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Original Article

구순구개열 환자의 악교정 수술 후의 골조직 안정도와 연조직 변화율

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Bony Stability and Soft Tissue Changes after Orthognathic Surgery on Patients with Cleft

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Purpose: The objective of this retrospective study was to assess the skeletal stability after orthognathic surgery for patients with cleft lip and palate. The soft tissue changes in relation to the skeletal movement were also evaluated.
Methods: Thirty one patients with cleft received orthognathic surgery by one surgeon at the Craniofacial Center, Chang Gung Memorial Hospital, Taoyuan, Taiwan. Osseous and soft tissue landmarks were localized on lateral cephalograms taken at preoperative (T0), postoperative (T1), and after completion of orthodontic treatment (T2) stages. Surgical movement (T0–T1) and relapse (T1–T2) were measured and compared.
Results: Mean anteroposterior horizontal advancement of maxilla at point A was 5.5 mm, and the mean horizontal relapse was 0.5 mm (9.1%). The degree of horizontal relapse was found to be correlated to the extent of maxillary advancement. Mean vertical lengthening of maxilla at point A was 3.2 mm, and the mean vertical relapse was 0.6 mm (18.8%). All cases had maxillary clockwise rotation with a mean of 4.4 degrees. The ratio for horizontal advancement of nasal tip/anterior nasal spine was 0.54/1, and the ratio of A' point/A point was 0.68/1 and 0.69/1 for the upper vermilion/upper incisor tip.
Conclusion: Satisfactory skeletal stability with an acceptable relapse rate was obtained from this study. High soft tissue to skeletal tissue ratios were obtained. Two-jaw surgery, clockwise rotation, rigid fixation, and alar cinch suture appeared to be the contributing factors for favorable results.

Keywords: Orthognathic surgery, Cleft lip and palate, LeFort I osteotomy

INTRODUCTION

Orthognathic surgery is required in 25 percent of patients with cleft lip and palate for correction of the dentofacial deformity.[1] It is because of the intrinsic embryological defect existing in patients with cleft as well as the facial growth disturbance restricted by scar tissues from surgical interventions. As a consequence, disturbance of the growth of the jaws, malocclusion, and discrepancy in maxillomandibular skeletal alignment develop.

Difficult situations are present in orthognathic surgery for patients with cleft. These are related to the severity of scarring

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from previous repairs, the less predictable vascular supply, the extent of advancement, the fixation of transposed segments, and the possibility of post–surgical relapse.[2] In addition, a mobile dysplastic premaxilla, misaligned hypoplastic lateral maxillary segment, residual oronasal fistula, bony defect and the absence of the maxillary incisor teeth are possible confounding factors rendering the difficulty on orthodontic treatment, planning and surgery.

Postoperative relapse is one of the most annoying problems after orthognathic surgery in patients with cleft. Relapse of LeFort I advancement in cleft patients with maxillary hypoplasia is reported to be from 25% to 50%.[3,4] Whereas the relapse for non–cleft patients is known to be 10%.[5] Intensive scarring, muscle pull, tension in soft tissues, interference with the nasal septum, and instability of bony fragments were the potential causes of the relapse in cleft patients.[6] These problems are related to the cleft itself, several factors such as the type of cleft, surgical method, extent of advancement, method of fixation, neuromuscular adaptation and orthodontics may also contribute to the relapse. There have been numerous studies on long term stability or relapse of maxillary advancement surgery by LeFort I osteotomy.[2–6] However, the results varied, and the majority of these studies were carried out on cases of Caucasian patients.

In this study, we sought to investigate the stability of maxilla after orthognathic surgery for Asian patients with cleft lip and palate performed by one surgeon. The associated soft tissue changes were also analyzed. The results from this study may serve to provide useful information for predictable guidelines of orthognathic surgery treatment plan for patients with cleft lip and palate.

MATERIALS AND METHODS

1. Patients

There were 57 patients with cleft lip and palate who had undergone orthognathic surgery by the senior surgeon (LJL) at the Craniofacial Center, Chang Gung Memorial Hospital, Taoyuan, Taiwan, between January 2007 and December 2009. The cephalometric evaluations of 31 patients whose orthodontic treatment had been finished were reviewed. There were 18 male and 13 female patients, and the age ranged from 16 to 37 years with a mean of 27 years. Surgery was performed on all patients after the growth spurt. In this study, there were 27 patients with unilateral cleft and plate and 4 patients with bilateral cleft and palate. Two–jaw surgery was performed in 28 patients, and single–jaw surgery with LeFort I osteotomy was performed in 3 patients. All patients had received full orthodontic treatment before and after surgery in the center. The postoperative orthodontic treatment period ranged from 9 to 34 months, with a mean of 15 months.

2. Cephalometric measurement and statistical analysis

The radiographs were taken within a month before operation (T0), one week after the orthognathic surgery (T1), and after completion of orthodontic treatment at debonding (T2). The tracing and cephalometric analysis of lateral cephalogram in T0, T1, and T2 stages were carried out by V–Ceph (Osstem, Seoul, Korea) (Fig. 1). The x–axis was determined by a line through nasion rotated 7° upwards from the sella–nasion line. This line runs parallel to the Frankfort horizontal plane. And the y–axis was determined as a perpendicular line to the x–axis through sella (S). The cephalometric anatomic landmarks and reference lines are shown in Fig. 2. The cepha-

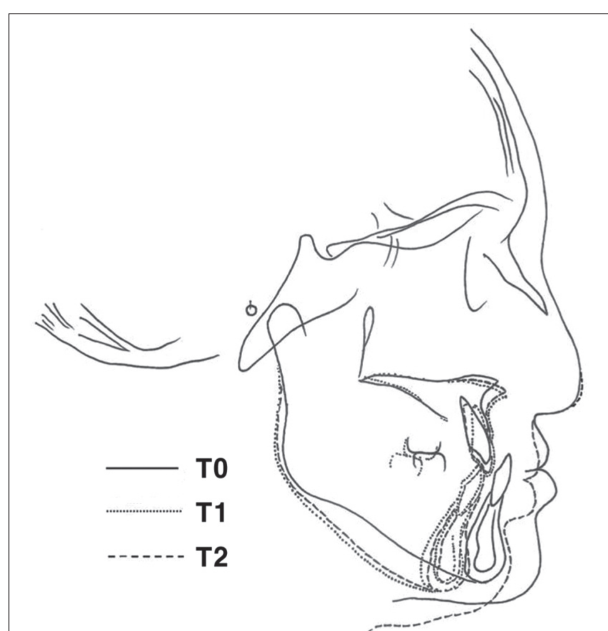

Fig. 1. The tracing of cephalogram in preoperative (T0), postoperative (T1), and debonding (T2) stage.

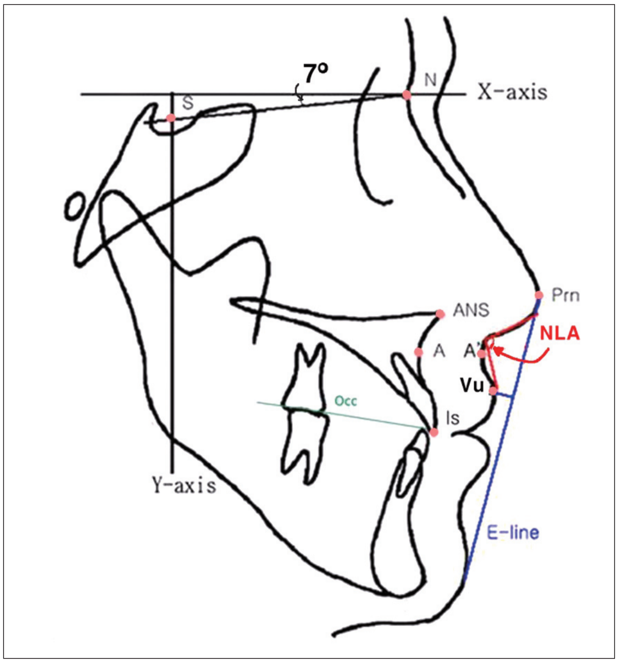

Fig. 2. Cephalometric landmarks and reference lines. **S**, sella: the estimated center of the bony contour of the preoperative sella turcica; **N**, nasion: the most anterior point of the frontonasal suture; **A**, A point: the deepest (most posterior) on the concave outline of the upper labial alveolar process; **ANS**, anterior nasal spine, most anterior limit of the floor of the nose, at the tip of the anterior nasal spine in the midsagittal plane; **Is**, incisivum superior: the tip of the crown on the long axis of the most prominent upper incisor; **Prn**, pronasale: the most prominent point on the nose profile; **A'**, soft tissue A point (), the deepest concavity on the upper lip profile; **Vu**, vermilion border of upper lip: the most anterior point on the convexity of the upper lip profile; **E–line**, the line is drawn from the tip of the nose to soft tissue pogonion; **NLA**, nasolabial angle: the angle is formed by two lines, namely, a columella tangent and upper lip tangent.

lometric variables in three stages (T0, T1, T2) were calculated by the computer program.

The amount of maxillary movement was determined by subtracting the values of T0 from T1, and the amount of relapse was calculated by subtracting T2 from T1. To avoid the errors due to postoperative edema, only the differences between T2 and T0 in the analysis of soft tissue change were calculated. For maxillary movement and relapse, positive values reflect forward movement or clockwise rotation, and negative values for backward movement or counterclockwise rotation.

All cephalometric tracing and measurement were performed twice by the same examiner, who did not perform the surgery, to avoid observer bias. Paired t–test was used for the statistical analysis. T–test statistics with p values equal to or less than 0.05 were considered to be statistically significant.

3. Surgical technique and orthodontic treatment

For presurgical preparation, plaster model surgery and prediction tracing were performed and occlusal splint was made. The LeFort I osteotomy was done using a down–fracture technique and moved to the preplanned position by the model surgery and guided by an occlusal splint. The mobilized maxilla was fixed with four titanium miniplates at each side of zygomatic buttress and the pyriform region. If necessary, patients received segmentation osteotomy of maxilla for two–piece LeFort I surgery. Following this, a sagittal split osteotomy of mandibular ramus was done with a setback of the mandible. After the maxillomandibular fixation using the occlusal splint, three bicortical screws were placed at the ramus area. The maxillomandibular fixation and occlusal splint were released and removed, and the relationship of the dental occlusion and condyle position were checked.

Bone grafting was not used in this group of patients. Intermaxillary fixation was released and the occlusal splint was removed at completion of surgery. Alar cinch suture was done through the vestibular approach in order to prevent widening of the nose. Suction drains were inserted in the ramal wounds overnight. Patients resumed orthodontic treatment in a month after the surgery.

RESULTS

Because anterior nasal spine was often altered during the operation and the upper incisor inclination was changed by postoperative orthodontic treatment, point A was used to measure the surgical movement and relapse of maxilla. Table I shows surgical maxillary change and relapse. The mean horizontal advancement of maxilla (point A) was 5.5 mm, and the mean horizontal relapse was 0.5 mm (9.1%). Fig. 3 in present study are based on the reproducible slope of the scattergram (R^2=0.73). There were significant correlations between the degree of horizontal relapse and the extent of maxillary advancement. The mean vertical lengthening of maxilla (point A) was 3.2 mm, and the mean vertical relapse was 0.6 mm (18.8%).

The horizontal relapse of anterior nasal spine (ANS) was 0.5 mm (9.8%), similar to the relapse of point A. In contrast, upper incisor tip was advanced a little bit more (1.9%) after surgery. This was likely related to the orthodontic treatment

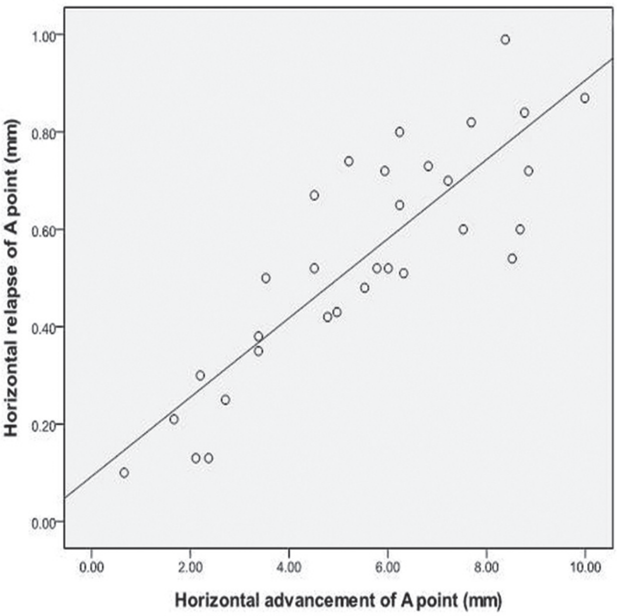

Fig. 3. Significant relation between horizontal advancement and relapse of A point.

and orthodontic compensation to the skeletal relapse. The mean SNA angle was changed from 75.8° to 79.6° and relapsed by 0.9°. Maxillary rotation was assessed as the change of the occlusal plane. All cases had clockwise rotation by mean of 4.4° with a mean relapse of −0.2°. Mean soft tissue changes are given in Table Ⅱ, and the ratios between soft and hard tissue changes are shown in Table Ⅲ. The mean change of soft tissue A' point was measured 3.4 mm and the nasal tip projection was increased by 2.5 mm. The vermilion border of upper lip was advanced mean 3.7 mm and the mean upper lip to E–line distance was increased 3.8 mm and became close to esthetic line. And the average nasolabial angle increased from 88.7° to 97.9°. The ratio for horizontal advancement of nasal tip (Prn)/anterior nasal spine (ANS) was 0.54/1 and the ratio of A' point/A point was 0.68/1 and 0.69/1 for the upper vermilion/upper incisor tip.

Table I. Cephalometric Variables (T0, T1, T2), Surgical Change and Relapse of Hard Tissue

	T0		T1		T2		Surgical change		Relapse	
	Mean	SD	Mean	SD	Mean	SD	T1-T0	SD	T1-T2 (%)	SD
Ax (mm)	56.8	3.4	62.3	6.3	61.8	6	5.5	2.4	0.5 (9.1)	0.2
Is-x (mm)	60.4	3.5	65.7	6.5	65.8	6.7	5.3	2.4	-0.1 (1.9)	0.3
ANS-x (mm)	60.2	3.6	65.3	5.8	64.8	6.4	5.1	2.1	0.5 (9.8)	2.3
Ay (mm)	61.9	5.1	65.1	3.6	64.5	3.8	3.2	2.0	0.6 (18.8)	1.5
SNA (°)	75.8	5.8	79.6	4.7	78.7	3.9	3.8	0.8	0.9 (23.7)	1.4
Occ. plane to SN (°)	10.6	5.2	15	5.6	15.2	4	4.4	3.0	-0.2 (-4.5)	2.2

T0, preoperative stage (within a month before operation); T1, postoperative stage (one week after the orthognathic surgery); T2, debonding stage (after completion of orthodontic treatment); SD, standard deviation; Ax, distance from A point to Y-axis (mm); Is-x, distance from incisivum superior to Y-axis (mm); ANS-x, distance from anterior nasal spine to Y-axis (mm); Ay, distance from A point to X-axis (mm); SNA, angle of N-S to N-A line; Occ. plane to SN, angle of occlusion plane to S-N line.

Table II. Cephalometric Variables (T0, T2) and Surgical Change of Soft Tissue

	T0		T2		Surgical change	
	Mean	SD	Mean	SD	T2-T0	SD
Prn-x	89	4.5	91.5	6.3	2.5	0.9
A'-x	71.4	4.9	74.8	6.4	3.4	2.3
Vu-x	76.8	5.2	80.5	5.7	3.7	2.5
Upper lip E-plane	-5.2	3	-1.4	2	3.8	1.2
Nasolabial angle	88.7	17.9	97.9	17	9.2	1.8

T0, preoperative stage (within a month before operation); T2, debonding stage (after completion of orthodontic treatment); SD, standard deviation; Prn-x, distance from pronasale to Y-axis (mm); A'-x, distance from A' point to Y-axis (mm); Vu-x, distance from vermilion border of upper lip to Y-axis; upper lip E-plane, the shortest distance from upper lip to E-plane; nasolabial angle, angle of columella tangent line to upper lip tangent line.

Table III. Correlation Ratio between Soft and Hard Tissue Movement

	Soft tissue change	Hard tissue change	Ratio
Prn-x/ANS-x	2.5	4.6	0.54
A'-x/A-x	3.4	5.0	0.68
Vu-x/Is-x	3.7	5.4	0.69

Prn-x, distance from pronasale to Y-axis (mm); ANS-x, distance from Anterior nasal spine to Y-axis (mm); A'-x, distance from A' point to Y-axis (mm); Ax, distance from A point to Y-axis (mm); Vu-x, distance from vermilion border of upper lip to Y-axis; Is-x, distance from incisivum superior to Y-axis (mm).

DISCUSSION

The treatment planning and operation of orthognathic surgery for cleft patients is more difficult than for non–cleft patients, because of further advancement, inadequate tissue quality and worse dental occlusion.[6] In many previous studies on patients with cleft, the relapse rate of LeFort I osteotomy was reported to be between 25% and 50%.[3,4] To reduce or prevent postoperative relapse in patients with cleft, multiple factors were discussed when performing orthognathic surgery. The amount of advancement for LeFort I osteotomy was considered one of the major factors. Some reports showed that the relapse was influenced by the amount of advancement[6] whereas the others could not find positive correlation between the relapse and the amount of advancement.[7] In our study, the positive correlation was found (Fig. 3). With this finding, it is rational to plan two–jaw surgery if excessive single maxillary advancement is expected. Other factors reported to be responsible for relapse included soft tissue scarring in palate and retromaxillary region.[4,6] Tightness of the upper lip created by cheiloplasty is another factor maxillary growth restraint and surgical relapse.[8] Adequate degloving and release of restraint are advisable in order to fully mobilize and advance the maxilla. Average horizontal relapse rate of 9.1% demonstrated good stability as compared with that of previous studies.

Several studies were done assessing the correlation between the amount of vertical displacement and the relapse, and found that the postoperative vertical relapse is more than the horizontal relapse. There was a significant difference between inferior repositioning and intrusion of maxilla. Most researchers agreed that maxillary intrusion was a stable movement but inferior repositioning of maxilla was more unstable.[9] It was explained that the inferior repositioning leads to reduction of bone contact at lateral portion of maxilla[10] and increases soft tissue stretching resulting in movement of the screws during bone healing.[11] The degree of vertical relapse in maxillary inferior repositioning has been reported to be variable,[9] and the amount of relapse was roughly around 2 mm.[2] Therefore, some authors recommend 2 mm overcorrection in inferior repositioning.[12] This is not observed in our study, with the amount of inferior repositioning 3.2 mm and relapse 0.6 mm. Although the vertical relapse rate was 18.8% and greater than the horizontal relapse in our study, this vertical relapse was lesser than that from previous studies.

Good stability was achieved without bone grafting in this study, but it should not be interpreted as negative function when there is a need in the situation of significant osseous gap. Bone grafting is recommended to promote stability.[7] Because it is regarded as a physical barrier against the relapse and can promote bone healing, bone grafting was recommended in cases of large advancement and inferior repositioning of maxilla.[13] Araujo et al.[14] suggested that bone grafting should be used if the advancement of maxilla was more than 6 mm.

Another approach to avoid skeletal relapse is to obtain a good functional occlusion and clockwise rotation of the inferiorly repositioned maxilla.[4] Quejeda et al.[15] reported that clockwise rotation plus inferior repositioning of maxilla produced better stability than inferior repositioning parallel to the horizontal plane. Others reported that two–jaw surgery is more advantageous to achieve good occlusal plane, clockwise rotation and three dimensional correction of the maxillomandibular complex.[16] Because LeFort I osteotomy may lead to autorotation of the mandible resulting in counterclockwise rotation of the occlusal plane, it is difficult to get a clockwise rotation for the maxillomandibular complex using LeFort I ostetomy alone.[17] It is recommended to apply two–jaw surgery for cleft patients with class III malocclusion who require more than 10 to 12 mm maxillary advancement.[18]

There were only four patients with bilateral cleft in this study, and therefore meaningful comparison of the relapse rate between the unilateral and bilateral clefts could not be made. It is assumed that relapse is more likely to occur in patients with bilateral cleft. Because of the problems with premaxillary scarring, bilateral alveolar cleft, multiple missing teeth, lip tension, unfavorable dental occlusion and unpredictable premaxillary circulation, forward movement of the maxilla in patients with bilateral cleft are likely to be associated with more difficulty and higher complication rate.[19] While some authors suspected that the degree of postoperative relapse might be related to the cleft types,[6,7] Heliovaara et al.[20] reported that the skeletal stability and relapse were similar in both cleft types although bilateral cleft patients had more cleft–related problems and required more extent of advancement. The maxillary relapse started immediately after surgery and continued to be observed for 6 months.[2,7] Surgeons and orthodontists must direct their efforts to reduce the relapse during the first 6 months after the orthognathic surgery.

In orthognathic surgery, bilateral sagittal split osteotomy (BSSO) is the preferred method for mandibular setback. The reasons include broad bony contact and stability for good bony healing, and it can be used for wide spectrum of deformity. Some authors studied skeletal stability after BSSO for mandibular advancement comparing two fixation methods, noncompressive bicortical screws and miniplates with unicortical screws, and concluded that the two methods did not differ significantly.[21] On the contrary, Amano et al.[22] found higher rigidity using screw fixation for BSSO setback, and that the postoperative morphological change continued in the plate fixation group for 1 years. They suggested that the plate fixation method might not be ideal for patients with Class III malocclusion and asymmetry who have a high risk of relapse. We prefer using the BSSO method for mandibular movement and fixing the segments by three bicortical screws for better rigidity.[23]

Subsequent to orthognathic surgery, the ultimate facial aesthetic appearance is a combination of dental, soft tissue and skeletal changes. Estimation of the resulting external soft tissue changes after the operation is as important as dental occlusion and skeletal changes. In previous studies, the ratio of soft to hard tissue change in nasal tip of cleft patients was reported to range from 0.25 to 0.53. It was a little higher ratio than that of non–cleft patients reported ranging from 0.13 to 0.29. However, the range of reported ratios was large and there were great individual variation. In our study, the ratio was 0.54 at nasal tip/anterior nasal spine level. The ratio at soft tissue A' point or superior labial sulcus was reported between 0.48 and 0.66. Our data is higher, with the advancement ratio 0.68 at soft tissue A' point/ A point. In several previous studies, patients treated with maxillary advancement showed similar ratios of soft tissue to hard tissue change between 0.5 and 0.66:1 for upper lip to upper incisor change in cleft patients and in non–cleft patients. But, the ratio of upper lip change in this study was 0.69, and it was higher as well. These ratios of soft tissue/hard tissue movement in cleft patients tend to be higher than those in non–cleft patients, possibly due to the scarred and less pliable soft tissues in the cleft patients which catch up more closely with the underlying hard tissue. In our study, the further higher ratios of nasal tip/anterior nasal spine and A'/A point might be due to cinch sutures in particular.

CONCLUSION

In the present study, better skeletal stability after orthognathic surgery was obtained as compared with previous reports. The anteroposterior horizontal relapse was 9.1%, and the vertical relapse was 18.8%. The better skeletal stability might be due to the fact that majority of the patients received two–jaw surgery with clockwise rotation as well as rigid fixation. Rigid fixation using bicortical screws is highly recommended. The ratios of soft tissue/hard tissue movement are 0.54:1 for nasal tip/anterior nasal spine, 0.68:1 for A' point/A point, and 0.69:1 for upper lip/upper incisor tip. The ratios of nasal tip/anterior nasal spine and A'/A point are higher comparing with those from previous reports, possibly due to the cinch suture on nasal base.

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