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Three-dimensional quantitative evaluation of facial morphology in adults with unilateral cleft lip and palate, and patients without clefts

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Abstract

The aims of this study were to assess the quantitative values of measurements using proportion indices in the craniofacial region in patients with repaired, non-syndromic, complete unilateral cleft lip and palate (UCLP), and compare them with a control group who did not have clefts using the non-invasive systems of 3-dimensional technology. Three-dimensional measurements of the facial surfaces of 15 Malay patients who had UCLP repaired and 100 Malay control patients aged 18–25 years were analysed. The 3-dimensional images of the respondents' faces were captured using the VECTRA-3D Stereophotogrammetry System. Eleven craniofacial proportions were assessed using a combination of 18 linear measurements obtained from 21 anthropometric soft tissue landmarks. These measurements were used to produce proportion indices to find the differences in the morphological features between the groups, and assessed using the independent sample *t* test and *z* scores. There were significant differences between the groups in 7 out of 11 craniofacial proportion indices ($p = 0.001$–0.044). *Z* scores of 2 indices were disproportionate. They were nasal index (which was severely supernormal) and upper lip index (which was moderately supernormal). Patients with UCLP had higher mean *z* scores, indicating that patients with UCLP tended to have larger faces than the control group. There were clinically important differences mainly in the nasolabial area, where the nose and the upper lip were wider, larger, or flatter in patients with UCLP.

Keywords: Cleft lip and palate; Facial morphology; Quantitative evaluation; Stereophotogrammetry; Three-dimensional analysis

Introduction

Quantitative assessment of patients with CLP that involves facial measurements between specified facial landmarks can be either direct on live subjects,[1] or indirect using soft tissue radiography,[2] plaster casts,[3] 2-dimensional photographs,[4,5] and 3-dimensional imaging.[6,7] Craniofacial anthropometry is important in clinical assessments such as planning and evaluation of treatment and assessment of outcome in various medical fields, particularly in dentistry.[8–10] Apart from that it is also useful in the diagnosis of syndromes, to estimate normal and abnormal growth, and plan and evaluate surgical or orthodontic treatment.[11]

Traditionally, facial morphology has always been analysed through observation and visual examination to identify the craniofacial complexity in facial anomalies. However, direct measurement of subjects has many disadvantages. It

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is time-consuming, requires the cooperation of the patient, poses risks of injury, and usually identifies only the most obvious proportions on the face to find imbalance. Visual judgement is also influenced by the most striking disproportions but usually cannot isolate the factors that cause them.[12] The calculation of indices and proportions were, therefore, introduced to estimate the quality of facial morphology. One of the uses of anthropometric proportion indices is in the measurement of facial attractiveness as an evaluation of surgical-orthodontic treatment.[13]

Non-invasive 3-dimensional technology systems have been developed in dentistry over the last decade. Currently, 3-dimensional stereophotogrammetry imaging systems are more reliable and have become the gold standard.[14] They provide surgeons, orthodontists, and others who deal with craniofacial structure with the opportunity to develop new approaches to the diagnosis and management of patients.[15] Although there are many publications about anthropometric measurement of the craniofacial complex, there are not many that document the measurement on subjects with CLP using proportion indices and 3-dimensional technology.

The aim of this study therefore was to assess the quantitative values of measurements using proportion indices in the several craniofacial regions in patients with repaired, non-syndromic, complete unilateral cleft lip and palate (UCLP), and compare their results with those of a control group without clefts using non-invasive 3-dimensional technology systems.

Materials and methods

Sample

The study sample comprised 15 patients with UCLP (5 men and 10 women) aged between 18 and 25 years who had attended the Combined Cleft Lip and Palate Clinic at the Faculty of Dentistry, University of Malaya. Inclusion criteria were: age between 18 and 25 years and they had repaired, non-syndromic, complete UCLP. The lip had been repaired at 3 months of age (Millard and Delaire) and they had palatal surgery at 9 months of age (Von Lagenbeck and Two Flap), the operations done by either a plastic or an oral maxillofacial surgeon. In addition, they had no orthognathic surgery before imaging, and they were of second generation Malay ethnicity.

One hundred respondents who had not had clefts (50 men and 50 women) aged between 18 and 25 years were selected from one of the private colleges in Kuala Lumpur. Inclusion criteria were: age between 18 and 25 years; they had no facial clefts or other facial abnormalities; they had no previous orthodontic treatment; and they were of second generation Malay ethnicity.

Ethical and written approval for this study was obtained from the Medical Ethics Committee, Faculty of Dentistry, University of Malaya [DF CD1211/0059(L)]. Verbal and written consent was also obtained from the participants. A questionnaire was used to confirm that all parents and grandparents were Malays and there had been no inter-racial marriages.

Capture, measurement, and analysis of 3-dimensional images

All 3-dimensional facial images were captured using the VECTRA-3D dual module system for full-face imaging (Canfield Scientific Inc., Fairfield, NJ, USA). The cameras were calibrated before the image was captured using the manufacturer's guidelines to ensure consistency and magnification. The subjects were seated 95 cm in front of the camera on a self-adjustable stool and each subject's head position was seen by live video preview, which is one of the features of the VECTRA-3D. The 3-dimensional images of the subjects were produced with a capture time of two milliseconds/image, and the scanned images were then displayed and analysed with the 3D Mirror Software.

A total of 18 linear measurements derived from 21 anthropometric soft tissue landmarks were recorded (mm) from 4 regions of the craniofacial complex (face, orbits, nose, and orolabial area) (Fig. 1).[12,16,17] Eleven craniofacial proportion indices were derived from the combination of these 18 linear measurements (Table 1).[12,16] All measurements and analysis were made by one assessor.

Method error

Thirty 3-dimensional facial images were selected at random from each group, and landmarks were identified and measurements made after a 2-week interval. The measurements obtained were compared with the first measurements to assess the reliability of measurements from repeat identification of landmarks. The intraclass correlation coefficient test (ICC) was used to assess the reproducibility of the 2 readings. ICC for all measurements ranged from 0.66 to 0.97, and indicated moderate to good reliability and reproducibility of all soft tissue landmarks.

Statistical analysis

The proportion index values were calculated by comparing the UCLP subjects with the control subjects. The proportion indices were converted to z scores by using the following formula: $z = (x - \mu)/\sigma$; where $z = z$ scores; $x =$ UCLP patient's facial index; $\mu =$ mean of the control subjects; and $\sigma =$ SD of the control subjects.

Z scores are a statistical measurement to see how far the evaluated data deviate from the mean of the normal measurements. The anthropometric categories for z scores were classified based on the normal values: harmony (-1.0 to $+1.0$) and disharmony (-1.0 to -2.0 or $+1.0$ to $+2.0$). Disproportions were: mildly subnormal (-2.01 to -2.50), moderately subnormal (-2.51 to -3.00), severely subnormal (-3.01