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# Soft tissue morphology of the naso-maxillary complex following surgical correction of maxillary hypoplasia

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*Abstract.* Orthognathic surgery is undergone to improve facial and dental aesthetics and to improve function. Three dimensional (3D) soft tissue analysis based on stereophotogrammetry provides a realistic measurement of facial morphology. There is a need for objective assessment of surgery outcomes. The study aim was to evaluate the 3D naso-maxillary complex soft tissue morphology following Le Fort I maxillary advancement and compare the findings with a local reference group. 3D images of 112 volunteers were captured using stereophotogrammetry and viewed by 8 lay people; 40 images (16 males and 24 females) were chosen as the reference group to have harmonious facial appearance. The linear and angular measurements of this group were compared with 35 patients (19 female and 16 male) who had maxillary advancement in the post-surgical group. Facial morphology post-surgery was similar to the reference group, except the nasal base width which was wider by 2.3 mm in males and 2.6 mm in females. In the orthognathic group, the females had a smaller nasolabial angle by 9.7° than the reference group. In conclusion, 3D imaging is a sensitive tool for analysing facial appearance. Compared with a control group, statistical differences were identified in soft tissue morphology which should be considered in surgical planning and patient consent.

Keywords: 3D; soft tissue morphology; orthognathic; Le Fort I advancement.

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The primary objective of orthognathic surgery is to improve facial and dental aesthetics to an acceptable clinical standard often with the secondary objective of improving function.[1,12] For the majority of patients the improvement in their soft tissue appearance is the prime motivating factor for seeking surgical treatment.[12,19]

At present the use of cephalometric 'normal' values aid diagnosis, treatment planning and assessing outcome. The values should be representative of the individual being treated (i.e. ethnicity) and be a true representation of the patient. The available cephalometric values are two dimensional (2D) measurements of three dimensional (3D) facial morphology and therefore lack geometric accuracy. In addition cephalometric measurements are poorly correlated with the perception of facial appearance and they are often not gender specific.[12,13,23] 3D soft tissue analysis based on stereophotogrammetry provides a realistic, meaningful measurement of facial morphology, which informs the clinical evaluation of dentofacial deformity.[6] To date no 'normal' soft tissue 3D data have been published to characterise facial morphology adequately for the British population.

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Subjective assessment of the face showed wide variations amongst clinicians and clear diversity when compared with lay assessors.[1,10,11,17] There is a need for a reliable method to assess facial appearance in an objective manner. Previous studies have used the visual analogue score (VAS) as a method of subjectively assessing facial appearance.[13,22] The VAS is a simple, quick to construct, valid, reliable, convenient, easily understood, readily accepted and easy to administer measurement method that can be used by both lay persons and professionals. There is a growing amount of evidence that showed the VAS to be a fairly reliable, valid and sensitive tool in the measurement of subjective phenomena, allowing scores on a large number of variables to be readily assessed by a panel of judges.[11]

This study was designed to test the hypothesis that following surgical correction of class III skeletal patterns, by maxillary advancement, the final soft tissue appearance of the naso-maxillary complex was similar to an untreated reference group. The aim of the study was to evaluate the 3D facial appearance following the surgical correction of maxillary hypoplasia with a Le Fort I osteotomy and compare the findings with the 3D facial aesthetic norms of a local reference group.

## Materials and methods

Ethical approval was obtained from the Local Area Ethics Committee.

### Sample size calculation

The clinical significance of the difference in landmark location was derived from the results of a previous study and was set at 3 mm.[9] A search of the literature indicated that the majority of soft tissue facial landmarks of potential interest had a standard deviation of $\pm 3.0$ mm.[21] Applying a significance level of 0.05 and a power of 80% a sample size of 16 subjects was required. This meant that within each group a minimum of 16 patients was required.

### Orthognathic group sample selection

In this retrospective study the records of patients who were 18–35 years of age and non-syndromic were selected from the multi-disciplinary dentofacial planning clinic over a two and a half-year period from October 2005 to June 2008. All patients were diagnosed with maxillary deficiency based on a comprehensive clinical and radiographic assessment and treated with a standard Le Fort I advancement procedure. The final position of the maxilla was determined by conventional 2D profile prediction methods and model surgery. None of the patients required any change in the vertical position of the maxilla or had facial asymmetry that required surgical intervention. A cinch stitch was applied if the alar base width had increased more than 3 mm peri-operatively. All patients were followed up post-operatively and full records including 3D images had been taken 1 year following surgery.

The records of 35 (19 female and 16 male) surgically managed cases, which had Le Fort I advancement for correction of maxillary hypoplasia in the anterior–posterior direction, were selected. The mean planned maxillary advancement was 7.5 mm (range 6–11 mm), there was no difference between the male and female groups. Vertical surgical changes were minimal.

### Reference group

112 volunteers were recruited from within the local population from April 2008 to January 2009. Subjects were 18–35 years of age, non-syndromic, had no previous history of facial surgery or facial trauma and were Caucasian with both parents from the same geographic location.

A panel of 4 male and 4 female lay assessors generated the reference group. None of the lay panel had a dental or medical background. Prior to viewing the images, the lay panel were given basic instructions on how to rate them. They were instructed to ignore skin complexion, hair, position of ears and to concentrate on facial appearance with respect to facial balance and harmony. Each lay panel member viewed a PowerPoint presentation, which included an embedded 3D standard facial video clip of each of the participants, in a single sitting. The lay assessors rated each image for overall facial harmony on a 100 mm horizontal VAS scale marked with the anchors 'least attractive' and 'most attractive'.[16]

The VASs were ranked from most attractive to least attractive for each subject. Individuals who were ranked in the top two tertiles by at least 6 lay panel members were chosen to be part of the reference group which generated 40 cases (16 males and 24 females) as the reference group.

### Imaging

Each individual from the reference and surgically managed groups were imaged, by the same operator (BSK) using the Di3D system (Di3D, Dimensional Imaging, Hillington Park, Glasgow, UK), which consisted of two camera stations placed at each side of the face to take a stereo image. Each station contained only a pair of colour high-resolution digital cameras (Eastman Kodak Company, Rochester, NY, USA). The face was simultaneously illuminated by commercial white-light studio flash units (Esprit Digital DX1000, Bowens, Essex, UK). For all captures, subjects were seated on a dental chair directly in front of the camera system (Fig. 1). To standardise the images, the face of each subject was captured in natural head position and lip repose; this was achieved by asking the individuals to say 'Mississippi', and then told to swallow once and say 'N'.[24] It took 1 ms to capture the full face using the two camera stations. A personal computer required less than 5 minutes to produce a 3D model of the captured subject. Prior to image capture, the Di3D system was calibrated. A 3D model of the subjects face was built using Di3D software (Di3D, Dimensional Imaging, Hillington Park, Glasgow, UK).

For each case, the face was captured according to the protocol above. Each image was viewed in the frontal view and then rotated slowly to the left and

*Fig. 1.* The Di3D system.