Original Article

Three Dimensional Soft Tissue Analysis Of Skeletal Class III Patients After Bimaxillary Orthognathic Surgery Using Laser Surface Scanner.

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Abstract

Objective: The purpose of this study was to assess the effect of bimaxillary orthognathic surgery on the short-term soft tissue changes of facial structures using a laser scanner for 3D facial acquisition.

Materials and methods: Thirty patients were selected for this study with skeletal class III malocclusion that required bimaxillary orthognathic surgery
A Le Fort I maxillary advancement with or without maxillary impaction and a bilateral sagittal split osteotomy were performed. 3D acquisition of the craniofacial structures was obtained by Planmeca ProMax® laser surface scanner, preoperatively and postoperatively after 6 months.

Result: These scans were superimposed over each other and was analyzed by the color-coded map. Bimaxillary orthognathic surgery resulted in soft-tissue changes that were maximized in the central parts of the face than in the lateral parts.

Conclusion: The color-coded analysis provides a better understanding of the three-dimensional soft tissue changes.

Key Words: Soft-Tissue Changes, Orthognathic Surgery, three dimensional, three-dimension, 3D

INTRODUCTION

Skeletal class III deformities can be the result of prognathic mandible with a normally positioned maxilla, retrognathic maxilla with a normal mandible or combination of maxillary retrognathism and mandibular prognathism.(Ackerman et al., 1999)
Orthognathic surgery is required in cases of significant deformities to reposition the skeletal and dental structures in the best aesthetic outcome for the patient. As a result, soft tissue analysis has grown in popularity and is now regarded as a critical component in determining the outcome of orthognathic surgery. (Sykes et al. 2011)
Analysis of the soft tissue has advanced greatly from anthropometry through two-dimensional photogrammetry to the many ways of three-dimensional analysis. (Baik and Kim 2010; Farkas and Deutsch 1996; Shujaat, Khambay, and Ju 2014)
Color coded analysis is considered as one of the most commonly used analysis method, it gives an excellent visual description of the facial surface change after orthognathic surgery. The entire facial surface is involved in the analysis, it produces visually displayed, easily interpreted findings for clinicians and researchers, the method provides both generalized surface measurements as well as localized patches on the area of interest.(Kau et al. 2010; Nanda et al. 2015; Soncul and Bamber 2004)
One of the three dimensional facial acquisition methods is the laser surface scanning that has long been considered as a simple and non-invasive technique for evaluating three-dimensional soft tissue changes. (Baik and Kim 2010; Moss et al. 1994; Verzé et al. 2012)

MATERIAL AND METHODS

The study included thirty patients who required bimaxillary orthognathic surgery for skeletal class III malocclusion. Male and female patients aged 17 years and older were included in this study. Excluding patients with cleft lip and palate, syndromic craniofacial deformity, facial scarring, post traumatic dentofacial deformity or any previous operation involving soft and bony structures.

I- 3D Data Acquisition

All patients were scanned with a standardized pre-operative laser scan using Planmeca ProMax® 3D (Planmeca, Helsinki, Finland) at T0 preoperatively and at T1 6-months postoperatively. Preoperative laser scans were performed on all patients utilising the Planmeca ProMax® 3D (Planmeca, Helsinki, Finland) system at T0 and T1 six months after surgery.

By projecting a classI laser stripe beam with a wavelength of 532 nm from 20 cm away from the subject, the device spins in order to perform a face laser scan. The capture cycle and the facial skin's texture are captured on video by two cameras that are mounted on either side of the laser panel.

The patient is instructed to remove any jewellery or eyeglasses from the head and neck region in order to avoid artefacts, stand still with their head in a natural position while looking in the opposite mirror while the laser machine rotates 360 degrees around them, and relax with their lips in a relaxed position and their teeth together while saying the letter M.

While the vertical rods for head positioning were utilised with the least amount of pressure possible to reduce soft tissue deformation, the chin support was not employed when the patient was positioned. The 3D images are obtained by laser triangulation from the beam projected onto the subject which is then converted into computer generated mesh.(Figure 1)

Figure 1 left image represents a magnified part of the polygonal mesh, middle image is the outline of the full polygonal mesh, right image represents skin textured mapping of the face over the polygonal mesh

II- Operative procedures

All patients received a Bimaxillary Orthognathic Surgery performed by the same surgical team, Le Fort I osteotomy to advance the maxilla with or without impaction and a Bilateral Sagittal Split Osteotomy to set back the mandible with no genioplasty

III- Data processing

The laser scanner's 3D model was processed with Romexis® software (Planmeca, Helsinki, Finland)

The preoperative and postoperative scans are superimposed by manually determining the region of interest in both meshes, which in our study was the forehead and orbital regions. Then, using surface topography matching between the two images, automated surface registration is performed by bringing the corresponding vertices of the two superimposed surfaces as close to each other as possible in the region of interest.

The employed algorithm, known as Iterative Closest Point (ICP), uses a series of translation and rotation iterations before calculating the distance between the two meshes as measured from each vertex to the nearest correspondence on the opposing mesh. For the purpose of maximising the superimposition of the two surfaces, iteration is carried out until this measurement reaches its minimum value. (Boehnen and Flynn 2005)

To enable direct comparisons between them using the colour millimetre scale, the face image meshes are compared. Every vertex on one of the meshes (Mesh A) is treated as a landmark by its mathematical method, which also searches for the nearest point on Mesh B to use as a correspondent point for distance measurements.

A generalised color-coded distance map that shows the distance between the two tested surface meshes in a variety of colours is created.

The hue shifts further toward the red side of the spectrum and has a positive sign the more apart the meshes are from one another in a forward direction.

On the other hand, the hue shifts further toward the blue side of the spectrum and has a negative sign the further apart the two meshes are in the backward direction. As a result, on both meshes, the vertices with zero distance are assigned the colour associated with the centre of the spectrum, which is green.

According to the size and direction of their geometrical variations, variable parts on the face will adopt different colours, creating a descriptive colour map.

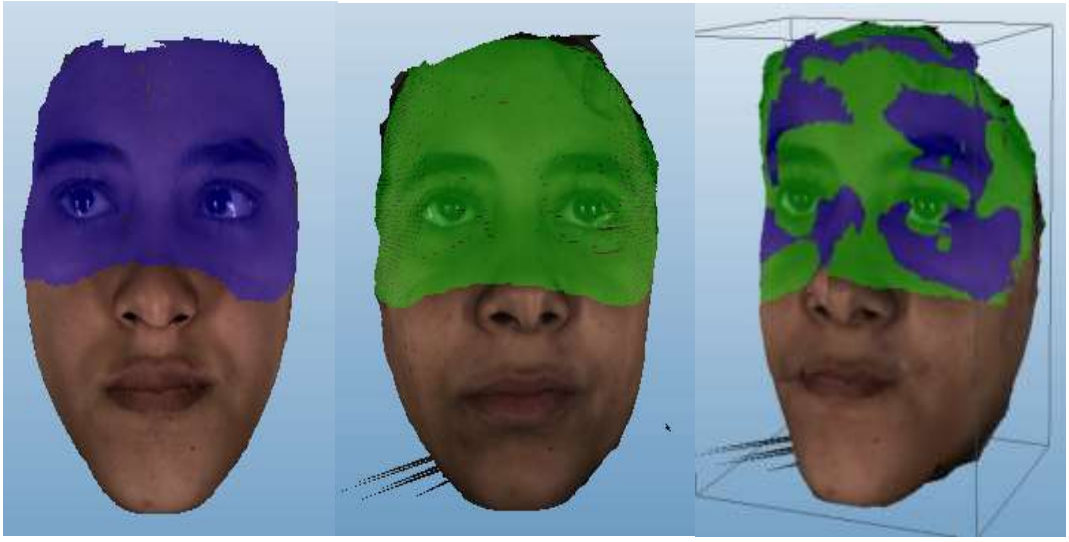

Figure 2 (a)determination of the region of interest in the preoperative model, (b) determination of the region of interest in the postoperative model (c) registration of the 2 models over each other

RESULTS

A total number of 15 preoperative and postoperative scans were obtained from the laser surface scanner and were successfully processed through our study protocol.

The pre and post-operative facial models were superimposed using Romexis® software (Planmeca, Helsinki, Finland). The comparative results were displayed as a color-coded distance map.

Different changes can be displayed in a range of colors describing the distance between the two-tested surface meshes.

The green color represents the midpoint of the spectrum which is allocated to the vertices with zero distance on both meshes. This can be seen over the nasal bridge area and the forehead which indicates good registration accuracy.

The red color that reflects the advancement of the soft tissue can be seen more clearly in the paranasal regions, which coincides with the surgical plan of the maxillary advancement. The blue color represents the setback and can be seen in the chin area, lower lip and slightly around the gonion area.

Readings are obtained in mm by movement of the cursor toward a specific patch on the map

Each patient analysis differs individually, and the color descriptive analysis can describe comprehensively the areas involved in the change.

Bimaxillary orthognathic surgery resulted in soft-tissue changes that were maximized in the central parts of the face than in the lateral parts.

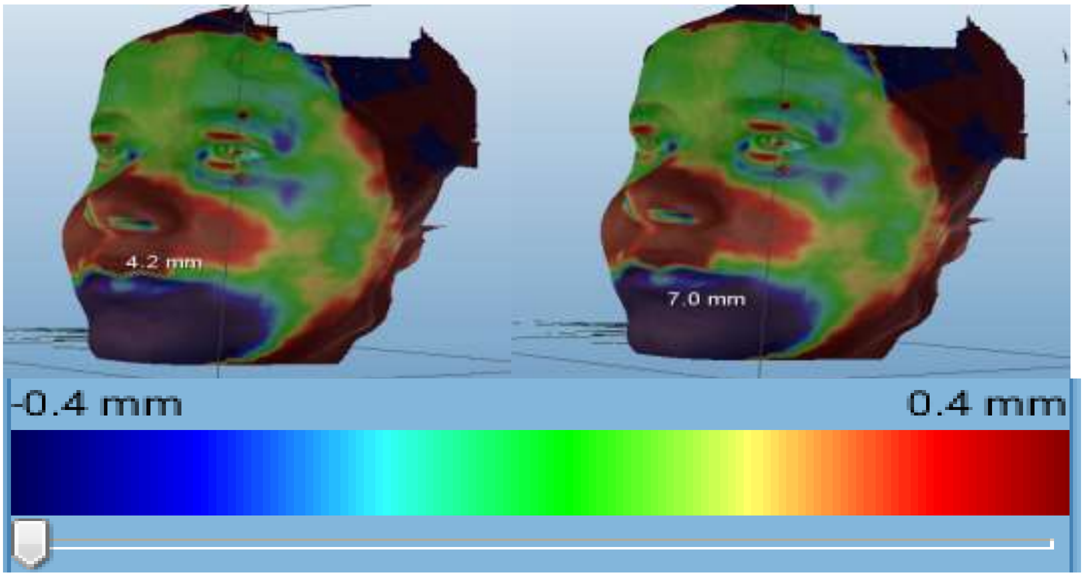

Figure 3 color coded distance map. note the red color indicating the amount of forward movement in this area, the blue color indicate backward movement in this area (the linear readings appear with moving the cursor over the desired area)

DISCUSSION

This study focuses on the short-term response of the static soft tissue position, as the long-term assessment is affected by other factors such as relapse of the surgery and/or aging changes.

The soft tissue assessment was performed 6 months after the surgery as many literature have documented that 60% of the postoperative swelling resolves by one month and 100% in less than 6 months. (Božič et al. 2010; Day, Lee, and Robert 2006; van der Vlis et al. 2014; Zizelmann et al. 2012)

Advances in the technology of both computer hardware and software technology led to the development of 3D image acquisition and analysis systems; in an attempt to overcome limitations of two-dimensional analysis.

Several methods have been proposed for three-dimensional image acquisition either optic based technologies as laser scanners, stereophotogrammetry or radiographic based technology as CT or CBCT. (Almukhtar et al. 2018; Alves et al. 2008; Hajeer et al. 2002; McCance et al. 1992; Ubaya et al. 2012; Verdenik and Ihan Hren 2014; Vittert et al. 2018)

In this study we obtained the 3D soft tissue model by a laser surface scanner using Planmeca ProMax® 3D (Planmeca, Helsinki, Finland). Laser scanning technique have proved be a simple and non-invasive method for 3D facial acquisition if acquired alone. Several studies have demonstrated the validity and high accuracy of different laser scanning systems and evaluated precision and reliability of data generated from the scans. (Soncul and Bamber 2004)

(Zhurov AI, Kau CH, and Richmond S 2005)reported the error of the Minolta Vivid 900 (Osaka, Japan) laser-scanning device in aligning the facial scans is 0.13 - 0.18 mm and the reproduction of facial morphology is accurate to within 0.85 mm. No validity studies have been reported on the Planmeca ProMax® 3D (Planmeca, Helsinki, Finland), however in our study several errors have been encountered in the obtained 3D scan such as deformation of the mesh, chin cut off and eye blurring or closure even with the reproducible NHP, this might be attributed to the long scanning time that ranges from 10-15s according to the manufacturer manual.

The soft tissue analysis types used in this study was color coded map analysis. In the color-coded map analysis, the entire facial surface is involved in the analysis; it produces visually displayed, easily interpreted findings for clinicians and researchers, the method provides both generalized surface measurements as well as localized patches on the area of interest.

It was possible to observe the different amounts of surgical movement of each patient according to the color pattern displayed. Lack of anatomical correspondence is a major limitation in the color-coded error map method.

The bimaxillary orthognathic surgery of maxillary advancement with or without impaction and mandibular advancement have shown to affect various regions in the face as the maximum effect was seen in lower chin region and the upper lip and paranasal regions. Moderate to minimal effect was in the gonial area, and the zygomatic region as shown in the color-coded map.

Similar finding has been reported by other studies. (Soncul and Bamber 2004) also reported that the highest ratio of change was in the chin region and estimated by 90-100% followed by the nasal and paranasal regions by 72-80% and moderate changes in the commissural areas by 40-47%.

(Verdenik and Ihan Hren 2014) in his group of bimaxillary orthognathic surgery the greatest change was reported to be in the nose, cheek, and upper lip, the lower lip and chin areas.

The results of our study and previous studies using the color-coded analysis gave a comprehensive idea about the areas affected by the surgeries and the degree of the changes that occurs in the soft tissue.

CONCLUSION

These findings help clinicians understand the orthognathic outcomes on different facial regions for patients with class III deformity.

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