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Comparison study of the Le Fort I osteotomy using 2- and 4-plate fixation

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ABSTRACT

This study was conducted to evaluate the postsurgical stability of Le Fort I osteotomy using zygomatic buttress internal fixation alone with no piriform aperture internal fixation. Patients with maxillary retrognathia and mandibular prognathism underwent the Le Fort I osteotomy with a bilateral sagittal split ramus osteotomy. In group I, fixation was accomplished using titanium plate and screws placed at the piriform aperture and the zygomatic buttress (4 plates). In group II, fixation was accomplished using titanium plate and screws placed at the zygomatic buttress (2 plates). Lateral cephalometric radiographs were taken preoperatively (T1), immediately after surgery (T2), and at 6 months to 1 year (T3) to evaluate skeletal movement. In total, 32 patients were included in this study. None of the patients had wound infection, dehiscence, bone fragment instability, and long-term malocclusion. Regarding point A and the posterior nasal spine (PNS), vertical and horizontal relapse in groups I and II did not differ significantly. In most hospitals, the maxilla was fixed using four plates (piriform aperture and zygomatic buttress); however, within the limitations of the study, the choice of the number of plates for osteosynthesis following Le Fort I osteotomy and repositioning of the maxilla can be left to the discretion of the surgeon without putting the patients at risk for increased relapse by careful intraoperative management.

Keywords: orthognathic surgery, Le Fort I osteotomy, skeletal stability, relapse

Abbreviations:
PNS: posterior nasal spine
SNA: sella-nasion-A point angle
PP/SN: angle between the palatal plane and the sella-nasion plane

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INTRODUCTION

The Le Fort type I osteotomy is a surgical technique used to treat patients with jaw deformity, including techniques such as a bilateral sagittal split ramus osteotomy and an intraoral vertical ramus osteotomy. A titanium plate and a resorbable plate are used for bone fragment fixation after osteotomy, and several studies have compared the postoperative stability of each fixation method.[1-5] In the majority of studies where plates and screws were used for fixation, the maxilla was secured using four plates (piriform aperture and zygomatic buttress). However, few studies have investigated the number of plates required for maxillary bone fragment fixation after performing Le Fort I osteotomy.[6,7] Therefore, this study aimed to clarify whether there was a difference in postoperative bone fragment displacement of maxillary fixation using either two or four titanium plates.

MATERIALS AND METHODS

Sample

This retrospective study was approved by the Institutional Review Board of the Nagoya University Hospital (research representative facility approval: 2018-0162). The study was performed in accordance with the Helsinki Declaration of 1975 and its amendments, and the laws and regulations of the Japan. The study subjects comprised patients without congenital malformations such as cleft lip and palate who underwent a Le Fort I osteotomy and a bilateral sagittal split ramus osteotomy with/without genioplasty under the diagnosis of maxillary retrognathia and mandibular prognathism at our department. Irrespective of the number of plates used, there was contact between the bone fragments, and in this case, stability was obtained. Cases in which bone fragments did not contact each other and stability was not obtained were excluded from study. Patients who underwent surgery at our department from April 1, 2013 to March 30, 2018, with bone fragments fixed 4 L-shaped titanium plates (group I) or 2 L-shaped titanium plates (group II), were included in this study. All surgeries were performed by a single surgeon who had more than 20 years of clinical experience.

Surgical technique

Surgery was performed using a circumvestibular incision or a longitudinal incision of the bilateral maxillary first molar and an intrasulcular incision. Osteotomy at the Le Fort I level and down-fracture were performed using a reciprocating saw and rowe forceps, respectively. The interocclusal splint was adapted to the upper and lower dentition, and intermaxillary fixation was performed. For patients in group I, four 0.8-mm-thick L-shaped titanium locking plates (Stryker Corporation, Kalamazoo, MI, USA) were used for fixation, which were placed at the piriform aperture and the zygomatic buttress and fixed using five locking screws with a length of 4 mm and a diameter of 1.7 mm (Stryker Corporation, Kalamazoo, MI, USA) each (Fig. 1A and 1C). If the surgeon determined that the use of two similar plates and screws on the zygomatic buttress provided sufficient fixation, it was designated as group II (Fig. 1B and 1D). In cases of bilateral sagittal split ramus osteotomy, the surgeon fixed the mandible with a set of one plate and four screws on each side. Bone fragment fixation in genioplasty was performed using titanium or absorbable screws. In all patients, elastics were used to maintain ideal occlusion, and a soft non-chew diet was started 10 days after the operation.

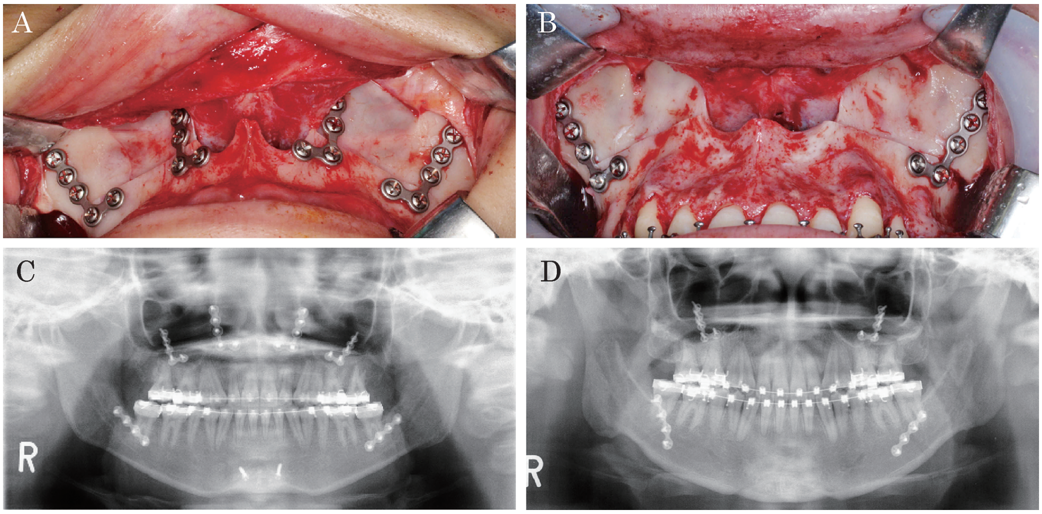

Fig. 1 Intraoperative photograph and X-ray after surgery
Intraoperative views in group I (A) and group II (B). Panoramic radiograph after surgery in group I (C) and group II (D).

Cephalometric analysis

Cephalometric radiographs were taken before operation (T1), immediately after surgery (T2), and after more than 6 months and within 1 year (T3) after surgery, and the following parameters were measured and analyzed by a single investigator.[3-7] Horizontal changes, positive value indicates anterior movements and negative value indicates posterior movement. Vertical changes, positive value indicates superior inferior movements and negative value indicates inferior movements.

Angle measurement

The sella-nasion-A point angle (SNA) and the angle between the palatal plane and the sella-nasion plane (PP/SN) were measured (Fig. 2).[8]

Distance measurement

The sella was considered as the origin, the sella-nasion plane as the X-axis, the straight line perpendicular to it as the Y-axis, A point and posterior nasal spine (PNS) were projected on each axis, and the vertical distance and horizontal distance were calculated (Fig. 2).[9]

Statistical analysis

The measurements obtained for each group were compared using the Mann–Whitney U test. Differences were considered to be significant at $P < 0.05$.

Postoperative complications were examined for wound infection that require the addition of antibiotics 24 hours after surgery, wound dehiscence, bone fragment instability that requires re-fixation of bone fragments, and long-term malocclusion that requires re-orthognathic surgery.

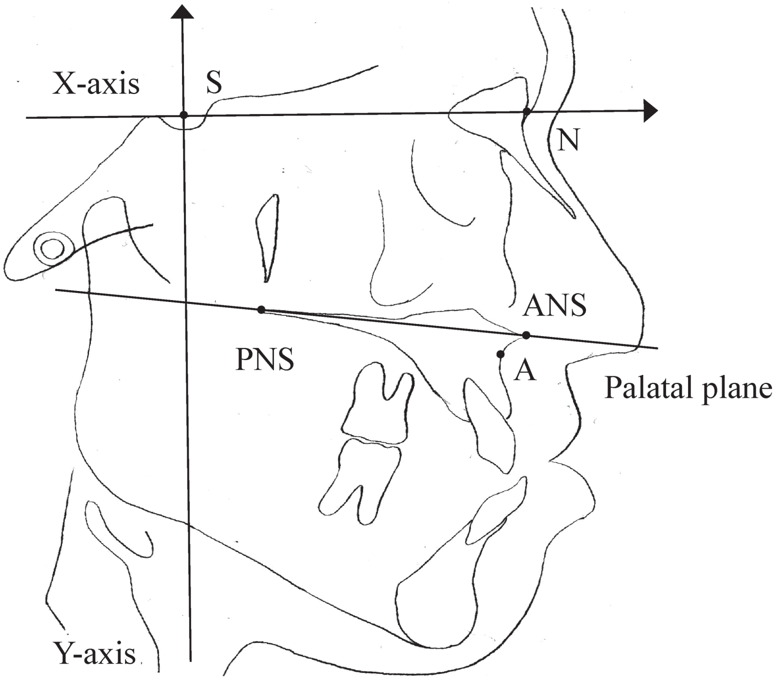

Fig. 2 Cephalographic landmarks
S (sella): the midpoint of sella turcica
N (nasion): the intersection of the internal suture with the nasofrontal suture in the midsagittal plane
ANS: anterior nasal spine
PNS: posterior nasal spine
Palatal plane: the plane formed by joining ANS to PNS
A: the deepest midline point on the premaxilla between the anterior nasal spine and prosthion
X-axis: SN plane
Y-axis: the line perpendicular to the X-axis passing through the sella

RESULTS

Of a total of 46 patients, 14 were excluded from the study due to congenital disease or lack of contact between the maxillary bone fragments. A total of 32 patients with maxillary retrognathia and mandibular prognathism underwent the Le Fort I osteotomy with a bilateral sagittal split ramus osteotomy. Group I had 19 cases and group II had 13 cases. None of the patients had complications such as wound infection, dehiscence, bone fragment instability, and long-term malocclusion.

The results of all patients along with median and range are presented in this study. In group I, median of the age at the time of surgery, operation time and amount of bleeding were 19 (16–31) years, 280 (220–410) minutes, 165 (26–474) mL, respectively. For patients in group II, median of the age, operation time, and amount of bleeding were 26 (16–46) years, 340 (220–390) minutes, and 211 (22–1110) mL, respectively. Age at the time of surgery (p = 0.14), the surgical duration (p = 0.15), and the amount of bleeding (p = 0.59) showed no significant differences (Table 1).

Table 1 Subjects

Measurement aspects	Group I median (range)	Group II median (range)	p value
Age at operation	19 (16–31)	26 (16–46)	0.14
Operation time (min)	280 (220–410)	340 (220–390)	0.15
Amount of bleeding (mL)	165 (26–474)	211 (22–1110)	0.59

Cephalometric analysis at T1

There was no significant difference between groups I and II in terms of SNA 80.8° (76.1°–86.1°) and 80.4° (77.5°–87.8°), PP/SN 8.6° (3.9°–13.3°) and 10.9° (5.9°–14.7°), vertical distance of A point 64.3 (60.8–70.5) mm and 66.4 (61.5–80.6) mm, horizontal distance of A point 58.9 (52.0–69.0) and 63.2 (56.0–67.6) mm, vertical distance of PNS 51.9 (48.7–59.9) mm and 50.9 (47.2–58.6) mm, horizontal distance of PNS 13.0 (7.6–19.1) mm and 13.0 (8.4–18.3) mm (p = 0.98, 0.67, 0.10, 0.41, 0.27 and 0.78, respectively) (Table 2).

Table 2 Preoperative data at T1

Measurement aspects	Group I median (range)	Group II median (range)	p value
SNA (degree)	80.8 (76.1–86.1)	80.4 (77.5–87.8)	0.98
PP/SN (degree)	8.6 (3.9–13.3)	10.9 (5.9–14.7)	0.67
Vertical distance [A] (mm)	64.3 (60.8–70.5)	66.4 (61.5–80.6)	0.10
Horizontal distance [A] (mm)	58.9 (52.0–69.0)	63.2 (56.0–67.6)	0.41
Vertical distance [PNS] (mm)	51.9 (48.7–59.9)	50.9 (47.2–58.6)	0.27
Horizontal distance [PNS] (mm)	13.0 (7.6–19.1)	13.0 (8.4–18.3)	0.78

SNA: sella-nasion-A point angle
PP/SN: angle between the palatal plane and the sella-nasion plane
PNS: posterior nasal spine

Surgical changes between T2 and T1

In both groups I and II, the maxilla was moved anteriorly and superiorly. No significant difference was observed between groups I and II in terms of SNA 2.3° (0.3°–4.5°) and 2.6° (0.4°–4.6°), PP/SN 2.6° (0.5°–8.1°) and 2.4° (0.1°–5.2°), vertical distance of A point 1.5 (0.1–3.4) mm and 1.3 (0.1–3.5) mm, horizontal distance of A point 2.4 (0.3–5.6) and 3.2 (0.8–6.4) mm, vertical distance of PNS 1.1 (0.0–5.4) mm and 2.3 (0.1–4.4) mm, horizontal distance of PNS 2.4 (0.1–7.3) mm and 2.5 (0.6–7.0) mm (p = 0.62, 0.39, 0.94, 0.11, 0.98 and 0.21, respectively) (Table 3).

Table 3 Surgical changes between T2 and T1

Measurement aspects	Group I median (range)	Group II median (range)	p value
SNA (degree)	2.3 (0.3–4.5)	2.6 (0.4–4.6)	0.62
PP/SN (degree)	2.6 (0.5–8.1)	2.4 (0.1–5.2)	0.39
Vertical distance [A] (mm)	1.5 (0.1–3.4)	1.3 (0.1–3.5)	0.94
Horizontal distance [A] (mm)	2.4 (0.3–5.6)	3.2 (0.8–6.4)	0.11
Vertical distance [PNS] (mm)	1.1 (0.0–5.4)	2.3 (0.1–4.4)	0.98
Horizontal distance [PNS] (mm)	2.4 (0.1–7.3)	2.5 (0.6–7.0)	0.21

SNA: sella-nasion-A point angle
PP/SN: angle between the palatal plane and the sella-nasion plane
PNS: posterior nasal spine

Change from T2 to T3

In group I and II, the vertical displacement of point A were 0.9 (0.6–2.2) mm and 0.7 (0.0–2.2) mm, respectively (p = 0.64). In group I and II, the horizontal displacement of point A were 1.1 (0.1–2.6) mm and 0.8 (0.3–2.3) mm, respectively (p = 0.33). The PNS moved 0.6 (0.0–3.6) mm vertically and 0.6 (0.0–3.9) mm horizontally in group I and 0.2 (0.0–2.1) mm vertically and 1.0 (0.2–1.9) mm horizontally in group II (p = 0.12 and 0.17). Consequently, the SNA and PP/SN changed by 0.7° (0.0°–2.0°) and 1.0° (0.0°–4.6°) in group I and by 1.0°(0.3°–2.3°) and 0.5° (0.0°–2.1°) in group II, respectively. No significant difference was observed between the two groups in terms of these parameters (p = 0.77 and 0.06) (Table 4).

Table 4 Changes in skeletal variables between T3 and T2

Measurement aspects	Group I median (range)	Group II median (range)	p value
SNA (degree)	0.7 (0.0–2.0)	1.0 (0.3–2.3)	0.77
PP/SN (degree)	1.0 (0.0–4.6)	0.5 (0.0–2.1)	0.06
Vertical distance [A] (mm)	0.9 (0.6–2.2)	0.7 (0.0–2.2)	0.64
Horizontal distance [A] (mm)	1.1 (0.1–2.6)	0.8 (0.3–2.3)	0.33
Vertical distance [PNS] (mm)	0.6 (0.0–3.6)	0.2 (0.0–2.1)	0.12
Horizontal distance [PNS] (mm)	0.6 (0.0–3.9)	1.0 (0.2–1.9)	0.17

SNA: sella-nasion-A point angle
PP/SN: angle between the palatal plane and the sella-nasion plane
PNS: posterior nasal spine

DISCUSSION

In previous 3D fine element analysis and experiments conducted using models, several researchers have reported the mechanical advantage of using four plates for fixation over using two plates.[10-13] However, the results of the present study showed that the amount of bone fragment movement that occurred within 1 year after the operation was not significantly different from that in the group in which four plates were used for fixation even when bone fragments were fixed using two titanium plates. In cases where bone fragments were in contact with each other and stability was obtained, it was suggested that the plate at the piriform aperture may not be necessary.

At least three points of contact between the zygomatic buttress and the piriform aperture on both sides are important when only two plates are used, and bone interference must be removed carefully. At our facility, we use rongeurs and ultrasonic cutting tools to remove only the areas of bone interference. Furthermore, after plating the zygomatic buttress, the operator manually moves the anterior teeth in the vertical direction. At that time, if any concern about the stability of the bone fragments arises, an L-shaped plate or screw is added to the piriform aperture.

In a previous study reported in 2003, Murray et al demonstrated the results obtained when a 2.0-mm-thick titanium plate was used only on the piriform aperture and also showed that there was no significant difference in the amount of postoperative bone fragment movement between the groups in which two plates were used for fixation and the group in which four plates were used. In the present study, we used a plate at the zygomatic buttress, because this part also has a thick bone as that of the piriform aperture. The thickness of the bone is important for the fixation force.[14] If the maxillary incision line is both longitudinal incisions on both sides of the first molar and an intrasulcular incision, the plate can be removed through longitudinal incisions alone. In addition, the plate can be removed under local anesthesia. This may be an advantage because the soft tissue around the nose does not need to be touched and the undesirable spread of the alar may be suppressed.[15] A limitation of this study is that bone thickness was not measured. In future studies, bone thickness must be measured, and its effects on postoperative stability must be assessed.

In this study, bone fragments were in contact with each other after osteotomy and were fixed with two plates only when stability was obtained. We did not include the inferior movement of the maxilla because if a gap was present between the bone fragments, the strength of the two plates would probably be insufficient. Therefore, when inferior movement of the maxilla is needed, many plates may be required for bone fixation. After fixing the zygomatic buttress, the surgeon confirms the degree of fixing with the sensation of the fingers, but it lacks objectivity. We are considering an objective evaluation method. This study included only patients undergoing bimaxillary surgery, which is a limitation of this study, and so the amount of movement of the maxilla was suppressed to a small extent; this is one of the aspects of postoperative stability that did not differ between groups I and II. It is unclear whether the same results as in this study can be obtained by surgery on the maxilla alone. With regard to postoperative stability, another limitation of this study is that the patient's chewing patterns should have been considered, but we did not investigate chewing patterns; in fact, we instructed patients to adhere to a soft diet for 2–3 months after the operation. Further study is required to determine the shape of the plate to be used in the future. In the present study, an L-shaped plate was used, but using a square plate would be more advantageous for fixation than using an L-shaped plate, because two portions would cross the incision. Moreover, the number of screws can be reduced from five to four.

CONCLUSION

The subjects of this study are the results of a retrospectively selected 13 patients with limited conditions operated by an experienced oral surgeon. Postoperative bone fragment fixation after

Le Fort type I osteotomy is not always possible with two plates. Within the limitations of this study the choice of the number of plates for osteosynthesis following Le Fort I osteotomy and repositioning of the maxilla can be left to the discretion of the surgeon without putting the patients at risk for increased relapse. We suggest that unnecessary plate and screw placement could be avoided by careful intraoperative management and skilled surgical procedures.

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CONFLICT OF INTEREST

The authors have no financial conflicts of interest to declare.

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