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Evaluation of maxillary sinus after Le Fort I osteotomy using various fixation materials

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ABSTRACT

Purpose: The purpose of this study was to evaluate maxillary sinus and predict the factors affecting the postoperative sinus condition after Le Fort I osteotomy using various fixation materials.
Materials and methods: The study subjects consisted of 71 patients (21 male and 50 female, 142 sides) who underwent Le Fort I osteotomy with sagittal split ramus osteotomy. The maxillary sinus bony area and the inside air area were measured in the coronal plane across the mesial aspect of the first molar perpendicular to the Frankfurt horizontal plane of a computed tomography (CT) image preoperatively and at 1 week and 1 year after surgery. The rate of intact sinus area (the inside air area/the maxillary sinus bony area) was calculated. Subjects were divided into groups according to gender, preoperative diagnosis (Angle class II and III with and without asymmetry), plate fixation material (PLLA and uHA/PLLA), and use or non-use of bone alternative material (α-tricalcium phosphate). Statistic comparisons between groups were performed in each division. Furthermore, age, operation time, amount of blood loss, and direction and amount of movement were examined as the continuous variables to statistically predict the rate of intact sinus area after 1 week and 1 year.
Results: The rate of intact sinus area after 1 week was significantly correlated with age, amount of anterio-posterior movement, and preoperative rate of the intact sinus area ($p < 0.0001$). Rate of intact sinus area after 1 year was significantly low in the group that used the bone alternative material compared to the group that did not ($p < 0.0282$).
Conclusion: The study suggests that the bone alternative material might be a cause of inflammation in the sinus after 1 year. Moreover, attention needs to be paid to older age, backward movement of the maxillary segment, and preoperative sinusitis including hypertrophy of sinus membrane in Le Fort I osteotomy.

1. Introduction

Le Fort I osteotomy is frequently used in combination with mandibular osteotomy for maxillary deformity. Many complications of Le Fort I osteotomy occur from unfavorable dysjunction of the pterygoid plates from the posterior maxillary wall, including excessive bleeding, cranial nerve injury, and carotid artery injury (Steel and Cope, 2012). A previous review on the incidence of complications and problems related to orthognathics revealed that the most common complication is neurosensory deficit in inferior alveolar nerves after mandibular surgery, as well as intraoperative bleeding (Panula et al., 2001). Postoperative maxillary sinusitis is uncommon after Le Fort I osteotomy. Therefore, there are few studies on the postoperative maxillary sinus situation after Le Fort I osteotomy (Nocini et al., 2016).

In Le Fort I osteotomy, various alternative materials have sometimes been used between the segments to obtain long-term stability. In earlier days, autogenous bone from the iliac crest or rib was recommended (Araujo et al., 1978; Bloomquist, 1980, 1982), although freeze-dried bone (Epker et al., 1976), proplast blocks

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(Burton et al., 1980), and the solid-block form of hydroxyapatite were also advocated (Kent et al., 1986). Demineralized bone matrix or iliac corticocancellous graft were also used for Le Fort I osteotomy interpositional graft (Lye et al., 2008; Posnic and Sami, 2015). Self-setting α-tricalcium phosphate (Biopex®; Pentax Co, Tokyo, Japan) has also been recognized as one of the most useful bone alternative materials (Monma et al., 1988; Ueki et al., 2013), and has been used in Japan. An absorbable plate system has been newly developed and frequently used in orthognathic surgery, and there have been many studies that proved the usefulness and skeletal stability of the absorbable plate (Ueki et al., 2005, 2006, 2011a,b).

Although studies on postoperative stability and nerve disturbance after Le Fort I osteotomy have been reported, no report has evaluated the effect of the maxillary sinus following use of various fixation materials.

The purpose of this study was to evaluate the maxillary sinus and to predict the factors affecting the postoperative sinus condition after Le Fort I osteotomy with the use of various fixation materials by computed tomography (CT).

2. Materials and methods

2.1. Study patients

The study subjects were 73 Japanese adults (male, 23; female, 50) with jaw deformities who underwent Le Fort I osteotomy with sagittal split ramus osteotomy (SSRO). At the time of orthognathic surgery, the patients ranged in age from 16 to 54 years, with a mean age of 27.6 years (standard deviation, 9.4 years). Although this study was retrospective, informed consent was obtained from the patients, and the study was approved by the ethical committee of clinical study of Yamanashi University Hospital.

2.2. CT assessment

Computed tomography was performed in all patients, preoperatively, immediately after surgery, and after 1 year. The patients were placed in the gantry with the tragacanthal line perpendicular to the ground for CT scanning. They were instructed to breathe normally and to avoid swallowing during the scanning process. CT scans were obtained in the radiology department by skilled radiology technicians using a high-speed, advantage-type CT generator (Light Speed Plus; GE Healthcare, Milwaukee, WI, USA) with each sequence taken 1.25 mm apart for three-dimensional (3D) reconstruction (120 kV, average 150 mA, 0.7 s/rotation, helical pitch 0.75).

A total of 146 sides (73 right and 73 left sides) were measured. The maxillary sinus bony area and the inside air area were measured in the coronal plane across the mesial aspect of the first molar perpendicular to the Frankfurt horizontal plane of CT. The rate of intact sinus area (the inside air area/the maxillary sinus bony area) was calculated using an image software (ImageJ; the Research Services Branch, National Institute of Mental Health, Bethesda, MD, USA) and SimPlant O & O (Materialise Dental n.v., Leuven, Belgium) (Figs. 1–3).

All CT images were measured by one author (K.U.). Fifteen patients were selected, and the calculation was performed using Dahlberg's formula (Dahlberg, 1940):

$$ME = \sqrt{\Sigma d^2/2n}$$

where d is the difference between two registrations of a pair, and n is the number of double registrations. The random errors did not exceed 2.0 mm^2 for the square measurements.

2.3. Statistical analysis

For the statistical analysis, groups were categorized based on the following:

1) Gender (male vs female)
2) Preoperative diagnosis (Angle class II vs III) and (symmetry vs asymmetry)
3) Plate fixation material (PLLA vs uHA/PLLA vs titanium). The two fixation materials were as follows. PLLA group: 4 PLLA L-type mini-plates (10 × 22 × 1.5 mm with 4 screws (2 × 6 mm), Fixorb®-MX; Takiron Co., Osaka, Japan), uHA/PLLA group: 4 uHA/PLLA L-type mini-plates (10 × 22 × 1.4 mm with 4 screws (2 × 6 mm), Super-Fixorb®-MX; Takiron Co., Osaka, Japan).
4) Use of bone alternative material: self-setting α-tricalcium phosphate (α-TCP) (Biopex®; Pentax Co, Tokyo, Japan) (Fig. 4) (yes vs no)
5) Removal of the interference between the pterygoid plate and posterior site of the maxillary bone using ultrasonic bone curette (yes vs no)

Furthermore, age, operation time, amount of blood loss, amount and direction of movement, and preoperative and 1 week postoperative rate of intact sinus area were selected as the continuous variables to statistically predict the rate of intact sinus area after 1 week and 1 year.

For the amount of anterior-posterior movement, a positive value indicated advancement and a negative value indicated setback at the A point. For the amount of lateral movement, a positive value indicated movement to the right and a negative value indicated movement to the left at the A point.

For the amount of impaction in the anterior site, a positive value indicated impaction movement and a negative value indicated downward movement at the midpoint of the bilateral incisor edge.

For the amount of impaction in the right molar site, a positive value indicated impaction movement and a negative value

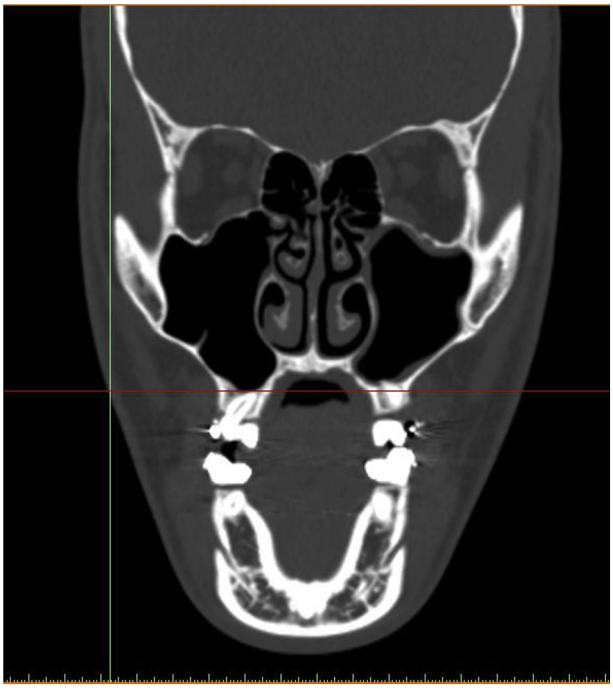

Fig. 1. Preoperative coronal computed tomographic image.