Abstract: Backsliding is a major problem when moving the maxilla significantly forward in orthognathic surgery. For example, in sleep surgery, maxillomandibular advancement is an application of orthognathic surgery, and it is well known that the anterior movement of the maxilla back and forth is an important factor that greatly widens the pharyngeal airway. However, postoperative backsliding is a major problem in this surgery. Therefore, a surgical method was devised to prevent the maxilla from retracting by adjusting the bone when moving the maxilla forward.

Keywords; Kumiki method, Le Fort I osteotomy, maxillomandibular advancement, orthognathic surgery

Introduction

Le Fort I osteotomy (LI osteotomy) was first reported by Wassmund in 1927. The procedure was later improved by Obwegeser and Bell, and has become established for orthognathic surgery. In conventional LI osteotomy, the stability of the maxillary segment depends largely on the fixation material, and if the amount of movement is large, postoperative stability may decrease. In recent years, there has been a focus on maxillomandibular advancement (MMA), which is a surgical treatment for obstructive sleep apnea (OSA) [1]. MMA is an application of orthognathic surgery. Surgery that moves the upper jaw significantly forward, such as MMA, can cause maxilla instability and backsliding after surgery [2]. Therefore, it is necessary to devise a surgical procedure that considers postoperative stability. A modified method of LI osteotomy (the Kumiki method) was developed to improve the postoperative stability of maxillary advancement by addition of osteosynthesis. In this paper, the Kumiki method is reported as a new surgical procedure.

Materials and Methods

Cephalometric analysis

Preoperative, immediately postoperative and postoperative lateral roentgenographic cephalograms were taken as required for treatment. The orthodontic cephalometric software WinCeph ver.9.0 (Rise Corporation, Sendai, Japan) was used to determine the number of pixels and the distance between the pixels based on Digital Imaging and Communications in Medicine data, and to calibrate the dimensions. Preoperative, immediately postoperative, and 1-year postoperative lateral roentgenographic cephalograms were traced and superimposed before and immediately after surgery, and immediately postoperatively and 1 year postoperatively, respectively. The reference points were set as the S point and N point. The SN plane was defined as the X-axis and the plane perpendicular to it as the Y-axis. Each measurement point was calculated based on the coordinates with respect to the X-Y coordinate axes, and was used as the amount of movement and the amount of change. The study was approved by the Nihon University School of Dentistry Ethics Committee ( Permit No. EP20D005).

Conditions for taking lateral roentgenographic cephalograms

An X-ray high-voltage device KXO-50 R (Toshiba, Tokyo, Japan) was used for imaging, and the imaging conditions were a tube voltage of 80 kVp, a tube current of 100 mA, and an irradiation time of 0.16 s. The subject was in a sitting position, with the Frankfurt plane parallel to the floor, and the head was fixed by inserting ear rods into the left and right external ear canals. At the time of imaging, the subject was instructed to close the lips without force and to lightly occlude at the molars. The X-ray bundle passed through the center of the ear rod and was positioned so that it was perpendicular to the mid-sagittal plane of the subject. The respiratory phase at the time of imaging was that of breath holding after inhaling once.

Surgical procedure

The outline of the Kumiki method is as follows. The maxillary segment is moved forward after down-fracture by conventional LI osteotomy (Figs. 1A, 2A). After this process, the amount of movement is slid by scraping the bone as a whole in conventional LI osteotomy (Fig. 2B, C), whereas in the Kumiki method, the nasal buttress and buccal buttress, which are parts of the bone that interfere, are cut into a dent shape (Figs. 1B, 2D) and the bone as a whole in conventional LI osteotomy (Fig. 2B, C), whereas in the Kumiki method, the nasal buttress and buccal buttress, which are parts of the bone that interfere, are cut into a dent shape (Figs. 1B, 2D) and the maxillary segment is fitted into the dent. In this manner, in the Kumiki method, the maxilla is skeletally moved forward by ≥10 mm. Aoki et al. [5] examined the optimal distance and direction of anterior movement of the maxilla and found that the airway was effectively extended by anterior movement of the maxilla of 4 mm or more and superior movement of 3 mm or more. This report showed the importance of effectively expanding the oral volume and incorporating the posteriorly depressed tongue into the oral cavity by combining anterior and upward movements rather than moving the maxilla only anteriorly. Therefore, the direction of forward movement of the upper jaw was set to move forward and upward. Preoperative maxillary movement was measured as follows. Before surgery, the amount of movement of the maxilla up and down and back and forth was determined by normalization of the occlusal plane and Sassouni analysis. Then, during
the operation, the amount of upward movement was finally adjusted using the position of the lip line of the upper lip and the incisal edge of the maxillary anterior tooth.

The technique of LI osteotomy was further improved by several surgeons. As reported by Macario et al. [6], with conventional LI osteotomy, the amount of bone that moves upward in the maxilla is completely removed (Fig. 2C). In contrast, the Kumiki method removes only interfering bones, creating overlapping bones in the nasal buttress and buccal buttress (Figs. 1, 2D). The bone in this site is thick and has mechanical strength to resist masticatory stress [7]. As a result, in conventional LI osteotomy, the contact between bones is a point, and bone stability depends on the function of the plate and screw. In contrast, the Kumiki method can increase bone interference by fitting the maxillary segments. Furthermore, the moving bone secured by a locking screw and plate system is more stable.

Dhol et al. [8], Ballon et al. [9] and Landes et al. [10] have examined maxillary stability in orthognathic surgery using conventional LI osteotomy and fixation with titanium plates and screws. Dhol et al. [8] and Ballon et al. [9] reported less backsliding in the relatively low-movement groups. On the other hand, Landes et al. [10] found backsliding of 2.88 ± 4.19 mm in the high-movement group with the maxilla moved forward 6.04 ± 6.66 mm. In this case, as a result of moving the maxilla forward by 5 mm, the maxilla showed stability based on movement of 1 mm or less from 1 month to 1 year postoperatively.

The Kumiki method is a suitable technique for moving the maxilla anteriorly and superiorly. However, there are some cases in which it is not suitable for the orthodontist to raise the maxillary anterior teeth upward. Therefore, surgeons and orthodontists should have thorough consultation before surgery.
Acknowledgments
This study was supported by the Japan Society for the Promotion of Science KAKENHI grants (grant number 19K10294). We would like to express our gratitude to Dr. Kotoe Mayahara of the Department of Orthodontics at our hospital for orthodontic analysis.

Conflict of interest
The authors have no conflict of interest to declare.

References