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EXISTENCE OF LINEARITY IN SOFT TO HARD TISSUE CHANGES FOLLOWING ORTHOGNATHIC SURGERY

Dental Science

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ABSTRACT

Introduction: Profile prediction is crucial to planning prior to orthognathic surgery. Today computerized simulation softwares have replaced acetate tracings, which are based upon mean ratios of soft tissue change following skeletal movements linearly. The aim of this study is to evaluate the soft tissue changes with skeletal movements following orthognathic surgery.
Method: Lateral cephalograms of 24 patients were taken preoperatively at least 2 months before (T1) and, postoperatively (T2) 6 months after the surgery and acetate paper tracings were done. The sample was divided into two groups (maxillary & mandibular) depending upon type of surgery. Five pairs of soft and hard tissue landmarks were studied pre and postoperatively. Paired t test was used to compare the corresponding soft tissue and hard tissue change in both the groups. Scatter plots were used to explore the relationships of the corresponding soft- and hard-tissue movements for both the groups. The Pearson correlation coefficient (r) was calculated for each pair of tissue movements in both the groups.
Result: The changes in soft tissue were closely correlated with hard tissue movement following orthognathic surgery. All the corresponding soft and hard tissue landmarks showed a linear relationship except for Sn-ANS pair.
Conclusion: Linear ratios can be safely used for a wide range of mandibular orthognathic surgeries. However for maxillary surgeries, simulation softwares using nonlinear ratios should be beneficial.

KEYWORDS

orthognathic surgery, profile prediction

INTRODUCTION

Facial esthetics, function and, craniofacial deformities are most common reasons for patients to undergo orthognathic surgery. Esthetics being the major motivational factor for patients as final outcome of the hard tissue change is reflected on the soft tissue.

Thickness of soft tissue over the hard tissue skeleton is diverse in the facial region. It also varies depending upon the site, the individual and, to some extent on the race/ethnic origin of the individual. Changes made during surgery on the hard tissue skeleton brings about changes on the overlying soft tissue. Therefore for an accurate prediction, the soft tissue changes should also be taken into account.

Earlier acetate paper tracings followed by various cephalometric analysis were used to predict soft and hard tissue change. Today they have been replaced with various simulation softwares to analyse and predict the changes virtually. These softwares are by and large based on various algorithms which are derived from percentage change in various soft and hard tissue landmarks before and after orthognathic surgery. Hence the software will be as accurate as the database used to formulate the simulation software.

The aim in this study was to study whether a linear relationship exists between soft to hard tissue change for both maxillary and mandibular cephalometric landmarks over a wide range of skeletal changes following orthognathic surgery.

MATERIALS AND METHODS

The sample for the study consisted of 24 patients which comprised of 7 males (29.2%) and 17 females (70.8%) who were referred to The Department of Oral and Maxillofacial Surgery for orthognathic surgery at The Oxford Dental College & Hospital, Bangalore and underwent surgery at the same after completion of presurgical orthodontic treatment.

Patients were included based on the following criteria: (1) Patients who had completed the pre-surgical orthodontic treatment. (2) Patients with preoperative & post operative lateral cephalograms. (3) Patients under ASA (American Society of Anaesthesiologist) class I and class II.

Patients were excluded from the study based on: (1) Patients requiring additional surgical procedures. (2) Patients with cleft lip and/or palate or any other congenital craniofacial anomalies. (3) Patients with incomplete records.

Lateral cephalograms used for the study were taken within 2 months before surgery (T1) after completion of pre-surgical orthodontics and postoperatively taken after 6 months (T2). Acetate paper tracings were made over the radiographs.

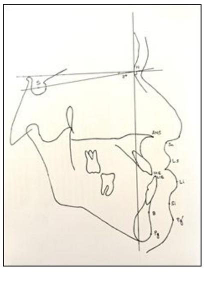

Figure 1 Cephalometric landmarks used for the study

In order to standardize the radiographs all cephalograms were taken in the natural head position with teeth in centric occlusion and lips in repose. In addition, all radiographs were shot at the end of expiration and each radiograph was taken by the same technician and radiographic machine.

The patients were divided into two groups based on the surgical procedures performed:

1. Maxillary group: patients with surgeries performed only in maxilla, midface
2. Mandibular group: patients with surgeries performed only in mandible, lower face

The pre and post operative lateral cephalograms obtained from both groups were studied separately. A line 7° superior to Sella–Nasion (SN) line is drawn on the tracing sheet (Fig. 1). The perpendicular line to that line passing through Nasion (N) is taken as the vertical reference line. Five pairs of soft and hard tissue landmarks were traced from the radiographs and the points were marked on the lateral cephalogram, and their distance measured in milimeters from the reference line. They are: Anterior Nasal Spine (ANS) - Subnasale(Sn), Maxillary Incisor Tip (U1E) - Labrale superius(Ls), Mandibular Incisor Tip (L1E) - Labrale inferius(Li), Point B (B) - Mentolabial sulcus(Si) and, Pogonion(Pg) - Soft tissue Pogonion (Pg').

Any change in measurement in pre-surgical and postsurgical cephalogram was recorded as surgical change. The following measurements were made for each pair of soft and hard tissue landmarks: (T1) Pre operative measurement; (T2) Post operative measurement.

- $\frac{\text{T2-T1 soft tissue change measurement}}{\text{T2-T1 hard tissue change measurement}}$ = RATIO of soft to hard tissue change

Statistical analysis

Paired t test was used to compare the corresponding soft tissue and hard tissue change in both the groups. Scatter plots were used to explore the relationships of the corresponding soft- and hard-tissue movements for both the groups. The Pearson correlation coefficient (r) was calculated for each pair of tissue movements in both the groups. Level of significance (α) was 0.05 and statistical significance was set as $P \leq 0.05$.

RESULTS

Group I included patients undergoing maxillary orthognathic surgery which comprised of total 10 patients (3 males and 7 females). Group II included patients undergoing mandibular orthognathic surgery which comprised of total 14 patients (4 males and 10 females).

All patients in Group I underwent maxillary orthognathic surgical procedures. The amount of advancement at ANS ranged from 1.5 mm to 9 mm in total of 8 patients. Superior maxillary repositioning was done in 2 patients, which lead to posterior movement of 2 mm at ANS in both the patients. Patients of Group II underwent mandibular bilateral sagittal split osteotomy. Out of 14 patients, 8 patients underwent mandibular setback and 6 patients underwent advancement without any additional surgical procedures. The amount of advancement carried out at point B ranged from 3 mm to 7.5 mm. The amount of setback carried out at point B ranged from 1 mm to 7.5 mm.

The scatter plots of the 5 pairs of corresponding soft- and hard-tissue landmarks in Group I and Group II show that relationships between the soft and hard tissues were reasonably linear, except for the Sn-ANS pair in Group II where no correlation could be seen. In Group I the correlation coefficient was weakest (r = 0.7294) for Sn-ANS and strongest for Ls-U1E (r =0.9929). In Group II the correlation coefficient was weakest (r = 0.6625) for Ls-U1E and strongest for Pg'-Pg ®=0.9457).

A significant change in the position of ANS (p=0.028) and Sn (p=0.0011) was observed with a mean soft to hard tissue ratio of 1.44:1 (±1.11) in Group I which was highly significant (p=0.0002). However, no correlation was seen in Group II in the Sn-ANS pair of landmarks as change in position of Sn was observed with no hard tissue change at ANS. In Ls-U1E pair of landmarks, significant change was observed at Ls in Group I patients (p=0.0085). U1E showed significant change in Group II (p=0.0118) with soft to hard tissue change ratio of 0.85 (±0.30) in Group I and 0.21 (±1.75) in Group II patients which was not significant. In Li-L1E pair of landmarks, soft to hard tissue change ratio of 1.29:1(±1.77) in Group I and 0.56:1(±0.44) in Group II patients was observed. In Si-B pair of landmarks, soft to hard tissue change ratio of 0.3:1(±0.93) in Group I and 1.26:1(±0.46) in Group II patients which was significant (p=0.0032). In Pg'-Pg pair of landmarks, soft to hard tissue change ratio of 0.08:1(±1.45) in Group I and 1.19:1(±0.46) in Group II patients was observed which was significant (p=0.0055).

DISCUSSION

Profile prediction is prerequisite for treatment planning in the orthodontic-surgical correction of dentofacial deformities[1]. Charles Burstone et al[2] designed the analysis for predicting outcome of orthognathic surgery using cephalometrics. However, to predict profile after orthognathic surgery is not a walk in the park as the soft tissue thickness over the craniofacial skeleton varies based upon age, gender and race of the individual. In the past, numerous studies about the profile prediction following osseous translations that have been published. On comparison of different studies, a wide range of relations was found[3]. In the present study, sample was homogenous as all patients were South Indian origin and were divided into groups based upon Skeletal Class II or III relation. As rigid fixation was done in all patients with Titanium plates it decreased the chance of relapse and post operative complications significantly.

With modern technological advances, the manual acetate tracing technique has been replaced by computerized prediction tracings software and 3D imaging procedures for planning orthognathic surgery[4,5]. All such available software programs are based on algorithms which are derived from studies that reported mean ratios of soft tissue change following osseous translation. Although clinically useful, the treatment simulation is only as accurate as the database used. Traditionally, the database was compiled based on the assumption that soft tissue change is a fixed percentage of osseous translation regardless of the magnitude of skeletal repositioning. This approach assumes soft-tissue response to be a fixed percentage of osseous movement, regardless of the amount and direction of skeletal repositioning[1]. However, some authors opt for using nonlinear ratios because the soft tissue becomes more resistant to movements when advanced more anteriorly[6]. For chin, initial ratio would be higher compared to the final ratio. The initial Li-L1E ratio could be small, the ratio may increase as the lower incisors are advanced further[7].

In the present study, a line was constructed 7° from Nasion to the Sella-Nasion line superiorly which was regarded as the horizontal plane. A line perpendicular to the horizontal plane was constructed passing through Nasion, which was regarded as vertical reference line. These reference lines were initially suggested by Charles Burstone et al in 1978 and have been used in similar studies numerous times thereafter[2].

Mandibular orthognathic surgery

In the present study, the sample included patients with wide spectrum of skeletal deformities in mandible as indicated by range of surgical movements. Eight patients (57%) underwent mandibular setback and 6 patients (43%) underwent mandibular advancement. Scatter plots of the 5 pairs of corresponding soft- and hard-tissue landmarks showed that when isolated mandibular surgery was carried out relationships between the soft and hard tissues were reasonably linear, except for the Sn-ANS pair where correlation was not seen. It is because no surgical procedure was done on maxilla but still changes were seen in upper lip and Subnasale. This finding was similar to the study conducted by Ming Tak Chew et al where he suggested that a nonlinear relationship exists between Sn and ANS[1]. In the isolated mandibular surgery group, the correlation coefficient was strongest at Pg'-Pg, followed by Si-B and weakest at Ls-U1E. Soft tissue to hard tissue change was closest to 1:1 at Pg, followed by point B. These findings were in accordance with similar studies reported in the literature as well[8-14]. The postoperative short follow up of only 2 months gave the idea of immediate soft to hard tissue change following surgery. However, a longer follow up of more than 1 year would have yielded in much more fruitful soft to hard tissue ratio.

Maxillary orthognathic surgery

In the present study, the sample included patients with wide spectrum of skeletal deformities in maxilla as indicated by range of surgical movements carried out in maxilla. 6 patients (60%) underwent maxillary superior repositioning and 4 patients (40%) underwent maxillary anterior repositioning. Scatter plots of the 5 pairs of corresponding soft- and hard-tissue landmarks in maxillary surgery group showed that relationships between the soft and hard tissues were reasonably linear. The correlation coefficient was strongest at Ls-U1E, followed by Si-B and weakest at Sn-ANS. When maxillary surgery was performed it resulted in rotation of mandible as well. As a result change was observed in postoperative position of both mandibular hard tissue and overlying lower lip and chin soft tissue. However, in sagittal plane rotation of mandible lead to the change which was different at different mandibular landmarks. Tateyuki Iizuka et al[15] and Mobarak et al[10] also mentioned similar observations in their respective studies. The postoperative short follow up of only 2 months gave the idea of immediate soft to hard tissue change following surgery. However, a longer follow up of more than 1 year would have yielded in much more fruitful soft to hard tissue ratio.

Bimaxillary orthognathic surgery

In the present study, soft tissue to hard tissue change ratio after bimaxillary orthognathic surgery was not included due to insufficient number of patients and only isolated or single jaw surgeries were included.

Expression of soft-to-hard tissue movements in mean ratios can lead to lower correlations. It is because studies that rely on mean values do not explain individual variation. Veltkamp et al. showed that the inclusion of up to five different variables into a multiple regression equation significantly improves the correlation. Henceforth, multiple regression could be used to predict vertical and horizontal coordinate changes for corresponding soft and hard tissue points and predict soft-to hard tissue movement more appropriately[16].

CONCLUSION

Results of the present study show that when isolated maxillary orthognathic surgical procedures are performed, skeletal change in the maxilla led to rotation in the mandible as well. This led to variable change in the sagittal plane at different mandibular landmarks. All maxillary and mandibular pair of soft and hard tissue landmarks showed linear relationship, with Ls-U1E showing relationship closest to 1:1.

When isolated mandibular orthognathic surgeries are performed, the mandibular pairs of hard tissue and overlying soft tissue show evidence of linear relationship, relationship being closest to 1:1 at chin region. However, maxillary pair of Sn-ANS showed nonlinear relationship. This supports use of nonlinear ratios for predicting maxillary landmarks in simulation softwares.

We suggest that future studies should include a larger sample size with a possibly longer duration of follow up of more than 1 year to predict the soft tissue change in a long term basis.

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