

Post-operative stability of the maxilla treated with Le Fort I and horseshoe osteotomies in bimaxillary surgery

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SUMMARY In this study, the post-operative change of the maxilla in six non-cleft patients who underwent combination (Le Fort I and horseshoe) osteotomy for superior repositioning of the maxilla was investigated. In all patients, the maxilla was first osteotomized and fixed with four Luhr plates. No iliac bone graft was applied to the maxilla. A bilateral sagittal split ramus osteotomy of the mandible (BSSRO) was then carried out and titanium screw fixation was performed. No maxillo-mandibular fixation (MMF) with stainless steel wire was used post-operatively in any patient. Lateral cephalograms were obtained pre-operatively, 5 days post-operatively, and 3, 6, and 12 months after surgery. The changes in anterior nasal spine (ANS), point A, upper incisor (U1), and point of maxillary tuberosity (PMT) were examined. The maxillae in the six subjects were repositioned nearly in their planned positions during surgery and no significant post-operative changes in the examined points of the maxilla were found. These results suggest that a combination of a Le Fort I and horseshoe osteotomy is a useful technique for reliable superior repositioning of the maxilla. The post-operative change in the maxilla using this combination osteotomy is comparatively stable.

Introduction

When the maxilla is treated with a single-segment Le Fort I osteotomy, superior repositioning of the posterior portion of the maxilla is believed to be difficult due to the presence of the descending palatine artery.

Bell and McBride (1977) reported a horseshoe palatal osteotomy combined with a Le Fort I osteotomy. In this technique, when the Le Fort I osteotomy and downfracture are performed carefully, there is no potential risk of cutting the descending palatine artery, as no bone has to be trimmed around this artery to superiorly reposition the maxilla, especially its posterior portion. However, there have been few reports describing the post-operative stability of the maxilla treated with a combination of a Le Fort I and horseshoe osteotomy (Bell and McBride, 1977).

In this study, the post-operative stability of the maxilla treated by a Le Fort I and horseshoe

osteotomy in bimaxillary surgery was assessed. The pre- and post-operative changes of the maxillary position using this technique were also investigated.

Subjects and methods

Subjects

The subjects were six non-cleft patients (four females, two males) with a mean age of 24.2 years (range 20–31 years), who underwent a combination Le Fort I and horseshoe osteotomy for superior repositioning of the maxilla. The mean superior movement of the maxillary tuberosity was 4.1 mm (range 3.1–4.8 mm). All patients received pre- and post-operative orthodontic therapy.

Surgical procedure

After the Le Fort I osteotomy and downfracture, a transverse palatal osteotomy in the premolar

region was made through the anterior nasal floor into the oral cavity, and then bilateral sagittal osteotomies were performed through the maxillary sinus into the oral cavity from the maxillary tuberosity anteriorly to the transverse palatal osteotomy site (Bell *et al.*, 1980). The horseshoe incision was made only through bone. Palatal periosteum and mucosa were carefully preserved. Using this horseshoe osteotomy technique, the maxilla was divided into two (palatal and dentoalveolar) segments (Figure 1 a,b) and only the dentoalveolar segment was superiorly repositioned. The palatal segment was maintained in its original position due to the presence of nasal septum and medial antral walls. The dentoalveolar segment was orientated to the mandible with an interocclusal splint prepared at the time of cast surgery. Maxillomandibular fixation (MMF) was applied temporarily to position the dentoalveolar segment into its predetermined relationship with the mandible. No bony fixation was performed for the palatal segment. Only the dentoalveolar segment was fixed with two Luhr mini-plates placed on each side of the piriform rim and zygomatic buttress. No maxillary iliac bone graft was carried out in any patient.

Once the maxilla was stabilized, the temporary MMF and interocclusal splint were removed, and a bilateral sagittal split ramus osteotomy (BSSRO) was carried out. The BSSRO technique was based on the methods of Trauner and Obwegeser (1957) and Dal Pont (1961). A specially developed appliance for repositioning the proximal segment of the mandible was used during bimaxillary surgery (Harada *et al.*, 1996). Prior to the Le Fort I and sagittal splitting osteotomies, the repositioning appliance was applied under MMF to record the pre-operative position of the proximal segment of the mandible. After maxillary fixation and splitting of the mandibular rami, the distal segment of the mandible was placed in its planned occlusion and MMF was again applied. The repositioning appliance was also re-applied in order to reproduce the pre-operative position of the proximal segment of the mandible. The bony segments of the mandibular rami were then fixed bicortically in the gonial region with three

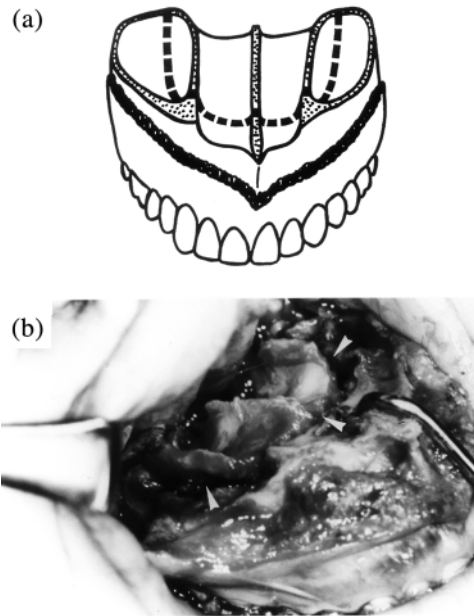


Figure 1 Schematic drawing (a) and intra-operative view (b) of the horseshoe osteotomy. The line of the horseshoe osteotomy is shown as a broken line in (a). The arrowheads in (b) indicate the region of the horseshoe osteotomy after the Le Fort I osteotomy and downfracture. Following the Le Fort I osteotomy and downfracture, a transverse palatal osteotomy in the premolar region was carried out through the anterior nasal floor into the oral cavity, and then a bilateral sagittal osteotomy was performed through the maxillary sinus into the oral cavity from the maxillary tuberosity anteriorly to the transverse palatal osteotomy site. Using this horseshoe osteotomy technique, the maxilla was divided into two (palatal and dentoalveolar) segments.

titanium position screws (2.7 mm in diameter) on each side. After completion of skeletal fixation, the repositioning appliance and MMF were removed, the occlusion was verified, and the wounds were sutured. Two inter-maxillary rubber elastics (3/16-inch or 1/4-inch, medium-light) were applied post-operatively. None of the patients underwent MMF with stainless steel wire after surgery.

Cephalometric evaluation

Lateral cephalograms were obtained pre-operatively, and 5 days and 3, 6, and 12 months post-operatively. The points of the anterior nasal

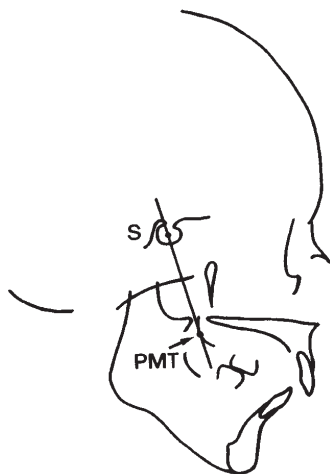


Figure 2 Diagram showing the point of maxillary tuberosity (PMT). The PMT was defined as a contact point of a line passing through the sella and outer line of the maxillary tuberosity (arrow).

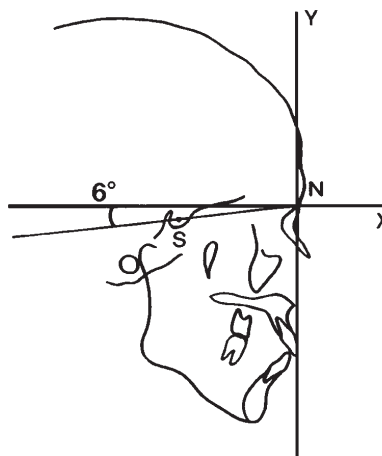


Figure 3 Method used for analysis of the lateral cephalograms. The X-axis was constructed by drawing a line through the nasion 6 degrees upward from the sella-nasion (S-N) line, and the Y-axis was drawn as a straight line crossing the X-axis and passing through N.

spine (ANS), point A, upper incisor (U1), and posterior nasal spine (PNS) were registered. However, the position of PNS was unchanged during surgery because this point was included in the palatal segment. In all patients, the palatal segment was maintained in its original position due to the presence of the nasal septum and medial antral walls. Therefore, the point of maxillary tuberosity (PMT) was defined as the contact point of a line passing through the sella and outer line of the maxillary tuberosity (Figure 2). The change of PMT rather than that of PNS was examined.

Changes in the positions of ANS, point A, U1, and PMT on lateral cephalograms were measured using the cephalometric analysis method of Miyazawa *et al.* (1985; Figure 3). In brief, the X-axis (the standard axis) was constructed by drawing a line through nasion 6 degrees upward from the sella-nasion line, and the Y-axis was drawn as a straight line crossing the X-axis and passing through nasion. The movements of the examined points were represented as linear measurements in millimetres on the X and Y axes.

Cephalometric evaluation was carried out by one investigator who was unaware of the order

or the cephalogram being examined, so maintaining impartiality. Cephalometric measurements were corrected for magnification.

Results

There were no complications during the follow-up period. No remarkable change of voice or palatal morphology was observed after the combination of a Le Fort I and horseshoe osteotomy.

Table 1 shows the pre- to 5 days post-operative changes of ANS, point A, U1, and PMT in each patient. The movements of the examined points on the X- and Y-axis represent antero-posterior and supero-inferior changes, respectively. The anterior and superior movements of the examined points are indicated by a positive value, and the posterior and inferior movements by a negative value. For all of the patients except subject 1, clockwise rotation (superior movement 3–5 mm in the posterior portion without inferior movement in the anterior portion) of the dento-alveolar segment was planned pre-operatively. In subject 1, superior movement (about 5 mm) of the total dentoalveolar segment was planned. In subjects 2–5, the mean superior movement of

Table 1 Pre- to 5 days post-operative changes (mm) of ANS, point A, U1, and PMT in each patient.

		Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6
ANS	X	1.0	4.5	2.0	4.5	5.7	4.1
	Y	5.8	-0.5	0.8	-0.7	0	-1.5
A	X	1.2	2.2	1.0	4.0	4.1	3.0
	Y	5.5	0.8	0.8	-0.7	0	-0.7
U1	X	2.0	0.2	0	3.0	2.0	0.5
	Y	6.1	0.2	0	-0.6	0	-0.5
PMT	X	1.0	2.5	2.2	4.0	4.9	3.8
	Y	4.0	4.0	4.0	3.1	4.5	4.8

The movements of the examined points on the X- and Y-axis represent antero-posterior and supero-inferior changes, respectively. The anterior and superior movements of the examined points are indicated by a positive value, and the posterior and inferior movements by a negative value.

ANS, anterior nasal spine; A, point A; U1, upper incisor; PMT, point of maxillary tuberosity; X, X-axis; Y, Y-axis.

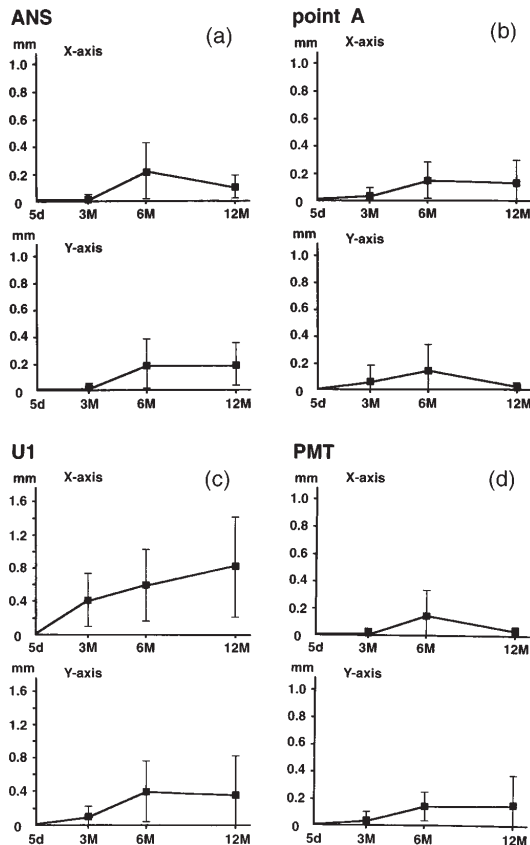


Figure 4 The post-operative change of (a) ANS, (b) point A, (c) U1, and (d) PMT (upper, change on the X-axis; lower, change on the Y-axis). The 5 d, 3 M, 6 M, and 12 M designations on the abscissas represent 5 days, and 3, 6, and 12 months after surgery, respectively. Data are expressed as mean values $\pm$ SD.

PMT was 4.1 mm (ranging from 3.1 to 4.8 mm) and the inferior movement of U1 was negligible. The maxillae of the six patients were repositioned nearly in their planned positions during surgery.

The post-operative changes of ANS, point A, U1, and PMT are shown in Figure 4 a, b, c, and d, respectively. Overall, the post-operative change of the examined points tended to increase up to 6 months after surgery, then remain comparatively stable from 6 to 12 months. The changes of the skeletal points (ANS, point A, and PMT) were very small (less than 0.5 mm) at any examination point.

Discussion

The design of the horseshoe osteotomy was first reported by Hall and Roddy (1975), who initially called it the 'total maxillary alveolar osteotomy (TMAO)'. Wolford and Epker (1975), and West and McNeil (1975) described similar maxillary osteotomies with some modifications, but these methods were not combined with a Le Fort I osteotomy. The term 'horseshoe osteotomy' was first used by Bell and McBride (1977) in a procedure they referred to as the 'horseshoe palatal osteotomy'. In their report, the horseshoe osteotomy was introduced as a palatal osteotomy combined with a Le Fort I osteotomy. While there have been several reports on the post-operative stability of the maxilla after TMAO or modified TMAO (Hall and Roddy, 1975; West and McNeil, 1975; Wolford and Epker, 1975;

Epker, 1981), few have described the post-operative stability of the maxilla after horseshoe osteotomy combined with a Le Fort I osteotomy (Bell and McBride, 1977).

In this study, the maxillae treated with Le Fort I and horseshoe osteotomies were repositioned nearly in their planned positions during surgery. This suggests that this combination is a useful method for reliable superior repositioning of the maxilla. In addition, post-operative changes of ANS, point A, and PMT were very small (less than 0.5 mm). Therefore, in bimaxillary surgery, it appears that the post-operative stability of the maxillary dentoalveolar segment superiorly repositioned with Le Fort I and horseshoe osteotomies was satisfactory.

Excellent maxillary stability after superior repositioning of the maxilla has been found (Hall and Roddy, 1975; West and McNeil, 1975; Wolford and Epker, 1975; Schendel *et al.*, 1976; Epker, 1981; Greebe and Tuinzing, 1987). Recently, Proffit *et al.* (1996) reported that the most stable orthognathic procedure was superior repositioning of the maxilla. However, the superior repositioning of the maxilla was not performed by horseshoe osteotomy combined with Le Fort I (two-piece osteotomy technique), but by a single piece technique such as a single-segment Le Fort I, TMAO, or modified TMAO (Hall and Roddy, 1975; West and McNeil, 1975; Wolford and Epker, 1975; Schendel *et al.*, 1976; Epker, 1981; Greebe and Tuinzing, 1987; Proffit *et al.*, 1996). Since the conditions (the method of maxillary fixation or presence of post-operative MMF, etc.) in the previous reports are different from those in this study, it is difficult to compare the data.

Conclusions

The horseshoe osteotomy combined with a Le Fort I osteotomy for superior repositioning of the maxilla has the following advantages: (1) reliable superior repositioning of the maxilla is possible, especially the posterior portion; (2) there is no risk of cutting the descending palatine artery when the Le Fort I osteotomy and downfracture are carefully performed; and (3) the maxilla can be moved superiorly without

narrowing the nasal airway or affecting the functional nasal airway.

On the other hand, this combination osteotomy has two disadvantages: (1) there is a potential risk of damage to the roots of the teeth in the molar region during the horseshoe palatal bone cut; and (2) it is difficult to apply this osteotomy to cleft patients since their bony palates are not intact.

The combination of a Le Fort I and horseshoe osteotomy is believed to be a useful technique for reliable superior repositioning of the maxilla, especially its posterior portion, without a risk of cutting the descending palatine artery. Up to 12 months after bimaxillary surgery, the post-operative stability of the superiorly repositioned maxilla using this combination osteotomy was satisfactory. However, a longer-term follow-up of the patients treated with this combination osteotomy and further research on more subjects will be needed.

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