point. The authors also found that 28 patients had less than 25% relapse, 15 patients had 25% to 50% relapse, and two patients had a relapse of more than 50% at B point.

Detailed review of the literature on long term postoperative stability found only two papers, by the same authors (Joss and Thüer (2008a, b) that reported on postoperative stability at more than 10 years after surgery. However, they did not analyse the effect of surgeon's experience, occlusal stability or psychological state of the patient in their results. Therefore, the lack of detailed long term studies on postoperative stability is evident and further research is necessary.

CHAPTER 3: LITERATURE REVIEW OF CEPHALOMETRY

3.1 Introduction

Cephalometric tracing superimposition is commonly used in clinical practice to determine the outcome of treatment. Cephalometry is also extensively used in research in particular to evaluate relapse following surgery. Since its introduction by Broadbent (1931), cephalometric error analysis has been discussed in many articles published in the literature and various methods have been documented to minimise such potential errors.

Houston (1983) stated that "the reproducibility of the measurements varies according to the quality of the records, the conditions under which they are measured, and the care and skill of the measurer". He classified experimental errors into systematic and random errors. Systematic errors maybe introduced when tracing series of radiographs by two different researchers who has different concepts of cephalometric landmarks. It can also occur when a single investigator measures cephalometric landmarks at different time intervals. Random errors could arise as a result of variations in patient positioning, film quality and cephalometric landmark identification.

Ching (1995) proposed that a potential error in cephalometric analysis can occur in any of the following steps:

- i) taking the lateral cephalogram ;
- ii) tracing the cephalogram ;
- iii) identification of landmarks;
- iv) recording the observation; and
- v) measuring the observation

Baumrind and Frantz (1971a) divided head film measurement errors into two general classes which included "errors of projection" and "errors of identification". Errors of projection are caused because the cephalogram is a two dimensional representation of a three dimensional object.

Errors of identification represent all errors encountered during the identification of anatomic landmarks on cephalograms. Several factors were identified in the errors of identification which involved the image quality, the reproducibility of the landmark location, the precision of landmark definition, the investigator, and the registration procedure (Adams et al, 2004).

Gravely and Murray-Benzies (1974) concluded that tracing errors were directly related to measurement errors and inaccurate landmark identification in the process of film tracing. Thickness of pencil was found to be a potential factor for errors of tracing and therefore, Hixon (1960) suggested punching holes directly on the film at each landmark to eliminate tracing errors.

Cephalometric measurement errors in this thesis follow the earlier basic classification proposed by Hing (1989) which included the following:

1. Errors of projection
2. Errors of landmark identification
3. Errors of digitising
4. Errors of measurement
5. Errors attributable to observer variability
6. Errors of superimposition

3.2 Errors of projection

Several studies on the errors of projection in cephalometry have been published, and these suggested compensatory mechanisms for the anticipated errors (Salzmann, 1964; Moyers and Bookstein, 1979; Bergersen, 1980; Luyk et al, 1986; Adams et al, 2004). Errors of projection are caused because a cephalogram is a two dimensional representation of a three dimensional object.

Baumrind and Frantz (1971) published a series of papers discussing the reliability of head film measurements. Distorted enlargement was seen on radiographs because x-ray beams are not parallel and originate from a very small source. It was further affected by foreshortening of distances between points situated in different planes. Adams et al (2004) stated that "bilateral structures in the symmetric head do not superimpose on the lateral cephalogram, because the fan of the x-ray beam expands as it passes through the head, causing a divergence between the images of all bilateral structures". Misalignment of the x-ray source, the cephalostat, the film or the rotation of the patient's head was also found earlier to be a major source of projection errors (Carlsson, 1967; Eliasson et al, 1982; Ahlqvist et al, 1983).

Ahlqvist et al (1986) examined the magnitude of projection errors in cephalometric linear measurements. They found that projection errors in length measurements were minor and related the rotational positioning of the head. Rotation of ± 5° from the ideal head position resulted in insignificant errors of less than one percent. Although rotation or tilting of the subject's head by more than 5° would cause significant error an experienced radiographer could easily recognize such excessive head rotation and this could be immediately corrected.

Several authors (Carlsson, 1967; Midtgard et al, 1974; Houston et al, 1986) showed that errors arising from obtaining lateral skull radiographs were minimal provided that appropriate care is practiced when positioning the patient's head in the cephalostat.

3.3 Errors of landmark identification

Errors in landmark identification have been considered a major source of variability in cephalometric evaluation and therefore, many papers have been published in the literature discussing this topic (Graber, 1958; Miller et al, 1966; Baumrind and Frantz, 1971a; Broch et al, 1981; Houston, 1983; Savage et al, 1987; Showfety et al, 1987; Eriksen and Solow, 1991; Trpkova et al, 1997; Adams et al, 2004; McClure et al, 2005).

Baumrind and Frantz (1971) recognised that the precision of identifying anatomic landmarks on head films varies from point to point. The nature and magnitude of the difference in precision of specific landmark identification resulted in the errors of identification. The authors found that each landmark had a specific characteristic and demonstrated “non circular envelope of error”. Pogonion showed more distribution of errors in the vertical direction than in the horizontal direction while menton demonstrated the opposite. They further demonstrated that points which lie on sharply curving surfaces were easier to identify than those points that lie on gently curving surfaces.

Midtgard et al (1974) suggested that some anatomical landmarks that lie outside the cranium are easier to locate than those lie in structures of the inner cranium. The outer landmarks are usually sharply defined with good contrast whereas the inner landmarks demonstrate least contrast due to summations of superimposed anatomical structures.

Broch et al (1981) quantified errors of identification in radiographic headplates using a digitizer, eliminating potential errors encountered from tracing and manual measurements. Although errors of landmark identification were found to be lower than those reported by Baumrind and Frantz (1971b), double determination analysis of 15 landmarks revealed similar considerable variation. The researchers proposed five factors that could affect the reliability of the landmark identification as follows:

i) characteristics of the cranial structures;

ii) the general quality of the head plates;

iii) blurring of the anatomical structures caused by secondary radiation or movement during exposure;

iv) precision of the recording method; and

v) accuracy of the operator

Stabrun and Danielsen (1982) studied identification errors of 14 anatomical landmarks in digitized headplates. Scattergrams of landmarks showed variable distribution of pattern and direction with similar trend reported earlier by Baumrind and Frantz (1971) and Broch et al (1981). Despite previous calibration training, the authors noted greater inter-observer variability than intra-observer variability in the precision of landmark identification.

Inter-individual variability of anatomical landmark location demonstrated in a longitudinal cephalometric study conducted by Sekiguchi and Savara (1972).

They reported that Individual morphological variations as a result of skeletal growth in a sample of children affected the radiographic image and subsequently influenced landmark identification. The anatomic complexity of the region of the face was also reported by the authors to be an additional factor for individual landmark location variability.

Trpkova et al (1997) published a meta-analysis study to assess the magnitude of cephalometric landmark identification error. After reviewing and analysing six studies, they recommended that "0.59 mm of total error for the x coordinate and 0.56mm for the y coordinate are acceptable levels of accuracy". The landmarks B, A, Ptm, S, and Go on the x coordinate, and Ptm, A, and S on the y coordinate were found to be reliable landmarks for cephalometric analysis with small value for total error and insignificant mean error.

Houston (1983) showed that the greatest errors arose from points identification rather than from actual measurement. Therefore, he suggested that random errors can be reduced significantly if tracing is replicated and averaged. Baumrind and Miller (1980) indicated that random errors can be halved if tracing was repeated four times using computer-based digitising. Eriksen and Solow (1991) proposed that errors in landmark identification can be minimised by obtaining good quality films, by thorough definition of the reference points, and by a good knowledge of radiographic anatomy.

3.4 Errors of digitising

Errors resulting from digitising cephalograms are considered to be low or even sometimes negligible. Interestingly, it was postulated by several authors that when a digitising system is used the only source of error is landmark identification (Bondevik et al, 1981; Broch et al, 1981; Houston, 1982). Houston (1982) suggested that errors associated with the use of digitising system could arise from "carelessness on the part of the operator, from an incorrect sequence of digitisation, from movement of the record during digitisation, from environmental variation affecting a sensitive digitiser and even from intermittent faults in the apparatus".

Richardson (1981) analysed 14 cephalometric points on 50 lateral skull radiographs using two different methods: conventional and computer-based methods. He found that traditional methods were generally inferior to those obtained by the digitizer but in some cases the traditional methods produced more accurate results.

Schulze et al (2002) investigated differences in landmark identification on direct digital and conventional cephalometric radiographs. The researchers found significant difference ($p < 0.05$) in the precision of identification for nasion (N), posterior nasal spine (PNS), sella (S), supraspinal (A), and orbital (Or), but average differences were all below 1 mm.

McClure et al (2005) compared the reliability of landmark identification between digital and conventional cephalometry. From 19 landmarks comparative analysis, A point demonstrated statistical significant error ($p = 0.040$) along the x-coordinate whereas anterior nasal spine (ANS, $p = 0.001$) and condylion (Co, $p = 0.002$) showed statistical significant errors along the y-coordinate. However, the difference of mean error between digital and conventional films was less than 1 mm which considered unlikely to be significant clinically. Roden-Johnson et al (2008) concluded that there was no difference in the precision of landmark identification between conventional film tracing and digital tracing with Quick Ceph 2000.

3.5 Errors of measurement

Measurement from cephalometric radiographs can be performed either manually, using callipers and protractors, or digitally with the aid of computer-assisted programs. Some authors believed that errors associated with manual measurement have been totally eliminated by the application of digitising systems (Baumrind and Frantz 1971b; Bondevik et al, 1981; Broch et al, 1981). Others advocated the importance of quantifying statistical errors of measurement for an optimal research design (Harris and Smith, 2009; Damstra et al, 2010).

Carlson (1967) found that the precision of measurement from cephalometric radiograph was enhanced significantly when measurements were estimated to one tenth than to one half a degree or millimetre. Baumrind and Frantz (1971b) and Nagasaka et al (2003) showed that the magnitude of linear and angular measurement errors influenced by the distance between anatomical landmarks. Measurement error was found to be greater when the distance between two landmarks was shorter.

Midtgard et al (1974) recommended double determination to calculate the degree of accuracy for distance measurements. They suggested that the variance of error calculated for the material as a whole should not exceed 3 percent. Two cranial distances (n-sm and n-ss) showed the greatest uncertainty with total variance of errors exceeding the recommended variance error and found to be related to the uncertainty of landmark identification.

Bergersen (1980) constructed compensation tables to overcome enlargement and distortion errors encountered in cephalometric linear measurements. He claimed that linear measurements can be corrected in all measured planes with errors not exceeding 0.7 percent.

Harris and Smith (2009) defined technical error of measurement (TEM) as “the variability encountered between dimensions when the same specimens are measured at multiple sessions”. They suggested that measurement accuracy in a research data analysis can be improved by minimising technical error of measurement. This method required incorporating repeated measures into a statistical, computer-based design.

Damstra et al (2010) investigated error of measurement in 25 digital lateral cephalograms using the smallest detectable difference (SDD). The concept of SDD represents the 95% confidence level of the method error and measures the smallest statistically significant measurement changes. The authors demonstrated that measurement errors calculated by means of the SDD were considerable and possibly clinically significant.

3.6 Errors attributed to observer variability

Almost all of the studies published in cephalometric analysis have demonstrated some degree of errors either when one observer or multiple observers were involved. However, measurement errors appeared to be considerably greater between observers and thought to be related to the observer's opinion of the landmark location (Hurst et al, 1979; Stabrun and Danielsen, 1982; Showfety et al, 1987; Damstra et al, 2010).

Hurst et al (1979) compared the findings of five observers when localizing cephalometric landmarks on radiographs of 29 patients. They found considerable disagreement between observers in determining the location of different points on two types of radiographs. Based on this apparent statistical analysis of agreement/ disagreement between observers, the authors were able to draw their conclusion that inter-observer reliability of certain landmark identification was superior in xeroradiography than conventional cephalometry.

Stabrun and Danielsen (1982) reported considerable variation between 2 observers in localizing cephalometric landmarks on a total of 100 headplates. Despite previous calibration training of landmark definitions, they showed that Inter-observer variability was greater than intra-observer variability. Intra-observer data analysis reflected an improved precision on landmark identification probably as a result of the individual's definite opinion on the anatomic location of the landmark.

Damastra et al (2010) evaluated the reliability of two examiners to analyse 14 cephalometric measurements from 25 lateral cephalograms. Inter-observer reliability was tested by comparing the means of repeated measurements. They found that the measuring error has increased when the inter-observer error was calculated. The consensus of opinion thus appears to be that measurement data from cephalograms should be obtained by a single observer to minimise cepahlometric errors.

3.7 Errors of superimposition

The surgical effect of orthognathic surgery in research studies is commonly evaluated from cephalometric tracing and therefore, accurate superimposition of serial skull radiographs is mandatory. It has been suggested that the magnitude of errors arising from inaccurate superimposition maybe equal to the potential positional changes of the jaws (Baumrind et al, 1976; Ghafari et al, 1987; Gliddon et al, 2006).

Baumrind et al (1976) classified errors of superimposition into primary and secondary errors. Primary errors result from rotational or transitional errors encountered by the investigator in an attempt to achieve best fit of the anatomic structures. Secondary errors are caused by the primary errors and related to the displacement of cephalometric landmarks. The authors demonstrated that the total error affected by the distance of the landmark from the plane of superimposition at the cranial base. Rotational errors were found to be higher for distant landmarks than closer ones. Gliddon et al (2006) compared four methods of superimposition and found different degree of errors for each method. Their results also showed gradual increase of errors on the order of ANS, Point A, Point B and Pogonion which confirmed the concept of an arc or radius. The investigators concluded that regardless of the superimposition method, superimposition errors increased when the anatomic landmark is located farther from the cranial base.

Houston and Lee (1985) investigated the accuracy of several different methods of superimposition on cranial base structures. Their results showed that, even under well controlled conditions, all methods carried appreciable errors associated with superimposition. Due to the recognised errors encountered in all methods of superimposition, the authors suggested that “no serial study should be considered adequate without a clear report on the method error of any superimpositions used”.

Baumrind and Frantez (1971) described a superimposition technique which involved punching holes directly on radiographs to serve as fiducial landmarks. These points were then transferred from the original film to the subsequent tracings according to the desired superimposition. Sluiter et al (1985) have suggested a method of superimposition based on the construction of two intersecting lines which were drawn at the left and lower sides of the cephalogram. The intersecting lines served as an individual reference coordinate grid for all landmarks on digitized radiographs. The authors reported greater accuracy of superimposition using this method and had the advantage of eliminating damage to the film created earlier by punching holes technique described by Baumrind and Frantez.

Ghafari et al (1987) reviewed four methods commonly used for cephalometric superimposition on the cranial base. They found statistical differences of up to 1 mm between all methods used to investigate six landmarks positional changes. Furthermore, differences of more than 1 mm were found for specific landmarks such as A point and anterior nasal spine (ANS) when examined by the Ricketts method while no clinically significant differences were demonstrated using the other techniques. The researchers concluded that the interpretation of facial changes should be viewed only in relation to the superimposition method used in any cephalometric evaluation study.

3.8 The selection of a suitable line of reference

Various reference lines have been used in cephalometric superimposition studies, and there has always been debate over their relative merits. However, the three most commonly used reference lines in cephalometric analysis are Frankfort horizontal (FH), sella-nasion (S-N) and SN-7 line. Each reference line has its own limitations and therefore, the line which shows least limitations with good reproducibility should be adopted in cephalometry (Wei, 1968).

The Frankfort horizontal line is defined as a line passing through the upper periphery of the external auditory canals (porion) and the lowest point of the left orbit (orbitale). One of the most important advantage of this line is cited as its approximation to the to the natural head position. However, the reproducibility of the Frankfort horizontal line is questionable because of the fact that orbitale has a large envelope of error as reported by Baumrind and Frantz (1971). Furthermore, Koski and Virolainen (1956) found a considerable variability on the anatomical location of porion and therefore, systematic error of measurement for Frankfort horizontal was found to be unacceptably high. Others also commented on the inadequacy of localizing the anatomic porion and related its variability to the anatomic complexity of the petrous temporal region (Martinoni, 1978; Chate, 1987).

The Broadbent line or sella-nasion (S-N) extends from nasion, the most anterior point on the nasofrontal suture, to sella, the midpoint of the sella turcica (Krogman, 1958). Several authors have reported that S-N line is relatively stable and advocated its use as a reference line in cephalometric evaluation (Brodie, 1953; Steiner, 1953; Bjerin, 1957; Wei, 1968; Pancherz and Hansen, 1984).

Steiner (1953) favoured the sella-nasion line for cephalometric superimposition studies over Frankfort horizontal. He claimed that sella and nasion landmarks can be easily and accurately identified on radiographs. Furthermore, he stated that “they are located in the midsagittal line of the head and therefore they are moved a minimum amount whenever the head deviates from the true profile position". However, limitations of sella-nasion line were also reported by several researchers and found to be dependent upon displacement of sella and nasion due to growth (Scott, 1953; Baume, 1957; Ford, 1958; Bjork and Skieller, 1983). Others criticized the use of sella-nasion line because of its failure to approximate the true horizontal (Burstone et al, 1978; Marcote, 1981).

SN-7 line is a surrogate line with its origin based either on sella or nasion and angulated 7° to the sella-nasion line. After a comprehensive review of the literature, Hing (1989) concluded that the SN-7 line is a favourable reference line for cephalometric evaluation purposes as it exploits the benefits of the sella-nasion line whilst favourably reorientates the head so that the influence on external landmarks is greatly reduced.

Figure 3.1 Reference lines used in cephalometric studies (Hing, 1989)

CHAPTER 4: PSYCHOLOGICAL ASPECTS OF ORTHOGNATHIC SURGERY

4.1 Introduction

Surgical orthodontic treatment has been commonly performed to correct maxillofacial discrepancies among adolescents as well as adults. It involves the surgical manipulation of the elements of the facial skeleton to restore the proper anatomical and functional relationship in patients with dentofacial skeletal anomalies. It has been implied (Pahkala and Kellokoski, 2007) that orthognathic patients generally experience functional and psychological benefits after surgical-orthodontic treatment.

Defining a harmonious facial skeleton versus one that is not, requires determining the degree of deviation from a specified population norm. The dichotomy of orthognathic surgery includes functional considerations (eg. ability of the patient to chew better) and cosmetic considerations (eg. the patient looking better). Clinicians often emphasize function whereas the patient emphasizes aesthetics. A clinical policy review by Aetna (1995) stated that orthognathic surgery intends to:

1. Correct skeletal jaw and cranio-facial deformities that maybe associated with functional impairment, and
2. To reposition the jaws when conventional orthodontic therapy alone is unable to provide satisfactory, functional dental occlusion within the limits of the available alveolar bone.

It is noted that the aim of the surgical procedure is to improve function and doesn't mention any specific intention to improve facial aesthetics. This appears where the intention of orthognathic surgery differs between patient and clinician.

Patients might realize that they have some degree of deviations from the ideal and hence resort to orthognathic surgery. Clinicians presume that correction of these deviations will result in functional and aesthetics improvement and thus a satisfied patient. Although clinicians might achieve what they consider is a surgical success, this does not always guarantee a happy patient (Van Steenbergen et al, 1996; Hatch et al, 1999). This could be directly related to the definition of satisfaction as viewed from either the clinicians or the patients' perspective. Pahkala and Kellokoski (2007) stated that" satisfaction involves physical, psychological, and social aspects, as well as factors such as realistic or unrealistic expectations, external or hidden motives, information, and communication between the patient and the professional". Therefore, the multi-factorial elements involved with satisfaction makes it difficult to be examined and evaluated as a single entity.

4.2 Psychological aspects of orthognathic patients

Orthognathic surgery involves rapid aesthetic changes and therefore, patients are placed on immediate demands to adapt and integrate into the new facial features. Kiyak et.al (1982) published a longitudinal study to determine the impact of orthognathic surgery on patients' personality and perception of oral function. They used a self-administered questionnaire to examine 55 patients over a 9-month follow-up period. Several functional variables were examined to evaluate changes in oral function. In this study, 78.6 percent of patients reported improved dental occlusion and more than half of the patients claimed to have increased ability of mastication. In addition, temporomandibular joint symptoms such as, popping and clicking has been reduced in 73.3 percent of patients. On the other hand, the remaining percentage of patients reported multiple functional problems postoperatively. However, no significant differences were found in patient satisfaction, body image and self-esteem when compared to two functional groups of patients at 9 months following surgery. Therefore, they demonstrated that residual functional problems failed to predict patient satisfaction.

Kiyak and associates (1982) found in the same study that satisfaction with outcome of surgery peaked at 4 months after surgery and declined significantly at 9 months. Similarly, there was also a significant decline of self-esteem at 9 months postoperatively. They proposed that this decline in satisfaction of surgery outcome and self-esteem at 9 month following surgery is due to patient perception of changes. At the intermediate phase, patients were still anticipating long-term improvement but when the final stabilisation of surgery achieved at 9 months, they might express a degree of disappointment which is reflected on the satisfaction of the surgery in general. They concluded that despite the fluctuation of perception of changes, patients generally expressed high levels of satisfaction, psychological status and oral function following orthognathic surgery.

Lam et al (1983) published a paper examining the effect of orthognathic surgery on patients' social and recreational activities. They used the same pool of patients investigated in the above study. They examined 12 variables reflecting social activities such as going to parties and movies at different time intervals post surgery and another 12 variables reflecting recreational activities such as swimming and participating in group sports. Self-administered questionnaires were used again to assess changes in those activities. The results of their study aimed to provide some insights on the behaviour and personality changes on orthognathic patients. The results are summarized as follows:

- Recreational and social activities were reduced 3 weeks after surgery.
- At 4 months post-surgery, social and recreational activities of patients increased to a higher level than that of pre-surgery.
- Both recreational and social activities started to decline after the 4 months postsurgical level. Nine months after surgery, the level of recreational and social activities returned to pre-surgery levels.

- Some patients showed increased extroversion after surgery but this wasn't significantly reflected on the level of recreational and social activities.

The paper concluded that clinicians should be aware that some patients might have unrealistic expectations from orthognathic surgery. Patients who are expecting improvement in their relationships with their peers within the community might become disappointed after the surgery. Therefore, clinicians must have a thorough communication, assessment and counselling with their patients to alleviate any possible unrealistic expectations of patients. It is shown in this paper that orthognathic surgery by itself cannot improve patients' psychological and recreational functioning. However, improvement in self-confidence and self-esteem after surgery might enhance psychosocial functioning of orthognathic patients.

In another study published in 1985, Kiyak et al (1985) compared the emotional changes of 156 patients requiring surgical-orthodontic treatment. In this study, patients were divided into 3 groups. Ninety patients underwent orthognathic surgery, 33 patients elected to have only orthodontic treatment and 33 patients declined any form of treatment.

The Profile of Mood States (POEM) was used to examine depression, anger, vigour, anxiety and overall mood of patients over 6 months follow-up whereas Eysenck's Personality Inventory and Fitts' Self-Concept Scale were used to evaluate neuroticism and self-esteem respectively.

Overall, mood score had declined rapidly immediately after surgery and up to 4-6 weeks after surgery reflecting the immediate surgical complications of pain, swelling, paraesthesias and difficulty with eating and swallowing. However, when fixation is removed 4-6 weeks after surgery overall mood score improved significantly and reached the most positive score at 6 months after surgery to a level even better than that reported by the group who did not undergo surgery.

Evaluation of neuroticism showed that patients who score high level of neuroticism before surgery are more likely to express overall negative moods at different time interval after surgery. Kiyak et al (1985) suggested that neurotic patients might benefit from more psychological support throughout the course of surgical treatment.

Kiyak and associates (1985) showed that patients who report more postsurgical problems such as pain, paraesthesias, swelling, eating and swallowing difficulties are more likely to be more emotionally disturbed than those with no serious surgical sequelae.

Finlay et al (1995) conducted a longitudinal study to evaluate 61 orthognathic surgery patients in the west of Scotland. They have found that 87 percent of patients were satisfied with the overall outcome of surgery. The percentage of satisfaction wasn't related to age, gender, procedure, physical or personal self-esteem. Dissatisfied patients reported more postoperative complaints of pain, swelling, scaring and numbness. Furthermore, inadequacy of information about the operative procedure before the surgery reported by all unsatisfied patients.

As highlighted earlier by Kiyak (1982b) and associates, neuroticism was found again in this study to be a possible predictor for dissatisfaction.

In a study by Cunningham et al (1996) demonstrated that self-esteem remained unchanged after surgical-orthodontic treatment although the majority of patients reported significant improvement in appearance, self-confidence and social life situation.

Flanary and colleagues (1985), in a retrospective study of 90 orthognathic surgery patients, found that postoperative experience of unexpected events was directly linked to patients' dissatisfaction. In addition, emotional disturbance following orthognathic surgery expressed more by patients who received inadequate explanation prior to the surgery.

When evaluating motives to undergo surgery, Flanary and associates reported that patients seeking aesthetic improvement had fewer difficulties, in adjusting to their change of appearance, than those who had preoperative functional motivation.

Lovius et al (1990) examined the psychosocial effect of orthognathic surgery on 153 patients. They divided their study sample into a longitudinal sample comprising of 41 patients who completed questionnaires before and 3-6 months after surgery, and a cross-sectional sample where 54 patients completed the same questionnaires before surgery only and 58 patients completed questionnaires only after surgery. Their results suggested specific and a generalised psychological benefit, “halo effect”, after orthognathic surgery. The specificity of improvement reflected from the findings of the body satisfaction scale where the ‘teeth and jaw’ measure found to have the highest improvement followed by the ‘head’ part and then the ‘general’ index. Similar specific improvement on the ‘head’ and ‘face’ image was found earlier by Kiyak et al (1982).

A team of psychologists (Garvil et al, 1992) evaluated 27 orthognathic surgery patients before and 18 months after treatment. They found that the majority of patients were relieved of preoperative functional problems and perceived aesthetic facial improvement. Such improvement influenced patients as individuals and at a social level in a positive way.

Modig et al (2006) evaluated 42 orthognathic surgery patients preoperatively and 4 years after surgery. They found that 70 percent of patients had functional reasons to seek surgical treatment and 30 percent of patients expected aesthetic improvement. Most patients in this study found to be generally satisfied with the outcome of treatment. A visual analogue scale (VAS) was used to measure postoperative changes and showed improvement in terms of chewing (n=26, 81%), appearance (n=28, 88%), headaches (n=26, 66%) and bullying (n=18, 56%).

Nicodemo and co-workers (2008) from Brazil used the SF-36 to measure the impact of orthognathic surgery on the quality of life of 29 patients with Angle’s class III malocclusion. Their results demonstrated that individual personal and social aspects of life were influenced by the dentofacial deviation from the normal appearance but no significant correlation was found to the degree of discrepancy. Postoperative evaluation of the results 6 months after surgery showed significant improvement of patients' physical and social activities.

In a prospective, multisite, randomized clinical trial Motegi at al. (2003) evaluated 93 patients who underwent orthognathic surgery to correct class II skeletal malocclusion. The Sickness Impact Profile (SIP) which designed to measure different health-related functional abilities showed significant improvement on their patients at 5 years compared to pre-surgery. Similar improvement was demonstrated using analysis of the Oral health-related quality of life questionnaires.

Frost and colleagues (1991) found that women were more likely to express short period of postoperative depression than men but were more enthusiastic about the end result**s** of the treatment. Patients reported short period of depression and thought was related to postoperative medication, loss of self image, house confinement and reduced chewing ability.

Hatch et al (1999) compared the psychological function of patients underwent bilateral sagittal split osteotomy with rigid and wire fixation from pre-surgery to 2 years post surgery. A sample of 117 patients included 59 subjects treated with wire fixation and 58 subjects treated with rigid fixation. All of their subjects completed the Symptom Check List 90-Revised (SCL-90-R) questionnaire that was previously validated to measure psychopathological symptom complexes. The researchers concluded that patients decided for orthognathic surgery were psychologically healthy. They further demonstrated that patients' psychological well-being and satisfaction after surgery were unaffected by the type of fixation; rigid or wire fixation.

Assessment and evaluation of psychological state in surgery was described by Sambrook (1989). Questionnaires formed a third of the assessment process of psychological state. Although it was standardized, problems were described which relate to the patients interpretation of the question and their delivery of the answers.

The illness behaviour questionnaire (IBQ) was first described by Mechanic (1962) and later modified by Pilowsky (1971). The IBQ was described as testing abnormal illness behaviours specifically:

1. General hypochondriasis
2. Disease Conviction
3. Psychological vs somatic focusing
4. Affective inhibition
5. Affective disturbance
6. Denial
7. Irritability

The seven factors listed above will be described in detail later.

Sambrook stated that the IBQ was used in a variety of clinical settings, ranging from preoperative and postoperative patients to those in chronic illness populations such as facial pain populations. They were able to assess patients not just suffering from abnormal illness but also comparing patient's psychological profiles against normal data.

Sambrook (1989) investigated body image through the Body Image Questionnaire. This was first described by Secord and Jourard (1953) who aimed to test patient's feelings about their bodies and also develop a method for appraising those feelings.

Body image appraisal was scored by patients ranking how they felt about a particular body part. Sambrook (1989) reported that the study by Secord and colleagues had a supporting hypotheses. It was confirmed and supported that patients feelings about their bodies were equal to feelings about the self, that negative feelings were associated with anxiety and that negative feelings were associated with personal insecurities. It could be summarized that this early paper was successful in determining an appropriateness of the body image index encompassing feelings of self.

Sambrook (1989) in his study into the psychological state of orthognathic patients incorporated some modified factors into self evaluation relating to making changes to improve patient's understanding of the questionnaires. These were incorporated into the body in which questionnaire with most general and the specific orthognathic questions.

Sambrook (1989) found that the majority of patients tested in the experimental groups via the IBQ did not have recognisable psychiatric disease. Conclusions were made showing that the questionnaires alone could not be used to predict satisfaction of the outcomes. However, if patients had abnormal behaviour score and a poor general and dentofacial body image, then they were least satisfied with the outcome of orthognathic surgery.

4.3 Psychological aspects of cosmetic rhinoplasty patients

In contrast, there are also patients who opt to undergo elective cosmetic surgery to correct their physical disfigurement. Surgeons should pay attention to the psychology of patients seeking cosmetic surgery since the dividing line between a genuine defect and a fancied one is often very vague. "A defect which seem insignificant to the surgeon, maybe of tremendous importance to the patient" (Barsky, 1944).

Rhinoplasty is among the most common facial cosmetic procedures. The psychological aspects of rhinoplasty procedures have been reported in the literature and these needs to be compared to the psychological aspects of orthognathic surgery.

Marcus (1984) studied the psychological aspects of cosmetic rhinoplasty (CR) patients. He evaluated the results of four different groups. The first group comprised of twenty CR patients who were examined 1 day before surgery and then 3 months after surgery. The second group involved ten CR patients who were interviewed only preoperatively. The third group consisted of eleven CR patients who were interviewed only about 2 years postoperatively. The fourth group was included as a control group of twenty five wisdom teeth patients who were psychologically assessed before and after surgery. The preoperative psychological evaluation of CR patients in this study demonstrated a higher psychological distress than that of the control group. More than 75 percent of CR patients were seeking the surgical intervention to "eliminate unhappiness" and 90 percent thought that the physical disfigurement of their nasal shapes reduced their capacity of social life enjoyment. Furthermore, Marcus in his study highlighted the narcissistic personality of CR patients. He showed that those patients exhibited features of narcissistic personality disorder such as the intense involvement in themselves; they often see others as extensions of themselves, or they exist for the purpose of serving themselves. In addition, they had very low self-esteem when compared to the control group.

Ercolani et al (1999) compared the short-term outcome of rhinoplasty on patients who sought the operation for either aesthetic or functional purposes. Self-administered questionnaires were used on different groups of patients to evaluate their pre- and postoperative neuroticism, extroversion and anxiety. They have shown that patients who requested surgery for aesthetic reasons had higher neuroticism scores before and after surgery than those who underwent surgery as a consequence of a medical advice to improve breathing or persistent headache. In addition, female patients demonstrated higher reduction of neuroticism score than male at 8 months following the surgery. They concluded that postoperative follow-up at 8 months showed improvement in the emotional health on the majority of rhinoplasty patients with significant reduction of neuroticism and anxiety scores and increase in the extroversion score. However, male patients experienced fewer psychological benefits from rhinoplasty than female and cosmetic patients were more psychologically disturbed than those who had a functional motivation to seek surgical rhinoplasty.

Ercolani et al(1999) in a later paper investigated 79 patients who had purely cosmetic motivation to request rhinoplasty. The psychological assessment conducted at 3 months before surgery, 6 months after and 5 years after surgery. Similar psychometric tests were used as in their previous study which included the Maudsley Personality Inventory (MPI) scales for neuroticism and extroversion and the Inventory for Personality and Anxiety Testing (IPAT) scale for anxiety. Post operative results showed significant reduction in neuroticism and anxiety scores at 6 months and 5 years follow-up whereas the mean score of extroversion was improved only at 6 months follow-up. They have suggested that rhinoplasty patients might expressed a higher social interaction in the first few months due to the euphoric reaction of the cosmetic surgery. Pre-operative assessment of their study sample revealed 27 patients (34.1%) showing psychological disturbances such as mild or moderate dysmorphophobia and personality abnormalities. Similar abnormal scores were found to persist in 24 patients (30.3%) at 6 months follow-up and in 22 patients (27.8%) at 5 years postoperatively.

Zojali et al (2007) investigated 66 Iranian patients requesting rhinoplasty to evaluate their personality traits using the Minnesota Multiphasic Personality Inventory (MMPI) test. The investigators found that 23 percent showed obsessive-compulsive personality trait. Other personality abnormalities were found on the remaining patients such as hypochondriasis (20%), good faking (20%), bad faking (12%), manic (9%), depressed (8%), liar (4%), psychasthenia (3%), and antisocial behaviour (1%). The rate of satisfaction at 6 months following rhinoplasty was found to be significantly related to patients' personality trait. Patients with obsessive and psychasthenic personality trait were the least satisfied with the surgical outcome and therefore it was suggested by the investigator that those patients who express such personality traits should be considered unfit for the cosmetic rhinoplasty.

Gipson et al (1975) in a survey of 194 rhinoplasties compared the incidence of psychological disorders, including schizophrenia, between a group of patients who requested the surgery for aesthetic reasons and another group who had rhinoplasty following nasal disease or recent trauma. At 10 years, they found that 32 out of 86 (37%) cosmetic rhinoplasty patients had severe psychological disorders. On the other hand, of 108 patients who had the surgery for functional reasons, 8 percent only demonstrated psychological disorders. Gipson et al suggested that some patients who request cosmetic rhinoplasty may have an early sign of schizophrenia or serious psychological illness.

4.4 Comparison of psychological profile between orthognathic patients and cosmetic rhinoplasty patients

The results of the above studies in the psychology of cosmetic rhinoplasty clearly demonstrate that the psychological profile of these patients is different than that of orthognathic patients. There is considerable percentage of cosmetic rhinoplasty patients with significant psychiatric disease including schizophrenia (Gipson et al, 1975), narcissistic personality disorder (Marcus, 1984) and dysmorphophobia (Ercolani et al, 1999). However, clinicians should be aware that there are some patients who might have unrealistic expectations from orthognathic surgery and should really be classified with the cosmetic surgery population (Lam et al, 1983; Sambrook 1989).

Orthognathic patients mostly undergo surgery for functional and aesthetic reasons. They are likely to be motivated externally by dental professionals to optimally correct a malocclusion when orthodontics alone could not predict stable results, or motivated internally to improve chewing ability or facial appearance. In the contrary, cosmetic rhinoplasty patients often request surgery for solely aesthetic reasons and this could explain the difference in the psychological profile between the cosmetic and orthognathic patients.

Preoperative counselling along with psychological screening was considered a valuable process to improve treatment outcome for both orthognathic patients (Flanary et al, 1985; Finlay et al, 1995) and cosmetic rhinoplasty patients (Ercolani, 1999; Zojali, 2007). It appears that the high level of dissatisfaction reported following cosmetic surgery for certain cases could be related to the type of psychiatric disorder. Similarly, although the majority of orthognathic patients report satisfactory results, there exists a small percentage with unrecognised psychiatric disease within the orthognathic population who are dissatisfied with technically satisfactory surgery.

4.5 The illness behaviour questionnaire

The purpose of the IBQ is specifically to:

1. Identify the presence of psychiatric illness in patients presenting for treatment with physical complaints.
2. Identify the factors involved in illness behaviour for a particular individual and the complaints they present with.

Other scenarios in which the IBQ is useful include:

- Assess responses of patients to their experiences in treatment
- Provide information for patients to respond to their health status
- A screening instrument to assess patients attitudes prior to beginning treatment
- Epidemiological tool to assess illness prevalence in a particular subgroup or population.

Of the 62 items used in IBQ, 40 are scored and the remainders are used predominantly to assess the presenting patients' attitudes and feelings, while also providing an adjunct to continuing research into the IBQ and its associated findings.

The IBQ does have limitations and it must be remembered that it is a questionnaire and does not diagnose a particular problem on its own. The IBQ however does have its advantages in clinical research and diagnosis and this includes:

- Provides a large amount of useful information relating to the patients illness, behavior and attitudes.
- Provides this information in a short amount of time
- Assists in identifying or making clearer a difficult diagnosis with weak clinical data.
- It is a valuable tool in patient management and treatment planning.

A study by Pilowsky et al (1984), derived their IBQ scores or “scales” from a factor analytical study of the responses of 100 pain clinic patients, and support from two independent studies.

A study by Prior and Bond (2008) reviewed the literature looking at the measurement of abnormal illness behaviour with a specific emphasis on the IBQ. Pilowsky and colleagues interpreted the scales as follows: High scores in Scale 1 indicated a phobia or anxiety associated with the patients concerns about their health. The researchers classified the first three primary factors as being the most commonly used. They described high scores in the first scale as the patient believing they will become seriously ill and generally being worried about their illness. They seem to take outside perceptions and views on illness very seriously and allow these views to affect their everyday lives.

Pilowsky et al (1984) illustrated that high scores in scale 2 indicated that patients recognised disease with a confirmation that symptoms were present. Prior and Bond (2008) showed that high scores in the second scale indicated patients believed similarly that there was something seriously wrong with their bodies and that this illness would also affect their everyday lives and day to day activities. This supports the conclusion that illness had a profound effect on the psychological health of these patients. The higher the score, the higher psychological belief that they were seriously affected by illness, thus outside influences from doctors and health professionals wouldn't be taken seriously.

Pilowsky et al (1984) revealed their third scale scores with high values indicating that the patient has an ability to perceive and recognize the pain psychologically and in some ways accept it versus a lower score in that scale which would indicate that recognition of the pain would only be through a somatic or physiological sense. Prior and Bond (2008) stated that a low score in the third scale revealed that a patient had a preoccupation with their physical symptoms while a high score showed that symptoms related to the patients psychological concerns rather than the actual presenting physical symptoms. In some ways people in this category feel a sense of personal responsibility for their illness and don't believe that the sensations or pains they feel relate only or inclusively to somatic sensations.

Pilowsky et al (1984) further described the remaining scales. The fourth scale analyses Affective inhibition or the extent a patient is not able to express their feelings. The fifth scale is describes as the Affective Disturbance scale which measures a patients level of anxiety and disturbance. The sixth scale assesses patients' denial where a high score show increased denial towards stress and illness attributing them to physical problems instead of having psychological links. The final and seventh scale measures irritability and measures a persons' anger in interpersonal situations. High scores would show that these patients are easily irritated an angry towards other when they are ill.

Speculand and Goss (1985) reviewed the psychological factors involved in temporomandibular joint (TMJ) dysfunction pain patients. They have suggested that patients could be considered to have "abnormal" illness behaviour if they are convinced to the presence of physical illness, show greater somatic preoccupation and does not easily accept explanation and assurance from their treating clinicians. These patients often reject the idea that their perceived pain is related to the possibility of a psychological disorder component. The above description of the abnormal illness behaviour was illustrated in patients suffered from intractable facial pain (Speculand et al, 1981). Furthermore, it has been found that responses to IBQ, in TMJ dysfunction studies, were able to identify “typical” TMJ patients who were previously described using other methods (Speculand, 1982; Speculand et al, 1983). These patients were “more convinced of the presence of disease, were more likely to show disturbances of affect such as anxiety and depression, and were unlikely to deny existence of problems in their lives”. Speculand et al (1983) found that thirteen percent of patients with TMJ disorder did not show any improvement after treatment and half of these patients had IBQ responses indicating abnormal illness behaviour.

Sambrook (1989) in his study of psychological aspects of orthognathic patients attempted to identify a reliable and rapid screening psychological questionnaire for patients undergoing orthognathic surgery. A psychological questionnaire package termed the “Sambrook-Goss package” was used in the study and consisted of six sections: illness behaviour questionnaire, body image, anxiety state, anxiety trait, and depression and life events questionnaires. The authors aimed to determine any existed correlation between satisfaction of surgical outcome and psychological variables. They found that there was a significant correlation between preoperative body image scores and the satisfaction of outcome. Patients with the poorest dentofacial body image were generally the dissatisfied ones. In addition, patients who had the poorest dentofacial body image also showed a positive score on the disease conviction scale (scale 2) of the illness behaviour questionnaire. It was postulated that those patients having poor body image and abnormal features on the illness behaviour questionnaire would probably have unrealistic expectations from the intended surgical intervention and therefore, may need psychological or psychiatric assessment or treatment prior to surgery.

4.6 The generic health survey (SF-36) questionnaire

The SF-36 health survey questionnaire is a self-administered questionnaire containing 36 questions which yields eight multi-item domains. The answers for the 36 questions are scored from 0 to 100, where higher scores indicating a better health state (Ware et al, 1993). A description of each health domain and what it intends to evaluate follows:

1. Physical functioning: limitations in daily physical activities due to health problems.
2. Social Functioning: limitations in social activities due to physical or emotional problems
3. Role-Physical: limitations in usual role activities due to physical health problems
4. Bodily pain :degree of pain and subsequent limitations in daily life
5. Mental Health: feelings such as anxiety, depression, nervousness and happiness.
6. Role-emotional: evaluate how much emotional state interferes with daily activities.
7. Vitality: deals with degree of energy or tiredness
8. General health: measure of own health and expectations for the future

The eight health domains were categorized into two broad scales: physical (physical functioning, social functioning, role-physical, role-emotional and bodily pain) and mental (mental health, vitality and general health). The physical scale defines health status as the absence of limitations or disability. The highest possible score of 100 for the physical subscales is recorded when no limitations or disabilities are observed. The mental scale measure a wider range of positive and negative health states. A score of 100 is achieved when respondents evaluate their health favourably and report positive health states (Ware et al, 1993).

The SF-36 instrument has been validated for adult age groups in the United Kingdom (Brazier et al, 1992) and the United States of America (McHorney et al, 1994). Likewise in Australia, the SF-36 instrument has been tested for reliability and validity (McCallum, 1995). The component scales of the SF-36 showed good discrimination between people with or without medical or psychiatric conditions. The Australian Bureau of Statistics used the SF-36 instrument in the National Health Survey in 1995 and it has been also used in clinical trials and monitoring health outcomes (McCallum, 1995).

CHAPTER 5: AESTHETIC CHANGES FOLLOWING ORTHOGNATHIC SURGERY

Facial attractiveness is often a prime goal for patients seeking orthognathic surgery. Even though clinicians usually focus on functional reasons for orthognathic surgery but patients tend to view aesthetic changes as a reason for treatment. Thus from the patient's perspective, facial attractiveness is of primary importance (Laufer et al 1976; Kiyak et al, 1981). People with attractive faces are mostly regarded as more competent and more socially active than those who are considered less attractive (Alley and Hildebrandt, 1988). It has been suggested that the definition of successful dentofacial treatment should involve the correction of dental occlusion and achieving satisfactory facial aesthetics (Proffit and White, 1990). Camouflage (orthodontics alone) treatment without surgical management may result in instability and result in a less than satisfactory aesthetic outcome (Turvey, 1988). However, in spite of the fact that surgical treatment may be recommended by dental specialists and indicated by cephalometric measurements, self-perception of profile are more important in the patient’s decision to elect surgical correction (Bell et al, 1985). Furthermore, it has been shown that attractiveness is not related to the degree to which a given face conformed either to the gold standard or to a cephalometric norm. The difficult issue is the assessment of improvement of facial appearance. Facial attractiveness is influenced by various factors such as age, race, culture and gender. It has been suggested that improvement in facial appearance can only be judged in form of relative change in relation to another face or group of faces from background population (Knight and Keith, 2005).

Some studies have demonstrated that in western population, a straight facial profile is preferred or considered “acceptable” (De Smit & Dermaut, 1984; Kerr & O’Donnell, 1990). However, it is varied by gender, males are preferred with straight profile while female with slightly convex profile are preferred or thought to be more aesthetically pleasing (Czarnecki et al, 1993). In another study of soft tissue profile preference, Polk et al (1995) found that African-American subjects preferred the more protrusive profiles for males than for female subjects.

Previous studies have shown that perception on facial attractiveness differed significantly between professionals and laypersons (Lines et al, 1978; Dunlevy at al., 1987). On contrast, recent studies reported no difference in attractiveness scores between layperson and professional group (Shelly et al, 2000; Maple et al, 2005). According to Hönn et al (2005), professionals were more critical in rating facial profiles than laypersons. In a recent study, Hönn et al (2008) found that university graduates had rated various facial profiles less positively than those who had not attended colleges.

Dunlevy et al (1987) used composite photographs of 19 female patients who underwent bilateral sagittal split osteotomy advancement procedures and found that patients with large skeletal changes following treatment were more likely to be judged as more improved by three groups of judges including laypersons, oral and maxillofacial surgeons and orthodontists. Likewise patients with small skeletal changes were more likely to be judged as "unimproved" by all groups. However, one in five laypersons found patients aesthetically "unimproved" regardless of the postoperative skeletal changes. Their findings also showed a general agreement among laypersons, Orthodontists and Oral and Maxillofacial surgeons concerning patient improvement in facial appearance following orthognathic surgery.

Shelly et al (2000) evaluated silhouettes of 34 surgically treated class II skeletal patients and found that patients with an initial ANB angle > or = 6 degrees, a consistent improvement in facial profile aesthetics was seen following surgery. They have recommended an ANB angle of at least 6 degrees prior to surgical intervention to warrant a noticeable improvement of facial profile. The recommended minimal preoperative ANB angle was also demonstrated in a study by Tsang et al

(2009). The authors investigated profile changes of twenty mandibular advancement patients. All patients' profiles were rated for attractiveness by three groups of judges: oral surgeons, orthodontists and laypersons. The results identified a consistent profile improvement after mandibular advancement osteotomy. Orthodontists and oral surgeons found profiles consistently improved when ANB angles were > or = 5.5 degrees, and > or = 6.5 degrees respectively. In the contrary, layperson showed no trend between ANB angle measures and profile changes.

Burcal et al (1987) used digitally simulated photographs and found that a horizontal change at pogonion of less than 4 mm was generally not recognised by more than half of a group of laypersons. The dental specialists were more accurate, but even they did not achieve better than 80% recognition until 6 mm of change at pogonion. In regards to features that have appeared changed in facial profiles, the authors found that dentists generally indicated the chin and laypersons put more emphasis on the lips.

Romani et al (1993) produced profile images for a female and a male patient using a digital video image processor. The images were manipulated digitally to simulate mandibular advancement and setback, maxillary advancement and setback, and mandibular down-grafting and impaction. Aesthetic preference was evaluated by 22 orthodontists and 22 lay people using simulated profile images containing different horizontal and vertical positions of the mandible and maxilla. The researchers found that when the mandible shifted about 1 mm in the horizontal direction, orthodontists were able to appreciate such change in only 65.9% of the cases. When the mandibular shift increased to 3mm and 5 mm, detection sensitivity increased substantially to 93.9% and 97% respectively. Lay people also demonstrated similar level of detection to changes of the mandible in the horizontal plane. Interestingly, lay people were found to be more sensitive than orthodontists to changes in upper to lower facial ratio in all evaluated images.

De Smit and Dermaut (1984) constructed twenty seven shadow profile photographs which represented different facial profiles. Facial profile preference was evaluated by a group who had no orthodontic background and a group who had received some orthodontic teaching. Their results demonstrated that open profile types were the least appreciated by the whole sample of investigators which had reflected the importance of the vertical profile characteristics as opposed to the anteroposterior features when evaluating facial profile preference. In addition, the researchers found that orthodontic knowledge had no effect on facial aesthetic preferences.

Recognition of soft tissue profile change at 5 years following bilateral sagittal split osteotomy advancement of the mandible was investigated in a study by Montini et al (2007). The researchers used presurgical and a 5-year postsurgical silhouettes which were constructed from lateral head cephalograms of fourteen surgical subjects. Paired silhouettes were scored for attractiveness, using a 100-mm visual analogue scale (VAS), by 53 orthodontists, 32 oral surgeons and 42 lay persons. Significant improvement in facial profile was perceived for 13 out of 14 surgical subjects. The highest improvement was found in subjects who treated with 3.20 mm, 7.38 mm, and 8.69 mm of surgical advancement. Interestingly, they found that the group of patients with highest hard tissue pogonion advancement (10.13 mm) was perceived by laypersons to have significant worsening in the VAS score. Moreover, the authors showed that orthodontists perceived greater number of improvements in the VAS scores than oral surgeons and, in turn that oral surgeons scored higher than laypersons.

III PATIENTS AND METHODS

CHAPTER 6: PATIENTS AND METHODS

6.1 Selection of study sample

Dental records were retrieved from the Oral and Maxillofacial Surgery Unit (OMSU), the University of Adelaide, for 226 Caucasian patients who received surgical orthodontic treatment for correction of mandibular deformity between 1985 and 2005. Socio-economic bias influenced the sample as patients were only eligible for treatment if they held Health Care Cards (School students, unemployed patients with sickness benefits).

Exclusion criteria were patients with syndromic or craniofacial anomalies and patients who received orthognathic surgery for the treatment of sleep apnoea or maxillary deformity only.

The study was approved by the Research Ethics Committee, Royal Adelaide Hospital (RAH protocol no: 090720). See appendix 1. Accordingly, all patients were contacted initially by mail and enclosed an information sheet describing the purpose, benefits and risks of the study, an informed consent form and a self-addressed, prepaid envelope. Patients were given options to choose for the most suitable way of contacting them for subsequent arrangements for a review appointment time. Contact options included mail, telephone or email addresses.

Ultimately, a total of 24 patients participated in the study, representing a participation rate of 11%, while the remainder of the patients were not included for the following reasons:

i) Patients who did not respond. This maybe because they had moved without a forwarding address or elected not to respond (n=155, 68%)

ii) Patients moved from their recorded addresses and the envelope was returned, “not known at this address” (n= 34, 15%)

iii) Patients replied but did not want to be part in the study (n=8, 4%)

iv) Patients who were initially agreed to participate but failed to attend the review appointment (n=5, 2%).

The postoperative review period following surgery was recorded for all 24 participants at the final review session. This is presented in Table 6.1.

SEX	NUMBER	MEAN POSTOPERATIVE REVIEW (YEARS)	STANDARD DEVIATION	MINIMUM	MAXIMUM	RANGE
Male	13	12.9	4.4	7	24	17
Female	11	13	5.6	7.2	24	16.8
TOTAL	24	12.9	4.8	7	24	17

Table 6.1 Postoperative review period (Pooled sample).

All participants were interviewed and assessed clinically in the OMSU by the author. The interview consisted of a standard and formulated questionnaire focusing at patient's subjective experience of the surgery and their satisfaction level with the long term results of surgery. This questionnaire is presented in appendix 2. In addition, patients were asked to complete three additional questionnaires: the Illness Behaviour Questionnaire (IBQ), the body image questionnaire (BIQ) and the SF-36 to assess the psychosocial state of the patients and to test whether psychological factors affect the patients' satisfaction level following orthognathic surgery. These questionnaires and their scoring systems are presented in appendix 3 (a, b), appendix 4 (a, b) and appendix 5 (a, b), respectively.

Clinical assessment of all patients was carried out systematically broadly based on the standard work-up form used in the OMSU for all patients undergoing orthognathic surgery. Some amendments were made on this form to make it simpler and more suitable for this particular study (appendix 6).

Standard cephalometric radiographs were taken for each individual participant.

I. Lateral head cephalogram
II. Orthopantomogram (OPG)

6.2 Cephalometric assessment of relapse

Cephalometric assessment of the current and past radiographs was performed under the following criteria.

i) Surgical treatment consisted of a BSSO, a VSSO alone or in combination with Lefort I maxillary osteotomy or/and genioplasty.
ii) Location of good quality cephalometric radiographs from the patient records at the following time intervals:

   T0: At completion of pre-surgical orthodontic treatment

   T1: Immediately following surgery.

   T5: Current cephalogram taken at an average of 11.6 years after surgery.

Twenty patients met these criteria for the assessment of long term skeletal relapse. The remaining 4 patients were excluded from the cephalometric study because of missing preoperative radiographs (n=3) or missing immediate postoperative radiograph (n=1). All patients received orthodontic treatment prior and following surgery through the Department of Orthodontics at the Adelaide Dental Hospital.

For the evaluation of long-term relapse, the records were assigned to a two broadly categorized groups:

I. Mandibular osteotomy only (N= 9)

II. Bimaxillary osteotomy (N= 11)

6.2.1 Superimposition and tracing procedure

Cephalometric tracing for all radiographs were carried out in a darkened room with exclusion of extraneous light to enhance landmark identification. Each radiograph was placed over a fluorescent light box, secured with a cellulose tape and traced on *3M Unitek* cephalometric tracing film acetate using a 0.5 mm lead pencil. A line was drawn on the presurgical film seven degrees from the sella-nasion line with origin at sella turcica. The location of each cephalometric landmark were identified and recorded with the film orientated to the SN-7 line (Figure 6.1).Linear and angular measurements were performed manually by the one investigator over a number of sittings with the aid of *3M Unitek* cephalometric protractor.

The postsurgical radiographs were superimposed on the presurgical radiograph for each subject using standard procedure modified from superimposition technique described by Bjork and Skieller (1983). The superimposition method based on certain stable structures located in the anterior cranial base and in the cranial vault. These natural structures were as follows: (1) the contour of the anterior wall of the sella turcica; (2) the anterior contour of the middle cranial fossa; (3) the inner surface of the frontal bone; (4) the contour of the cribriform plate; (5) trabecular system in the anterior cranial base; (6) the cerebral surfaces of the orbital roof. The superimposition and tracing technique can be described in the following stages:

1. The pre-surgical radiograph was examined over the light box and sella and nasion were identified and marked lightly on the film. The film then orientated to the SN-7 line which formed the horizontal X-axis and secured with tape on the viewing box.

2. Three cross markers were drawn randomly on the cranial vault of the pre-surgical film.
3. The postsurgical radiograph was superimposed on the pre-surgical radiograph and orientated according to a best fit on the above described natural structures in the anterior cranial base.
4. The three cross markers, sella and nasion were transferred and drawn on to the postsurgical film.
5. The postsurgical film was then orientated, according to the SN-7 line and the cross markers, adjacent to the pre-surgical film and secured with a cellulose tape.
6. The cephalometric tracing acetate sheets were placed on each radiograph and secured with tapes. The subject identification and time interval (Tx) for each radiograph were marked.
7. Tracing of each cephalogram was then performed. The landmarks and reference lines were identified according to the definitions and specifications listed below.
8. Linear and angular measurements were calculated and recorded on the corresponding acetate sheet and then transferred to excel worksheet for further calculations and data analysis.

The superimposition method facilitated skeletal changes to be studied in relation to the stable cranial base. Positional changes of hard tissue landmarks were measured relative to horizontal and vertical reference planes. SN-7 line formed the x-axis while the y-axis was constructed by drawing a perpendicular line to SN-7 through sella turcica (Figure 6.I)

Where immediate postoperative cephalograms had open occlusion due to either the presence of occlusal wafer or postsurgical soft tissue swellings, a correction was made by rotating a mandibular template until the lower incisal tips contacted the upper incisal tips with the centre of rotation estimated at the lingula of mandible (Figure 6.1).

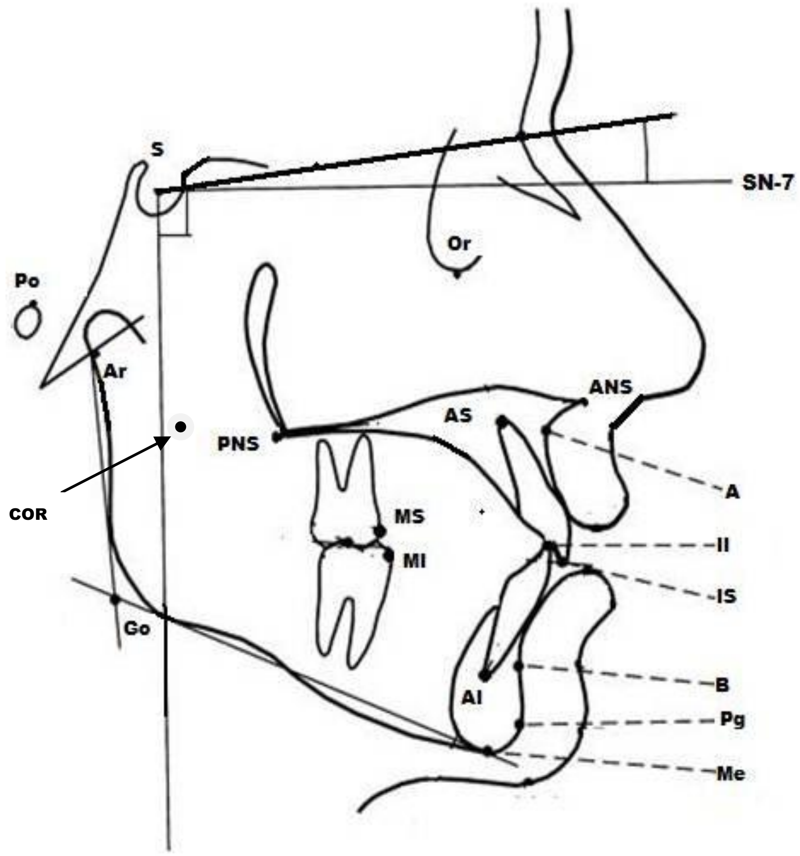


Figure 6.1 Hard tissue points.

(S= sella, N= nasion, Or= Orbitale, Po= Porion, Ar= Articulare, ANS= Anterior nasal spine, PNS= Posterior nasal spine, AS= Upper incisal apex, IS= Upper incisal tip, II= lower incisal tip, AI= Lower incisal apex, MS= Upper molar crown, MI= Lower molar crown, A= Down's A point, B= Down's B point, Pg= Pogonion, Me= Menton, Go= Gonion, COR= centre of rotation)

6.2.2 Reference points and lines

Reference points and reference lines (Figure 6.1 and Figure 6.2) throughout the text were selected from the earlier thesis produced by Hing (1989) which were derived from the Adelaide Oral and Maxillofacial Surgery Unit handbook (1983) and from the *Quick Ceph* manual (1986).Cephalometric points which relied on bilateral radiographic structures (orbitale, porion and gonion) were taken as the midpoint where the two images did not coincide.

6.2.2.1 Hard tissue points (Figure 6.1)

Sella (S): the centre of the pituitary fossa of the sphenoid bone determined by inspection.

Nasion (N): the most anterior point of the frontonasal suture.

Porion (Po): the most superior point on the external auditory meatus. The external auditory meatus has three radiolucent areas which distinguish it from the internal auditory meatus: the fenestrum vestibulae superiorly, the fenestrum cochlea posteriorly and the promontory anteriorly.

Orbitale (Or): the lowest point on the average of the right and left borders of the bony orbit.

Articulare (Ar): the point at the junction of the contour of the external cranial base and the dorsal contour of the condylar processes projected in the midsagittal plane.

Gonion (Go): a point on the bony contour of the angle of the mandible located by bisecting the angle formed by the line tangent to the lower border and a line through articulare and the posterior border of the ramus.

Menton (Me): the most inferior point on the symphyseal outline.

Pogonion (Pg): the most anterior point on the contour of the bony chin relative to a perpendicular to SN-7 plane.

Down's B point or supramentale (B): the deepest point in the midsagittal plane between infradentale and pogonion, usually anterior to and slightly below the apices of the mandibular incisors.

Lower incisal apex (AI): the root tip of the mandibular central incisor.

Lower incisal edge (II): the incisal tip of the mandibular central incisor.

Upper incisal edge (IS): the incisal tip of the maxillary central incisor.

Upper incisal apex (AS): the root tip of the maxillary central incisor.

Down's A point or subspinale (A): the deepest point in the midsagittal plane between the anterior nasal spine and supradentale, usually around the level of and anterior to the apex of the maxillary central incisors.

Anterior nasal spine or acanthion (ANS): the tip of the median sharp bony process of the maxilla at the lower margin of the anterior nasal opening.

Posterior nasal spine (PNS): the most posterior point at the sagittal plane on the bony hard palate.

Upper molar crown (MS): the distal contact (height of the contour) of the maxillary first molar relative to the occlusal plane.

Lower molar crown (MI): the distal contact (height of the contour) of the mandibular first molar relative to the occlusal plane.

6.2.2.2 Cephalometric lines (Figure 6.2)

Nasion-sella line (NSL): a line passing through nasion and sella.

Sella-nasion-7 (SN-7): a line constructed by drawing a line 7° to SN plane with its origin at sella.

Frankfort horizontal (FH): the line passing through porion and orbitale.

Mandibular line or plane (ML): a line drawn through menton and gonion. This line has also been defined as the tangent to the lower border of the mandible or a line joining gonion and gnathion.

Functional occlusal line (FOL): a line averaging the points of posterior occlusal contact from the first permanent molars to the first premolars.

True vertical line (TVL): a line constructed by drawing a line perpendicular to SN-7 line with its origin at sella.

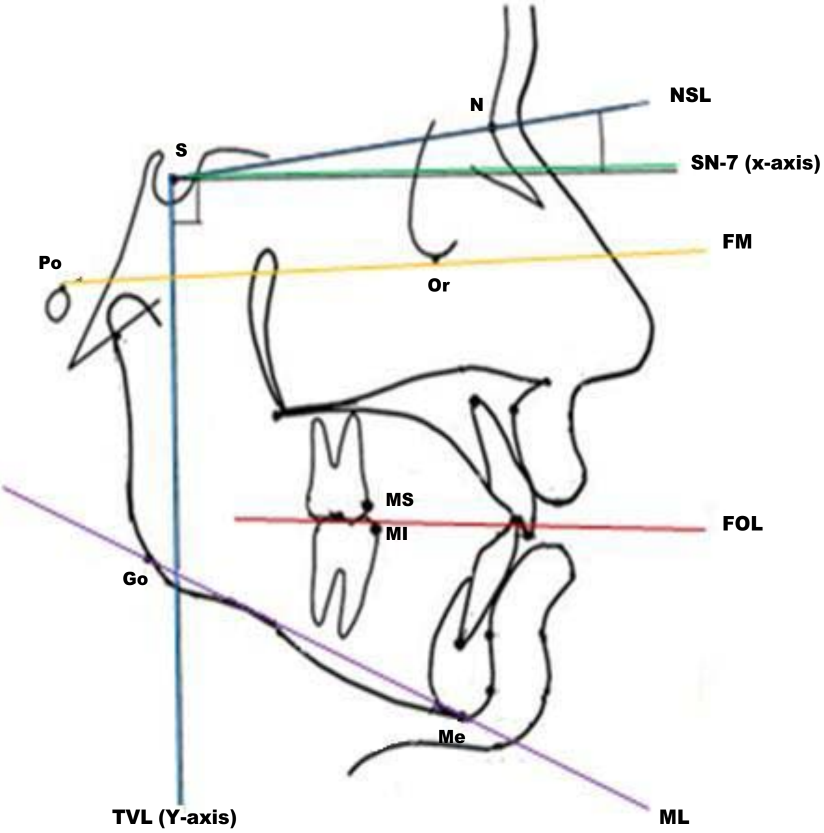


Figure 6.2 Reference lines used in the study

6.2.3 Calculations of linear and angular variables

The variables were selected from those used in previous thesis produced at the department of Oral and Maxillofacial Surgery, the University of Adelaide (Hing, 1989 and Ching, 1995). There were 10 linear variables measured in millimetres and 8 angular variables measured in degrees. All linear and angular variables were measured manually and stored in a Microsoft excel program.

6.2.3.1 Linear and angular variables

Anterior facial height (AFH): The distance between menton and nasion perpendicular to the SN-7 line.

Posterior facial height (PFH): the distance between gonion and sella perpendicular to the SN-7 line.

Point A horizontal (Ax): The distance between Down's Point A and the true vertical line.

Point A vertical (Ay): The distance between down's Point A and SN-7 line.

Point B horizontal (Bx): The distance between Down's Point B and the true vertical line.

Point B vertical (By): The distance between Down's Point B and the SN-7 line.

Point Pg horizontal (Pgx): The distance between pogonion (Pg) and the true vertical line.

Point Pg vertical (Pgy): The distance between pogonion (Pg) and the SN-7 line.

Point Me horizontal (Mex): The distance between menton (Me) and the true vertical line.

Point Me vertical (Mey): The distance between menton (Me) and the SN-7 line.

Overjet (OJ): The distance between IS and II measured parallel to the occlusal plane.

Overbite (OB): The distance between IS and II measured perpendicular to the occlusal plane.

Mandibular plane angle (SNGoMe): The angle formed between nasion-sella line and the mandibular line.

SNA: The angle formed between nasion-sella line and a line drawn through nasion and Down's Point A.

SNB: The angle formed between nasion sella line and a line drawn through nasion and Down's Point B.

Upper incisor angle (Mx1-SN7): The angle between SN-7 line and a line drawn through IS and AS.

Lower incisor angle (IMPA): The angle between the mandibular line and the line drawn through II and AI.

Interincisal angle (IIA): The angle between the line IS-AS and the line II-AL.

6.2.4 Assessment of the effect of surgeon's experience and time on the long term relapse

Four different Surgeons performed the operations. Eight patients were treated by one experienced surgeon (group A) and the remaining twelve patients had their operation performed by one of the other 3 less experienced surgeons (group B). Patients were further divided into two groups according to their associated percentage relapse (≤ 40% and > 40%) to allow for the assessment of the impact of surgeon's experience on postoperative relapse.

The effect of time on long term postoperative relapse was assessed by allocating all patients in either of two further groups according to their postoperative review period (≤ 11.6 years versus > 11.6 years).

A cross tabulation analysis was performed to assess for statistical significance.

6.2.5 Statistical analysis of relapse

All calculations and statistical evaluation were performed on the raw data using the Statistical Analysis System version 9.2 (SAS Institute Inc., Cary, NC, USA).

The independent samples t-tests were used to determine the significance of difference for each variable between the two groups (single jaw surgery vs double jaw surgery) and between genders (male vs female).

6.2.6 Errors of cephalometric method

In an attempt to assess the magnitude of overall cephalometric error, a random sample of 4 sets of cephalograms was selected from the main study sample. Each set consisted of 3 cephalograms for each subject at the following time interval:

T0: at completion of presurgical orthodontic treatment.

T1: immediately following surgery.

T5: current cephalogram (at an average of 11.6 years post surgery).

Double determinations were calculated and assessed for the total of 12 cephalograms. Tracing, superimposition and measurement were repeated at 1 month interval by one observer using similar procedure previously described in sections 5.2.2 and 5.2.3.

6.2.6.1 Statistical analysis of the experimental error

The Bland Altman method (1986) was used to assess agreement between the two measures for the various variables. This involves plotting the difference of the 1st and 2nd measure against the average of the two measures. The plot contains both an estimate of the bias between the two measures (calculated as the mean of the differences) and limits of agreement (calculated as the mean difference ± 1.96 standard deviations of the differences) in which 95% of the differences are expected to lie. The paired sample t-test was used to assess whether the bias differed significantly from zero.

6.3 Assessment of postoperative occlusal stability

The final late postoperative state of the patients was assessed by means of study models. Impressions were taken at the final assessment session. The original intent was to compare them to pre and immediate postoperative study models. Unfortunately so few were available, and then at varying stages, that this comparison was not feasible. However, from the dental and orthodontic point of view the final models were used to determine whether the occlusion was stable or not. The models were located into their final occlusion with a bite registration. The pairs of models were then assessed independently by two clinicians who were unaware of patient's details, including their cephalometric assessment. All 24 patients had final models made; these were assessed by examination of the intercuspation overjet, overbite and canine relation. The molar relation was missing in 6 (25%) cases by subsequent extraction of one or more of the molars and therefore, molar relation was excluded from the assessment.

The observed late postoperative occlusal stability was then compared to the recorded cephalometric relapse using cross tabulations and statistical significance was determined by Fisher's exact test.

6.4 Evaluation of long term postoperative oral health

The long term postoperative oral health status was evaluated by assessing the current dental status of the patients. At the time of orthodontic and orthognathic surgery patients were required to have an intact healthy mouth. Dental caries experience at the final review session was assessed clinically using the DMFT index. The clinical intraoral examination for all 24 patients was undertaken in a dental chair using an operating light, mouth mirror and dental probe.

The study sample was divided into three categories according to the number of the decayed and missing teeth (DMT) score.

1. Caries-free category: patients who were free from any dental decay and had no missing teeth.
2. Moderate-caries rate category: patients who had DMT score of 3 or less.
3. High-caries rate category: patients who had DMT score of 4 or more.

Further examination of the data was then undertaken to investigate any correlations between the dental health status and the psychological profile of patients.

CHAPTER 7. PSYCHOLOGICAL EVALUATION OF ORTHOGNATIC SURGERY PATIENTS

7.1 Quality of life assessment

The long term effect of orthognathic surgery on the quality of life was examined using the SF-36. See appendix 4, part a. This consists of thirty six questions which contribute to eight health domains:

1. Physical Functioning (PF).
2. Role limitations due to Physical health problems (RP)
3. Bodily Pain (BP)
4. General Health
5. Vitality (VT)
6. Social Functioning (SF)
7. Role limitations due to Emotional problems (RE)
8. Mental Health (MH)

All of the eight health domains were scored for the entire twenty four study sample using the scoring algorithm presented in appendix 4, part b. The eight aspects of quality of life mean scores were compared to the published South Australian normative data (South Australian population norms for the SF-36 Health Status Questionnaire. Adelaide, South Australian Health Commission, August 1995) using the independent samples t-tests.

7.2 Patient satisfaction following surgery

Patient satisfaction level was calculated from the sum score of the last four questions in the orthognathic satisfaction questionnaire presented in appendix 2. A high score indicated high satisfaction level of the treatment outcome. While a low score indicated a low level of satisfaction. This is illustrated in table 7.1

Question	Answer (Score)		
Q6. Have you noticed any change in your facial appearance?	Improvement (5)	No change (3)	Worsening (1)
Q7. How satisfied you are with the treatment outcome	Very satisfied (5)	Rather satisfied (3)	Unsatisfied (1)
Q8.The result of the treatment was:	Better than I expected (5)	As good as I expected (3)	Worse than I expected (1)
Q9. Would you undergo the same treatment again?	Yes (3)	No (1)	

The highest possible satisfaction score= 18 (Extremely satisfied)

The lowest possible satisfaction score = 4 (Extremely dissatisfied)

Table 7.1 Scoring of satisfaction level

7.3 Patient satisfaction and abnormal illness behaviour

The completed IBQ for each individual patient was transferred to computer software designed in the OMSU, Adelaide University. This computer software calculates whether the patient has normal or abnormal illness behaviour.

Cross tabulations statistical analysis was used to examine the effect of illness behaviour on patient satisfaction level. Statistical analysis was processed using the Statistics Package for the Social Sciences (SPSS). Significance was assessed according to Fisher's Exact test (two sided) SPSS.

CHAPTER 8. PERCEPTION OF AESTHETIC OUTCOME FOLLOWING ORTHOGNATHIC SURGERY

Recognition of differences in perception of long term aesthetic changes in profile following orthognathic surgery were assessed using a survey based on pre-operative (T0) and long term post-operative (T5) silhouettes. Those were constructed from the twenty surgical subjects who had their cephalometric radiographs traced previously for the cephalometric relapse study.

8.1 Silhouette construction technique

Tracings from 20 pairs of cephalometric radiographs were transferred on to A4 papers. This was performed in the darkened room and on the light box. Previously traced acetate film for each radiograph was orientated on the light box with the SN-7 line parallel to the horizontal axis. The acetate film was secured with tape. A4 paper was then placed on the acetate film with the upper and lower edges of the paper parallel to the SN-7 line. Soft tissue profile tracing was transferred to the paper using 0.5mm black pen. An identification code number was placed on the top left corner of each paper (Xto or Xt5) where:

X= alphabetical letter coded for each individual subject profile

t0= preoperative radiograph

t5= postoperative radiograph

The tracings were then scanned on *hp scanner,* set to a standard size and converted into silhouettes using *Microsoft paint program software*. These silhouettes were then used in the survey.

The survey consisted of eleven pages. The first page included attractiveness scoring instructions for the investigator and an investigator identification number. An example for attractiveness scoring was also included on the first page. The example was based on construction of ideal profile with a high score and badly disfigured profile with a low score. The next ten pages included a total number of 40 silhouettes which were randomly distributed. The attractiveness survey is presented in appendix 7.

8.2 Evaluators

All silhouette profiles were assessed by three different groups of people. The first group consisted of 10 professionals selected from the Oral and Maxillofacial Surgery and Orthodontic departments of Adelaide Dental Hospital, the University of Adelaide. It included 5 consultants and 5 senior registrars. The second group consisted of 10 lay Caucasian Australians who were randomly selected from the waiting area of the Oral and Maxillofacial Surgery outpatient clinic. The third group comprised of different ethnic group and consisted of 10 lay Omanis studying in Adelaide. The total of the thirty evaluators were further divided into two groups according to gender to determine if any differences in perception of facial attractiveness existed between male and female judges (Table 8.1).

SEX	NUMBER	MEAN AGE (YEARS)	STANDARD DEVIATION	MINIMUM	MAXIMUM	RANGE
Male	19	37.2	14.3	18	67	49
Female	11	28	9.8	18	48	30
TOTAL	30	33.8	13.4	18	67	49

Table 8.1 Gender and age distribution of the evaluators.

The survey was placed in an envelope and handed to each investigator. A verbal consent was obtained from all investigators. Arrangements were made for a suitable collection of surveys following completion. All investigators received no compensation for their participation. The inclusion criterion was comprehension of English and acceptance of the informed consent. The exclusion criteria were inability to follow instructions or rejection of the verbal informed consent.

8.3 Statistical analysis of aesthetic changes

To compare improvements in attractiveness scores from pre to 11.6 years post surgery according to evaluator group (Professionals (B) vs. lay-Australians (A) vs. lay Omanis (C)), evaluator gender and patient group (I - VII), linear mixed effect models were fitted to the data. In the models, evaluator group, gender, and patient groups were considered as predictors (fixed effects) while patient and evaluator were considered as random effects. Note that random effects were included in the model to adjust for the dependence in scores from either the same patient or the same evaluator.

Statistical analysis was performed on the raw data to answer the following questions:

1. At the long-term review, is there a perceivable significant improvement on facial attractiveness?
2. Does improvement score vary according to evaluator group?
3. Does improvement score vary according to evaluator gender?
4. Does improvement score vary according to patient group?
5. Does the difference in improvement scores between patient groups (I-VII) depend on evaluator group?

IV RESULTS

CHAPTER 9. LONG TERM RELAPSE FOLLOWING MANDIBULAR ORTHOGNATHIC SURGERY

9.1 Introduction

All patients in the cephalometric study had mandibular deformity alone or in combination with maxillary deformity and underwent single mandibular surgery or double jaw operation (bimaxillary osteotomy). The summary of all procedures is presented in Table 9.1.

PROCEDURE	NUMBER OF PATIENTS
BSSO advancement only	6
BSSO advancement + genioplasty setback	3
BSSO advancement + Le Fort I	4
BSSO advancement + genioplasty advancement + Le Fort 1	3
VSSO setback + Le Fort I	2
BSSO setback + Le Fort I	1
BSSO setback + genioplasty advancement + Le Fort I	1
TOTAL	**20**

Table 9.1 Surgical procedures performed.

The age of patients at the time of surgery was calculated from the date of birth to the nearest month and expressed in years (Table 9.2).

SEX	NUMBER	MEAN AGE (YEARS)	STANDARD DEVIATION	MINIMUM	MAXIMUM	RANGE
Male	12	22.4	8.6	16.5	48.2	31.7
Female	8	18.9	6.8	14.9	36	21.3
TOTAL	20	21	7.9	14.9	48.2	33.3

Table 9.2 Age at operation

The study sample of twenty patients was similar to the overall sample of 226 patients in surgery type and age group. However, the sample showed a male predominance 12 of 20 (60%) when compared to the overall sample which demonstrated a female predominance 153 of 226, (68%).

The postoperative review period for all of the 20 patients recruited for the cephalometric study is presented in Table 9.3.

SEX	NUMBER	MEAN POSTOPERATIVE REVIEW (YEARS)	STANDARD DEVIATION	MINIMUM	MAXIMUM	RANGE
Male	12	12	2.9	7	16.4	9.4
Female	8	11	3.2	7.2	17.6	10.4
TOTAL	20	11.6	3.0	7	17.6	10.6

Table 9.3 Postoperative review period (cephalometric study sample)

In this study, relapse was defined as a shift towards the preoperative state (Reitzik, 1988). It was calculated as a positive value while negative values indicated changes in the same direction of the initial surgical shift which may account for further growth or migration. To allow assessment of long term horizontal mandibular relapse of all mandibular osteotomy cases as a whole sample, the initial surgical movement and the subsequent long term relapse for mandibular advancement cases were calculated as follows:

- Initial surgical movement (+ve movement) = measurement at T1 – measurement at T0.
- Long term relapse (+ve relapse) = measurement at T1 – measurement at T5.

Whereas for mandibular setback cases, the following were used:

- Initial surgical movement (+ve movement) = measurement at T0 – measurement at T1.
- Long term relapse (+ve relapse) = measurement at T5 – measurement at T1.

Analyses of the initial surgical horizontal and vertical mandibular movements and their long term relapse were examined at Pogonion (Pg), Menton (Me), and B Point (B) for all of the twenty patients and then long term relapse was compared between the two broad groups:

I. Mandibular osteotomy only (N= 9)
II. Bimaxillary osteotomy (N= 11)

9.2 Horizontal movement and relapse

9.2.1 Horizontal relapse at pogonion

The mean initial surgical horizontal mandibular movement at pogonion (T0-T1) was 7.9mm ± 6.5 mm. The long term relapse (T1- T5) was measured as a shift towards the preoperative position. The long term relapse at pogonion was measured as a relapse of 3.1 mm ± 3.3 mm (39%). This relapse was found statistically significant (Table 9.4).

The percentages horizontal relapse at pogonion for group II (the bimaxillary group) was 37 percent from the initial surgical movement (3.7 ± 3.0 mm) and for group I (single jaw group) was found to be higher and measured 44 percent (2.3 ± 2.6 mm). However, the difference in relapse between the two groups did not reach statistical significance (Table 9.7).

Time Period	Shift (mm)	t- value	Probability
T0- T1	7.9 ± 6.5	5.39	<0.0001*
T1- T5	3.1 ± 3.3	4.25	0.0004*

*statistically significant ($p < 0.01$)

Table 9.4 Comparison of horizontal relapse at pogonion (PgX)- pooled data

9.2.2 Horizontal relapse at menton

A mean initial movement of 8.1 mm ± 6.5 mm (T0-T1) was measured at menton for the 20 patients who underwent mandibular osteotomy. In the long term period (T1-T5), a relapse of the mandible was noted and measured at 3.0 mm ± 3.1 mm (37%). This shift was statistically significant (Table 9.5).

Time Period	Shift (mm)	t- value	Probability
T0 - T1	8.1 ± 6.5	5.55	<0.0001*
T1 - T5	3.0 ± 3.1	4.33	0.0004*

*statistically significant ($p < 0.01$)

Table 9.5 Comparison of horizontal relapse at menton (MeX)- pooled data

The recorded percentage relapse for group II (3.4 ± 2.6 mm; 34%) was found to be less than that calculated for group I (2.6 ± 3.7 mm; 46%) but statistical analysis showed that this difference was not significant (Table 9.7).

9.2.3 Horizontal relapse at B Point

The mean surgical shift of mandible at point B for the total study sample was 7.1 mm ± 3.9 mm. A relapse movement at point B measured at T5 was 2.3 mm ± 2.6 mm (32%) and this overall shift was statistically significant (Table 9.6).

Time Period	Shift (mm)	t- value	Probability
T0 - T1	7.1 ± 3.9	8.10	<0.0001*
T1 - T5	2.3 ± 2.6	3.94	0.0009*

*statistically significant ($p < 0.01$)

Table 9.6 Comparison of horizontal relapse at B point (BX)- pooled data

For group II (the bimaxillary group), the long term percentage relapse at point B was measured to be 36 percent (2.8 ± 2.2 mm). While, interestingly, a smaller percentage relapse of 26 percent (1.6 ± 2.9 mm) was recorded for group I (the single jaw group). However, the independent samples t-test showed no statistical significance between the two groups (Table 9.7).

VARIABLE	GROUP	T STATISTIC	P VALUE
PgX	I- II	0.57	0.57
MeX	I- II	0.95	0.35
BX	I- II	1.11	0.28

Table 9.7 Comparison of horizontal relapse at pogonion (PgX), menton (MeX) and B point (BX) between groups.

9.3 Vertical movement and relapse

9.3.1 Vertical relapse at pogonion

A mean initial vertical downward movement of 2.8 mm ± 5.9 mm was measured at pogonion for the whole study sample. After an average of 11.6 years after surgery (T5), there was a further downward shift of - 0.4 mm ± 2.8 mm recorded at pogonion, but this shift was not statistically significant (Table 9.8).

Time Period	Shift (mm)	t- value	Probability
T0 - T1	2.8 ± 5.9	2.11	0.048
T1 - T5	- 0.4 ± 2.8	- 0.64	0.53

Table 9.8 Comparison of vertical relapse at pogonion (PgY) - pooled data

At the long term follow up (T5), group II (bimaxillary group) showed a further downward movement of – 1.1 mm ± 3.2 mm whereas group I (single jaw group) demonstrated an upward movement or a slight vertical relapse of 0.4 mm ± 2.0 mm. However, this difference in the vertical change between both groups did not reach statistical significance (Table 9.11).

9.3.2 Vertical relapse at menton

The initial vertical change recorded at menton measured a downward movement of 1.7 mm ± 3.7 mm. A further downward movement of -0.5 mm ± 2.3 mm was measured at the long term follow up (T5) but this long term change was not statistically significant (Table 9.9).

Time Period	Shift (mm)	t- value	Probability
T0 - T1	1.7 ± 3.7	2.05	0.05
T1 - T5	- 0.5 ± 2.3	- 0.98	0.34

Table 9.9 Comparison of vertical relapse at menton (MeY)- pooled data

At an average of 11.6 years after surgery, a further downward movement of -1.2 mm ± 1.9 mm was found for group II (the bimaxillary group) at menton, but an upward relapse of 0.3 mm ± 2.5 mm was recorded for group I (the single jaw group). The difference of long term changes between the two different groups was not significant (Table 9.11).

9.3.3 Vertical relapse at B point

An initial downward movement of 1.0 mm ± 3.6 mm was measured at B point. At T5, an upward relapse of 0.7 mm ± 3.0 mm was recorded at B point, which meant that a long term vertical relapse was evident, but did not reach statistical significance (Table 9.10).

Time Period	Shift (mm)	t- value	Probability
T0 - T1	1.0 ± 3.6	1.16	0.26
T1 - T5	0.7 ± 3.0	0.97	0.34

Table 9.10 Comparison of vertical relapse at B point (BY)- pooled data

Vertical relapse at B point for group I (single jaw group) and group II (bimaxillary group) was found to be 1.4 mm ± 3.8 mm and 0.0 mm ± 2.1 mm, respectively. The difference of long term relapse at B point between both groups did not reach statistical significance (Table 9.11).

VARIABLE	GROUP	T STATISTIC	P VALUE
PgY	I- II	-1.24	0.23
MeY	I- II	-1.53	0.14
BY	I- II	-1.08	0.3

Table 9.11 Comparison of vertical relapse at pogonion (PgY), menton (MeY) and B point (BY) between groups.

9.4 Angle SNB

Following mandibular osteotomy, the change in the anteroposterior direction of the mandible was further observed from postoperative changes at angle SNB. Immediately after surgery, the angle SNB demonstrated a mean change of 4.0° ± 2.4°. At the long term follow up (T5), a statistically significant relapse of 1.8° ± 1.6° (45%) was measured for this angular variable (Table 9.12).

Time Period	Shift (degrees)	t- value	Probability
T0 - T1	4.0° ± 2.4°	7.43	< 0.0001*
T1 - T5	1.8° ± 1.6°	4.90	< 0.0001*

*statistically significant ($p < 0.01$)

Table 9.12 Comparison of relapse for angle SNB - pooled data

9.5 Posterior facial height (PFH)

A mean increase of 2.0 mm ± 3.1 mm was measured for the posterior facial height immediately after surgery. After an average of 11.6 years follow up, PFH showed a return towards the preoperative state by a mean change of 2.8 mm ± 4.3 mm. This observable relapse was statistically significant (Table 9.13).

Time Period	Shift (mm)	t- value	Probability
T0 - T1	2.0 ± 3.1	2.92	0.0087*
T1 - T5	2.8 ± 4.3	2.92	0.0088*

*statistically significant ($p < 0.01$)

Table 9.13 Comparison of relapse for PFH - pooled data

9.6 Anterior facial height (AFH)

Anterior facial height increased a mean of 2.1 mm ± 3.6 mm for the 20 patients at surgery. This linear vertical distance has increased a further 0.6 mm ± 2.3 mm at the long term follow up (T5), but the further increase was not statistically significant (Table 9.14).

Time Period	Shift (mm)	t- value	Probability
T0 - T1	2.1 ± 3.6	2.51	0.02
T1 - T5	- 0.6 ± 2.3	- 1.07	0.3

Table 9.14 Comparison of relapse for AFH - pooled data

The anterior facial height for group II (the bimaxillary group) showed a decrease of -0.1 mm ± 2.5 mm at surgery whereas group I (single jaw group) showed an increase of 4.7 mm ± 3.2 mm. This difference was found to be statistically significant (p= 0.0014). At an average of 10 years after surgery, the long term relapse was 1.2 mm ± 1.9 mm and 0.2 mm ± 2.6 mm for group II and group I, respectively. However, this difference of relapse between both groups was not statistically significant (p= 0.18).

9.7 Mandibular plane angle (SNGoMe)

The mandibular plane angle decreased minimally after surgery, measuring -0.8° ± 4.3°. In the long follow up period, the mandibular plane angle increased an amount of 1.7° ± 3.9° favouring a further decrease from its preoperative position but this shift was not statistically significant (Table 9.15).

Time Period	Shift (degrees)	t- value	Probability
T0 - T1	-0.8° ± 4.3°	-0.84	0.41
T1 - T5	1.7° ± 3.9°	1.91	0.07

Table 9.15 Comparison of relapse for mandibular plane angle (SNGoMe) - pooled data

Immediately after surgery, the mandibular plane angle for group II (the bimaxillary group) decreased -2.8° ± 4.6°and increased for group I (the single jaw group) by 1.7° ± 1.9° (p= 0.014). At the long term follow up, the mandibular plane angle showed a tendency to return towards the preoperative state for group II (the bimaxillary group), measuring 2.4° ± 3.9°, while for group I (the single jaw group) a further increase of 0.8° ± 3.8° was observed. However, the difference of long term changes between both groups did not reach statistical significance (p= 0.38).

9.8 Dentoskeletal changes

Statistical analysis of the dentoskeletal changes from immediately after surgery (T1) to long term follow up (T5) did not demonstrate any significant differences between group I (the single jaw group) and group II (the bimaxillary group) for all the angular and linear variables (Table 9.16). Therefore, the two groups were combined and analysed as one group.

VARIABLE	GROUP	T STATISTIC	P VALUE
Mx1-SN7	I- II	1.37	0.19
IMPA	I- II	-1.90	0.07
IIA	I- II	0.94	0.36
OJ	I-II	2.14	0.05
OB	I-II	1.39	0.18

Table 9.16 Comparison of dentoskeletal relapse for maxillary incisal angle (Mx1-SN7), lower incisal angle (IMPA), interincisal angle (IIA), overjet (OJ) and overbite (OB) between groups.

9.8.1 Maxillary incisal angle (Mx1SN)

Immediately following surgery, the maxillary incisal angle showed non-statistical increase of 0.8° ± 4.8° (p= 0.47). At the long term follow up period (T5), the maxillary incisal angle demonstrated a decrease of 4.7° ± 4.8° and this was statistically significant (Table 9.17).

Time Period	Shift (degrees)	t- value	Probability
T0 - T1	0.8 ± 4.8	0.74	0.47
T1 - T5	4.7 ± 4.8*	4.38	0.0003**

***** +ve value here indicates change at T5 in the opposite direction of the initial change at T1

**statistically significant ($p < 0.01$)

Table 9.17 Comparison of relapse for angle Mx1-SN7 - pooled data

9.8.2 Lower incisal angle (IMPA)

The lower incisal angle demonstrated a minimal decrease of -0.8° ± 4.9° immediately after surgery. Further retroclination of lower incisors was demonstrated at the long term follow up, and measured 2.2° ± 8.4°. However, the changes of the IMPA over the study periods were not statistically significant (Table 9.18).

Time Period	Shift (degrees)	t- value	Probability
T0 - T1	-0.8 ± 4.9	-0.74	0.47
T1 - T5	2.2 ± 8.4*	1.17	0.25

***** +ve value here indicates change at T5 in the same direction of the initial change at T1

Table 9.18 Comparison of relapse for angle IMPA - pooled data

9.8.3 Interincisal angle (IIA)

The interincisal angle changes are affected by the combined changes of Mx1-SN7 and IMPA. Immediately after surgery, the interincisal angle has increased an amount of 2.0°± 6.3°. As a result of upper and lower incisors retroclinations that were found at the long follow up (T5) period, the interincisal angle demonstrated an increase of 4.6° ± 9.0°but again these observed changes for the IIA were not statistically significant (Table 9.19).

Time Period	**Shift (degrees)**	**t- value**	**Probability**
T0 - T1	2.0 ± 6.3	1.39	0.18
T1 - T5	-4.6 ± 9.0*	-2.25	0.04

* -ve value here indicates change at T5 in the same direction of the initial change at T1

Table 9.19 Comparison of relapse for interincisal angle - pooled data

9.8.4 Overjet

The overjet decreased significantly immediately after surgery by -5.7 mm ± 4.2 mm. At an average of 11.6 years review, the overjet remained relatively stable with a relapse of -1.0 mm ± 1.9 mm. This observed relapse did not reach statistical significance (Table 9.20).

Time Period	Shift (mm)	t- value	Probability
T0 - T1	-5.7 ± 4.2	-6.23	<0.0001**
T1 - T5	-1.0 ± 1.9*	- 2.20	0.04

*-ve value here indicates relapse as an opposite direction to the initial shift

**statistically significant ($p < 0.01$)

Table 9.20 Comparison of relapse for overjet - pooled data

9.8.5 Overbite

In all of the twenty orthognathic patients, the overbite showed non-significant decrease of -1.1 mm ± 3.5 mm following surgery. A measurable relapse occurred in the long follow up period resulting in an increase of -1.4 mm ± 1.8 mm and this shift was statistically significant (Table 9.21).

Time Period	Shift (mm)	t- value	Probability
T0 - T1	-1.1 ± 3.5	-1.42	0.17
T1 - T5	-1.4 ± 1.8*	- 3.50	0.002**

*-ve value here indicates relapse as an opposite direction to the initial shift

**statistically significant ($p < 0.01$)

Table 9.21 Comparison of relapse for overbite - pooled data

9.9 Gender of patients

The total sample of the twenty patients in this study was divided into two groups according to gender to determine if any differences in relapse existed between male and female patients. There were 8 female patients and 12 males. The statistical analysis using the independent sample t-test could not demonstrate any significant difference between the relapse, in both horizontal and vertical directions, of the two groups (Table 9.22 and Table 9.23).

Variable	Relapse (mm)		t- value	Probability
	Female	Male		
PgX	4.8 ± 3.8	2.5 ± 2.9	1.01	0.33
MeX	3.8 ± 4.1	2.5 ± 2.3	0.88	0.39
BX	2.8 ± 3.5	1.9 ± 1.8	0.71	0.49

Table 9.22 Comparison of differences in horizontal relapse at pogonion (PgX), menton (MeX) and B point (BX) by genders.

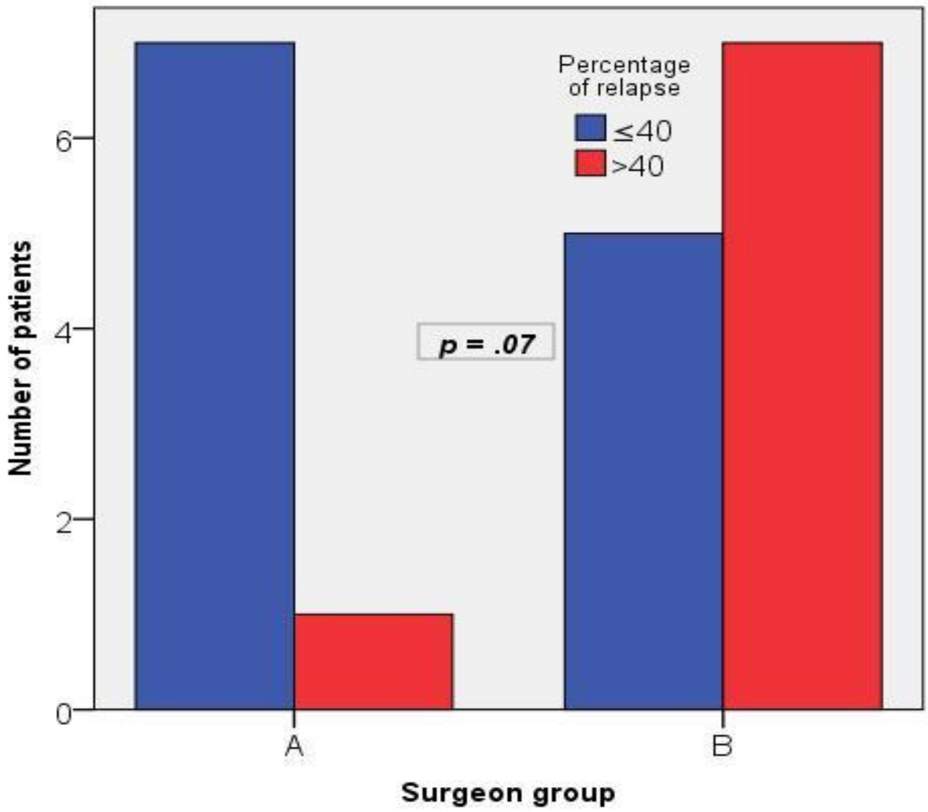
Variable	Relapse (mm)		t- value	Probability
	Female	Male		
PgY	- 0.5 ± 3.4	- 0.3 ± 2.5	-0.13	0.9
MeY	- 1.1 ± 2.5	- 0.1 ± 2.1	-1.00	0.33
BY	- 0.4 ± 1.5	1.3 ± 3.6	-1.27	0.22

Table 9.23 Comparison of differences in vertical relapse at pogonion (PgY), menton (MeY) and B point (BY) by genders.

9.10 The effect of surgeon's experience on postoperative relapse.

The results showed that 87 percent of patients managed by surgeon A experienced a relapse of ≤ 40 percent and only one patient had a relapse of > 40 percent. On the other hand, there were 7 out of 12 patients in surgeon group B had a long term relapse of >40 percent and approximately 42% of patients experienced ≤ 40 relapse (Figure 9.1). Cross tabulation results are shown in Table 9.24.

There appear to be a trend of positive effect on long term stability for cases treated by the experienced surgeon (group A). However, this observation did not reach statistical significance when tested by the Fisher's Exact test (P=0.07).



P value according to Fisher's exact test (2-sided)

Figure 9.1 The effect of surgeon's experience on postoperative relapse

		Total (n)	Percentage of relapse	
			≤40	>40
Surgeon group	A	8	7	1
	B	12	5	7
Total		20	12	8

Table 9.24 Cross tabulation Surgeon group versus percentage of relapse

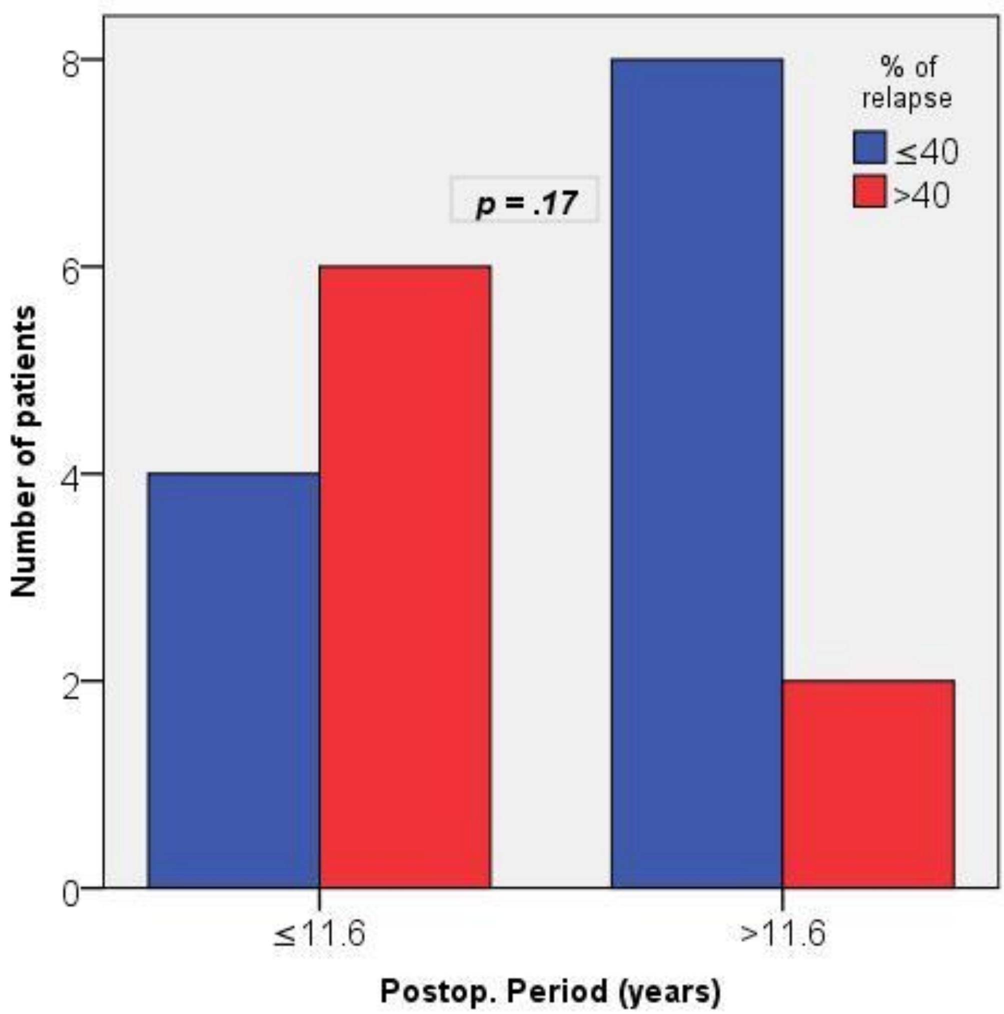
9.11 The effect of postoperative period on cephalometric relapse

The mean postoperative review period for the whole twenty cephalometric study subjects was 11.6 years. The study subjects were separated into four groups based upon postoperative review period (≤ 11.6 years and > 11.6 years) and the percentage relapse (≤ 40% and > 40%). A Chi-square analysis was undertaken to determine the impact of time on postoperative relapse.

Six subjects had a relapse of > 40 percent within a period of ≤ 11.6 years and only 2 subjects were found to have > 40 percent of relapse at the more than 11.6 years review. The remaining twelve subjects experienced a relapse of ≤ 40 percent. Eight of these subjects experienced the relapse at > 11.6 years review period and four at ≤ 11.6 years. The cross tabulation analysis and Fisher's Exact test demonstrated no significant correlation between postoperative time and long term relapse (p= 0.17). These results are recorded in Table 9.25 and illustrated in Figure 9.2.

		Total (n)	% rel	
			≤40	>40
Postop. Period	≤11.6 yrs	10	4	6
	>11.6 yrs	10	8	2
Total		20	12	8

Table 9.25 Crosstabulation Postoperative Period versus percentage of relapse (% rel)



P value according to Fisher's Exact test (2-sided).

Figure 9.2 The effect of time on postoperative relapse

CHAPTER 10. ERRORS OF CEPHALOMETRIC METHOD

10.1 Errors of the Cephalometric Method

The reproducibility of all linear and angular variables used in the cephalometric study of relapse was assessed from double determination of twelve cephalograms using the Bland-Altman method. Summary of the outcome is presented in Table 10.1.

The maximum mean difference (bias) measured for the linear variables were 3.17 mm and for the angular variables was -1º.

The anterior facial height (AFH) was the most reliable linear variable. The bias for AFH was not significantly different from zero and it had the smallest limits of agreement (-1.63, 1.63). The posterior facial height (PFH) was the most unreliable linear variable. The bias for PFH was measured 3.17 mm ($p< 0.001$). It is expected that on 95% of occasions that differences between the two measures for PFH will lie between -0.8 and 7.13 mm.

For angular variables, SNB was the most reliable measurement with its bias found not to be significantly different from zero and the width of its limits of agreement was 3.32. The most unreliable angular variable was the mandibular plane angle (bias= -1; limits of agreement= -3.30, 1.30).

The paired sample t-test showed that the bias differed significantly from zero for two variables. These were posterior facial height (PFH) and mandibular plane angle (SNGoMe).

The Bland-Altman plots for each of the variables are illustrated showing how well repeated measurements agree.

Variable	Bias (M diff)	Probability (p value)	Limits of agreement
PgX	0.33	0.39	-2.53, 3.20
PgY	0.25	0.43	-2.07, 2.57
MeX	0.42	0.42	-3.39, 4.22
MeY	0	1	-1.88, 1.88
BX	-0.08	0.86	-3.53, 3.36
BY	0.42	0.66	-6.64, 7.47
AX	0.67	0.27	-3.67, 5.00
AFH	0	1	-1.63, 1.63
PFH	3.17	**<0.001**	-0.80, 7.13
OJ	0.33	0.3	-2.03, 2.70
OB	0.58	0.11	-1.98. 3.15
SNA	0.17	0.66	-2.62, 2.96
SNB	0.25	0.27	-1.41, 1.91
SNGoMe	-1	**0.007**	-3.30, 1.30
Mx1SN7	0.58	0.32	-3.66, 4.83
IMPA	1.17	0.35	-7.97, 10.31
IIA	-0.17	0.9	-9.64, 9.30

Table 10.1 Degree of agreement for various variables by double determination

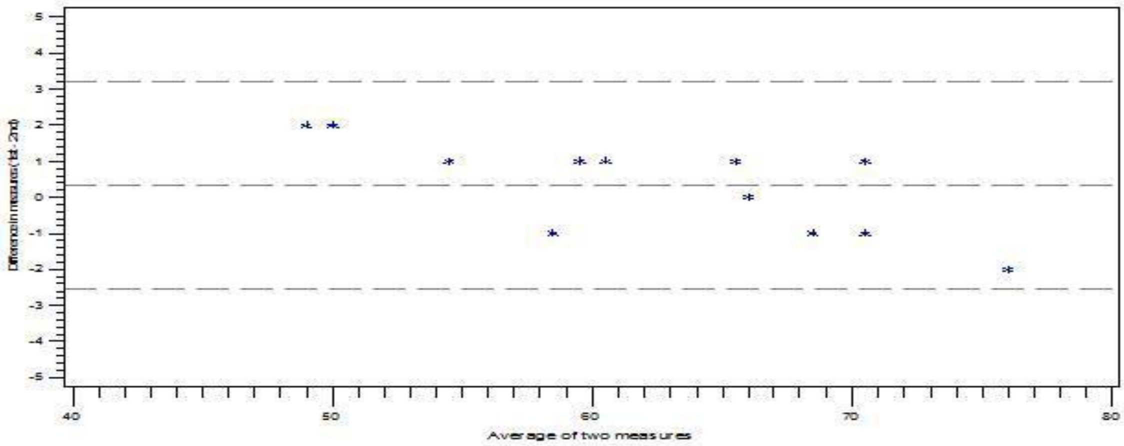


Figure 10.1 The Bland-Altman plot for point Pg horizontal (PgX)

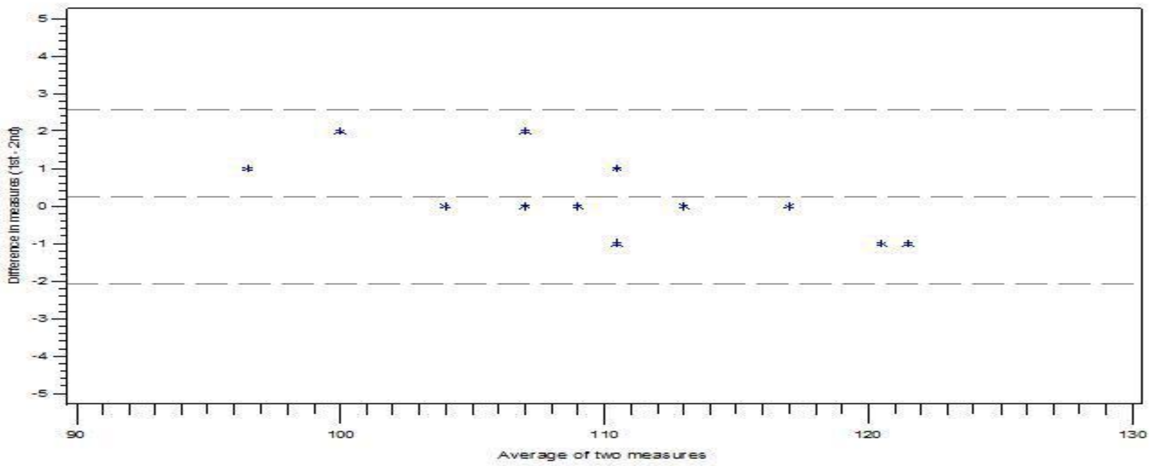


Figure 10.2 The Bland-Altman plot for point Pg vertical (PgY)

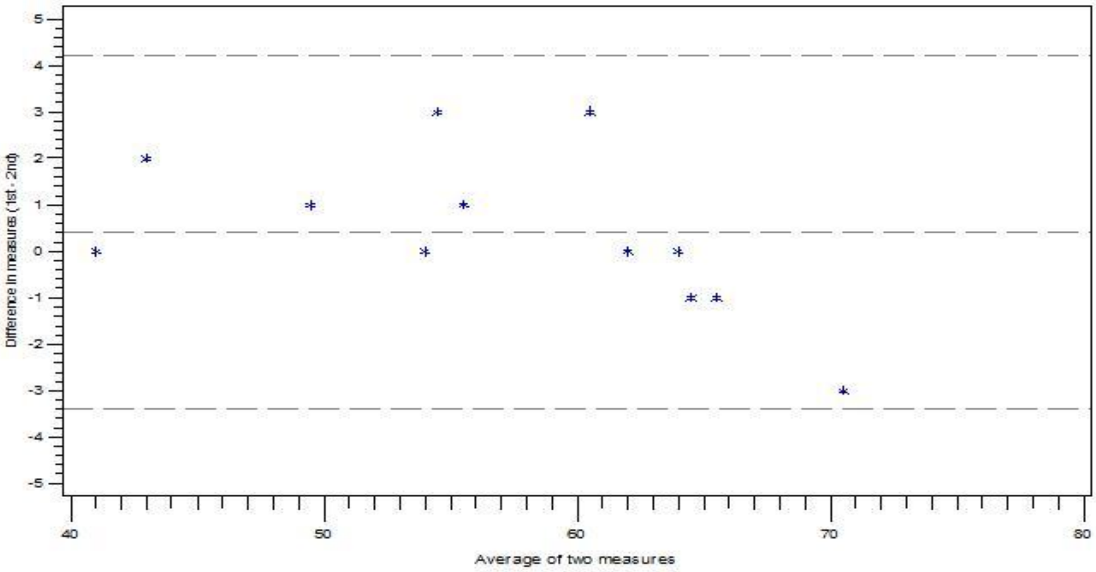


Figure 10.3 The Bland-Altman plot for point Me horizontal (MeX)

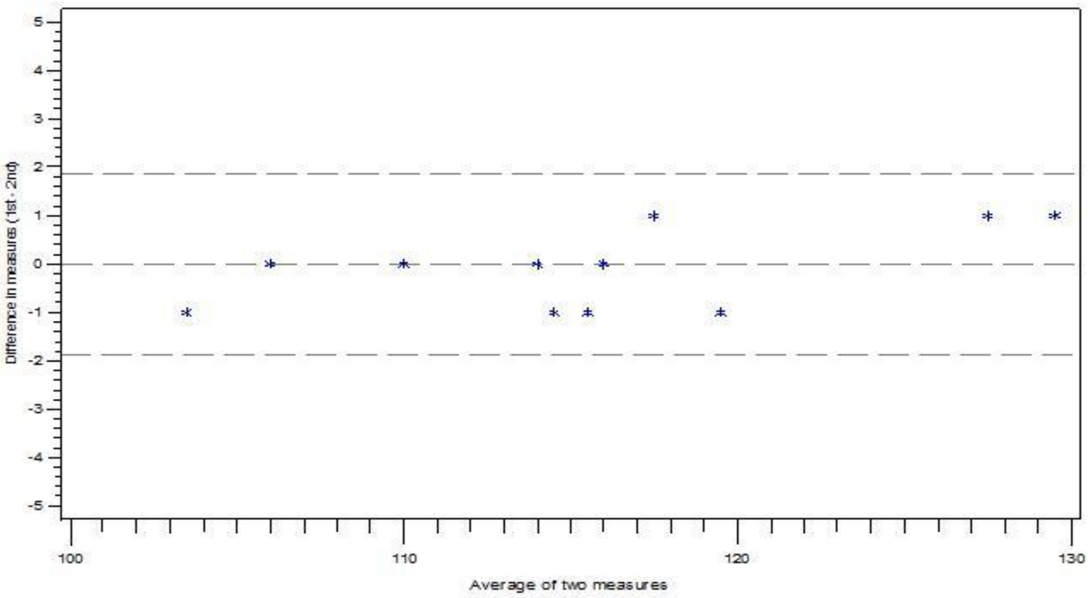


Figure 10.4 The Bland-Altman plot for point Me vertical (MeY)

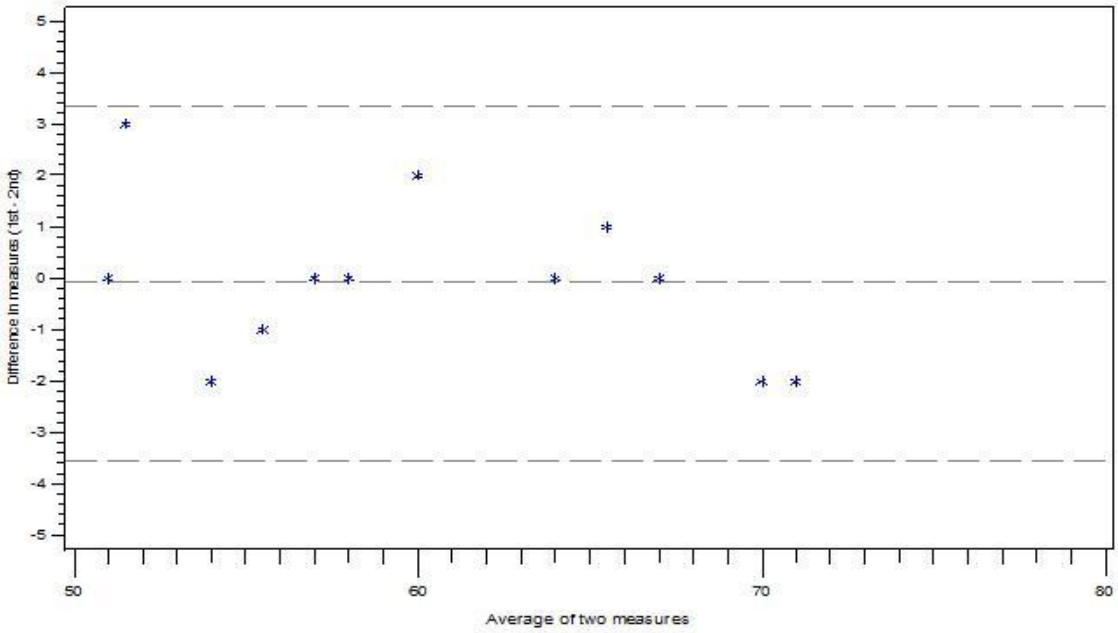


Figure 10.5 The Bland-Altman plot for point B horizontal (BX)

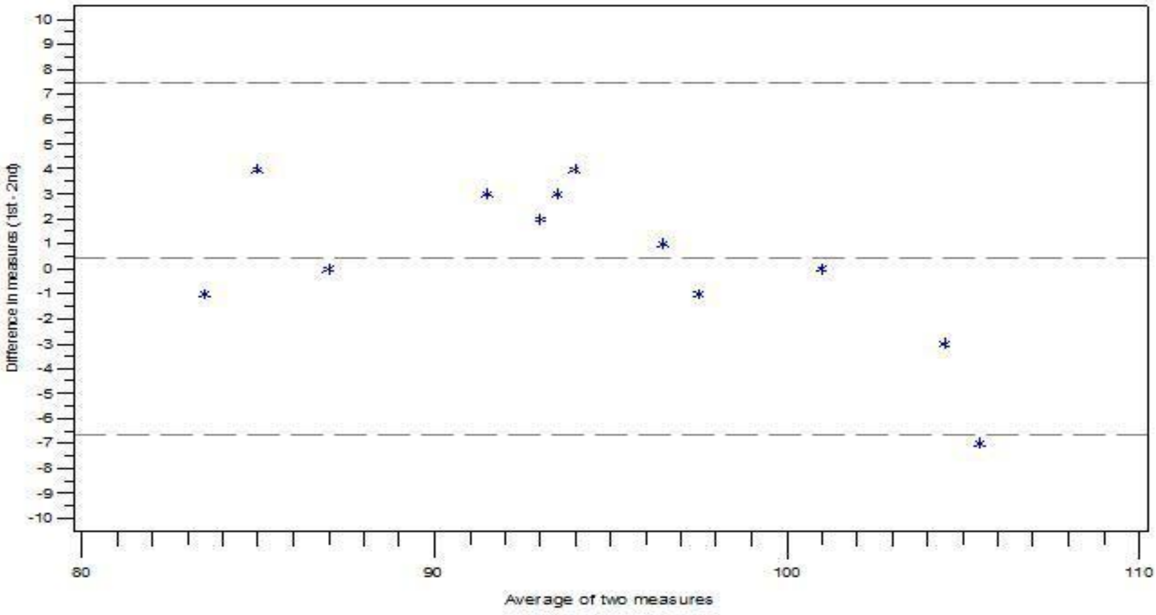


Figure 10.6 The Bland-Altman plot for point B vertical (BY)

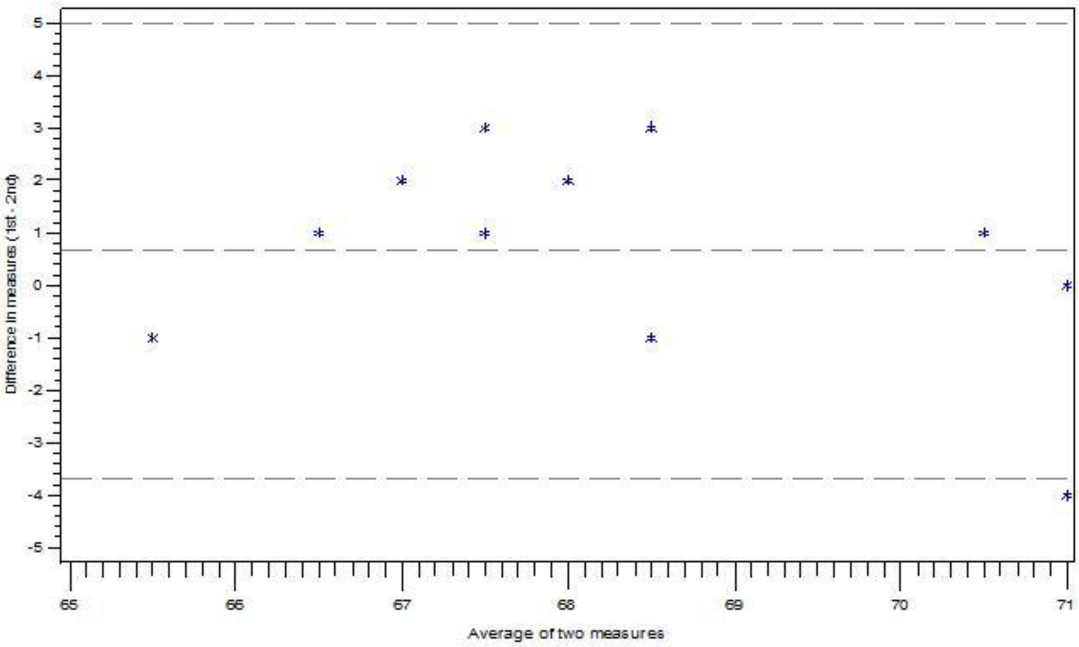


Figure 10.7 The Bland-Altman plot for point A horizontal (AX)

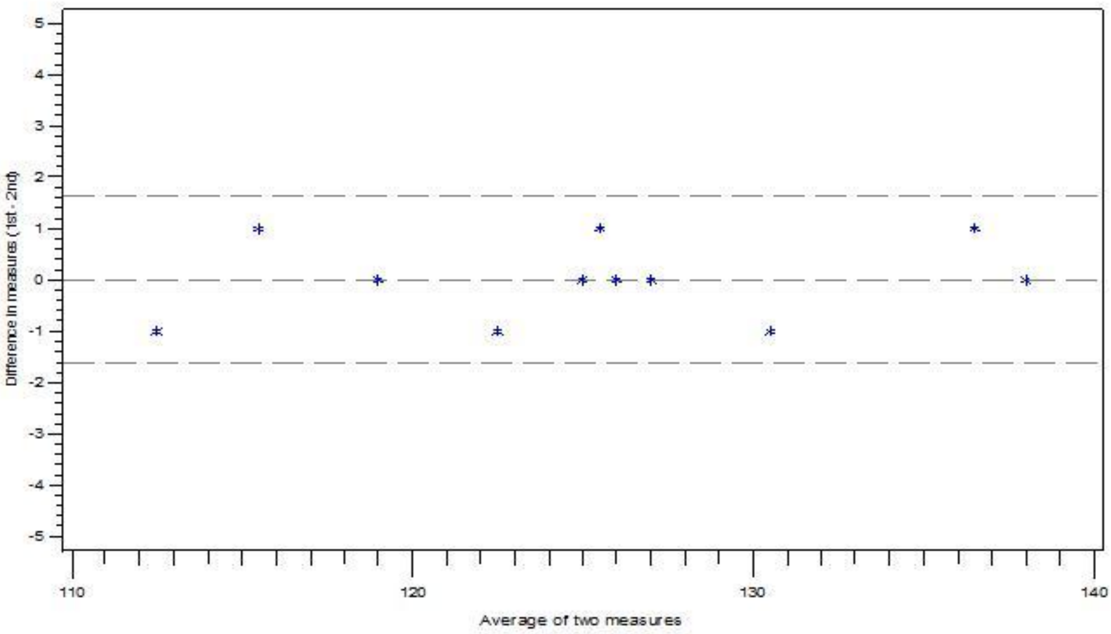


Figure 10.8 The Bland-Altman plot for anterior facial height (AFH)

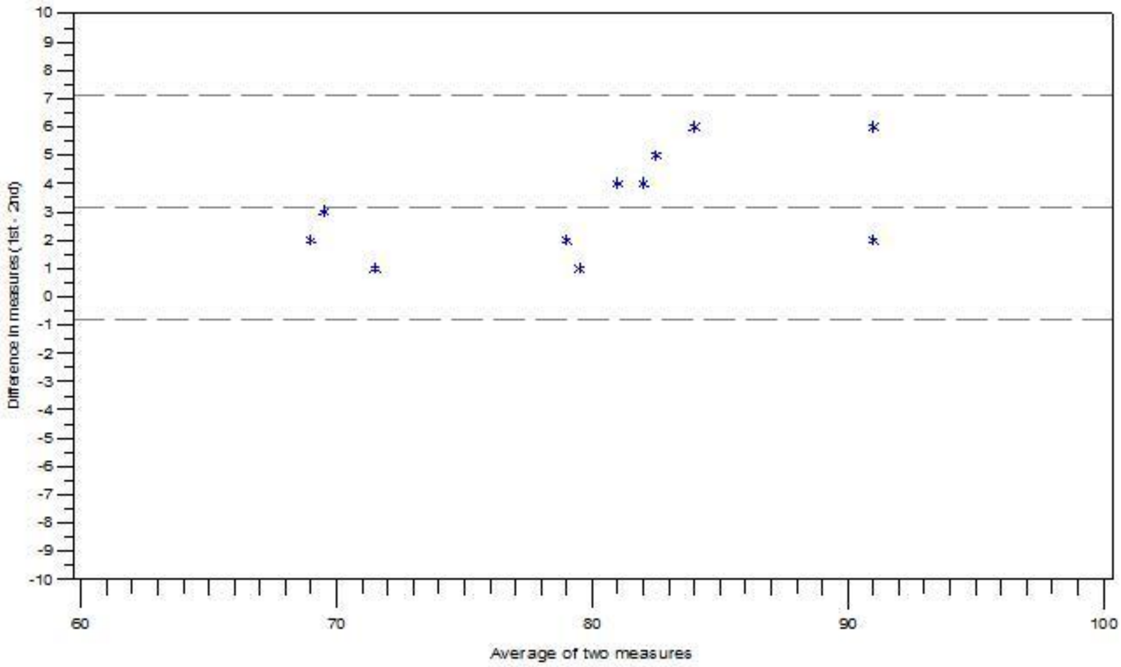


Figure 10.9 The Bland-Altman plot for posterior facial height (PFH)

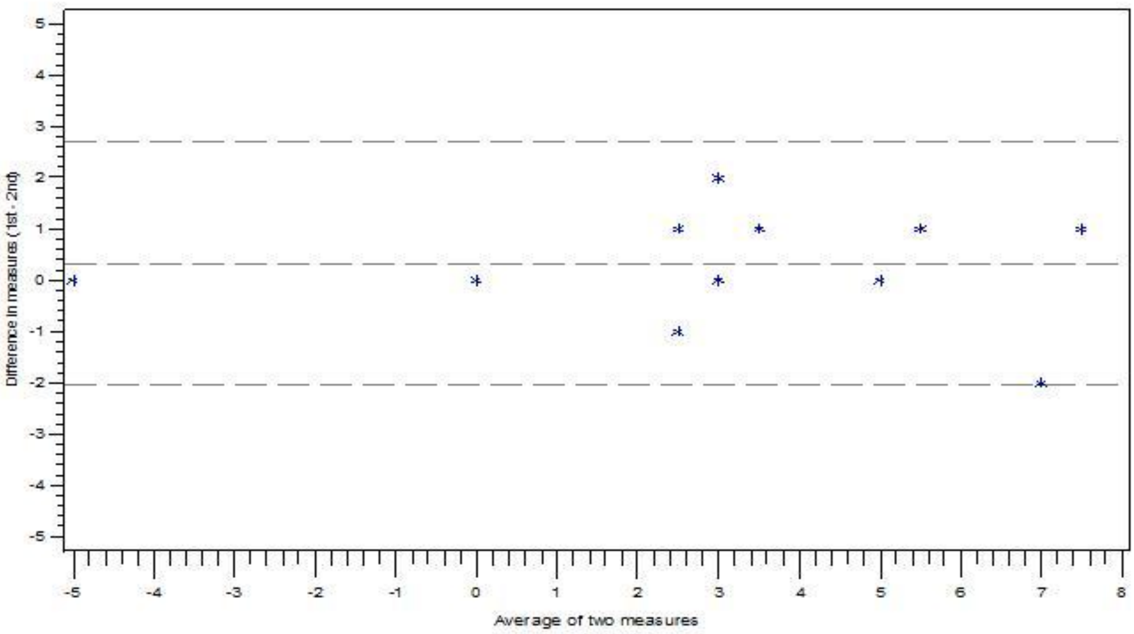


Figure 10.10 The Bland-Altman plot for overjet (OJ)

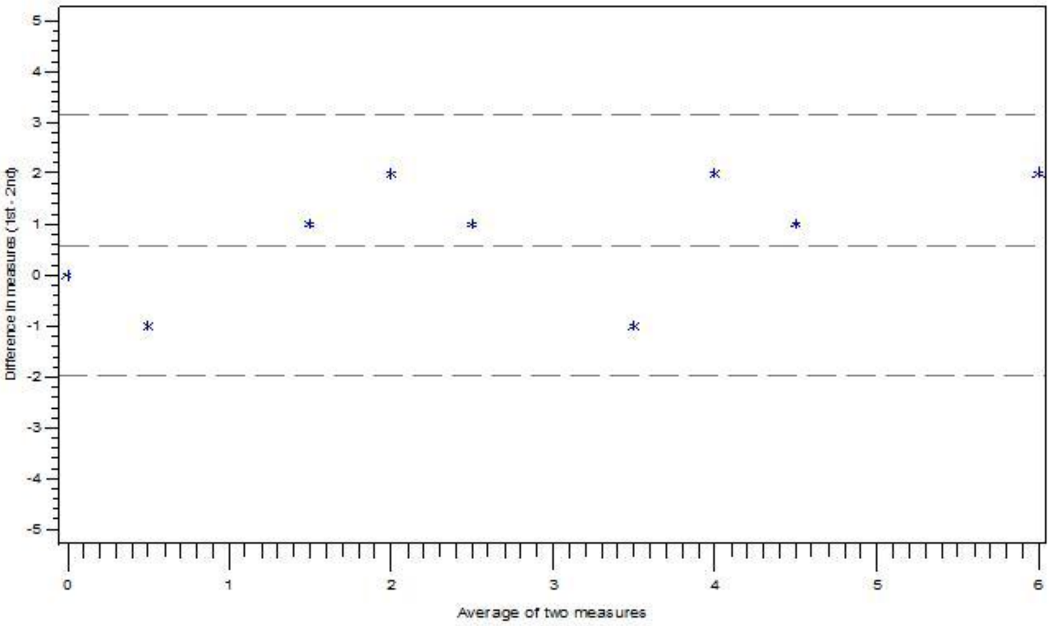


Figure 10.11 The Bland-Altman plot for overbite (OB)

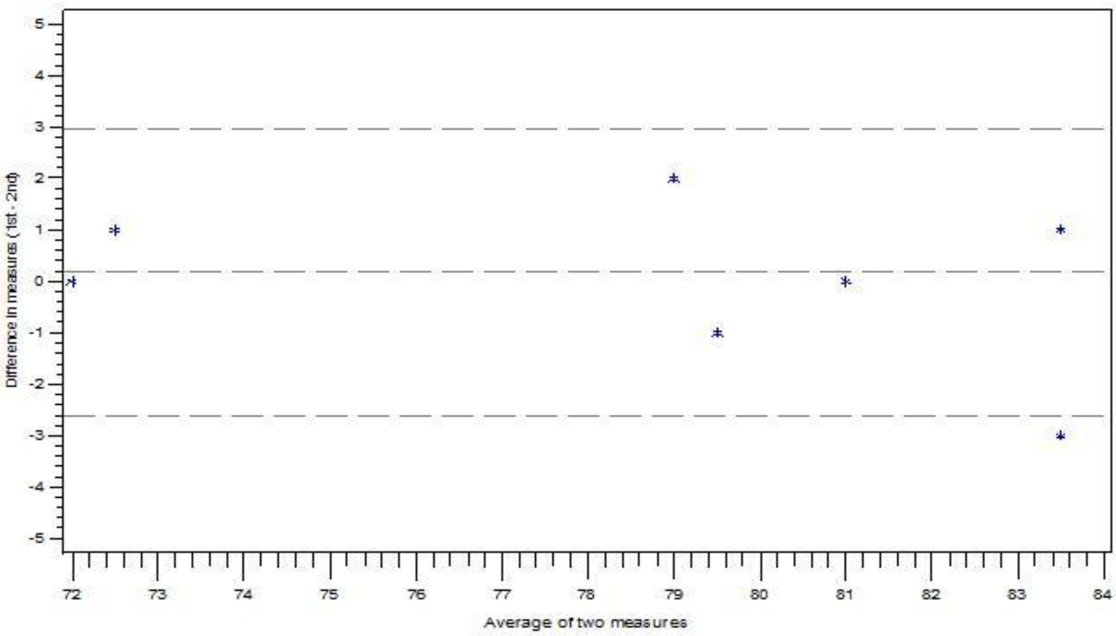


Figure 10.12 The Bland-Altman plot for SNA

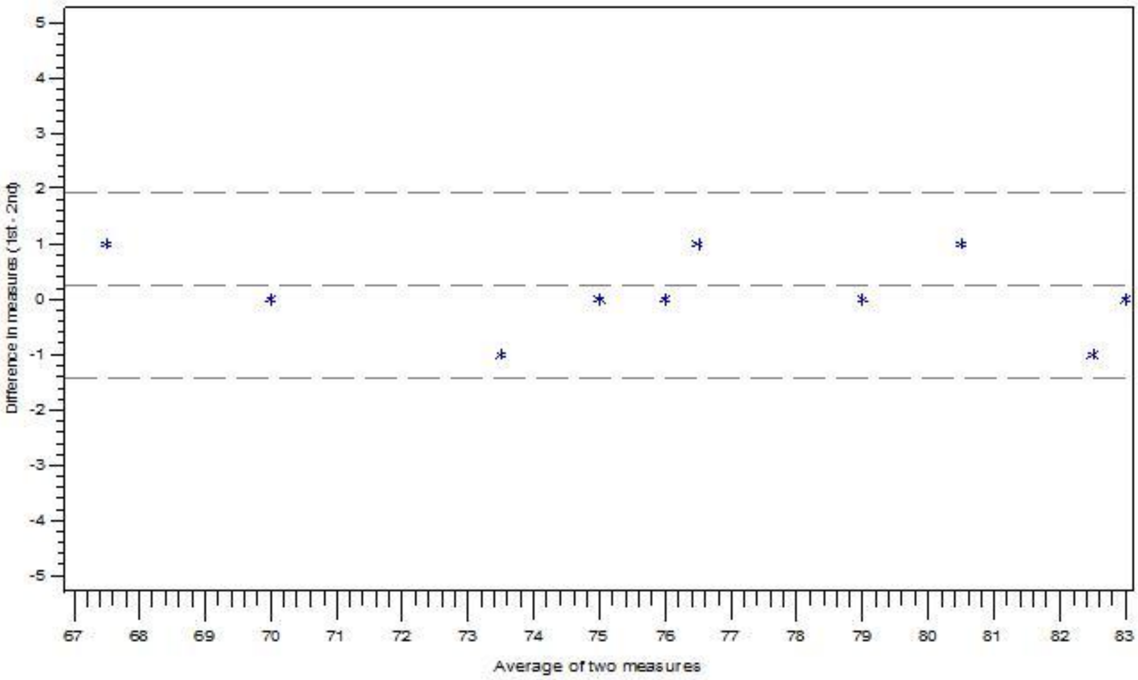


Figure 10.13 The Bland-Altman plot for SNB

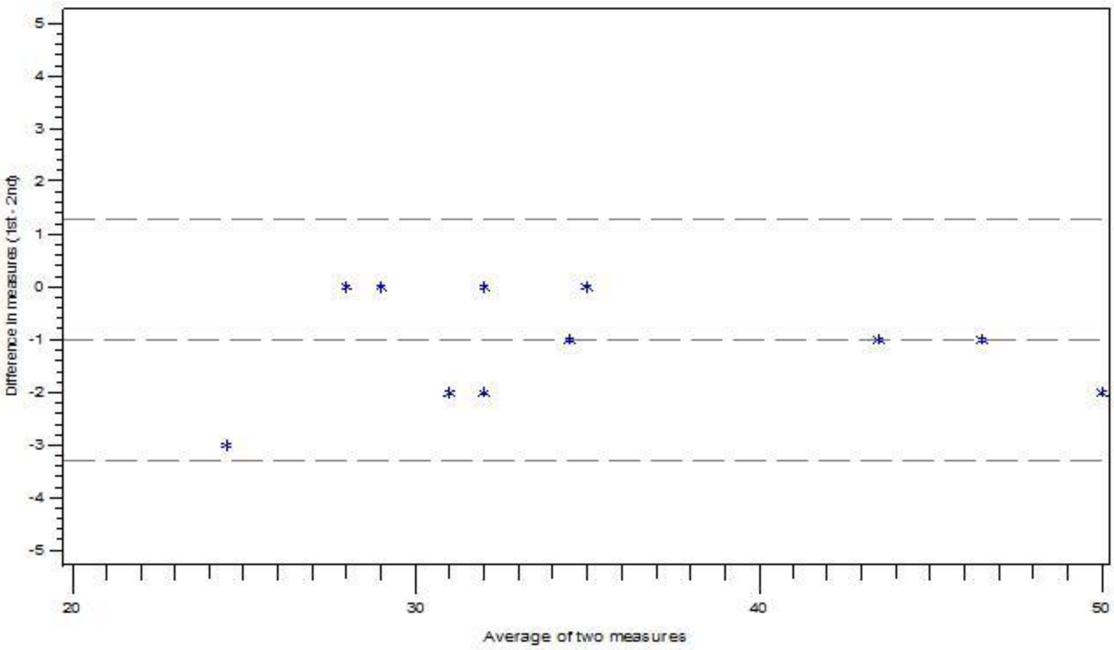


Figure 10.14 The Bland-Altman plot for mandibular plane angle (SNGoMe)

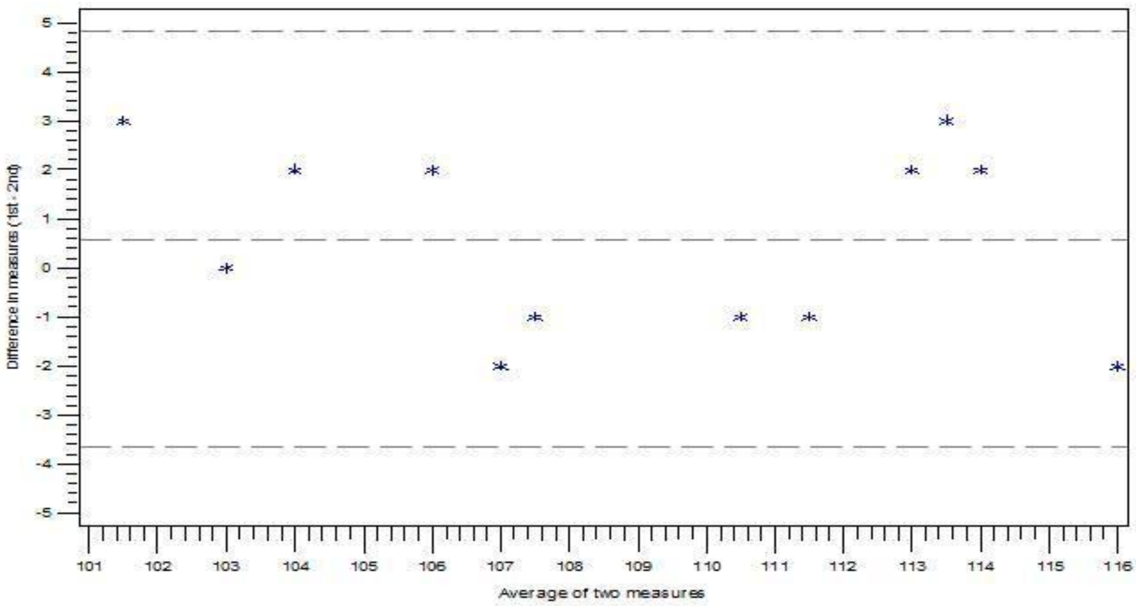


Figure 10.15 The Bland-Altman plot for upper incisor angle (Mx1SN7)

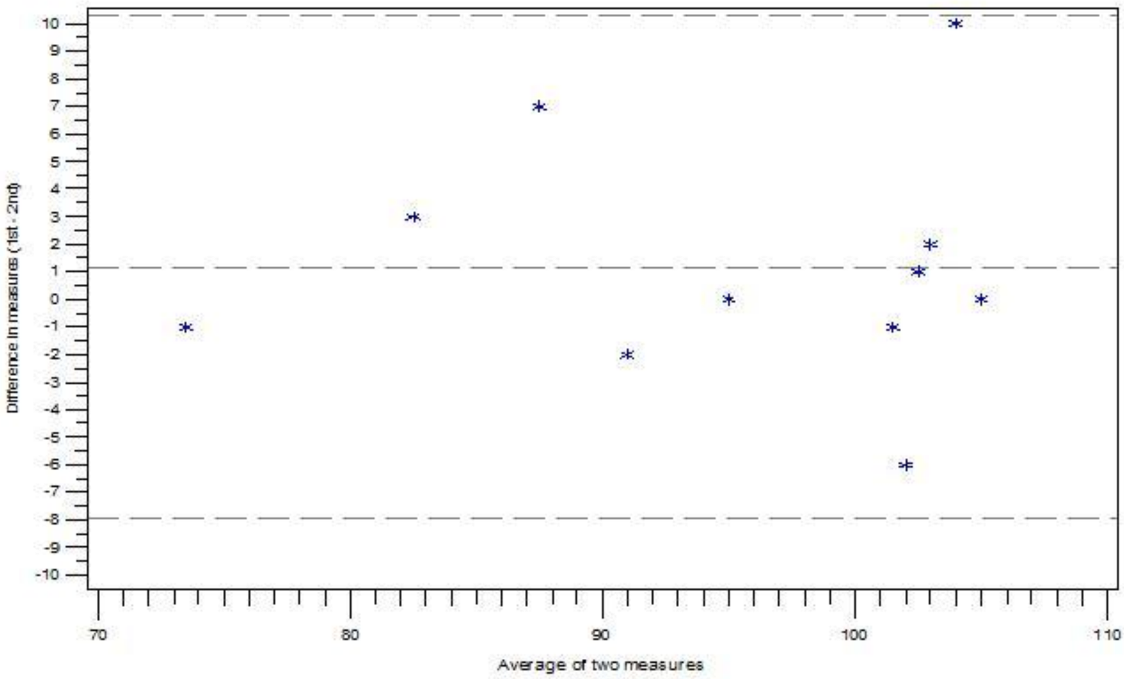


Figure 10.16 The Bland-Altman plot for lower incisor angle (IMPA)

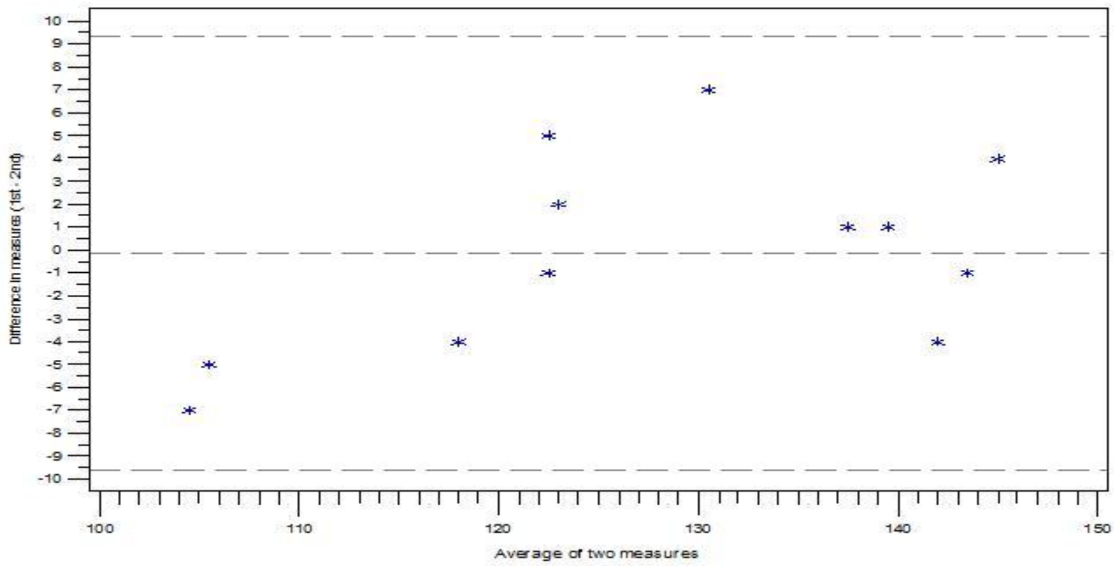


Figure 10.17 The Bland-Altman plot for inter incisal angle (IIA)

CHAPTER 11 ASSESSMENT OF POSTOPERATIVE OCCLUSION AND ORAL HEALTH STATUS

11.1 The final postoperative occlusal stability

The final postoperative study models were assessed independently by two clinicians who were unaware of patient's details, or the individuals' cephalometric assessment. The two assessments where then compared. It was found that they independently arrived at similar conclusions. The results are presented in Table 11.1.

	Satisfactory		Not satisfactory	
	N	%	N	%
Intercuspation	20	83.3	4	16.7
Overjet	21	87.5	3	12.5
Overbite	23	95.8	1	4.2
Canine relation	21	87.5	3	12.5

Table 11.1 Visual assessment of the final postoperative study models.

The results showed that 20 out of 24 patients had satisfactory interdigitation (Figure 11.1). Of the 4 with an unsatisfactory occlusion, one had developed a small anterior open bite. This followed a vertical subsigmoid osteotomy for mandibular prognathism (Figure 11.2). The patient could, however, still adequately masticate.

The other 3 all showed horizontal relapse following single jaw bilateral sagittal split advancement osteotomies (BSSO) to correct retrognathic mandibles (Figure 11.3).

Figure 11.1 An example of a case demonstrating a satisfactory postoperative occlusion

Figure 11.2 Vertical relapse following single jaw vertical subsigmoid osteotomy setback of the mandible

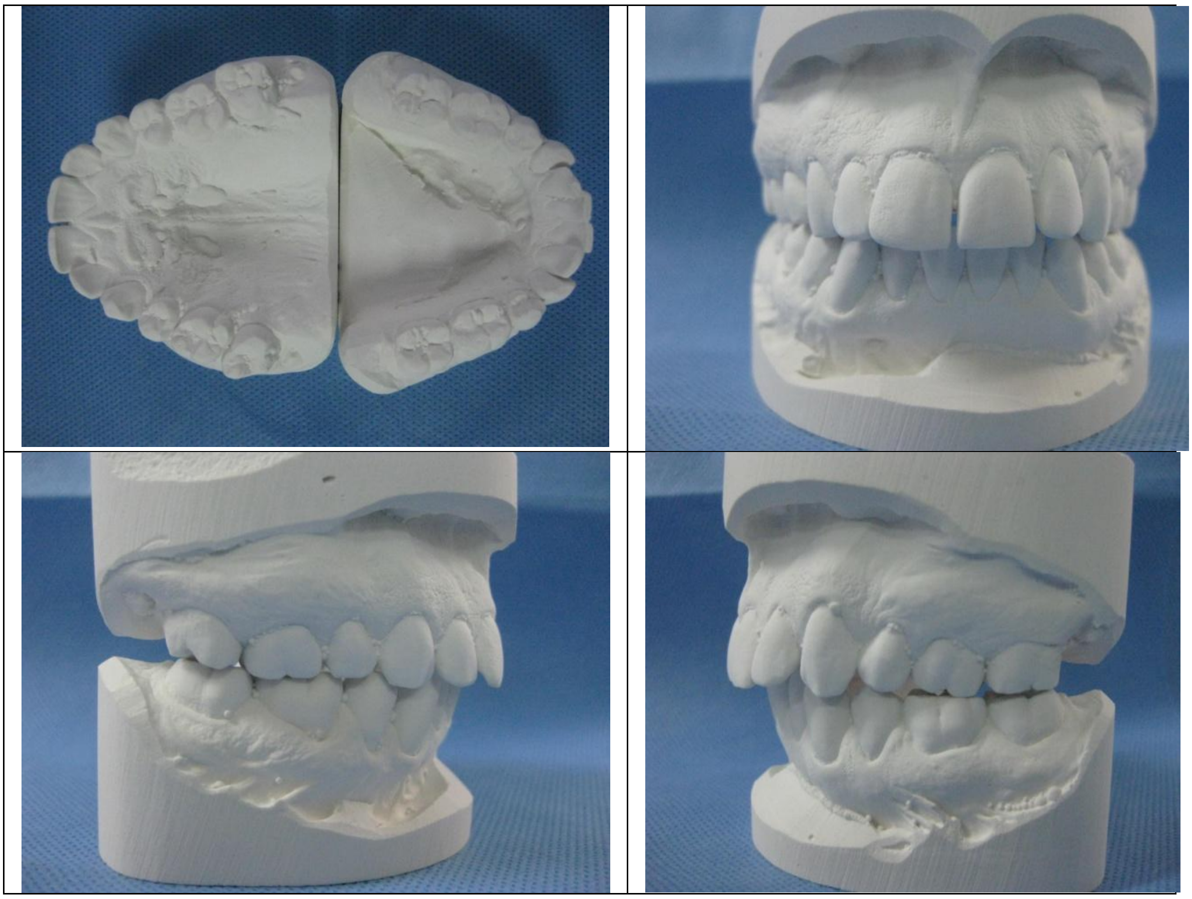


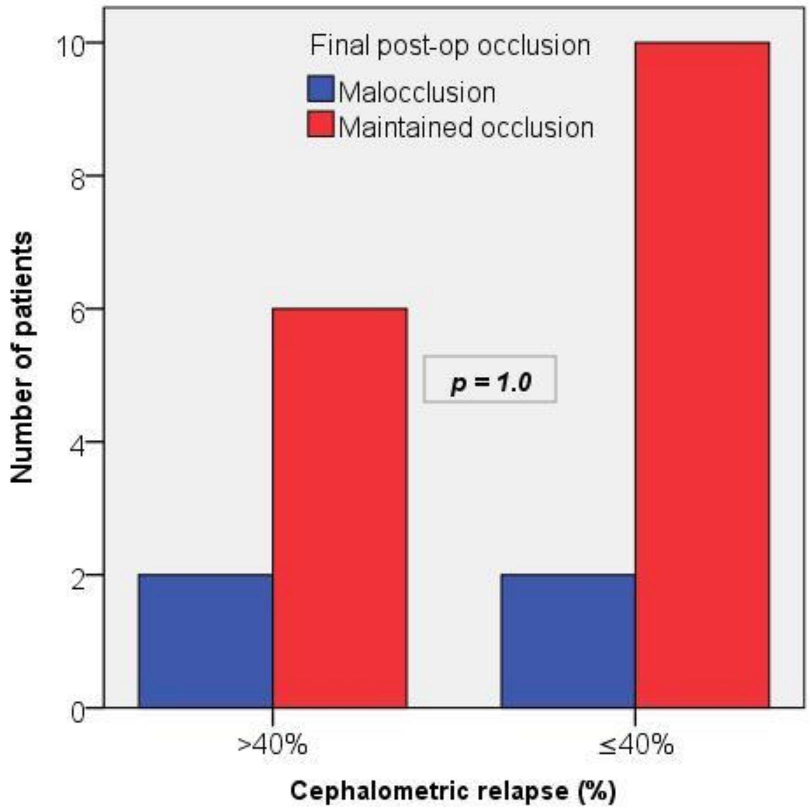
Figure 11.3 Horizontal relapse following bilateral sagittal split osteotomy advancement of the mandible.

11.2 The relationship between cephalometric relapse and occlusal stability.

The following analyses were performed following the division of the cephalometric study population into four groups. These groups were determined by the percentage relapse recorded for each subject in their cephalometric relapse study (≤ 40%, > 40%) and the recorded occlusal state for an individual subject in their final study model assessment (Maintained occlusion, Malocclusion). Malocclusion in this category included open bite (anterior or posterior), cross bite (lateral or anterior), deep overbite with palatal contact or increased overjet (> 6 mm).

The results showed that the majority of patients (80%) had maintained their postoperative occlusion at the long term follow-up. There were only 2 subjects in each of the two groups found to have malocclusions. These results are illustrated in Figure 11.3.

Cross tabulation analysis is presented in Table 11.2. The fisher's Exact test demonstrated no significant relation between postoperative cephalometric relapse and occlusal stability (P=1.0).



P value according to Fisher's Exact test (2-Sided)

Figure 11.4 The relationship between cephalometric relapse and occlusal stability

		Total	Postop. Occlusion	
			Malocclusion	Maintained occlusion
Cephalometric relapse	>40% rel	8	2	6
	≤40% rel	12	2	10
Total		20	4	16

Table 11.2 Cross tabulations cephalometric relapse and occlusal stability

11.3 Oral health status of patients at the final postoperative review

The majority of patients 18 of 24 (75%) demonstrated caries-free, preoperative dentition (caries-free category). There were 4 out of 24 patients (17%) who had 3 or less teeth with decay or extracted because of dental decay (moderate-caries rate category). The remaining 2 patients (8 %) had more than 4 teeth with decay or extracted due to dental decay (high-caries rate category).

The results for the DMFT scores for each of the 3 categories are presented as means and standard deviations in Table 11.3. The mean value of DMFT index score for all patients was 5.3 ± 6.2.

Patient category (n)	Decayed (D)	Missing (M)	Filled (F)	DMFT
Caries-free (18) (DM = 0)	0.0 ± 0.0	0.0 ± 0.0	2.7 ± 3.5	2.7 ± 3.5
Moderate caries rate (4) (DM ≤ 3)	1.0 ± 1.2	2.0 ± 1.2	8.5 ± 6.8	12.7 ± 7.7
High caries rate (2) (DM ≥ 4)	7.5 ± 2.1	3.0 ± 2.8	4.5 ± 3.5	15.0 ± 2.8
Total (24)	0.79 ± 2.2	0.6 ± 1.3	3.8 ± 4.5	5.3 ± 6.2

Table 11.3 Components of DMFT scores across all three categories (mena ±SD)

11.4 Is long term oral health influenced by the patient's psychological background?

Examination of the individual's IBQ scores in each of the 3 categories showed that all patients in the high-caries category (n=2, 100%) demonstrated some signs of abnormal illness behaviour. In the moderate-caries category, there was only one patient out of 3 (33 %) who had signs of abnormal illness behaviour. Seven out of eighteen patients (39 %) in the caries-free category showed some signs of abnormal illness behaviour. Figure 11.4 illustrates the percentage of patients with abnormal illness behaviour in each caries-experience category.

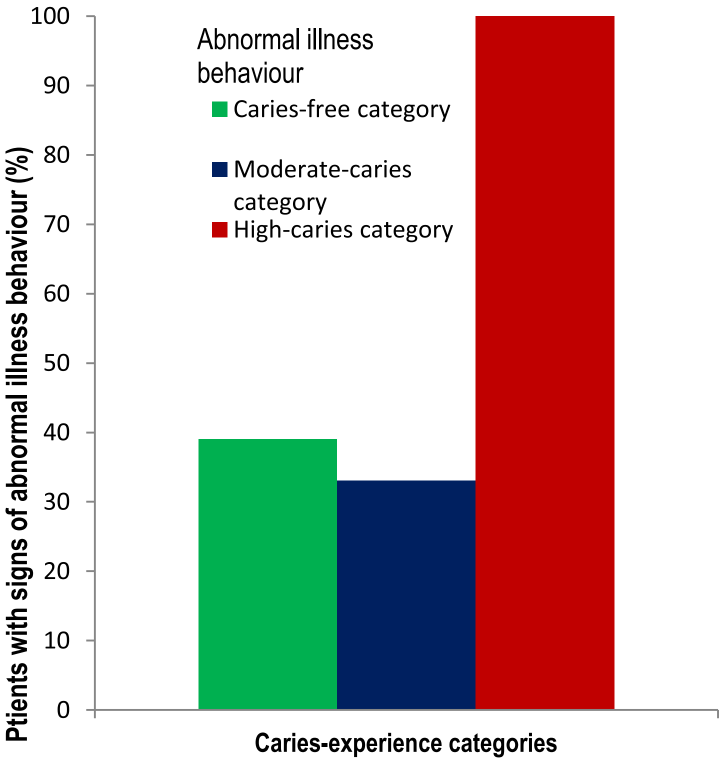


Figure 11.5 Patients with signs of abnormal illness behaviour in each of the caries-experience categories

CHAPTER 12 PATIENTS' PERCEPTION AND PSYCHOLOGICAL STATUS FOLLOWING ORTHOGNATHIC SURGERY

12.1 Motivation for seeking orthognathic surgery

In the total study sample of twenty four orthognathic surgery patients almost half of the patients (n=13, 54%) were recommended by professionals to undergo surgery to correct their dentofacial deformity. The majority of patients (n=17, 71%) were dissatisfied with their facial appearance. Other reasons were chewing difficulties (7/24) and problems with their temporomandibular joints (3/24). Summary is outlined in Table 12.1

Motivation	Patients (n)	%*
Professional recommendation	13	54
Dissatisfaction with facial appearance	17	71
Chewing difficulties	7	29
Temporomandibular joint problems	3	12

*some patients chose more than one reason

Table 12.1 Reasons for seeking orthognathic surgery

12.2 Patients' perception of orthognathic surgery

Almost all patients (n=22, 92%) felt that they have received sufficient information prior to surgery. However, two patients were of the opinion that they had received very little information regarding the possible complications of surgery.

The majority of patients 20 of 24 (83%) experienced sensory change in the lower lip and chin, post surgery. Approximately half of these patients 11 of 20 (55%) reported a return of their normal facial sensation within 6 months following surgery. Out of the twenty four patients, 9

(45%) had variable levels of persistent sensory deficits on the face. Neurological testing confirmed that only one patient (4%) suffered from complete lip and chin numbness “anaesthesia” and 8 (33%) patients had subjectively altered sensation “paresthesia” (Table 12.2).

Sensory facial disturbance (Post surgery) (n = 24)	**N**	**%**
None	4	17
Resolved	11	46
Persistent Paresthesia	8	33
Persistent Anaesthesia	1	4

Table 12.2 Sensory disturbance following mandibular osteotomy

Fifty percent of patients perceived an improvement in their biting and chewing ability, while 10 patients felt no change and two patients felt that their chewing ability had worsened. The majority of patients 16 of 24 (67%) noticed no change in their temporomandibular joints function. Six out of 24 patients (25%) experienced worsening jaw joint symptoms such as clicking and noises but this occurred at variable period of years following the orthognathic surgery and two patients (8%) felt that they had less temporomandibular joint symptoms.

The two patients who claimed to have not received sufficient information regarding surgical complications, also complained of difficulty in chewing food, have more joint symptoms and neurosensory deficit following surgery.

Persistent anaesthesia at an average of 12.9 years post surgery was reported by one patient who had bilateral sagittal split osteotomy of the mandible. She was one of the few patients who were extremely dissatisfied with the outcome of surgery. The patient further elaborated “I can’t feel the food on my lips....., I’m embarrassed to eat in a restaurant especially soup as I don’t know if there is remanent of it on my face”.

12.3 Quality of life

The mean scores and comparative statistical analysis of the eight health domains between orthognathic surgery group at an average of 12.9 years post surgery and the South Australian normative data is presented in Table 12.3.

Health Domain	Orthognathic group			Aust. Norm			T-test		
	N	Mean	SD	N	Mean	SD	T statistic	*DF	P value
PF	24	71.83	34.45	3010	85.4	21.6	3.05	3032	0.0023**
RP	24	79.17	39.47	3010	80.2	34.9	0.14	3032	0.89
BP	24	76.15	27.78	3010	77.2	25.5	0.2	3032	0.84
GH	24	70.63	26.72	3010	73.2	21.7	0.58	3032	0.56
VT	24	60.63	24.20	3010	64	21.4	0.77	3032	0.44
SF	24	81.77	26.32	3010	88.2	21.3	1.47	3032	0.14
RE	24	86.11	32.48	3010	87.5	28.9	0.23	3032	0.81
MH	24	77.25	17.23	3010	78.7	17.7	0.4	3032	0.69

*note that the degree of freedom for t-statistic is 3032

**statistically significant ($p < 0.01$)

Table 12.3 Statistical comparison of SF-36 scores between the orthognathic group and normal population.

Except for physical functioning, there were no significant differences in the mean scores of all health domains between the orthognathic surgery group in the long term review and the South Australian normative data.

For the score of physical functioning (PF), there was statistically significant evidence ($p = 0.0023$) that the mean score of Australian normative data is greater than the mean score of the orthognathic surgery patients.

12.4 Satisfaction following surgery and illness behaviour

Although there was a tendency for patients with high disease conviction (scale 2) score to have lower level of satisfaction score (=< 10) than patients with normal illness behaviour (Figure 12.1). This difference did not reach statistical significance ($p = 0.095$) when cross tabulations and exact Fisher's test was used (Table 12.4).

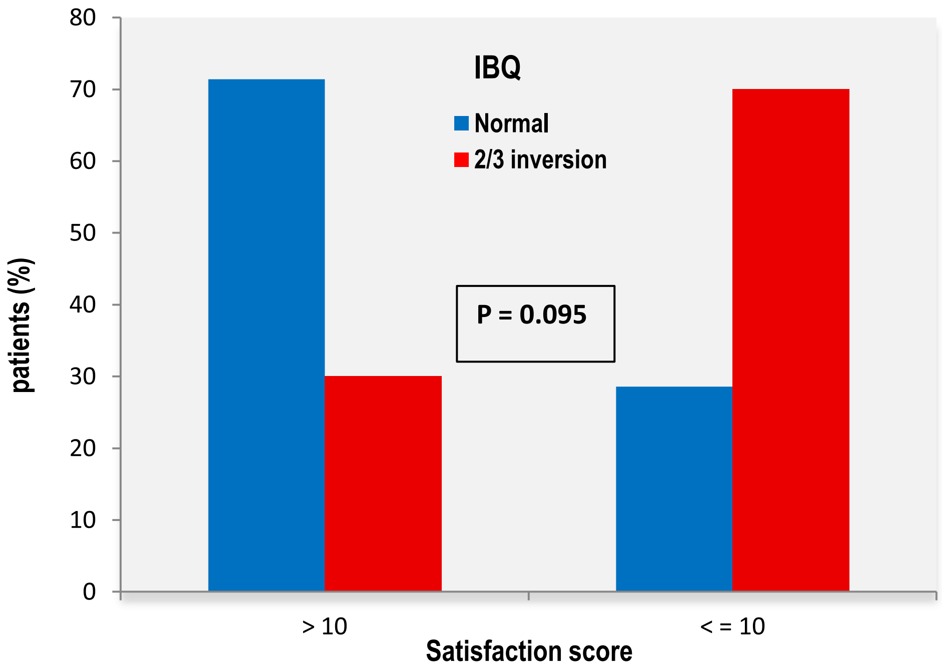


Figure 12.1 The effect of illness behaviour on the satisfaction level following surgery

Crosstab

			IBQ		Total
			Normal	2/3 inversion	
Satisfaction score	=< 10	Count	4	7	11
		% within IBQ	28.6%	70.0%	45.8%
	> 10	Count	10	3	13
		% within IBQ	71.4%	30.0%	54.2%
Total		Count	14	10	24
		% within IBQ	100.0%	100.0%	100.0%

Table 12.4 Cross tabulation illness behaviour and satisfaction score

12.5 Satisfaction after surgery and body image

There seemed to be a tendency for patients with normal body image to exhibit a higher satisfaction level than patients with abnormal body image (Figure 12.2). However, this observation was found to be statistically not significant (p= 0.66), when cross tabulations were performed (Table 12.5).

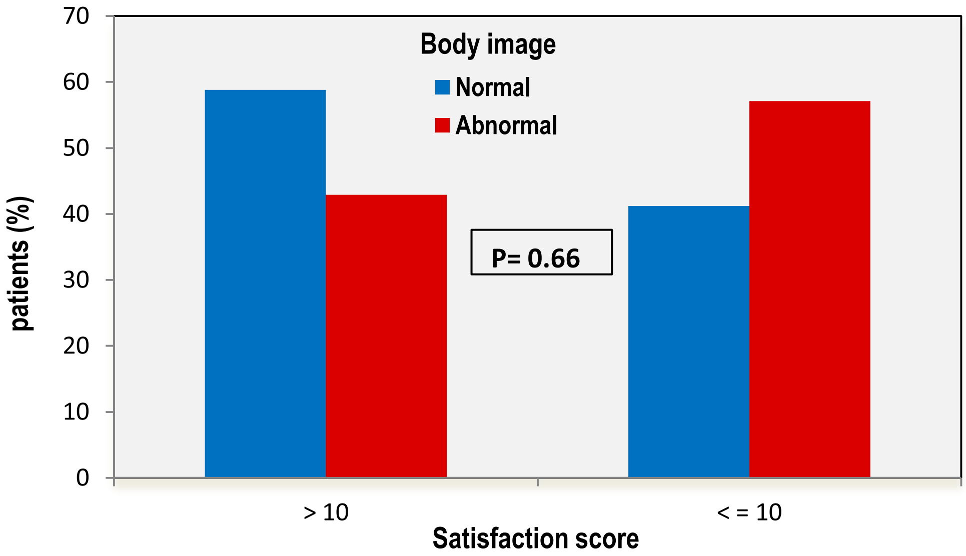


Figure 12.2 The effect of body image on the satisfaction level following surgery

Crosstab

			Body Image		Total
			Normal	Abnormal	
Satisfaction score	=< 10	Count	7	4	11
		% within Body Image	41.2%	57.1%	45.8%
	> 10	Count	10	3	13
		% within Body Image	58.8%	42.9%	54.2%
Total		Count	17	7	24
		% within Body Image	100.0%	100.0%	100.0%

Table 12.5 Cross tabulation body image and satisfaction score

CHAPTER 13 PERCEPTION OF ORTHOGNATHIC SURGERY AESTHETIC OUTCOME

13.1 Introduction

Perception of aesthetic profile changes were investigated by a total of thirty evaluators. The attractiveness scores ranged from 0 to 10; where:

0= extremely unattractive

10= extremely attractive

The facial profile changes (Estimates) were measured by subtracting the preoperative scores from the postoperative scores, of patients' soft tissue facial profiles, at an average of 11.6 years after surgery. A positive value indicates improvement whereas a negative value indicates worsening of profile aesthetic at the long-term review (T5).

13.2 Overall perceptions of facial profile changes

The total sample of thirty investigators recognised a significant overall aesthetic improvement in profile at 11.6 years following surgery (p= 0.0048). The overall mean improvement in attractiveness score was 0.92 and ranged from 0.32 to 1.5 (Table 13.1).

Effect	Estimate**	Standard Error	P value	Lower	Upper
Intercept	0.9167	0.2871	0.0048*	0.3158	1.5176

*statistically significant (p< 0.01)

**Estimate= postoperative score (T5) – preoperative score (T0)

Table 13.1 Overall perception of facial profile aesthetic changes

13.3 Perceptions of facial profile change according to evaluator groups

The mean improvement in attractiveness scores was found to be significant for each of the three evaluator groups. The largest improvement (estimate=1.05) was detected by the dental professionals (group B), while there were improvements of 0.75 and 0.95 for the lay Australians (group A) and lay Omanis (group C), respectively (Table 13.2). However, the linear mixed effect model showed that the differences between the evaluator panels were statistically non significant (p= 0.33), (Table 13.3).

Least Squares Means						
Effect	**Evr. group**	**Estimate**	**Standard Error**	**P value**	**Lower**	**Upper**
Evr. group	A	0.7500	0.3104	0.0160**	0.1403	1.3597
Evr. group	B	1.0500	0.3104	0.0008*	0.4403	1.6597
Evr. group	C	0.9500	0.3104	0.0023*	0.3403	1.5597

Evr.= Evaluator

**statistically significant (p< 0.01), **statistically significant (p< 0.05)*

Table 13.2 Perception of profile aesthetic by different evaluators

Effect	Evr. group	Estimate	Standard Error	P value	Lower	Upper
Intercept		0.9500	0.3104	0.0064	0.3003	1.5997
Evr. Group	A	-0.2000	0.2048	0.3291	-0.6022	0.2022
Evr. Group	B	0.1000	0.2048	0.6255	-0.3022	0.5022
Evr. Group	C	0	_	_	_	_

Effect	Num DF	Den DF	F Value	P value
Evr. group	2	551	1.11	0.3293

Table 13.3 The linear mixed effect model for the comparison between the three groups

13.4 Perception of profile aesthetic changes according to gender of evaluators

The total of thirty evaluators were further divided into two groups according to gender to determine if any differences in perception of facial profile aesthetic existed between male and female evaluators. There were 11 female evaluators and 19 males. A slightly higher improvement was judged by female evaluators than males (Table 13.4). However, the linear mixed effect model has demonstrated no significant differences between evaluator genders (p= 0.92), (Table 13.5).

Least Squares Means						
Effect	**Evr. gender**	**Estimate**	**Standard Error**	**P value**	**Lower**	**Upper**
Evr. gender	F	0.9273	0.3087	0.0028*	0.3210	1.5336
Evr. gender	M	0.9105	0.2948	0.0021*	0.3315	1.4896

**statistically significant (p< 0.01)*

Table 13.4 Illustration of profile aesthetic changes according to evaluator gender

Effect	Evr. gender	Estimate	Standard Error	P value	Lower	Upper
Intercept		0.9105	0.2948	0.0060	0.2935	1.5275
Evr. gender	F	0.01675	0.1772	0.9247	-0.3313	0.3648
Evr. gender	M	0	_	_	_	_

Effect	Num DF	Den DF	F Value	P value
Evr. Gender	1	551	0.01	0.9247

Table 13.5 The linear mixed effect model for evaluator gender differences

13.5 Perception of profile changes according to the type of surgery

The results of the aesthetic profile changes were also studied according to the procedure performed on patients. There were seven groups of patients as illustrated in Table 13.6.

PATIENT GROUP	PROCEDURE	NO. OF PROFILE PAIRS
Group I	BSSO advancement only	6
Group II	BSSO advancement + Le Fort I	4
Group III	BSSO advancement + genioplasty advancement + Le Fort 1	4
Group IV	BSSO advancement + genioplasty setback	3
Group V	VSSO setback + Le Fort I	2
Group VI	BSSO setback + genioplasty advancement + Le Fort I	1
Group VII	BSSO setback + Le Fort I	1

Table 13.6 Distribution of patient groups according to surgical procedure

The statistical analysis of the linear mixed effect model was fitted to the raw data to determine the perception of aesthetic profile change according to each type of procedure performed and to test whether perception of aesthetic changes by different groups of evaluators differ for a specific type of a surgical procedure used for correction of dentofacial deformity.

The profile aesthetic was significantly improved for patient group III (BSSO advancement + genioplasty advancement + Le Fort I) (estimate= 2.1; p=0.0002) and patient group V (VSSO setback + Le Fort I) (estimate= 2.9; p= <0.0001) whereas no significant changes were found for the remaining patient groups (Table 13.7).

Least Squares Means						
Effect	**Patient group**	**Estimate**	**Standard Error**	**P value**	**Lower**	**Upper**
Patient group	I	0.4444	0.3993	0.2661	-0.3398	1.2287
Patient group	II	-0.1250	0.4885	0.7981	-1.0846	0.8346
Patient group	III	2.1000	0.5638	**0.0002***	0.9925	3.2075
Patient group	IV	0.4667	0.5638	0.4082	-0.6409	1.5742
Patient group	V	2.8833	0.6902	**<.0001***	1.5275	4.2391
Patient group	VI	1.2667	0.9757	0.1947	-0.6498	3.1831
Patient group	VII	1.4333	0.9757	0.1424	-0.4831	3.3498

*statistically significant (p< 0.01)

Table 13.7 Illustration of profile aesthetic changes for patient groups.

The linear mixed effect model demonstrated a significant difference in improvement scores between the seven patient groups (p= 0.0037). Table 13.8 shows the linear mixed effect model for the different patient groups.

Effect	**Patient group**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept		1.4333	0.9757	13	1.47	0.1656
Patient group	I	-0.9889	1.0533	551	-0.94	0.3482
Patient group	II	-1.5583	1.0903	551	-1.43	0.1535
Patient group	III	0.6667	1.1260	551	0.59	0.5541
Patient group	IV	-0.9667	1.1260	551	-0.86	0.3910
Patient group	V	1.4500	1.1944	551	1.21	0.2253
Patient group	VI	-0.1667	1.3791	551	-0.12	0.9039
Patient group	VII	0	_	_	_	_

Effect	**Num DF**	**Den DF**	**F Value**	**P value**
group_pat	6	551	3.26	0.0037*

*statistically significant (p<0.01)

Table 13.8 The linear mixed effect model for the differences between patient groups

When analysing the differences of the least squares means between patient groups, the highest significant difference was found between patient groups II (BSSO advancement + Le Fort I) and V (VSSO setback + Le Fort I). The perceived improvement scores were 3 units lower in patient group II when compared to patient group V (p=0.0004). Other significant differences were found between some groups (Table 13.9). Interestingly, the contribution of genioplasty advancement on the improvement of facial profile was observed following the simultaneous bimaxillary corrections of patients with Class II malocclusions. There was a significant difference in facial profile aesthetic improvement between patient groups II (BSSO advancement + Le Fort I) and III (BSSO advancement + genioplast advancement + Le Fort I) (p= 0.0029). Similarly, single bilateral sagittal split mandibular osteotomy (group I), used for the treatment of mandibular deficiency, had less significant effect on facial profile aesthetic improvement when compared to double jaw procedures combined with genioplasty advancement (group III). In addition, a significant aesthetic improvement (p= 0.041) was noted for group III (BSSO advancement + genioplasty advancement + Le Fort I) when compared to group IV (BSSO advancement + genioplasty setback).

Differences of Least Squares Means						
Patient group	**Patient group**	**Estimate**	**Standard Error**	**DF**	**T value**	**P Value**
I	II	0.5694	0.6295	551	0.90	0.3661
I	III	-1.6556	0.6896	551	-2.40	**0.0167****
I	IV	-0.02222	0.6896	551	-0.03	0.9743
I	V	-2.4389	0.7962	551	-3.06	**0.0023***
I	VI	-0.8222	1.0533	551	-0.78	0.4354
I	VII	-0.9889	1.0533	551	-0.94	0.3482
II	III	-2.2250	0.7448	551	-2.99	**0.0029***
II	IV	-0.5917	0.7448	551	-0.79	0.4273
II	V	-3.0083	0.8445	551	-3.56	**0.0004***
II	VI	-1.3917	1.0903	551	-1.28	0.2023
II	VII	-1.5583	1.0903	551	-1.43	0.1535
III	IV	1.6333	0.7962	551	2.05	**0.0407****
III	V	-0.7833	0.8902	551	-0.88	0.3793
III	VI	0.8333	1.1260	551	0.74	0.4596
III	VII	0.6667	1.1260	551	0.59	0.5541
IV	V	-2.4167	0.8902	551	-2.71	**0.0068***
IV	VI	-0.8000	1.1260	551	-0.71	0.4777
IV	VII	-0.9667	1.1260	551	-0.86	0.3910
V	VI	1.6167	1.1944	551	1.35	0.1764
V	VII	1.4500	1.1944	551	1.21	0.2253
VI	VII	-0.1667	1.3791	551	-0.12	0.9039

*statistically significant ($p<0.01$)

**statistically significant ($p<0.05$)

Table 13.9 Differences of least squares means between patient groups

Finally, to test whether improvement scores depended on evaluator and patient groups, a linear mixed effects model including an interaction term was fitted to the data. The interaction term was not statistically significant (p = 0.1099) therefore, the difference in improvement scores between patient groups did not depend on evaluator groups (Table 13.10).

Effect	Num DF	Den DF	F Value	P value
Evr. Group	2	539	0.17	0.8456
Pat. Group	6	539	3.26	0.0037
Evr. group*Pat. group	12	539	1.53	**0.1099**

Table 13.10 The interaction of improvement scores between evaluator and patient groups

The linear mixed effect model for the test of interaction between evaluator and patient groups is presented in Table 13.11.

Table 13.12 shows the least squares means of evaluator groups for each patient group. There was an agreement between dental professionals (group B), Lay Australians (group A) and Lay Omanis (group C) on a significant improvement of facial profile for patient groups III and V. The only profile worsening was detected for group II (BSSO + Le Fort I) by lay Australians and lay Omanis (-0.82 and -0.07, respectively). However, this was not statistically significant. The dental professionals have generally detected an improvement of facial profile after treatment for all patient groups. Even though for some patient groups, the improvement was not statistically significant.

Effect	Evr. group	Pat. group	Estimate	Standard Error	P value	Lower	Upper
Intercept			1.9000	1.0937	0.1060	-0.4627	4.2627
Evr. Group	A		-0.6000	0.8559	0.4836	-2.2814	1.0814
Evr. Group	B		-0.8000	0.8559	0.3504	-2.4814	0.8814
Evr. Group	C		0	_	_	_	_
Pat. Group		I	-1.4167	1.1799	0.2304	-3.7345	0.9012
Pat. Group		II	-1.9750	1.2213	0.1064	-4.3742	0.4242
Pat. group		III	0.5333	1.2614	0.6726	-1.9445	3.0112
Pat. group		IV	-1.6667	1.2614	0.1870	-4.1445	0.8112
Pat. group		V	0.5500	1.3379	0.6812	-2.0782	3.1782
Pat. group		VI	-0.3000	1.5449	0.8461	-3.3347	2.7347
Pat. group		VII	0	_	_	_	_
Evr. group*Pat. group	A	I	0.2667	0.9210	0.7723	-1.5425	2.0758
Evr. group*Pat. group	A	II	-0.1500	0.9533	0.8750	-2.0227	1.7227
Evr. group*Pat. group	A	III	0.3000	0.9846	0.7607	-1.6341	2.2341
Evr. group*Pat. group	A	IV	0.8000	0.9846	0.4168	-1.1341	2.7341
Evr. group*Pat. group	A	V	1.6500	1.0443	0.1147	-0.4014	3.7014
Evr. group*Pat. group	A	VI	0.4000	1.2059	0.7402	-1.9688	2.7688
Evr. group*Pat. group	A	VII	0	_	_	_	_
Evr. group*Pat. group	B	I	1.0167	0.9210	0.2701	-0.7925	2.8258
Evr. group*Pat. group	B	II	1.4000	0.9533	0.1425	-0.4727	3.2727
Evr. group*Pat. group	B	III	0.1000	0.9846	0.9191	-1.8341	2.0341
Evr. group*Pat. group	B	IV	1.3000	0.9846	0.1873	-0.6341	3.2341
Evr. group*Pat. group	B	V	1.0500	1.0443	0.3151	-1.0014	3.1014
Evr. group*Pat. group	B	VI	-163E-16	1.2059	1.0000	-2.3688	2.3688
Evr. group*Pat. group	B	VII	0	_	_	_	_
Evr. group*Pat. group	C	I	0	_	_	_	_
Evr. group*Pat. group	C	II	0	_	_	_	_
Evr. group*Pat. group	C	III	0	_	_	_	_
Evr. group*Pat. group	C	IV	0	_	_	_	_
Evr. group*Pat. group	C	V	0	_	_	_	_
Evr. group*Pat. group	C	VI	0	_	_	_	_
Evr. group*Pat. group	C	VII	0	_	_	_	_

Table 13.11 The linear mixed effect model for the correlation between evaluator and patient groups.

Least Squares Means							
Effect	**Evr. group**	**Pat. group**	**Estimate**	**Standard Error**	**P value**	**Lower**	**Upper**
Evr. group*Pat. group	A	I	0.1500	0.4491	0.7385	-0.7322	1.0322
Evr. group*Pat. group	A	II	-0.8250	0.5487	0.1333	-1.9029	0.2529
Evr. group*Pat. group	A	III	2.1333	0.6329	0.0008*	0.8901	3.3766
Evr. group*Pat. group	A	IV	0.4333	0.6329	0.4938	-0.8099	1.6766
Evr. group*Pat. group	A	V	3.5000	0.7742	<.0001*	1.9791	5.0209
Evr. group*Pat. group	A	VI	1.4000	1.0937	0.2011	-0.7484	3.5484
Evr. group*Pat. group	A	VII	1.3000	1.0937	0.2351	-0.8484	3.4484
Evr. group*Pat. group	B	I	0.7000	0.4491	0.1196	-0.1822	1.5822
Evr. group*Pat. group	B	II	0.5250	0.5487	0.3391	-0.5529	1.6029
Evr. group*Pat. group	B	III	1.7333	0.6329	0.0064*	0.4901	2.9766
Evr. group*Pat. group	B	IV	0.7333	0.6329	0.2471	-0.5099	1.9766
Evr. group*Pat. group	B	V	2.7000	0.7742	0.0005*	1.1791	4.2209
Evr. group*Pat. group	B	VI	0.8000	1.0937	0.4648	-1.3484	2.9484
Evr. group*Pat. group	B	VII	1.1000	1.0937	0.3150	-1.0484	3.2484
Evr. group*Pat. group	C	I	0.4833	0.4491	0.2823	-0.3988	1.3655
Evr. group*Pat. group	C	II	-0.07500	0.5487	0.8913	-1.1529	1.0029
Evr. group*Pat. group	C	III	2.4333	0.6329	0.0001*	1.1901	3.6766
Evr. group*Pat. group	C	IV	0.2333	0.6329	0.7125	-1.0099	1.4766
Evr. group*Pat. group	C	V	2.4500	0.7742	0.0016*	0.9291	3.9709
Evr. group*Pat. group	C	VI	1.6000	1.0937	0.1441	-0.5484	3.7484
Evr. group*Pat. group	C	VII	1.9000	1.0937	0.0829	-0.2484	4.0484

*statistically significant (p< 0.01)

Table 13.12 The least squares means for evaluator groups according to patient groups

V DISCUSSION

CHAPTER 14 DISCUSSION

14.1 Methodological aspects

The participation rate in this study was low (11%), reflecting a major issue in conducting long term retrospective studies for orthognathic surgery patients. It is maybe for this reason that the definition of "long-term" used in previous studies (Van Sickels et al, 1988; Scheerlinck et al, 1994; Mobarak et al, 2000; Borstlap et al, 2004; Arpormaeklong et al, 2004) published in the literature discussing orthognathic surgery stability has been restricted to an average of 1-3 years follow-up. The current study followed up patients at an average 12.9 years, range (7 to 24). Determined efforts were made to contact all of the 226 patients who had mandibular osteotomies between 1985 and 2005.

When assessing the postoperative skeletal relapse, the study sample of twenty patients was generally a true representation of the whole sample of 226 patients in terms of age at surgery and surgery type except for gender. The cephalometrically analysed sample showed a male predominance 12 of 20 (60%) whereas the gender distribution for all patients who had mandibular osteotomies within the study period showed a female predominance 153 of 226, (68%). This study indicated a sample bias in gender distribution. Generally speaking, females seek treatment more than males and this concept has been demonstrated by the observed gender distribution in previous studies of orthognathic surgery patients (Moenning et al, 1990; Watzke et al, 1990; Mommaerts, 1991; Joss and Thüer, 2008a).

Previous studies have suggested that the differences between respondents and nonrespondents are of greater concern than low response rates alone (Williams and macdonald, 1986; Asch et al, 1997). A study by Mazer et al (2002) found a disparity between satisfaction rates of patients who responded to follow up research studies. They found that patients who were more satisfied with their treatment were more likely to respond. Therefore, response biases might jeopardize the validity of interpretations and thereby influence obtained satisfaction rating. However, in our experience with orthognathic surgical outcomes, dissatisfied patients would be more likely to have underlying psychological disturbances and would repeatedly represent for reassurance and discussion of options. Hence, we presume that they would have been more likely to respond. We suspect that the low response rate may actually signify that the majority of patients are satisfied with their results.

Most patients have orthognathic surgery between 15 to 20 years of age. One reason for the low response rate may relate to the fact that Adelaide is located in one of the smaller states of Australia. Hence some young people at end of school tend to move interstate for higher university education or employment opportunities interstate. Furthermore, people tend to change addresses multiple times during the course of 5-10 years. Even if they still living in Adelaide, their addresses may have changed. This observation stemmed from the fact that 34 patients (15%) in this study had moved from their recorded addresses and mail was returned.

In the current study, five patients had responded that they would attend for the follow up review but they failed to show up on the appointment dates. There was a lack of incentive for the patients to present for the review. There was no financial compensation available to encourage the patients to present for follow up. However, financial compensation for follow up in Australia is unusual and contrary to accepted ethical principles.

There were eight patients who had responded saying they did not want to be part in the proposed study. The most commonly cited reason for these refusals was lack of time or distance to travel to attend the follow up review. In addition, one female patient was pregnant at the time of the study and elected not to take the risk of radiation exposure.

The ethical approval of the study only allowed us to contact the patients by mail. The Ethics Committee approval did not allow contact by phone as this would be disruptive to the patient's life and an invasion of their privacy. Therefore, we believe the phone contact method would be more efficient and yield higher response as we would be able to locate more patients quicker. Similarly, a semi formal interview on the phone could also be possible. This may encourage the patient to return for more formal interview and x-rays. Hence, the method of mail only contact is another major downfall of this study.

However maintenance of patients' privacy and not intruding too much is an important ethical consideration in Australia.

Incomplete radiographic records were another pitfall that was encountered in the current study. Although an established protocol for radiographic records existed in the OMSU, four out of the 24 (~17%) participants were missing either preoperative radiograph (n=3) or immediate postoperative radiograph (n=1). The problem of incomplete records is not uncommon; Ching (1995) had to exclude approximately 50% of patients from his initial study sample due to the lack of complete radiographic records. He has suggested that this was probably due to records being misplaced, not requested postoperatively by the unit registrars, requested but not taken or the patient failed to attend for subsequent follow-up. Again these are common issues in long term clinical research.

14.2 Long term relapse following mandibular surgery

One of the main aims of the current study was to determine the long term skeletal relapse at an average of 11.6 years following mandibular orthognathic surgery. Most studies published in the literature discussing long term skeletal changes were restricted to an average of 1 to 3 years post surgery (Van Sickels et al, 1988; Scheerlinck et al, 1994; Mobarak et al, 2000; Van Sickels et al, 2000; Borstlap et al, 2004; Kahnberg et al, 2007). The reason for postoperative skeletal relapse is thought to be multifactorial, and that in long term stability studies the cephalometric evaluation of the degree of relapse could be obscured by some factors such as the mandibular growth, condylar remodelling and the differences in the time of follow-up (Komori et al, 1989; De Villa et al, 2005).

When analysing the amount of the surgical shift in the horizontal direction, the mean mandibular surgical movement of 7.1 mm at B point for the current study sample was slightly higher than in other studies reported on mandibular osteotomies (Sorokolit and Nanda, 1990; Gassman et al, 1990; Scheerlinck et al, 1994; Van Sickels et al, 2000; Mobarak et al, 2000; Mombarak et al, 2001; Eggensperger et al, 2004; Kahnberg et al, 2007; Joss and Thuer, 2008). The mean long term horizontal relapse of 2.3 mm (32%) at B point and 3.1 mm (39%) at pogonion in this study was more favourable than the relapse of 2.42 mm (50.3%) and 3.21 mm (60.2%) measured at B point and pogonion respectively, as reported by Joss and Thuer (2008) after an average of 12.7 years following mandibular advancement surgery (Table 2.1). Nevertheless, it should be kept in mind that the current study sample also involved other patients (n=3) with class III skeletal malocclusion who were treated with mandibular setback procedures. Generally speaking, the long term relapse rate following mandibular setback is smaller than that following mandibular advancement (Ching, 1995; Proffit et al, 2007). The amount of overall long term percentage relapse found in the current study could have been influenced by the combined long term relapse of both mandibular advancement and setback procedures. Furthermore, it has been highlighted that the direct comparison between values which are drawn from different retrospective cephalometric studies could be problematic due to the lack of control over the variables between studies such as the surgeon's level of experience, the preoperative mandibular plane angle, the method of fixation and the degree of mandibular advancement. All of which are reported as possible factors affecting postoperative mandibular osteotomy stability (Arpornmaeklong et al, 2004).

The magnitude of surgical correction has been cited as a major factor contributing to skeletal relapse especially, following mandibular advancement (Hing, 1989; Gassman et al, 1990; Van

Sickels et al, 2000; Eggensperger et al, 2004). On the other hand, there are differing opinions reported in the literature to whether or not a correlation exists between the amount of surgical movement and its subsequent relapse, especially in mandibular setback procedures. Some authors believe that there is a strong correlation between the amount of surgical setback and postoperative anterior relapse of the mandible (Kobayashi et al, 1986; Mombarak et al, 2000, Eggensperger et al, 2004). Others could not demonstrate any significant correlation between the magnitude of setback and the amount of skeletal relapse (Komori et al, 1987; Sorokolit and Nanda, 1990; Ching, 1995; De Villa et al, 2005). It has been suggested that the long term skeletal relapse could be mostly anticipated when advancing the mandible more than 6 to 7 mm (Van Sickels at al., 1988; Eggensperger et al, 2004). The observed correlation between the magnitude of advancement and long term skeletal relapse has been attributed largely to the over stretch of the surrounding paramandibular connective tissue and the sometimes encountered process of progressive condylar resorption (Gassman et al, 1990; Scheerlinck et al, 1994). In the current study, no attempt was made to investigate the effect of the magnitude of surgical movement on long term relapse due to the multiple procedures performed on the relatively small patient pool. However, when analysing the effect of gender on the long term mandibular relapse, the surgical horizontal movement for the female group at B point was significantly higher than that of the male group (9.6 mm versus 5.4 mm; $p < 0.01$). However, the long term relapse did not differ significantly between males and females ($p = 0.49$) regardless of the initial surgical movement.

In addition, it has been proposed that the use of rigid internal fixation across the osteotomy site may reduce the affect of the unbalanced tension of paramandibular connective tissue, thereby producing improved postoperative stability (Van Sickels et al, 1986; Perrott et al, 1994; Dolce et al, 2002). In this study, rigid internal fixation was used for all cases treated with bilateral sagittal split osteotomy of the mandible (n=17). Therefore, the use of internal fixation did not prevent relapse. Overall a relapse tendency of 32% was found in this study.

In the vertical plane, the surgical changes among the present study sample showed a downward movement of 2.8 mm (p=0.048) at pogonion, 1.7 mm (p=0.05) at menton and 1 mm (p=0.26) at B point. The only long term vertical relapse was found at B point (1.0 mm) and accounted for 70 percent of the initial movement but this was statistically non significant (p=0.34). The amount of vertical relapse found in this study is in agreement with the findings of De Villa et al (2005), who showed a vertical relapse of 69.9% at B point after an average follow-up of 28 months. However, most authors have uniformly reported small values for vertical changes following mandibular orthognathic surgery (Sorokolit and Nanda, 1990; Proffit et al, 1991; Mombarak et al, 2000). The relatively smaller amount of changes observed in the vertical direction than that in the horizontal direction could have been attributed to the mostly reported non-significant vertical relapse. Proffit et al (2007), in his paper on the hierarchy of stability and predictability in orthognathic surgery, regarded the small amount of change (<2 mm) as being clinically insignificant. In this study, long term vertical changes measured at pogonion, menton, B point and anterior facial height were found to be minimal and statistically non significant after an average of 11.6 years follow-up.

14.2.1 Single jaw surgery *versus* 2-jaw surgery

Bimaxillary procedures are generally considered as a preferable method for achieving improved occlusal and aesthetic outcome than mandibular surgery alone. This is particularly important, in severe class III malocclusion and in class II malocclusion with associated vertical maxillary excess. However, controversy exists in the literature concerning mandibular stability after bimaxillary surgery compared with that following mandibular surgery alone (Hiranaka and Kelly, 1987; Turvey et al, 1988; Kahnberg and Ridell, 1988; Kerstens et al, 1990; Satrom et al, 1991; Ayoub et al, 1995; Emshoff et al, 2003; Eggensperger et al, 2004). Earlier studies have reported an improved mandibular stability after simultaneous 2-jaw surgery for correction of Class II malocclusions (Brammer at al., 1980; Hiranaka and Kelly, 1987). Other investigators demonstrated a comparable mandibular relapse rate, following the correction of mandibular deficiency, between single mandibular advancement alone and when combined with maxillary osteotomy (Ayoub et al, 1995). On the other hand, Kerstens et al (1990) demonstrated a higher mandibular relapse in cases that underwent bimaxillary surgery than in subjects underwent mandibular advancement surgery alone. They have attributed the differences in relapse tendency to the occurrence of postoperative condylar resorption. They should have shown that out of the twelve patients who experienced condylar resorption only one patient had single jaw surgery while the remaining eleven patients had bimaxillary procedures. In contrast to mandibular advancement, the literature suggests that bimaxillary procedures performed to correct mandibular prognathism are more stable than single mandibular setback osteotomy alone (Kahnberg and Ridell, 1988; Bailey et al, 1998). However, there are other researchers who could not demonstrate any significant difference on mandibular stability between single jaw procedures and bimaxillary procedures (Franco et al, 1989; Satrom et al, 1991).

In the current study, the percentage horizontal long-term relapse at menton and pogonion was smaller for the bimaxillary group than the single jaw surgery group (37% and 34% versus 44% and 46%, respectively). This could suggest a better long-term mandibular stability after bimaxillary procedures than mandibular surgery alone. On the other hand, the long term relapse recorded at B point was higher in the bimaxillary group than the single jaw group (36% versus 26%) and this may arguably; suggest a superior mandibular stability following single jaw procedures. However, because the recorded differences for all the predictors of horizontal relapse between both groups were statistically non-significant (Pgx: $p=0.57$; Mex: $p=0.35$; Bx: $p=0.28$), no definitive conclusion could be drawn whether bimaxillary procedures would provide better long-term mandibular stability than single jaw procedures or vice versa.

14.2.2 The effect of postoperative follow-up period and surgeon experience on long term relapse

The follow-up time after surgery seems to influence the extent of reported postoperative skeletal relapse. Some authors found that the majority of relapse occurred within the first year post surgery (Mobarak et al, 2000; Busby et al, 2002; Eggensperger et al, 2005; Jakobsone et al, 2011). In the current study, the correlation between the severity of relapse and the follow-up time was explored by separating the study sample according to the postoperative review period and the percentage of relapse. Within the follow-up period of 11.6 years, the highest relapse (> 40%) was experienced by 75 percent of patients while the other 25 percent of patients had similar relapse at the follow-up time of more than 11.6 years. This supports the view that relapse occurs in the period directly following the surgery and then stabilises.

The surgeon's level of experience is another factor which has been suggested to influence postoperative relapse after surgery (Arpornmaeklong et al, 2004). However, while reviewing the literature, no studies have been found which statistically relate postoperative relapse to the surgeon's level of experience. In this study, the whole cephalometric study sample of 20 patients was separated into four groups according to their operated surgeon and the encountered long term postoperative relapse. The results showed that only 1 out of 8 patients (12%) in surgeon A group experienced a relapse of > 40 percent. While in the surgeon B group (which consisted of 3 less experienced surgeons), more than half of their patients (7 out of 12) had a relapse of > 40 percent at an average follow-up of 11.6 years. Although statistically not significant (P=0.07), which has been probably influenced by the relatively small study sample, the results favoured a better postoperative stability for patients treated by a single more experienced surgeon compared to a group of less experienced surgeons.

14.3 Long term postoperative occlusal stability and oral health status

The final late postoperative state of the occlusion of the patients in the current study was assessed by means of study models. The original intent was to compare them to pre and immediate postoperative study models. Unfortunately so few models were available, and then at varying stages, that this comparison was not feasible. However, from the dental and orthodontic point of view the final models can be used to determine whether the occlusion was stable or not. It would be noted that sometimes the cephalometric assessment show relapse but if the teeth are well interdigtated the occlusion has remain stable. It has been stated that the goals of orthognathic surgery are to improve aesthetics and functional harmony, not to improve the cephalometric analysis (Turvey et al, 1982).

Study models are the only non-invasive 3-dimensional records that provide information that is important for orthodontic diagnosis and treatment planning. Various methods of space analysis and relevant information can be obtained from study models within limitations. However, study models are considered essential as starting and finishing records in orthodontic treatment. They also constitute important medico-legal information.

Previous studies have shown that despite the observed cephalometric skeletal relapse the anterior occlusion remained generally stable (Mobarak et al, 2000; Jakobsone et al, 2011). In a study of 81 patients who had bimaxillary osteotomy to correct mandibular prognathism, a relapse of anterior open bite was found in approximately 10 percent of patients (Jakobsone et al, 2011). In the current study, the majority of patients (20 out of 24) had satisfactory interdigitation. Of the 4 with an unsatisfactory occlusion, one patient (4%) had developed a small anterior open bite following vertical subsigmoid osteotomy to correct mandibular prognathism. The patient could, however, still adequately masticate.

The other 3 (12%) all showed horizontal relapse following single jaw, bilateral sagittal split osteotomy advancement of mandible to correct class II malocclusions.

Eight out of twenty patients in the current study exhibited a skeletal relapse of more than 40 percent as demonstrated cephalometrically. Of those patients only 2 had an observed malocclusion whereas the remaining 6 patients maintained a satisfactory occlusion. In the immediate preoperative phase there was close consultation by both the surgeon and orthodontist to ensure that orthodontic decompensation was complete. In the six cases with satisfactory occlusion then this had occured. In the two with occlusal relapse it was probably that the presurgical orthodontic decompensation was suboptimal. The negative effect of skeletal relapse would probably counteracted by dentoalveolar compensation. This mechanism of dentoalveolar compensation to counteract skeletal relapse is in agreement with the findings of Espland et al (2008). Further statistical analysis in the current study had demonstrated the concept that postoperative occlusion is independent of cephalometric skeletal relapse. This reflects the need for postoperative clinical monitoring by both observation of the dental occlusion and by cephalometry.

This study shows that orthognathic patients have generally maintained a good standard of oral health many years after treatment when measured by the decayed, missing index. The DMFT index is traditionally used to describe the epidemiologic prevalence of dental caries in the population (Al-Dajani, 2009). However, it has also been used in medical studies to evaluate oral health status of patients, with cleft lip and palate (Besseling and Dubois, 2004; Tannure et al, 2012), diabetes (Jones et al, 1992; Alavi et al, 2006), and chronic renal failure (Malekmakan et al, 2011). In these chronic disease patients there was a correlation between general and oral health.

Cleft lip and palate patients generally undergo multiple surgical operations from early life. The oral health of these surgical patients has been investigated in different studies. Although some authors reported no difference in caries experience between cleft and non-cleft patients (Tannure et al, 2012), others have clearly indicated a higher caries experience rate in cleft patients when compared to non-cleft controls (Al-Djajni, 2009; Besseling and Dubois, 2004).

Al-Dajani (2009) investigated the dental caries experience of 53 cleft lip and/or palate patients. He compared them to a group of siblings to correct for socioeconomic factors such as carbohydrates-rich diet and oral hygiene that can influence the rate of dental caries experience. He found a higher caries rate in left lip and/or palate patients (DMFT score = 6.8) compared to their matched siblings (DMFT score= 3.8). The findings were independent of socioeconomic status.

The mean DMFT value for the current study patients was 5.3. This was proportionally lower compared to the value of the published South Australian mean score of 12.7 for the general population (AIHW Dental Statistics and Research Unit 2008). Moreover, the majority of patients (n= 18, 75 %) in the current study were caries-free and maintained the same number of teeth present prior to surgery. This indicates a good level of dental health awareness in orthognathic surgery patients. To the best of the author's knowledge, there were no previous studies that evaluated the long term oral health status in patients undergoing surgical correction of dentofacial deformities. However, the findings of this study showed that dental health of orthognathic patients was maintained with generally a high standard, unlike cleft lip and/or palate patients.

Despite the good overall long term oral health status of the surgical-orthodontic patients in the current study, there were a small group of patients (n= 2) who had poor oral health with high prevalence of caries. All patients in the high-caries category were also found to have signs of abnormal illness behaviour. Unfortunately, the correlation between the individual's caries experience and their psychological status could not be tested for statistical significance due to the relatively small sample investigated in the current study. However, the findings suggest the individual's psychological status might have a negative impact on the long term postoperative oral health status of the surgical-orthodontic patients.

14.4 Patient's perception following orthognathic surgery

Aesthetic improvement and alleviation of functional problems are the most commonly cited motivators for orthognathic patients (Finlay et al, 1995; Cunningham et al, 1996; Williams et al, 2005). Similar reasons were found in this study, 17 out of 24 patients (71%) wanted to pursue with surgery to improve facial appearance and 10 out of 24 (42%) patients stated functional reasons such as chewing difficulties (29%) and problems with their temporomandibular joints (12%). The decision to undergo surgery has been also influenced by dental professional recommendations in more than half of the patients (54%) in the present study. The results correspond to the findings of Garvill et al (1992) who demonstrated that orthognathic patients have a multicausal background for treatment with approximately 60% of patients giving more than two reasons for surgery. They found that 50% of patients have been influenced by a family member or dentist in their decision to undergo surgery. Seventy four percent mentioned facial appearance and 59% indicated craniomandibular symptoms.

Neurosensory damage following mandibular orthognathic surgery is a commonly recognised complication. In this study, there was a high incidence (83%) of neurosensory disturbance of the lip and chin immediately after surgery, but more than half of the patients (55%) reported a return to their presurgical status within 6 months. Even though patients, who reported altered sensation on their lower lip and chin (33%) at the long- term review, did not feel any discomfort as a result of the persistent paresthesia. Other studies have shown a greater chance of neurosensory recovery at 6-12 months after surgery (Yoshida et al, 1989; Fridrich et al, 1995). One reason for this difference could be due to the tests for neurosensory disturbance used in the different studies. It was noted that the more objective the test, the more abnormalities that were present.

Although the neurosensory deficit of the inferior alveolar nerve affects a small area of the lower lip and chin, this change in sensation is usually reported as very distressing complication following mandibular orthognathic surgery (Guernsey and de Champlain, 1971). The sensory disturbance on the lip and chin can also affect speech and mastication (Jones et al, 1990). The finding of complete numbness "anaesthesia" was found in only one patient in this study. This patient was very distressed and wished that she had not undertaken the surgery. It had affected her psychosocial life in a negative way and she was extremely dissatisfied with the surgical outcome. The results indicate that long-term, persistent numbness of the lower lip and chin is an important factor that may have an effect on a patient's overall satisfaction following surgery and this concur with the findings of others (Finlay et al, 1995; Pahkala and Kellokoski, 2007). Similarly, earlier report by Kiyak et al (1985) demonstrated that patients who report more postsurgical problems such as pain, paresthesia, swelling, eating and swallowing difficulties are more likely to be more emotionally disturbed than those with no serious surgical sequelae. These patients were also found to be dissatisfied with the treatment outcome.

The findings of this study suggested a correlation between the preoperative counselling and patients' perception of surgical outcome. Two patients reported that they weren't given sufficient information before surgery and both had experienced postsurgical functional problems. They claimed to have worsening chewing ability, increased temporomandibular joint symptoms and persistent neurosensory deficit. Therefore, the preoperative preparation of patients undergoing orthognathic surgery should not be overlooked. Cunningham et al (1996) recommended that all patients undergoing surgery should be given all the necessary information regarding the surgery and its possible postoperative problems. The information should be given verbally and enforced by a written leaflet which "should be attractive to look at and easy to read".

14.5 Long-term quality of life evaluation following orthognathic surgery

Several studies have shown that orthognathic surgery has a wide variety of beneficial psychosocial effects, at least in the short to medium term, including improved self-confidence, self-esteem, body image, social and physical functioning, overall mood and social life situation (Lam et al, 1983; Kiyak et al, 1985; Lovius et al, 1990; Cunningham et al, 1996; Hunt et al, 2001; Nicodemo et al, 2008).In a series of papers, Kiyak et al (1982, 1982, 1984) investigated the psychological impact of orthognathic surgery at 4-month, 9-month and 24-month after surgery. They found that satisfaction and self-esteem has peaked at 4 months following surgery but declined at 9 months after surgery. They have suggested that this decline in satisfaction of surgery outcome and self-esteem at 9 month following surgery was due to patient perception of changes. At the intermediate phase, patients were still anticipating long-term improvement but when the final stabilisation of surgery is achieved at 9 months, they might expressed a degree of disappointment which is reflected on the satisfaction of the surgery in general. However, this decline in self-esteem did not persist and showed an increase again at 2 years follow-up, but was found to be statistically lower than that recorded at pre-surgery. The investigators have reasoned this finding to the imprecise baseline time taken prior to surgery. The preoperative baseline was taken at the completion of presurgical orthodontic treatment, therefore the quality of life scores would be expected to be relatively higher than that before any treatment has commenced due to the improved dental alignment and aesthetic that was gained from the orthodontic treatment. More recently, Hatch et al (1999) showed a significant improvement ($p<0.05$) in quality of life and psychosocial functioning at 2 years following bilateral sagittal split osteotomy advancement in 93 patients, when evaluated using the Sickness Impact Profile self-administered questionnaire. These improvements found to be stable when re-evaluated again at an average of 5 years after surgery (Motegi et al, 2003).

Orthognathic patients usually anticipate an improvement of their facial appearance therefore, the surgical outcome might have an important short and long-term psychosocial consequences. According to Hunt et al (2001) the long-term psychosocial benefits reported in the literature have not been defined in a meaningful scientific approach due to the absence of baseline data prior to surgery. This issue was encountered in the present retrospective study. Therefore, evaluation of the possible long-term impact of orthognathic surgery on patients was attempted in this study using the SF-36 instrument and compared to the published normative data available for the South Australian population. Statistically significant outcomes were recorded for physical functioning domain only ($p=0.0023$) while the other seven health domains were non-significantly different from the normal values (Table 12.3). The mean physical functioning score for the study sample was lower when compared to that of the normal population. This health domain reflects limitations in daily physical activities due to health problems (Ware et al, 1992). The study sample in the current study was derived from a low socioeconomic population with approximately 20% found to be never employed, 12.5% were not working due to physical illness and one patient (4%) reported that he was hospitalized for few months due to a major motor vehicle accident about 2 years ago. These findings would probably explain the lower overall mean score of physical functioning domain when compared to the general population. Nevertheless, the remaining health domains evaluated by the SF-36 questionnaire (social functioning, role-physical, bodily pain, mental health, role-emotional, vitality and general health) were statistically non significant between our study sample and the general population. These results thus indicate that orthognathic patients at the long-term review exhibited a comparable quality of life to that of the general population.

14.6 Perception of aesthetic profile change following orthognathic surgery

Orthognathic surgery involves more than correcting a functional problem. The alteration of facial appearance is equally important for many patients requesting the surgery (Laufer et al 1976; Kiyak et al, 1981; Frost et al, 1991). In this study, a significant improvement (p= 0.0048) in soft tissue profile was perceived at 11.6 years after surgical-orthodontic treatment by groups of evaluators consisting of dental professionals and laypersons. The overall aesthetic improvement is in agreement with other published studies (Burcal et al, 1987; Phillips et al, 1992; Shelly et al, 2000; Montini et al, 2007).

When analysing the differences between evaluator groups, the linear mixed effect model have demonstrated no significant differences between groups (p= 0.33). The results indicate that soft tissue profile changes can be perceived equally by dental professionals and laypersons at 11.6 years following surgery. These findings are different to previously published studies that have shown dental professionals and laypersons perceived changes in certain profiles differently (Lines et al, 1978; Dunlevy at al, 1987; Montini et al, 2007). However, other studies have found no difference in attractiveness scores between layperson and professional groups (Shelly et al, 2000; Maple et al, 2005).

The effect of racial differences on facial profile preference was investigated in the present study. Lay Omanis detected comparable improvement in facial profiles to that of lay Caucasian Australians for the majority of patients. There was a further agreement between both racial groups in the detection of profile changes for group II (BSSO advancement + Le Fort I) patients. Although statistically non significant, both racial groups have detected the only profile worsening following bimaxillary corrections of class II malocclusions (Table 12.12).

The present study revealed significant difference in improvement scores between seven different procedures (P= 0.0037). The only statistical improvements were found for patient group III (p=

0.0002) and patient group V ($p < 0.0001$). The results indicate that significant improvement can be perceived at 11.6 years following bimaxillary corrections of mandibular deficiency when combined with genioplasty advancement. A further improvement in chin projection produced by genioplasty advancement procedures could account for the facial profile aesthetic improvement observed in the present study. Thus surgeons should carefully consider the need for genioplasty from the aesthetic point of view. This agrees with Tsang et al (2009) who suggested that genioplasty advancement should be considered for patients exhibiting flat or insufficient mentolabial contour if improvement in facial profile appearance is to be achieved. The other significant aesthetic improvement was found following simultaneous bimaxillary corrections of Class III malocclusions (group V). The results concur with the findings of others (Lindorf and Steinhauser, 1978; Moser and Freihofer, 1980) who have recommended simultaneous double jaw procedures for correction of class III dentofacial deformities to achieve the best possible aesthetic results.

VI CONCLUSION

CHAPTER 14 CONCLUSION

1. This study looked at a sample group of 24 patients drawn from a total group of 226 patients who had mandibular orthognathic surgery performed in the OMSU, The University of Adelaide between 1985 and 2005. The sample was reviewed at 12.9 years (range 7 to 24) post surgery. The sample was similar in age and type of surgery but with greater male predominance than the total group.

2. The results from this study indicated that long-term relapse in the horizontal direction at an average follow-up of 11.6 years (range 7 to 24 years) was statistically significant and accounted for 39% ($p < 0.0009$) and 32% ($p < 0.0004$) of the surgical mandibular movement when measured at pogonion and B point, respectively.
3. In general, no statistical differences were found between the type of osteotomy (single jaw or bimaxillary surgery) or any of the studied variables in each of the groups in this long-term retrospective study. Similarly, no statistical differences in gender were found.
4. The long term postoperative stability was broadly influenced by the surgeon's experience. In this study, better postoperative stability was observed for patients managed by a single more experienced surgeon compared to a group of less experienced surgeons.
5. The reproducibility of the cephalometric method was proved to be generally reliable for most linear and angular variables except for the mandibular plane angle (SNGoMe) and posterior facial height (PFH). The mean differences for these two variables were significantly different from zero when repeated measurements were undertaken (SNGoMe: $p = 0.007$; PFH: $p < 0.001$). The observed cephalometric changes for these two variables should be interpreted with caution.

6. The majority of patients 20 (83%) showed satisfactory long term occlusal stability. The stability of occlusion was independent of the observed cephalometric relapse. This reflects the need for postoperative clinical monitoring by both observation of the dental occlusion and cephalometry.
7. The majority of 18 (75 %) were caries-free and maintained the same number of dentition present prior to surgery. However, there was a small group of patients 2 (8%) who demonstrated a neglected dental health with high caries experience. These patients were also found to suffer from some signs of abnormal illness behaviour.
8. When analysing perception of orthognathic surgery from the patient point of view, the majority of patients cited aesthetic improvement as the main reason for electing the surgical correction of their dentofacial deformities. Functional reasons such as chewing difficulties and problems with the temporomandibular joint were minority reasons for the patients to undergo surgery. Although most patients were generally satisfied with the surgical outcome, there was small percentage of patients who were dissatisfied. Dissatisfaction with surgery seems to be related to lack of preoperative preparation and counseling. Dissatisfied patients usually claimed to have persistent postoperative functional complications, particularly with neurosensory deficit of the lower lip and chin.
9. In common with the conclusion of Sambrook (1989), dissatisfaction with the treatment outcome appeared to be correlated with some signs of abnormal illness behaviour and abnormal body image, although this observation did not reach statistical significance due to the relatively small sample investigated in this study.
10. When evaluated by the SF-36 health survey questionnaire, the quality of life for orthognathic patients at the long-term review was generally the same as the general population.

11. This study has confirmed the aesthetic facial profile improvement following mandibular orthognathic surgery. The soft tissue profile improvement was perceived at 11.6 years after surgery by a panel of evaluators ($p = 0.0048$). However, there was no statistical difference between dental specialists and layperson in profile aesthetic preference, nor between different racial groups (lay Caucasian Australians versus lay Omanis).
12. The assessment of facial profile preference indicated a significant aesthetic improvement when genioplasty advancement was performed in combination with bimaxillary osteotomy for the correction of mandibular deficiency ($p = 0.0002$). Similarly, a significant aesthetic improvement was achieved following correction of Class III malocclusions by the means of bimaxillary surgery ($p < 0.0001$).
13. This study confirms that orthognathic surgery, when evaluated many years later is stable and generally has a good outcome for both the patient and clinicians perspective.

VII APPENDICES

APPENDIX 1

The research ethics approval protocol

Government of South Australia
SA Health

25 August 2009

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Research Ethics Committee
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Heather.O'Dea@health.sa.gov.au

Dear Dr AlAjmi,

Re: "Long-term relapse following mandibular orthognathic surgery."

RAH PROTOCOL NO: 090720.

I am pleased to advise Research Ethics Committee APPROVAL has been given to the above project. Please quote the RAH Protocol Number allocated to your study on all future correspondence.

The following have been reviewed and approved:

- **Protocol Version 1 (August 2009).**
- **Patient Information Sheet, Version 2 (August 2009).**
- **Consent Form, Version 1 (August 2009).**
- **IBQ Questionnaire**
- **SI Questionnaire**
- **Letter to participants**

Research Ethics Committee deliberations are guided by the NHMRC National Statement on Ethical Conduct inHuman Research 2007.

The general conditions of approval follow:

- For all clinical trials, the study must be registered in a publicly accessible trials registry prior to enrolment of the first participant.
- Adequate record-keeping is important. If the project involves signed consent, you should retain the completed consent forms which relate to this project and a list of all those participating in the project, to enable contact with them in the future if necessary. The duration of record retention for allclinical research data is 15 years.
- You must notify the Research Ethics Committee of any events which might warrant review of the approval or which warrant new information being presented to research participants, including:

  (a) serious or unexpected adverse events which warrant protocol change or notification to research participants,
  (b) changes to the protocol,
  (c) premature termination of the study,
  (d) a study completion report within 3 months of the project completion.
- The Committee must be notified within 72 hours of any serious adverse event occurring at this site.
- Approval is ongoing, subject to satisfactory annual review. Investigators are responsible for providing an annual review to the RAH REC Executive Officer each year using the Annual Review Form availableat: http://www.rah.sa.gov.au/rec/index.php

Yours sincerely,

Dr A Thornton
CHAIRMAN
RESEARCH ETHICS COMMITTEE

APPENDIX 2.

Orthognathic surgery satisfaction questionnaire

APPENDIX 2

Orthognathic surgery satisfaction questionnaire

1. What was the main reason for seeking treatment?

   Chewing difficulties — Problems with jaw joints

   Facial pain/ headache — Dissatisfaction with facial appearance

   Professional recommendation — Other reason

2. Did you get enough information about treatment?

   No — Yes

3. Have you had numbness in the lips or jaws after surgery?

   No — Yes, for how long?

4. Have you noticed any change in chewing ability?

   Improvement — No change — Worsening

5. Have you noticed any change in the jaw joint area?

   Less symptoms — No change — More symptoms

6. Have you noticed any change in your facial appearance?

   Improvement — No change — Worsening

7. How satisfied you are with the treatment outcome?

   Very satisfied Rather satisfied Unsatisfied

8. The result of the treatment was:

   Better than I expected As good as I expected worse than I expected

9. Would you undergo the same treatment again?

   Yes No

APPENDIX 3. PART A.

The illness behaviour questionnaire

APPENDIX 3 - Part A

I.B.Q.

Here are some questions about you and your health. Circle either YES or NO to indicate your answer to each question.

1.	Do you worry a lot about your health?	YES	NO
2.	Do you think there is something seriously wrong with your body?	YES	NO
3.	Does your illness interfere with your life a great deal?	YES	NO
4.	Are you easy to get on with when you are ill?	YES	NO
5.	Does your family have a history of illness?	YES	NO
6.	Do you think you are more liable to illness than other people?	YES	NO
7.	If the doctor told you that he could find nothing wrong with you would you believe him?	YES	NO
8.	Is it easy for you to forget about yourself and think about all sort of other things?	YES	NO
9.	If you feel ill and someone tells you that you are looking better, do you become annoyed?	YES	NO
10.	Do you find that you are often aware of various things happening in your body?	YES	NO
11.	Do you ever think of your illness as a punishment for something that you have done wrong in the past?	YES	NO
12.	Do you have troubles with your nerves?	YES	NO
13.	If you feel ill or worried, can you be easily cheered up by the doctor?	YES	NO
14.	Do you think that other people realise what it is like to be sick?	YES	NO
15.	Does it upset you to talk to the doctor about your illness?	YES	NO

16. Are you bothered by many pains and aches?	YES	NO
17. Does your illness affect the way you get on with your family or friends a great deal?	YES	NO
18. Do you find you get anxious easily?	YES	NO
19. Do you know anybody who had the same illness as you?	YES	NO
20. Are you more sensitive to pain than other people?	YES	NO
21. Are you afraid of illness?	YES	NO
22. Can you express your personal feelings easily to other people?	YES	NO
23. Do people feel sorry for you when you are ill?	YES	NO
24. Do you think that you worry about your health more than most people?	YES	NO
25. Do you find that your illness affects your gender relations?	YES	NO
26. Do you experience a lot of pain with your illness?	YES	NO
27. Except for your illness, do you have any problem in your life?	YES	NO
28. Do you care whether or not people realise that you are sick?	YES	NO
29. Do you find that you get jealous of other people's good health?	YES	NO
30. Do you ever have silly thoughts about your health which you can't get out of your mind, no matter how hard you try?	YES	NO
31. Do you have any financial problem?	YES	NO
32. Are you upset by the way people take your illness?	YES	NO
33. Is it hard for you to believe the doctor when he tells you there is nothing to worry about?	YES	NO
34. Do you often worry about the possibility that you have got a serious illness?	YES	NO
35. Are you sleeping well?	YES	NO

36. When you are angry, do you tend to bottle up your feelings? YES NO
37. Do you think that you might suddenly fall ill? YES NO
38. If a disease is brought to your attention (through the radio, television, newspapers or someone you know) do you worry about getting it yourself? YES NO
39. Do you get the feeling that people are your illness seriously enough? YES NO
40. Are you upset by the appearance of your face or body? YES NO
41. Do you find that you are bothered by many different symptoms? YES NO
42. Do you frequently try to explain how you feel to others? YES NO
43. Do you have any family problems? YES NO
44. Do you think there is something the matter with your mind? YES NO
45. Are you eating well? YES NO
46. Is your bad health the biggest difficulty of your life? YES NO
47. Do you think that you get sad easily? YES NO
48. Do you worry or fuss over small details that seen unimportant to others? YES NO
49. Are you always a co-operative patient? YES NO
50. Do you often have the symptoms of a very serious disease? YES NO
51. Do you find that you get angry easily? YES NO
52. Do you have any work problems? YES NO
53. Do you prefer to keep your feelings to yourself? YES NO
54. Do you often find that you get depressed? YES NO
55. Would all your worries be over if you were physically healthy? YES NO
56. Are you more irritable towards other people? YES NO

57. Do you think that your symptoms may be caused by worry? YES NO
58. Is it easy for you to let people know when you are cross with them? YES NO
59. Is it hard for you to relax? YES NO
60. Do you have personal worries which are not caused by physical illness? YES NO
61. Do you often find that you lose patience with other people? YES NO
62. Is it hard for you to show your personal feeling? YES NO

APPENDIX 3. PART B.

Scoring the illness behaviour questionnaire

(note that not all IBQ items contribute to scale score)

Question No.	Scale 1	Scale 2	Scale 3	Scale 4	Scale 5	Scale 6	Scale 7
2		Yes					
3		Yes					
4							No
7		No					
9	Yes						
10		Yes					
11			Yes				
12					Yes		
16			No				
17							Yes
18					Yes		
20	Yes						
21	Yes						
22				No			
24	Yes						
27						No	
29	Yes						
30	Yes						
31						No	
32	Yes						
35		No					
36				Yes			
37	Yes						
38	Yes						
41		Yes					
43						No	
44			Yes				
46			No				
47					Yes		
51							Yes
53				Yes			
54					Yes		
55						Yes	
56							Yes
57			Yes				
58				No			
59					Yes		
60						No	
61							Yes
62				Yes			

Final profile							

Whitely Index of Hypochondriasis

Question No.	1	2	8	9	10	16	21	24	33	34	38	39	41	50
Scored Response	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

APPENDIX 4. PART A.

The body image questionnaire

The body image questionnaire

Consider each item, then tick to indicate how you feel about the particular part of your body right now. There are no right or wrong answers and do not spend too much time on each item.

	Not happy Want changed	Not happy-tolerate	No particular feeling	Satisfied	Consider fortunate	For office use
Hair						
Facial complexion						
Appetite						
Hands						
Distribution of hair over body						
Nose						
Fingers						
Wrists						
Breathing						
Waist						
Energy level						
Back						
Exercise						
Ears						
Chin						
Ankles						
Neck						
Shape of Head						
Body build						
Profile						
Height						

Age						
	Not happy Want changed	Not happy-tolerate	No particular feeling	Satisfied	Consider fortunate	For office use
Width of Shoulders						
Arms						
Chest						
Eyes						
Hips						
Skin Texture						
Upper Lip						
Legs						
Lower teeth						
Feet						
Lower Lip						
Forehead						
Upper Teeth						
Speech						
Health						
Gender Activities						
Knees						
Face						
Weight						

APPENDIX 4. PART B.

Scoring the body image questionnaire

Scoring the body image questionnaire

A mark against the item attracts the following score,

not happy, want changed	5
not happy- tolerate	4
no particular feelings	3
satisfied	2
consider fortunate	1

The general body image consisted of the following items,

1. Hair.
2. Appetite.
3. Hands.
4. Body hair.
5. Fingers.
6. Wrists.
7. Waist.
8. Energy level.
9. Back.
10. Exercise.

11. Ankles.
12. Neck.
13. Body build.
14. Height.
15. Age.
16. Width of shoulders.
17. Arms.
18. Chest.
19. Hips.
20. Skin texture.
21. Legs.
22. Feet.
23. Health.
24. Sexual.
25. Knees.
26. Weight.

The dentofacial body image consisted of the following items,

1. Facial complexion.
2. Nose.
3. Breathing.
4. Ears.
5. Chin.
6. Head shape.
7. Profile.
8. Eyes.
9. Upper lip.
10. Lower teeth.
11. Lower lip.
12. Forehead
13. Upper teeth.
14. Speech.
15. Face.

APPENDIX 5. PART A.

The generic health survey SF-36 questionnaire

SF-36 QUESTIONNAIRE

1. In general, would you say your health is: (circle one)

   Excellent Very good Good Fair Poor

2. Compared to one year ago, how would you rate your health in general now? (circle one)

   Much better now than one year ago.

   Somewhat better now than one year ago.

   About the same as one year ago.

   Somewhat worse than one year ago.

   Much worse than one year ago.

3. The following items are about activities you might do during a typical day. Does your health limit you in these activities? If so, how much? (Mark each answer with an **X**)

ACTIVITIES	**Yes, Limited A lot**	**Yes, Limited A little**	**No, Not Limited At All**
a. Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports.			
b. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf.			
c. Lifting or carrying groceries.			
d. Climbing several flights of stairs.			
e. Climbing one flight of stairs.			
f. Bending, kneeling or stooping.			
g. Walking more than a mile.			
h. Walking several block.			
i. Walking one block.			
j. Bathing or dressing yourself.			

4. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health? (Mark each answer with an **X)**

	YES	**NO**
a. Cut down on the amount of time you spent on work or other activities.		
b. Accomplished less than you would like.		

c. Were limited in the kind of work or other activities.		
d. Had difficulty performing the work or other activities (for example, it took extra effort)		

5. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)? (Mark each answer with an **X)**

	YES	**NO**
a. Cut down the amount of time you spent on work or other activities.		
b. Accomplished less than you would like.		
c. Didn't do work or other activities as carefully as usual.		

6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours or groups?

Not at all Slightly Moderately Quite a bit Extremely

7. How much bodily pain have you had during the past 4 weeks? (circle one)

None Very mild Mild Moderate Severe Very severe

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

Not at all A little bit Moderately Quite a bit Extremely

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks- (Mark each answer with an **X**)

	All of the Time	**Most of the Time**	**A good Bit of the Time**	**Some of the Time**	**A little of the Time**	**None of the Time**
a. Did you feel full of pep?						
b. Have you been a very nervous person?						
c. Have you felt so down in the dumps that nothing could cheer you up?						

d. Have you felt calm and peaceful?						
e. Did you have a lot of energy?						
f. Have you felt downhearted and blue?						
g. Did you feel worn out?						
h. Have you been a happy person?						
i. Did you feel tired?						

10. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)? (circle one)

All of the time Most of the time Some of the time A little of the time None of the time

11. How TRUE or FALSE is each of the following statements for you?

	Definitely True	**Mostly True**	**Don't Know**	**Mostly True**	**Definitely False**
a. I seem to get sick a little easier than other people.					
b. I am as healthy as anybody I know.					
c. I expect my health to get worse.					
d. My health is excellent.					

APPENDIX 5. PART B.

Scoring the SF-36 questionnaire

How to score SF-36 Questionnaire

Step 1: Scoring questions

QUESTION NUMBER	ORIGINAL RESPONSE	RECORDED VALUE
1, 2, 20, 22, 34, 36	1	100
	2	75
	3	50
	4	25
	5	0
3, 4, 5, 6, 7, 8, 9, 10, 11, 12	1	0
	2	50
	3	100
13, 14, 15, 16, 17, 18, 19	1	0
	2	100
21, 23, 26, 27, 30	1	100
	2	80
	3	60
	4	40
	5	20
	6	0
24, 25, 28, 29, 31	1	0
	2	20
	3	40
	4	60
	5	80
	6	100
32, 33, 35	1	0
	2	25
	3	50
	4	75
	5	100

Step 2: Averaging items to form 8 scales:

SCALE	NUMBER OF ITEMS	AFTER RECORDING AS PER TABLE 1, AVERAGE THE FOLLOWING ITEMS
Physical functioning	10	3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Role limitations due to physical health problems	4	13, 14, 15, 16
Bodily pain	2	21, 22
General health	5	1, 33, 34, 35, 36
Vitality	4	23, 27, 29, 31
Social functioning	2	20, 32
Role limitations due to emotional problems	3	17, 18, 19
Mental health	5	24, 25, 26, 28, 30

Step 3: Figuring scores

All questions are scored on a scale from 0 to 100, where:

100= the highest level of functioning possible

0= the lowest level of functioning possible

Aggregate scores are compiled as a percentage of the total points possible, using the scoring table (Step 1 chart).

The scores from those questions that address specific area of functional health domain (Step 2 chart) are then averaged together, for a final score within each of the above eight health parameters measured.

APPENDIX 6.

Postoperative clinical assessment form

Postoperative clinical assessment form

1. INTREVIEW

   a. Name:

   D.O.B.:

   Gender:

   Occupation:

   b. Residual surgical complaint

   c. Medical and Dental History

2. CLINICAL EXAMINATION

   a. Masticatory Apparatus:

   TMJ‘s:

   Muscle of Mastication

   Occlusion: (CR/CO, interferences)

   Mouth opening (mm) and deviations:

   b. Assessment of any residual lip numbness

   Light touch sensation test

   Pin prick sensation test

   Two point discrimination test

   c. General Dental Examination

   Oral pathology:

   Teeth Present:

   Teeth carious:

   Teeth filled:

DMFT score:

Periodontium:

3. INVESTIGATIONS
    a. Alginate dental impressions and bite registration for construction of study dental models.
    b. Radiographic examination

        Lateral head cephalometric radiograph

        Orthopantamograph (OPG)

APPENDIX 7

Perception of facial attractiveness survey

- **Investigator number (   )**

INSTRUCTIONS:

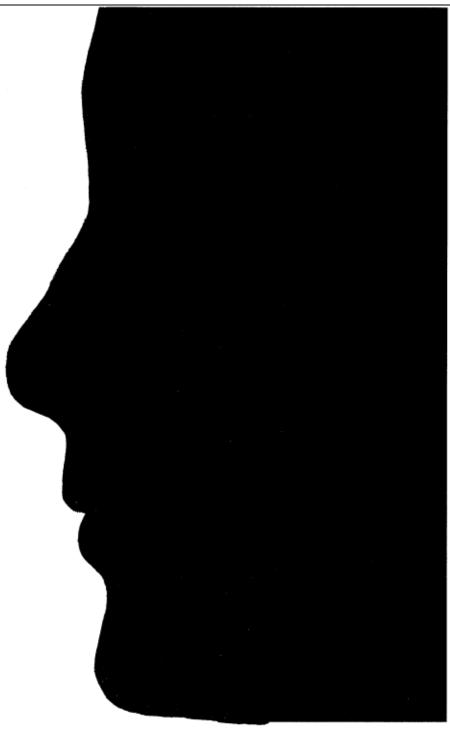
1. **Please give a score of attractiveness you attribute to each silhouette. The score should be from 0- 10, where:**

   Score (10) = very attractive
   Score (0) = very unattractive

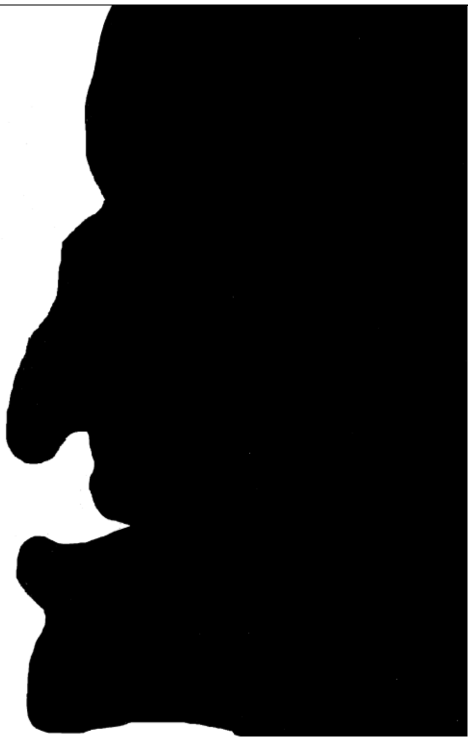
2. **Please score from the first look.**

EXAMPLES:

On the left is the classical profile from Da Vinci's work. Hence a high score. On the right is the profile of a patient with marked mandibular prognathism and nasal deformity. Hence a low score.



Score: (9)



Score: (2)

Investigator number (   )

Score: ( )

Score: ( )

Score: ( )

Score: ( )

Investigator number (   )

Score: ( )

Score: ( )

Score: ( )

Score: ( )

Investigator number (   )

Score: ( )

Score: ( )

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Investigator number (   )

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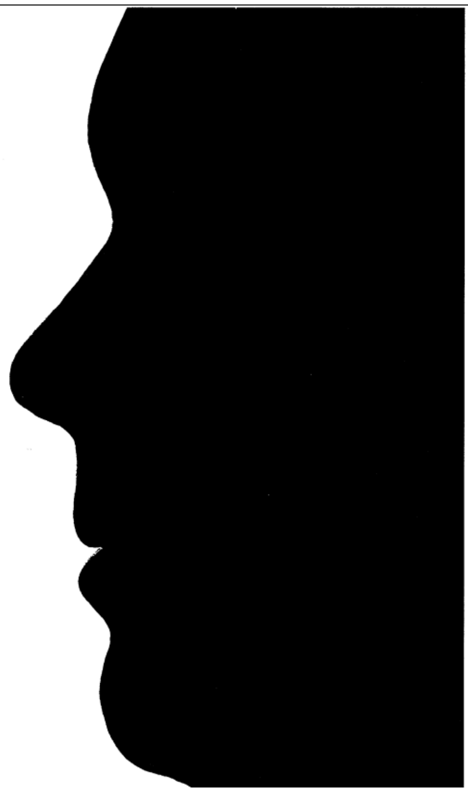
Score: ( )

Score: ( )

Investigator number (   )

Score: ( )



Score: ( )

Score: ( )

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Investigator number (   )

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Investigator number (   )

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Score: ( )

Score: (   )

Score: ( )

VIII BIBILOGRAPHY

BIBILOGRAPHY

Abeltins A, Jakobsone G, Urtane I, Bigestans A. The stability of bilateral sagittal ramus osteotomy and vertical ramus osteotomy after bimaxillary correction of class III malocclusion. J Craniomaxillofac Surg 2011;39:583-7.

Adams GL, Gansky SA, Miller AJ, Harrell WE Jr, Hatcher DC. Comparison between traditional 2-dimensional cephalometry and a 3-dimensional approach on human dry skulls. Am J Orthod Dentofacial Orthop 2004;126:397-409.

Aetna. Clinical Policy Bulletin: Orthognathic Surgery 1995; [Updated 2010 March 19; cited 2010 June 20]. Available from: http://www.aetna.com/cpb/medical/data/1_99/0095.html

Ahlqvist J, Eliasson S, Welander U. The cephalometric projection. Part II. Principles of image distortion in cephalography. Dentomaxillofac Radiol1983;12:101-8.

Ahlqvist J, Eliasson S, Welander U. The effect of projection errors on cephalometric length measurements. Eur J Orthod 1986; 8:141-8.

AIHW Dental Statistics and Research Unit 2008. The National Survey of Adult Oral Health 2004–06: South Australia. Cat. no. DEN 179. Dental Statistics and Research Series no. 43. Canberra: Australian Institute of Health and Welfare.

Alavi AA, Amirhakimi E, Karami B. The prevalence of dental caries in 5 - 18-year-old insulin-dependent diabetics of Fars Province, southern Iran. Arch Iran Med 2006; 9:254-60.

Al-Dajani M. Comparison of dental caries prevalence in patients with cleft lip and/or palate and their sibling controls. Cleft Palate Craniofac J 2009; 46:529-31.

Alley TR, Hildebrandt KA. Determinants and consequences of facial aesthetics. In: Alley TR (ed.) Social and applied aspects of perceiving faces. Lawrence Erlbaum Associates, Hillsdale, New Jersey, pp. 101-140.

Arpornmaeklong P, Shand JM, Heggie AA. Skeletal stability following maxillary impaction and mandibular advancement. Int J Oral Maxillofac Surg 2004; 33:656-63.

Asch D, Jedrziewski M, Christakis N. Response rates to mail surveys published in medical journals. J Clin Epidemiol 1997; 50:1129-36.

Astrand P, Bergljung L, Nord PG. Oblique sliding osteotomy of the mandibular rami in 55 patients with mandibular prognathism. Int J Oral Surg 1973; 2:89-101.

Astrand P, Ridell A. Positional changes of the mandible and the upper and lower anterior teeth after oblique sliding osteotomy of the mandibular rami. A roentgen-cephalometric study of 55 patients. Scand J Plast Reconstr Surg 1973; 7:120-9.

Ayoub AF, Stirrups DR, Moos KF. Stability of sagittal split advancement osteotomy: single-versus double-jaw surgery. Int J Adult Orthodon Orthognath Surg 1995; 10:181-92.

Bailey LJ, Proffit WR, White RP Jr. Trends in surgical treatment of Class III skeletal relationships. Int J Adult Orthod Orthognath Surg 1995; 10:108-118.

Barsky A. Psychology of the patient undergoing plastic surgery. Am J Surg 1944; 2:238-43.

Baume LJ. A biologic looks at sella point. Trans Eur Orthod Soc 1957; 150-59.

Baumrind S, Frantz RC. The reliability of head film measurements. 1. Landmark identification. Am J Orthod 1971a; 60:111-27.

Baumrind S, Frantz RC. The reliability of head film measurements. 2. Landmark identification. Am J Orthod 1971b; 60:505-17.

Baumrind S, Miller D, Molthen R. The reliability of head film measurements. 3. Tracing superimposition. Am J Orthod 1976; 70:617-44.

Baumrind S, Miller DM. Computer-aided head film analysis: the University of California San Francisco method. Am J Orthod 1980; 78:41-65.

Bell WH. Correction of skeletal type anterior open bite. J Oral Surg 1971; 29:706–14.

Bell R, Kiyak HA, Joondeph DR, McNeil RW, Wallen TR. Perceptions of facial profile and their influence on the decision to undergo orthognathic surgery. Am J Orthod 1985; 88:323-32.

Bell WH, Schendel SA. Biologic basis for modification of the sagittal ramus split operation. J Oral Surg 1977; 35:362-69.

Bergersen EO. Enlargement and distortion in cephalometric radiography: compensation tables for linear measurements. Angle Orthod 1980; 50:230-44.

Besseling S, Dubois L. The prevalence of caries in children with a cleft lip and/or palate in Southern Vietnam. Cleft Palate Craniofac J 2004; 41:629-32

Bjerin R. A comparison between the Frankfort horizontal and the sella turcica-nasion as reference planes in cephalometric analysis. Acta Odontol Scand 1957; 15:1-12.

Björk A, Skieller V. Normal and abnormal growth of the mandible. A synthesis of longitudinal cephalometric implant studies over a period of 25 years. Eur J Orthod 1983; 5:1-46.

Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986; 1:307-10.

Bondevik O, Røsler M, Slagsvold O. The digital read-out system CM-1: an instrument for rational measuring on radiographic headplates and dental models. Eur J Orthod 1981; 3:1-8.

Borstlap WA, Stoelinga PJ, Hoppenreijs TJ, van't Hof MA. Stabilisation of sagittal split set-back osteotomies with miniplates: a prospective, multicentre study with 2-year follow-up. Int J Oral Maxillofac Surg 2005; 34:487-94.

Borstlap WA, Stoelinga PJ, Hoppenreijs TJ, van't Hof MA. Stabilisation of sagittal split advancement osteotomies with miniplates: a prospective, multicentre study with two-year follow-up. Part II. Radiographic parameters. Int J Oral Maxillofac Surg 2004; 33:535-42.

Brammer J, Finn R, Bell WH, Sinn D, Reisch J, Dana K. Stability after bimaxillary surgery to correct vertical maxillary excess and mandibular deficiency. J Oral Surg 1980; 38:664-70.

Brazier JE, Harper R, Jones NM, O'Cathain A, Thomas KJ, Usherwood T, Westlake L. Validating the SF-36 health survey questionnaire: new outcome measure for primary care. BMJ 1992; 305:160-4.

Broadbent BH. A new x ray technique and its application to orthodontics. Angle Orthod 1931; 1:45-66.

Broch J, Slagsvold O, Røsler M. Error in landmark identification in lateral radiographic headplates. Eur J Orthod 1981; 3:9-13.

Brodie AG. Late growth changes in the human face. Angle Orthod 1953;23: 146-157.

Burcal RG, Laskin DM, Sperry TP. Recognition of profile change after simulated orthognathic surgery. J Oral Maxillofac Surg 1987; 45:666-70.

Burstone CJ, James RB, Legan H, Murphy GA, Norton LA. Cephalometrics for orthognathic surgery. J Oral Surg 1978; 36:269-77.

Busby BR, Bailey LJ, Proffit WR, Phillips C, White RPJr. Long-term stability of surgical class III treatment: a study of 5-year postsurgical results. Int J Adult Orthodon Orthognath Surg 2002; 17:159-70.

Carlsson GE. Error in x-ray cephalometry. A method study and a longitudinal investigation of the facial skeleton on series with and without natural teeth over a 5-year period. Odontol Tidskr 1967; 75:99-129.

Chate RA. Cephalometric landmark identification within the petrous temporal region. Br J Orthod 1987; 14:33-41.

Chen CM, Lai SS, Wang CH, Wu JH, Lee KT, Lee HE. The stability of intraoral vertical ramus osteotomy and factors related to skeletal relapse. Aesthetic Plast Surg 2011; 35:192-7.

Ching M. Cephalometric evaluation of mandibular relapse following vertical subsigmoid osteotomy. MDS Thesis, University of Adelaide, South Australia, 1995.

Cunningham SJ, Hunt NP, Feinmann C. Perceptions of outcome following orthognathic surgery. Br J Oral Maxillofac Surg 1996; 34:210-3.

Czarnecki ST, Nanda RS, Currier GF. Perceptions of a balanced facial profile. Am J Orthod Dentofacial Orthop 1993; 104:180-7.

Dal Pont G. Retromolar osteotomy for the correction of prognathism. J Oral Surg Anesth Hosp Dent Serv 1961; 19:42-7.

Damstra J, Huddleston Slater JJ, Fourie Z, Ren Y. Reliability and the smallest detectable differences of lateral cephalometric measurements. Am J Orthod Dentofacial Orthop 2010; 138:546.e1-546.e8.

De Smit A, Dermaut L. Soft-tissue profile preference. Am J Orthod 1984; 86:67-73.

De Villa G, Huang C, Chen P, Chen U. Bilateral sagittal split osteotomy for correction of mandibular prognathism: long-term results. J Oral Maxillofac Surg 2005; 63:1584–92.

Dolce C, Hatch JP, Van Sickels JE, Rugh JD. Rigid versus wire fixation for mandibular advancement: skeletal and dental changes after 5 years. Am J Orthod Dentofacial Orthop 2002; 121:610-9.

Dolce C, Van Sickels JE, Bays RA, Rugh JD. Skeletal stability after mandibular advancement with rigid versus wire fixation. J Oral Maxillofac Surg 2000; 58:1219-27.

Drommer RB. The history of the "Le Fort I osteotomy". J Maxillofac Surg 1986; 14:119-22.

Dunlevy HA, White RP Jr, Turvey TA. Professional and lay judgment of facial aesthetics changes following orthognathic surgery. Int J Adult Orthodon Orthognath Surg 1987; 2:151-8.

Egbert M, Hepworth B, Myall R, West R. Stability of Le Fort I osteotomy with maxillary advancement: a comparison of combined wire fixation and rigid fixation. J Oral Maxillofac Surg 1995; 53:243-8; discussion 248-9.

Eggensperger N, Smolka K, Luder J, Iizuka T. Short- and long-term skeletal relapse after mandibular advancement surgery. Int J Oral Maxillofac Surg 2006; 35:36-42.

Eggensperger N, Smolka W, Rahal A, Iizuka T. Skeletal relapse after mandibular advancement and setback in single-jaw surgery. J Oral Maxillofac Surg 2004; 62:1486-96.

Eliasson S, Welander U, Ahlqvist J. The cephalometric projection. Part I: General considerations. Dentomaxillofac radiol 1982; 11:117-122.

Emshoff R, Scheiderbauer A, Gerhard S, Norer B. Stability after rigid fixation of simultaneous maxillary impaction and mandibular advancement osteotomies. Int J Oral Maxillofac Surg 2003;32: 137-42.

Epker BN. Modifications in the sagittal osteotomy of the mandible. J Oral Surg 1977; 35:157-9.

Epker BN, Wessberg GA. Mechanisms of early skeletal release following surgical advancement of the mandible. Br J Oral Surg 1982; 20:175-82.

Ercolani M, Baldaro B, Rossi N, Trombini E, Trombini G. Short-term outcome of rhinoplasty for medical or cosmetic indication. J Psychosom Res 1999 ; 47:277-81.

Ercolani M, Baldaro B, Rossi N, Trombini G. Five-year follow-up of cosmetic rhinoplasty. J Psychosom Res 1999 ; 47:283-6.

Eriksen E, Solow B. Linearity of cephalometric digitizers. Eur J Orthod 1991; 13:337-42.

Espeland L, Dowling PA, Mobarak KA, Stenvik A. Three-year stability of open-bite correction by 1-piece maxillary osteotomy. Am J Orthod Dentofacial Orthop 2008; 134:60-6.

Finlay PM, Atkinson JM, Moos KF. Orthognathic surgery: patient expectations; psychological profile and satisfaction with outcome. Br J Oral Maxillofac Surg 1995; 33:9-14.

Flanary CM, Barnwell GM Jr, Alexander JM. Patient perceptions of orthognathic surgery. Am J Orthod 1985; 88:137-45.

Ford EH. Growth of the human cranial base. Am J Orthod 1958; 44:498-506.

Franco JE, Van Sickels JE, Thrash WJ. Factors contributing to relapse in rigidly fixed mandibular setbacks. J Oral Maxillofac Surg 1989; 47:451-6.

Fridrich KL, Holton TJ, Pansegrau KJ, Buckley MJ. Neurosensory recovery following the mandibular bilateral sagittal split osteotomy. J Oral Maxillofac Surg 1995; 53:1300-06.

Frost V, Peterson G. Psychological aspects of orthognathic surgery: how people respond to facial change. Oral Surg Oral Med Oral Pathol 1991; 71:538-42.

Garvil J, Kahnberg KE, Lundgren S. Psycological factors in orthognathic surgery. J Craniomaxillofac Surg 1992; 20:28-33.

Gassmann CJ, Van Sickels JE, Thrash WJ. Causes, location, and timing of relapse following rigid fixation after mandibular advancement. J Oral Maxillofac Surg 1990; 48:450-4.

Ghafari J, Engel FE, Laster LL. Cephalometric superimposition on the cranial base: a review and a comparison of four methods. Am J Orthod Dentofacial Orthop 1987; 91:403-13.

Gipson M, Connolly FH. The incidence of schizophrenia and severe psychological disorders in patients 10 years after cosmetic rhinoplasty. Br J Plast Surg 1975; 28:155-9.

Gliddon MJ, Xia JJ, Gateno J, Wong HT, Lasky RE, Teichgraeber JF, Jia X, Liebschner MA, Lemoine JJ. The accuracy of cephalometric tracing superimposition. J Oral Maxillofac Surg 2006; 64:194-202.

Gomes MA, Wisth PJ, Tornes K, Bøe OE. Skeletofacial changes by mandibular advancement using sagittal split osteotomies. Int J Adult Orthodon Orthognath Surg 1993; 8:87-94.

Graber TM. Implementation of roentgenographic cephalometric technique. Am J Orthod 1958; 44:906-31.

Gravely JF, Benzies PM. The clinical significance of tracing error in cephalometry. Br J Orthod 1974; 1:95-101.

Guernsey LH, de Champlain RW. Sequelae and complications of the intra oral sagittal osteotomy in the mandibular rami. Oral Surg 1971; 32:176-92.

Hall HD, McKenna SJ. Further refinement and evaluation of intraoral vertical ramus osteotomy. J Oral Maxillofac Surg 1987; 45:684-8.

Harris EF, Smith RN. Accounting for measurement error: a critical but often overlooked process. Arch Oral Biol 2009;54 Suppl 1:S107-17.

Hatch JP, Rugh JD, Bays RA, Van Sickels JE, Keeling SD, Clark GM. Psychological function in orthognathic surgical patients before and after bilateral sagittal split osteotomy with rigid and wire fixation. Am J Orthod Dentofacial Orthop 1999; 115:536-43.

Hebert JM, Kent JN, Hinds EC. Correction of prognathism by an intraoral vertical subcondylar osteotomy. J Oral Surg 1970; 28:651-3.

Hennes JA, Wallen TR, Bloomquist DS, Crouch DL. Stability of simultaneous mobilization of the maxilla and mandible utilizing internal rigid fixation. Int J Adult Orthodon Orthognath Surg 1988; 3:127-41.

Hibi H, Ueda M. A technique for ensuring accurate bone cuts in the intraoral vertical ramus osteotomy. J Oral Maxillofac Surg 1995; 53:1480-1.

Hing NR. Cephalometric evaluation of mandibular relapse following bilateral sagittal split osteotomy. MDS Thesis, University of Adleiade, South Australia, 1989.

Hiranaka DK, Kelly JP. Stability of simultaneous orthognathic surgery on the maxilla and mandible: a computer-assisted cephalometric study. Int J Adult Orthodon Orthognath Surg 1987; 2:193-213.

Hixon EH. Cephalometrica and longitudinal research. Am J Orthod 1960; 46:36-42.

Hoenig JF. Sliding osteotomy genioplasty for facial aesthetic balance: 10 years of experience. Aesthetic Plast Surg 2007; 31:384-91.

Hoffman GR, Brennan PA. The skeletal stability of one-piece Le Fort 1 osteotomy to advance the maxilla; Part 1. Stability resulting from non-bone grafted rigid fixation. Br J Oral Maxillofac Surg 2004; 42:221-25.

Hönn M, Dietz K, Eiselt ML, Göz G. Attractiveness of facial profiles as rated by individuals with different levels of education. J Orofac Orthop 2008; 69:20-30.

Hönn M, Dietz K, Godt A, Göz G. Perceived relative attractiveness of facial profiles with varying degree of skeletal anomalies. J Orofac Orthop 2005; 66:187-96.

Houston WJ. A comparison of the reliability of measurement of cephalometric radiographs by tracings and direct digitization. Swed Dent J Suppl 1982; 15:99-103.

Houston WJ. The analysis of errors in orthodontic measurements. Am J Orthod 1983; 83:382-90.

Houston WJ, Lee RT. Accuracy of different methods of radiographic superimposition on cranial base structures. Eur J Orthod 1985; 7:127-35.

Houston WJ, Maher RE, McElroy D, Sherriff M. Sources of error in measurements from cephalometric radiographs. Eur J Orthod 1986; 8:149-51.

Hullihen SB. Case of elongation of the under jaw and distortion of the face and neck, caused by a burn, successfully treated. Am J Orthodont 1849;13: 67.

Hunt OT, Johnston CD, Hepper PG, Burden DJ. The psychological impact of orthognathic surgery: A systematic review. Am J Orthod Dentofacial Orthop 2001; 120:490-7.

Hurst RV, Schwaninger B, Shaye R. Interobserver reliability in xeroradiographic cephalometry. Am J Orthod 1979; 75:179-83.

Hwang SJ, Haers PE, Seifert B, Sailer HF. Non-surgical risk factors for condylar resorption after orthognathic surgery. J Craniomaxillofac Surg 2004; 32:103-11.

Jakobsone G, Stenvik A, Sandvik L, Espeland L. Three-year follow-up of bimaxillary surgery to correct skeletal ClassIII malocclusion: Stability and risk factors for relapse. Am J Orthod Dentofacial Orthop 2011; 1:80-9.

Johanson B, Kahnberg KE, Lilja J, Ridell A. Surgical correction of mandibular prognathism by the oblique sliding osteotomy. A clinical and radiological follow-up study of 112 consecutive cases. Scand J Plast Reconstr Surg 1979; 13:453-60.

Jones DL, Wolford LM, Hartog JM. Comparison of methods to assess neurosensory alterations following orthognathic surgery. Int Adult Orthod Orthognath Surg 1990; 5:35-42.

Jones RB, McCallum RM, Kay EJ, Kirkin V, McDonald P. Oral health behaviour in a population of diabetic outpatient clinic attenders. Community Dent Oral Epidemiol 1992; 20:204-7.

Joss CU, Thüer UW. Stability of the hard and soft tissue profile after mandibular advancement in sagittal split osteotomies: a longitudinal and long-term follow-up study. Eur J Orthod 2008a; 30:16-23.

Joss CU, Thüer UW. Stability of hard tissue profile after mandibular setback in sagittal split osteotomies: a longitudinal and long-term follow-up study. Eur J Orthod 2008b; 30:352-8.

Joss CU, Vassalli IM. Stability after bilateral sagittal split osteotomy setback surgery with rigid internal fixation: a systematic review. J Oral Maxillofac Surg 2008; 66:1634-43.

Joss CU, Vassalli IM. Stability after bilateral sagittal split osteotomy advancement surgery with rigid internal fixation: a systematic review. J Oral Maxillofac Surg 2009; 67:301-13.

Kahnberg KE, Kashani H, Owman-Moll P. Sagittal split advancement osteotomy: Comparison of the tendency to relapse after two different methods of rigid fixation. Scand J Plast Reconstr Surg Hand Surg 2007; 41:167-72.

Kahnberg KE, Ridell A. Combined Le Fort I osteotomy and oblique sliding osteotomy of the mandibular rami. A follow-up. J Craniomaxillofac Surg 1988; 16:151-6.

Kerr WJ, O'Donnell JM. Panel perception of facial attractiveness. Br J Orthod 1990; 17:299-304.

Kerstens HC, Tuinzing DB, Golding RP, van der Kwast WA. Condylar atrophy and osteoarthrosis after bimaxillary surgery. Oral Surg Oral Med Oral Pathol 1990; 69:274-80.

Kiyak HA, McNeill RW, West RA, Hohl T, Heaton PJ. Personality characteristics as predictors and sequelae of surgical and conventional orthodontics. Am J Orthod 1986; 89:383-92.

Kiyak HA, Hohl T, Sherrick P, West RA, McNeill RW, Bucher F. Sex differences in motives for and outcomes of orthognathic surgery. J Oral Surg 1981; 39:757-64.

Kiyak HA, McNeill RW, West RA, Hohl T, Bucher F, Sherrick P. Kiyak HA, McNeill RW, West RA, Hohl T, Bucher F, Sherrick P. J Oral Maxillofac Surg 1982a; 40:150-5.

Kiyak HA, McNeill RW, West RA. The emotional impact of orthognathic surgery and conventional orthodontics. Am J Orthod 1985; 88:224-34.

Kiyak HA, West RA, Hohl T, McNeill RW. The psychological impact of orthognathic surgery: a 9-month follow-up. Am J Orthod 1982b; 81:404-12.

Knight H, Keith O. Ranking of facial attractiveness. Eur J Orthod 2005; 27:340-8.

Kobayashi T, Watanabe I, Ueda K, Nakajima T. Stability of the mandible after sagittal ramus osteotomy for correction of prognathism. J Oral Maxillofac Surg 1986; 44:693-97.

Komori E, Aigase K, Sugisaki M, Tanabe H. Cause of early skeletal relapse after mandibular setback. Am J Orthod Dentofacial Orthop 1989; 95:29-36.

Koski K, Virolainen K. *On* the relationships between roentgenographic lines of reference. Acta Odont Scand 1956; 14:23-32.

Krogman WM. Validation of the roetgenographic cephalometric technique. Am J Orthod 1958; 44:933-39.

LaBanc JP, Turvey T, Epker BN. Results following simultaneous mobilization of the maxilla and mandible for the correction of dentofacial deformities: analysis of 100 consecutive patients. Oral Surg Oral Med Oral Pathol 1982; 54:607-12.

Lai SS, Tseng YC, Huang IY, Yang YH, Shen YS, Chen CM. Skeletal changes after modified intraoral vertical ramus osteotomy for correction of mandibular prognathism. J Plast Reconstr Aesthet Surg 2007; 60:139-45.

Lam T, Kiyak HA, Hohl T, West RA, McNeill RW. Recreational and social activities of orthognathic surgery patients. Am J Orthod 1983; 83:143-52.

Laufer D, Glick D, Gutman D, Sharon A. Patient motivation and response to surgical correction of prognathism. Oral Surg Oral Med Oral Pathol 1976; 41:309-13.

Lindorf HH, Steinhauser EW. Correction of jaw deformities involving simultaneous osteotomy of the mandible and maxilla. J Maxillofac Surg 1978; 6:239-44.

Lines PA, Lines RR, Lines CA. Profilemetrics and facial aesthetics. Am J Orthod 1978; 73:648-57.

Louis PJ, Waite PD, Austin RB. Long-term skeletal stability after rigid fixation of Le Fort osteotomies with advancements. Int J Oral Maxillofac Surg 1993; 22:82-6.

Lovius BB, Jones RB, Pospisil OA, Reid D, Slade PD, Wynne TH. The specific psychosocial effects of orthognathic surgery. J Craniomaxillofac Surg 1990; 18:339-42.

Luyk NH, Whitfield PH, Ward-Booth RP, Williams ED. The reproducibility of the natural head position in lateral cephalometric radiographs. Br J Oral Maxillofac Surg 1986; 24:357-66.

Malekmakan L, Haghpanah S, Pakfetrat M, Ebrahimic Z, Hasanlic E. Oral health status in Iranian hemodialysis patients. Indian J Nephrol 2011; 21:235-8.

Maple JR, Viq KW, Beck FM, Larsen PE, Shanker S. A comparison of providers' and consumers' perception of facial-profile attractiveness. Am J Orthod Dentofacial Orthop 2005; 128:690-6.

Marcotte MR. Head posture and dentofacial proportions. Angle Orthod 1981; 51:208-13.

Marcus P. Psychological aspects of cosmetic rhinoplasty. Br J Plast Surg 1984; 37:313-8.

Martinoni L. Improving petrous bone reproduction in lateral cephalometric films. Am J Orthod 1978; 73:161-8.

Mazor KM, Clauser BE, Field T, Yood RA, Gurwitz JH. A demonstration of the impact of response bias on the results of patient satisfaction surveys. Health Serv Res 2002; 37:1403-17.

Mechanic D. The concept of illness behaviour. J Chron Dis 1962; 15:189-94.

McCallum J. The SF-36 in an Australian sample: validation. Australian Journal of Public Health. 1995; 19:160-166.

McClure SR, Sadowsky PL, Ferreira A, Jacobson A. Reliability of digital verus conventional cephalometric radiology: A comparative evaluation of landmark identification error. Semin Orthod 2005; 11:98-110.

McHorney JE, Ware JE, Raczek AE. The MOS 36-item short form health survey (SF-36): III. Tests of data quality, scaling assumptions and reliability across diverse patient groups. Medical Care. 1994; 32:247-263.

Merkx MA, Van Damme PA. Condylar resorption after orthognathic surgery. Evaluation of treatment in 8 patients. J Craniomaxillofac Surg 1994; 22:53-8.

Midtgård J, Björk G, Linder-Aronson S. Reproducibility of cephalometric landmarks and errors of measurements of cephalometric cranial distances. Angle Orthod 1974; 44:56-61.

Miller PA, Savara BS, Singh IJ. Analysis of errors in cephalometric measurement of three-dimensional distances on the maxilla. Angle Orthod 1966; 36:169-75.

Mobarak KA, Espeland L, Krogstad O, Lyberg T. Mandibular advancement surgery in high-angle and low-angle class II patients: different long-term skeletal responses. Am J Orthod Dentofacial Orthop 2001; 119:368-81.

Mobarak KA, Krogstad O, Espeland L, Lyberg T. Long-term stability of mandibular setback surgery: a follow-up of 80 bilateral sagittal split osteotomy patients. Int J Adult Orthodon Orthognath Surg 2000; 15:83-95.

Modig M, Andersson L, Wårdh I. Patients' perception of improvement after orthognathic surgery: pilot study. Br J Oral Maxillofac Surg 2006; 44:24-7.

Moenning JE, Bussard DA, Lapp TH, Garrison BT. Comparison of relapse in bilateral sagittal split osteotomies for mandibular advancement: rigid internal fixation (screws) versus inferior border wiring with anterior skeletal fixation. Int J Adult Orthodon Orthognath Surg 1990; 5:175-82.

Mommaerts MY. Lag screw versus wire osteosynthesis in mandibular advancement. Int J Adult Orthodon Orthognath Surg 1991; 6:153-60.

Montini RW, McGorray SP, Wheeler TT, Dolce C. Perceptions of orthognathic surgery patient’s change in profile. A five-year follow-up. Angle Orthod 2007; 77:5-11.

Moore KE, Gooris PJ, Stoelinga PJ. The contributing role of condylar resorption to skeletal relapse following mandibular advancement surgery: report of five cases. J Oral Maxillofac Surg 1991; 49:448-60.

Moser K, Freihofer HP. Long-term experience with simultaneous movement of the upper and lower jaw. J Maxillofac Surg 1980; 8:271-7.

Motegi E, Hatch JP, Rugh JD, Yamaquchi H. Health-related quality of life and psychosocial function 5 years after orthognathic surgery. Am J Orthod Dentofacial Orthop 2003; 124:138-43.

Moyers RE, Bookstein FL. The inappropriateness of conventional cephalometrics. Am J Orthod 1979; 75:599-617.

Nagasaka S, Fujimura T, Segoshi K. Development of a non-radiographic cephalometric system. Eur J Orthod 2003; 25:77-85.

Nicodemo D, Pereira MD, Ferreira LM. Effect of orthognathic surgery for class III correction on quality of life as measured by SF-36. Int J Oral Maxillofac Surg 2008; 37:131-4.

Pahkala RH, Kellokoski JK. Surgical-orthodontic treatment and patients' functional and psychosocial well-being. Am J Orthod Dentofacial Orthop 2007; 132:158-64.

Pancherz H, Hansen K. The nasion-sella reference line in cephalometry: a methodologic study. Am J Orthod 1984; 86:427-34.

Pepersack WJ, Chausse JM. Long term follow-up of the sagittal splitting technique for correction of mandibular prognathism. J Maxillofac Surg 1978; 6:117-40.

Perrott DH, Lu YF, Pogrel MA, Kaban LB.Stability of sagittal split osteotomies. A comparison of three stabilization techniques. Oral Surg Oral Med Oral Pathol 1994; 78:696-704.

Phillips C, Trentini CJ, Douvartzidis N. The effect of treatment on facial attractiveness. J Oral Maxillofac Surg 1992; 50:590-4.

Pilowsky I. The diagnosis of abnormal illness behaviour. Aust NZ J Psychiatry 1971; 5:136-8.

Pilowsky I, Spence N, Cobb J, Katsikitis M. The Illness Behavior Questionnaire as an aid to clinical assessment. Gen Hosp Psychiatry 1984; 6:123-30.

Politi M, Costa F, Cian R, Polini F, Robiony M. Stability of skeletal class III malocclusion after combined maxillary and mandibular procedures: rigid internal fixation versus wire osteosynthesis of the mandible. J Oral Maxillofac Surg 2004; 62:169-81.

Polk MS Jr, Farman AG, Yancey JA, Gholston LR, Johnson BE, Reqennitter FJ. Soft tissue profile: a survey of African-American preference. Am J Orthod Dentofacial Orthop 1995; 108:90-101.

Prior KN, Bond MJ. The measurement of abnormal illness behavior: toward a new research agenda for the Illness Behavior Questionnaire. J Psychosom Res 2008; 64:245-53.

Proffit WR, Phillips C, Dann C 4th, Turvey TA. Stability after surgical-orthodontic correction of skeletal Class III malocclusion. I. Mandibular setback. Int J Adult Orthodon Orthognath Surg 1991;6 :7-18.

Proffit WR, Turvey TA, Phillips C. The hierarchy of stability and predictability in orthognathic surgery with rigid fixation: an update and extension. Head Face Med 2007;3:21.

Proffit WR, White RP Jr. Who needs surgical-orthodontic treatment?. Int J Adult Orthodon Orthognath Surg 1990; 5:81-9.

Reitzik M. The surgical correction of mandibular prognathism using rigid internal fixation--a report of a new technique together with its long-term stability. Ann R Coll Surg Engl 1988; 70:380-5.

Richardson A. A comparison of traditional and computerized methods of cephalometric analysis. Eur J Orthod 1981; 3:15-20.

Roden-Johnson D, English J, Gallerano R. Comparison of hand-traced and computerized cephalograms: landmark identification, measurement, and superimposition accuracy. Am J Orthod Dentofacial Orthop 2008; 133:556-64.

Romani KL, Agahi F, Nanda R, Zernik JH. Evaluation of horizontal and vertical differences in facial profiles by orthodontists and lay people. Angle Orthod 1993; 63:175-82.

Rosenquist B, Wall G. Mobility of the osteotomy site following Le Fort I osteotomy stabilized by titanium plate osteosynthesis. J Oral Maxillofac Surg 1995; 53:1276-82.

Salzmann JA. Limitations of roentgenographic cephalometrics. Am J Orthod 1964; 50:169-87.

Sambrook P. Psychological aspects of dentofacial surgery patients. MDS Thesis, University of Adelaide, South Australia.

Satrom KD, Sinclair PM, Wolford LM. The stability of double jaw surgery: a comparison of rigid versus wire fixation. Am J Orthod Dentofacial Orthop 1991; 99:550-63.

Savage AW, Showfety KJ, Yancey J. Repeated measures analysis of geometrically constructed and directly determined cephalometric points. Am J Orthod Dentofacial Orthop 1987;91: 295-9.

Scheerlinck JP, Stoelinga PJ, Blijdorp PA, Brouns JJ, Nijs ML. Sagittal split advancement osteotomies stabilized with miniplates. A 2-5-year follow-up. Int J Oral Maxillofac Surg 1994; 23:127-31.

Schendel SA. Genioplasty: a physiological approach. Ann Plast Surg 1985; 14:506-14.

Schendel SA, Eisenfeld J, Bell WH, Epker BN, Mishelevich DJ. The long face syndrome: vertical maxillary excess. Am J Orthod 1976; 70:398-408.

Schendel SA, Epker BN. Results after mandibular advancement surgery: an analysis of 87 cases. J Oral Surg 1980;38: 265-82.

Schulze RK, Gloede MB, Doll GM. Landmark identification on direct digital versus film-based cephalometric radiographs: a human skull study. Am J Orthod Dentofacial Orthop 2002; 122:635-42.

Scott JH. The growth of the human face. Proc Roy Soc Med 1953; 47:91-100.

Secord PF, Jourard SM. The appraisal of body-cathexis: body-cathexis and the self. J Consullt Psychol 1953; 17:343-7.

Sekiguchi T, Savara BS. Variability of cephalometric landmarks used for face growth studies. Am J Orthod 1972; 61:603-18.

Shelly A, Southard T, Southard K, Casko J, Jakobsen J, Fridrich K, Mergen J. Evaluation of profile aesthetic change with mandibular advancement surgery. Am J Orthod Dentofacial Orthop 2000; 117:630-37.

Showfety KJ, Vig PS, Matteson S, Phillips C. Associations between the postural orientation of sella-nasion and skeletodental morphology. Angle Orthod 1987; 57:99-112.

Sluiter RM, Ligthelm-Bakker AS, Wattel E. A new method for computer aided serial radiograph superimposition. Eur J Orthod 1985; 7:103-07.

Sorokolit CA, Nanda RS. Assessment of the stability of mandibular setback procedures with rigid fixation. J Oral Maxillofac Surg 1990; 48:817-22.

Speculand B. Temporomandibular joint dysfunction pain, illness behaviour, and recent stressful life events experience. MDS Thesis, Univ. Bristol 1982.

Speculand B, Goss AN. Psychological factors in temporomandibular joint dysfunction pain. A review. Int J Oral Surg 1985;14:131-7.

Speculand B, Goss AN, Hughes A, Spence ND, Pilowsky I. Temporo-mandibular joint dysfunction: pain and illness behaviour. Pain 1983;17:139-50.

Speculand B, Goss AN, Spence ND, Pilowsky I. Intractable facial pain and illness behaviour. Pain 1981;11:213-9.

Stabrun AE, Danielsen K. Precision in cephalometric landmark identification. Eur J Orthod 1982;4: 185-96.

Stearns JW, Fonseca RJ, Saker M. Revascularization and healing of orthognathic surgical procedures. In: Fonseca RJ (ed) Oral and maxillofacial surgery. Philadelphia, Pa: WB Saunders Co.; 2000.

Steiner CC. Cephalometrics for you and me. Am J Orthod 1953; 39:729-55.

Tannure PN, Costa Mde C, Küchler EC, Romanos HF, Granjeiro JM, Vieira AR. Caries experience in individuals with cleft lip and palate. Pediatr Dent 2012; 34:127-31.

Trauner R, Obwegeser H. The surgical correction of mandibular prognathism and retrognathia with consideration of genioplasty. I. Surgical procedures to correct mandibular prognathism and reshaping of the chin. Oral Surg Oral Med Oral Pathol 1957; 10:677-89.

Tsang ST, McFadden LR, Wiltshire WA, Pershad N, Baker AB. Profile changes in orthodontic patients treated with mandibular advancement surgery. Am J Orthod Dentofacial Orthop 2009; 135:66-72. (82).

Trpkova B, Major P, Prasad N, Nebbe B. Cephalometric landmarks identification and reproducibility: a meta analysis. Am J Orthod Dentofacial Orthop 1997; 112:165-70.

Turvey TA. Orthognathic surgery: a significant contribution to facial and dental aesthetics. J Am Dent Assoc 1988;117: 49E-55E.

Turvey T, Hall DJ, Fish LC, Epker BN. Surgical-orthodontic treatment planning for simultaneous mobilization of the maxilla and mandible in the correction of dentofacial deformities. Oral Surg Oral Med Oral Pathol 1982; 54:491-8.

Turvey TA, Phillips C, Zaytoun HS Jr, Proffit WR. Simultaneous superior repositioning of the maxilla and mandibular advancement. A report on stability. Am J Orthod Dentofacial Orthop 1988; 94:372-83.

Van Sickels JE, Dolce C, Keeling S, Tiner BD, Clark GM, Rugh JD. Technical factors accounting for stability of a bilateral sagittal split osteotomy advancement: wire osteosynthesis versus rigid fixation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000; 89:19-23.

Van Sickels JE, Flanary CM. Stability associated with mandibular advancement treated by rigid osseous fixation. J Oral Maxillofac Surg 1985; 43:338-41.

Van Sickels JE, Larsen AJ, Thrash WJ. Relapse after rigid fixation of mandibular advancement. J Oral Maxillofac Surg 1986; 44:698-702.

Van Sickels JE, Larsen AJ, Thrash WJ. A retrospective study of relapse in rigidly fixated sagittal split osteotomies: contributing factors. Am J Orthod Dentofacial Orthop 1988;93:413-8.

Van Steenbergen E, Litt MD, Nanda R. Presurgical satisfaction with facial appearance in orthognathic surgery patients. Am J Orthod Dentofacial Orthop 1996;109:653-9.

Ware JE, Snow KK, Kosinski M, Gandek B. SF-36 ® Health Survey Manual and Interpretation Guide. Boston, MA: New England Medical Centre, The Health Institute, 1993.

Watzke IM, Turvey TA, Phillips C, Proffit WR. Stability of mandibular advancement after sagittal osteotomy with screw or wire fixation: a comparative study. J Oral Maxillofac Surg 1990;48:108-21.

Wei SH. The variability of roentogenographic cephalometric lines of references. Angle Orthod 1968;38:74-8.

Will LA, West RA. Factors influencing the stability of the sagittal split osteotomy for mandibular advancement. J Oral Maxillofac Surg 1989;47:813-8.

Williams AC, Shah H, Sandy JR, Travess HC. Patients' motivations for treatment and their experiences of orthodontic preparation fororthognathic surgery. J Orthod 2005;32:191-202.

Williams P, Macdonald A. The effect of non-response bias on the results of two-stage screening surveys of psychiatric disorder. Soc Psychiatry 1986; 21:182-6.

Wolford LM, Fields RT. Surgical planning 1999. In: Booth PW, Schendel SA, Hausman J-E (eds) Maxillofacial surgery. Churchill Livingstone, Edinburgh, pp. 1205-1257.

Yoshida T, Nagamine T, Kobayashi T, Michimi N, Nakajima T, Sasakura H, Hanada K. Impairment of the inferior alveolar nerve after sagittal split osteotomy. J Craniomaxillofac Surg 1989;17:271-78.

Yoshioka I, Khanal A, Tominaga K, Horie A, Furuta N, Fukuda J. Vertical ramus versus sagittal split osteotomies: comparison of stability after mandibular setback. J Oral Maxillofac Surg 2008;66:1138-44.

Zojali R, Javanbakht M, Ghanadan A, Hosien H, Sadeghi H. High prevalence of personality abnormalities in patients seeking rhinoplasty. Otolaryngol Head Neck Surg 2007;137: 83-7.