CRANIOFACIAL GROWTH CHANGES IN MALAYSIAN MALAY CHILDREN AND YOUNG ADULTS: A CROSS-SECTIONAL 3-DIMENSIONAL CT STUDY

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DECLARATION

I declare that this thesis contains no material which has been accepted for the award of any other degree or diploma in any other University and that, to the best of my knowledge and belief, the thesis contains no material previously published or written by another person, except where due reference is made in the text.

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SUMMARY

This thesis presents a three-dimensional computed tomography (3D-CT) analysis of craniofacial morphology and growth changes in Malaysian Malay subjects. A large number of CT scans (n=205) from birth to adulthood were gathered for this purpose. CT scans were obtained using a GE Lightspeed Plus Scanner. Craniofacial morphology has been analysed based on cephalometric landmarks located in three-dimensions, using specially-designed computer software.

The main aims were to produce new 3D normative reference data for selected craniofacial variables in Malaysian Malays and to study growth changes in different craniofacial regions.

The specific areas of investigation included:

1. Construction of craniofacial growth references (in tabular and graphical formats) for Malaysian Malays;
2. Quantitative analysis of growth changes in the craniofacial complex using linear and angular measurements derived from landmark data;
3. Comparison of craniofacial measurements between males and females to determine the extent of sexual dimorphism;
4. Quantitative analysis of the nature and extent of directional asymmetry of selected craniofacial regions;
5. Comparisons of selected variables with published data from other ethnic groups.

Craniofacial morphology and growth changes were analysed using 3D osseous landmarks. A computer program, PERSONA, was used to locate and analyse the three-dimensional cephalometric landmarks. The accuracy of landmark location was assessed using double determinations. Selected measurements were derived from the landmark data to describe the morphology of different craniofacial regions, e.g. facial skeleton, cranial base and cranial vault.

Normative reference data for a large number of variables covering the skull, cranial base and face at selected age categories for males and females were constructed. These data were presented in tables and scatter plots of variables against age. From the normative data collected, patterns of growth changes of different craniofacial regions in three-dimensions were also investigated.

Generally, each craniofacial region showed a unique growth pattern as observed from differential growth patterns. All measurements showed size increase from infancy to adulthood. Periods of increased size differences were also noted for most variables in all regions that corresponded to the timing of mid- and adolescent growth spurts.

These extensive normative reference data, specific for age categories and sexes, provide normal references against which the craniofacial morphology of individuals with craniofacial abnormalities can be compared. Clinical applications of this quantitative approach to the craniofacial skeleton should facilitate the management of craniofacial abnormalities.

Following the construction of normative data and description of growth changes for different craniofacial regions, intra-populational differences were studied. This included analysis of sexual dimorphism of the craniofacial structures and an investigation of asymmetry between paired left and right measurements.

Sexual dimorphism was observed for linear variables in this study. Differences in size between males and females were not very obvious during infancy as only a few variables showed significant differences. The number of variables that showed sexual dimorphism in size increased from infancy to adulthood. Sexual dimorphism in the craniofacial region was most evident during adulthood with 46% of variables displaying significant differences between the sexes. During infancy, only 3% of the variables showed significant size differences between the sexes, increasing to 7% during childhood. Magnitudes of sexual dimorphism were calculated to highlight the pattern of dimorphism in different craniofacial regions and across different ages.

A small degree of directional asymmetry was noted in all of the craniofacial regions investigated. Asymmetry analysis revealed that the cranial base, face and mandible tended to be larger on the right side than the left. Other regions exhibited asymmetry but without any clear trend in direction. Asymmetry percentages were also calculated to enable the patterns and magnitudes of asymmetry in different craniofacial regions to be compared. Generally, the amount of asymmetry exhibited in the craniofacial structures for Malaysian Malays was small.

Having established that differences existed within the Malay sample, craniofacial data for Malays were compared with published data for two Caucasian populations. This analysis revealed that differences exist in craniofacial morphology between different ethnic groups. Some of the differences can be discerned from childhood but many variables only display differences during adulthood. Craniofacial structures tended to be smaller in Malays than in Caucasians.

The intent of this investigation has been to provide clinicians with normative values of measurements that will be useful in diagnosis, treatment planning and post-operative care of patients with craniofacial abnormalities. Important treatment goals include producing a

balanced cranial and facial form to approximate that of unaffected people and also improving the quality of life of patients. Therefore, it is important for clinicians to be able to recognise the nature and extent of normal variation in craniofacial structures and also appreciate the growth changes that may occur over time, before investigating these changes in patients with craniofacial abnormalities. Comparisons of measurements of affected patients with well-characterised referent data can facilitate diagnosis and overall patient management. Moreover, quantification based on three-dimensional data provides new insights into craniofacial growth changes and morphology compared with conventional 2D approaches.

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