The Impact of Orthognathic Surgery on Facial Expressions

Ali Al-Hiyali, BDS, MSc, [*] *Ashraf Ayoub, BDS, MDS, PhD,* [†] *Xiangyang Ju, PhD, BENG, MENG,* [‡] *Mohammad Almuzian, BDS, MSc,* [§] *and Thamer Al-Anezi, BMS, BM BCh, BDS, MSc* [‖]

Purpose: The aim of this study was to evaluate the impact of orthognathic surgical correction of facial asymmetry and maxillary hypoplasia on the magnitude and pattern of facial expressions.

Patients and Methods: This study was carried out on 2 cohorts of patients: in group 1, 10 patients had surgical correction of facial asymmetry; in group 2, 13 patients had Le Fort I osteotomy to correct maxillary hypoplasia. The patients were asked to perform 3 facial expressions (maximal smile, lip purse, and cheek puff) that were recorded using the Di4D image-capture system before and after surgery. The capture of each expression generated 180 3-dimensional (3D) facial images. Twenty-seven facial soft tissue landmarks were digitized on the first frame of the 3D image of each expression and a mathematical generic mesh was applied on the 3D model to clone each patient's face. The cloned mesh was superimposed automatically on each sequence of the 3D images to evaluate the pattern of facial expressions. The digitization of facial landmarks was satisfactorily accurate and reproducible.

Results: In group 1, the asymmetry of facial expressions was significantly decreased after surgical correction ($P = .0458$). In group 2, Le Fort I osteotomy decreased the magnitude of facial expressions ($P = .0267$).

Conclusion: This study confirmed that orthognathic surgery affects the dynamics of facial expressions; this should be considered when planning the surgery and informing patients about the surgical correction of dentofacial deformities.

J Oral Maxillofac Surg 73:2380-2390, 2015

Facial expressions are the most common means of communication among humans, with 55% of daily social interactions being nonverbal and dependent on facial expressions.[1] In addition, dentofacial deformities are associated with compromised facial expressions.[2]

In living creatures, flawless bilateral facial and body symmetry is a hypothetical concept that rarely exists. Minor asymmetry exists in pleasing-looking faces and does not require treatment. For minor facial asymmetry, the right half of the face is frequently wider than the left, with the chin deviated to the left.[3]

Maxillary hypoplasia combined with relative mandibular excess results in skeletal Class III skeletal deformity; this deformity esthetically affects the attractiveness of the affected individuals. Most patients with Class III skeletal deformity have the appearance of an angry person and they look older than their actual

[*]Master's Student of Oral and Maxillofacial Surgery, College of Medicine, College of Medical, Veterinary and Life Sciences, Glasgow University Dental Hospital and School, Glasgow, UK.

[†]Professor, Oral and Maxillofacial Surgery, College of Medical, Veterinary and Life Sciences, University of Glasgow Medical School, Glasgow, UK.

[‡]Senior Software Engineer, Medical Devices Unit, NHS Greater Glasgow and Clyde; Honorary Research Fellow, Faculty of Medicine, College of Medical, Veterinary and Life Sciences, Glasgow University Dental Hospital and School, Glasgow, UK.

[§]Master's Student, College of Medical, Veterinary and Life Sciences, Glasgow University Dental Hospital and School, Glasgow, UK.

[‖]Master's Student in Oral and Maxillofacial Surgery, Faculty of Medicine, College of Medical, Veterinary and Life Sciences, Glasgow University Dental Hospital and School, Glasgow, UK.

Conflict of Interest Disclosures: None of the authors reported any disclosures.

Address correspondence and reprint requests to Prof Ashraf: Department of Oral and Maxillofacial Surgery, University of Glasgow, Dental School, 378 Sauchiehall Street, Glasgow G2 3JZ, UK; e-mail: ashraf.Ayoub@glasgow.ac.uk

Received March 11 2015

Accepted May 13 2015

0278-2391/15/00592-3

http://dx.doi.org/10.1016/j.joms.2015.05.008

age; therefore, they seek treatment to improve their facial esthetics.[4] Maxillary hypoplasia and facial asymmetry are among the common facial deformities that are readily correctable with orthognathic surgery.[5-8] However, the impact of orthognathic surgery on facial expressions has not been fully investigated.

The most common concerns of patients who seek orthognathic surgery are the dysmorphology of facial appearance at rest and with facial expressions. Expressions are dependent on the movement of facial muscles and their relation to underlying bones. Therefore, it is logical to assume that orthognathic surgery will alter the orientation of facial muscles. It also has been suggested that postsurgical stability is dependent on muscle balance and that relapse is more likely if the functional impairments of facial expressions persist after orthognathic surgery.[9]

Several studies have assessed the impact of orthognathic surgery on the bony structures and the covering soft tissue[10-14]; however, the impact of orthognathic surgery on the dynamics of facial expressions is rarely investigated.[9,15-17] The published studies on this topic have limitations. The direct placement of multiple markers on a patient's face before image captures can vary between imaging sessions, which introduces inaccuracies into the assessment. Direct application of facial markers also is time consuming for the clinician and requires a high level of cooperation from the patient. Moreover, the application of markers onto the face could prevent the achievement of a natural facial expression.[18,19] The small number of landmarks to describe facial movements limits the comprehensiveness of the analysis and the interpretation of the results.[17]

Various methods have been developed to assess facial expressions,[19-21] some of them are 2-dimensional, including photography and videotaping. However, these methods underestimate the magnitude of facial expressions by 43%.[22] Facial expressions also have been assessed using 3-dimensional (3D) statistic imaging-based systems.[23] However, these methods do not record or analyze the dynamic of facial expressions.

The objective assessment of facial muscle movements requires the recording of the associated expressions in a dynamic state. Static capture of maximum facial expressions does not record the direction, speed, and pattern of facial movements, which limits the robustness of the analysis.[6] Various 3D dynamic motion-capture systems have been developed recently that are based on active stereophotogrammetry, in which a textured pattern is projected onto the face to aid the 3D build of the facial model,[24] or passive stereophotogrammetry, which depends on skin texture to build the 3D facial models.[25] The dynamic imaging system captures 60 3D images of the face per second; the capture of each expressions takes approximately 3 seconds, which generates approximately 180 3D facial images for analysis. Facial landmarks are digitized on the first 3D facial image, and their locations are automatically tracked throughout the sequence of the images of the captured facial expression. The accuracy of the software in tracking the digitized facial landmarks across the sequence of the 3D images of each facial expression captured by a passive stereophotogrammetry imaging system has been validated[26] and the clinical application of the method has been tested.[27]

The purpose of this study was to investigate the impact of orthognathic surgical correction of maxillary hypoplasia and facial asymmetry on facial expressions.

Patients and Methods

This study was carried out on 2 cohorts of patients: 10 patients (5 male and 5 female; 17 to 29 yr old) who had surgical correction of facial asymmetry (group 1) and 13 patients (8 female and 5 male; 18 to 50 yr old) who had had Le Fort I osteotomy to address maxillary hypoplasia (group 2). All patients were treated by the same surgeon and followed a standard protocol of data recording and analysis before and after surgery. Preoperative facial expressions were captured 1 week before surgery and 6 to 18 months after surgery (Table 1) using the Di4D capture system (Dimensional Imaging Ltd, Hilington Park, Glasgow, UK). The system consisted of 2 gray-scale cameras (Model avA 1600-65km/kc; resolution, 1,600 × 1,200 pixels; sensor model KAI-02050; Kodak, Basler, Germany), 1 color camera that captured 60 frames per second, and a lighting system (Model DIV-401-DIVALITE; Kino Flo Corporation, Burbank, CA). The system was connected to a personal computer (Win 8.1 professional; Intel Core i7; CPU, 3.40 GHz; RAM, 32.0 GB). The Di4D system was calibrated before each capture session to synchronize the intrinsic camera parameters. The image recording and building of the dynamic 3D imagines were based on passive stereophotogrammetry, which allowed the automatic tracking of facial landmarks throughout the sequence of the captured images of each facial expression.

Three nonverbal, reproducible facial expressions were captured in this study, which included maximal smile, lip purse, and cheek puff, according to a previously published protocol.[18,20,21] Patients sat in an upright and comfortable position at a 95-cm distance from the cameras. Patients were asked to keep their eyes open and remain relatively still during image capturing. The system's illumination lights were adjusted by the operator to avoid excessive brightness that could affect the patient's facial expressions. Three facial expressions were recorded: maximum smile, lip