Endoscopic Maxillary Sinus Lift Without Vestibular Mucosal Incision or Bone Graft

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Aim: To augment the thickness of the maxilla in cases with marked absorption of the alveolar bone of the upper jaw due to severe periodontal disease by performing a minimally invasive sinus lift procedure without an iliac bone graft.

Methods: An endoscope is inserted into the nasal cavity, and a large drainage opening is created in the inferior meatus extending from the maxillary sinus to the nasal cavity. The endoscope and forceps for mucosal removal are then inserted into the maxillary sinus via the drainage opening, and approximately, the lower half of the maxillary sinus mucosa is excised.

Results: Computed tomographic scans more than 1 year (range, 12–36 mo; mean, 23.5 mo) after performing this procedure verified maxillary sinus floor bone growth of 2.7 to 15.4 mm (mean, 7.6 mm) on 33 sides of 17 cases. Bone growth of 5 mm or more was obtained on 31 of 33 sides.

Conclusions: With this procedure, it is possible to perform a sinus lift without the need for oral vestibular incision or bone graft. The results suggest it could provide a more minimally invasive approach to performing sinus lift.

Key Words: Periodontitis, endoscopy, maxillary sinus lift, regeneration, iliac bone marrow graft

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In cases of marked maxillary alveolar bone absorption due to severe periodontitis, maxillary sinus lift using cancellous iliac bone is performed to provide a site for implant placement.[1–12] However, postoperative problems including paranasal sinusitis and absorption of iliac bone have been associated with this procedure.[13] In addition, until approximately 15 to 20 years ago in the otolaryngologic field, the entire mucous membrane of the maxillary sinus was excised as a radical treatment of chronic sinusitis (inflammation of the maxillary sinus). In radiographs and computed tomographic (CT) scans taken several years after maxillary sinus lift using cancellous iliac bone, bony thickening of the maxillary sinus wall, including the maxillary sinus floor (Fig. 1), has been observed in all patients. In cases of reoperation due to the development of postoperative maxillary cyst, hard bony narrowing of the maxillary sinus space was confirmed with both macroscopic examination and palpation. This situation was experienced by almost all otolaryngologists at that time. By exploiting this phenomenon, it is possible to elevate the maxillary sinus floor without performing iliac bone grafts, as is the case with the currently applied procedure for maxillary sinus lift.

Furthermore, in otolaryngology, marked advances in endoscopic procedures for nasal and paranasal sinus surgeries now permit surgery of the maxillary sinus floor using an endoscopic operation alone without a vestibular mucosal incision approach.

We have previously performed regenerative medical treatment for patients with severe periodontitis using tooth and cancellous iliac bone (bone marrow) grafts, with almost satisfactory results.[14] However, one problem that was encountered during the treatment was that some of the dental roots were exposed in the maxillary sinus when grafting teeth to the maxilla, which posed a risk for odontogenic maxillary sinusitis. To solve this problem, with the cooperation of an otolaryngologist, we performed an endoscopic drainage procedure from the maxillary sinus to the nasal cavity, thereby preventing odontogenic maxillary sinusitis. At the same time, we attempted to elevate the maxillary sinus floor by endoscopically excising the mucous membrane of the maxillary sinus from the drainage opening. The results were extremely satisfactory. This is a report of the possible use of the procedure for augmenting maxilla thickness in cases of severe periodontal disease.

METHODS

Patients

Seventeen patients (8 men and 9 women; aged 31–69 y; mean, 47 y) all had marked absorption of the maxillary alveolar bone. They were examined with CT 1 year or more after being treated on a total of 33 sides with the alveolar bone regeneration treatment we previously reported[14] and endoscopic maxillary sinus lift.

Surgical Techniques

Surgery was performed by a team that included a dentist, a plastic surgeon, and an otolaryngologist.

Alveolar Bone Regeneration Treatment

First, the dentist extracted all of the teeth loosened by severe periodontitis. Root canal treatment (pulpectomy) was performed on the extracted teeth, and infected tissue including the periodontal membrane adhering to the teeth was completely removed. Next, the plastic surgeon marked an incision in the gingiva at the alveolar crest slightly toward the lip and buccal mucous membrane, and the gingiva was separated extensively from that incision line to below the periosteum. This prepares a wide surgical field for the alveolar bone while creating stretched gingival and interdental gingival flaps. After this, the dentist used a curette and/or bur to completely excise infected and cicatricial tissues, including unhealthy granulation tissue, surrounding the alveolar bone and tooth socket (Fig. 2A, B). The dentist then grafted the teeth. As a rule, teeth are grafted into their

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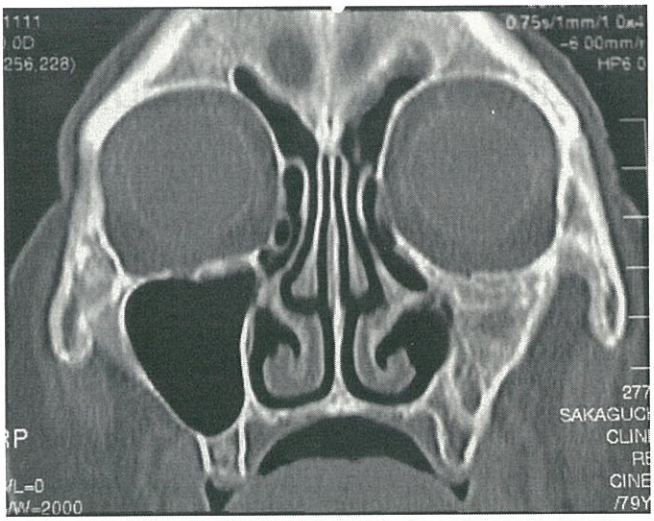

FIGURE 1. Computed tomographic findings in a case in which excision of the mucous membrane of the maxillary sinus had been performed as a radical treatment of right maxillary sinusitis 18 years previously. Compared with the right side where no surgical procedures were performed, on the left side, there is marked bony thickening of the maxillary sinus wall including the maxillary sinus floor.

original position, but there are cases in which they are grafted to a different location. If there is marked absorption of the maxillary alveolar bone, when a hole is made in the bone to graft a tooth, in many cases, part of the dental root is exposed in the maxillary sinus.

To regenerate alveolar bone, the plastic surgeon then grafted the cancellous iliac bone (bone marrow) to the areas surrounding the grafted teeth and stretched and sutured gingival flaps (Fig. 2C).[14]

Endoscopic Maxillary Sinus Lift

This was performed by an otolaryngologist. First, a wide drainage opening was created extending from the inferior nasal meatus wall to the maxillary sinus. Forceps, an aspiration tube, and a periosteal elevator were then inserted endoscopically via this drainage opening, and approximately the lower half of the maxillary sinus mucosa, including the maxillary sinus floor, was excised (Figs. 2B, C; and Fig. 3). Postoperatively, dental roots protruding into the maxillary sinus act as supporting pillars that become embedded in granulation tissue growing from the maxillary sinus floor and, after several months, in bone (Fig. 2D).

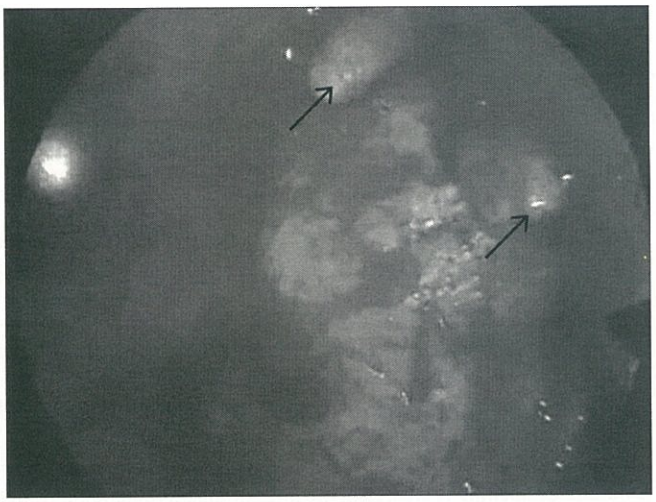

FIGURE 3. Endoscopic photograph of the maxillary sinus after excision of the mucous membrane. The root of a replanted tooth (arrow) can be seen protruding into the maxillary sinus.

Measurement of Maxillary Sinus Floor Bone Growth

Frontal section CTs were performed after surgery. The vertical thickness of newly formed bone was measured from the original location of the maxillary sinus floor. The position of the original maxillary sinus floor bone and its border could be easily determined on the CT scan because the newly formed bone is less dense than the original bone (Fig. 4). Bone growth of 0 to 5 mm was graded as fair, 5 to 8 mm as good, and 8 mm or more as excellent.

RESULTS

Computed tomographic scans taken more than 1 year (12–36 mo; mean, 23.5 mo) after the procedure demonstrated maxillary

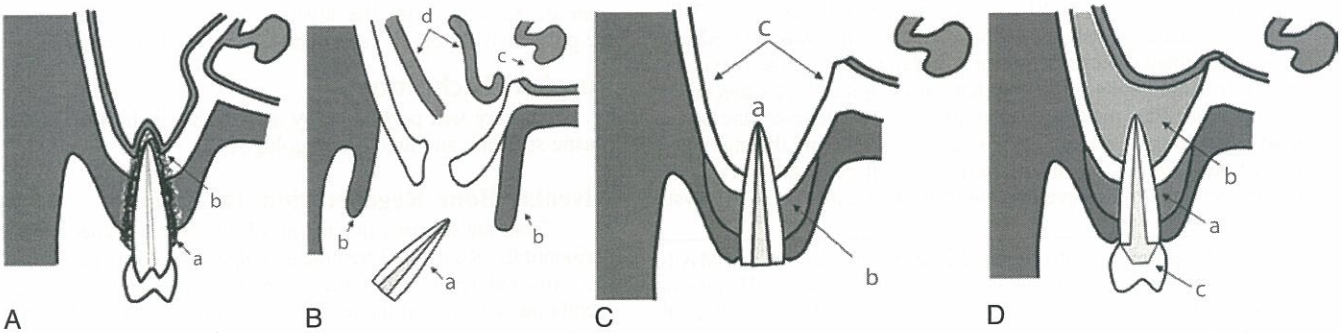

FIGURE 2. Schema of alveolar bone regeneration therapy and the endoscopic maxillary sinus lift operative procedure. A, (a) Severe preoperative periodontitis; (b) abundance of dental plaque and inflammatory tissue surrounding the dental roots, with loose teeth due to marked alveolar bone absorption. B, (a) Teeth extraction and root canal treatment; (b) gingival flap procedure; (c) creation of a drainage hole; (d) separation of maxillary sinus mucous membrane. C, Teeth replantation and bone marrow graft. (a) Protrusion of root apex into the maxillary sinus; (b) cancellous iliac bone (bone marrow) graft; (c) maxillary sinus mucous membrane excision. D, Several months to several years after surgery. (a) Alveolar bone regeneration due to bone marrow graft and (b) maxillary sinus floor bone regeneration (hyperplasia) due to mucous membrane peeling, resulting in the roots of replanted teeth becoming completely embedded in bone; (c) preparation of replanted teeth and fitting of an upper bridge.

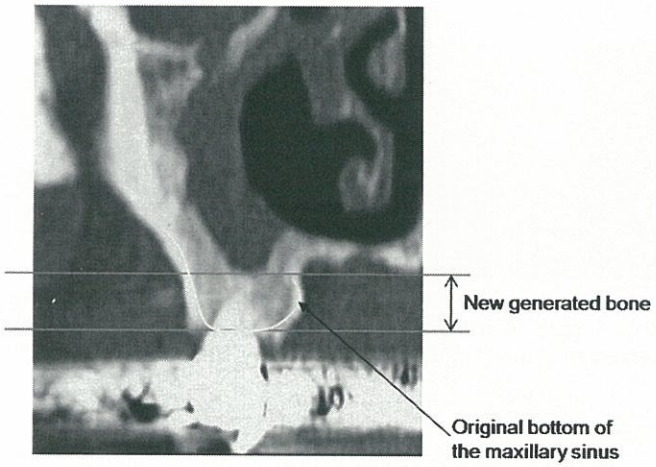

FIGURE 4. Method of measuring the thickness of regenerated maxillary sinus floor bone.

sinus floor bone growth of 2.7 to 15.4 mm (mean, 7.6 mm) on 33 sides of 17 cases. Bone growth was fair (range, 0–5 mm) on 2 sides, good (range, 5–8 mm) on 14 sides, and excellent (8 mm or more) on 17 sides.

In a patient who underwent orthognathic surgery (Le Fort I osteotomy) on the maxillary bone 8 months after surgery because of maxillary hypogrowth, regeneration of maxillary sinus bone was verified by both macroscopic examination and palpation. In addition, no postoperative evidence of complications, such as sinusitis or chronic pain, was observed in any of the cases.

Sample Cases

Patient 1

This 41-year-old male patient had experienced gradual worsening of periodontitis for the previous few years. Tooth loosening for the last 6 months had resulted in the loss of 2 teeth, causing masticatory disturbance. The only treatment option offered at numerous other hospitals was extraction of all teeth followed by replacement with a complete denture. At first visit to our hospital, periodontitis was severe in both the maxilla and mandible, and loose teeth were evident (Fig. 5A). Orthopantomogram and CT scan verified marked absorption of upper and lower alveolar bones.

The patient had all of his teeth extracted and underwent bone regenerative therapy[14] and endoscopic maxillary sinus lift. At the same time, 5 implants were embedded where teeth were missing. The postoperative course was satisfactory, with adhesion of 15 of 16 replanted teeth and all 5 of the implants. Teeth preparation was performed 4 months after surgery, and mastication was again possible. One year 9 months after surgery, masticatory function has been restored almost to its former level (Fig. 5B).

A CT scan 1 year 4 months after the procedure verified maxillary sinus floor bone growth of approximately 9.7 mm on the right side and 7.7 mm on the left (Fig. 5C).

Patient 2

Periodontitis was severe in the right mandible and left maxilla of this 58-year-old woman, and teeth had begun loosening in these areas approximately 3 to 4 months previously. The patient had been advised at several other institutions that the only treatment was extraction of all loose teeth and replacement with dentures. At first visit to our hospital, periodontitis was present throughout the maxilla and mandible but was particularly severe in the right mandible and left maxilla. Orthopantomogram revealed marked alveolar bone absorption in these 2 areas (Fig. 6A).

The patient had 7 loose teeth extracted and underwent bone regenerative therapy[14] and endoscopic maxillary sinus lift. The postoperative course was satisfactory with adhesion of all replanted teeth. Two years 5 months after surgery, masticatory function has been restored almost to its former state, whereas an orthopantomogram confirmed that the dental roots of all replanted teeth were embedded in the bone that regenerated from the bone marrow graft and in the maxillary sinus floor. A CT scan 1 year 10 months after surgery showed maxillary sinus floor bone regeneration of approximately 12.0 mm on the right and 13.3 mm on the left (Fig. 6B).

Patient 3

In this 44-year-old man, periodontitis had gradually worsened for several years, and all his teeth had begun to loosen approximately 6 months previously, making mastication difficult for the last 3 to 4 months. During consultations at several other institutions, this patient was also advised that the only treatment was extraction and replacement of all teeth with a complete denture. He consulted our hospital for an alternative treatment option. At first visit, severe periodontitis throughout the maxilla and mandible was verified (Fig. 7A), together with a severe inherent anterior overbite (mandibular protraction; Figs. 7B, C). The patient first had all teeth extracted, and bone regenerative therapy[14] and endoscopic maxillary sinus lift were performed.

The postoperative course was satisfactory, with adherence of all the replanted teeth. Four months after surgery, the teeth were

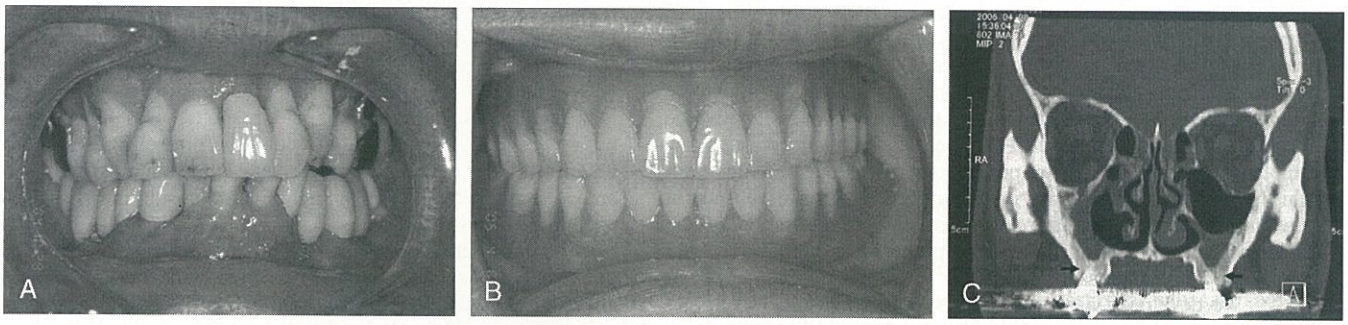

FIGURE 5. Patient 1: 41-year-old man. A, Preoperative oral cavity findings. Loosening of all of the teeth observed due to severe periodontitis. B, Oral cavity findings 1 year 4 months after surgery. An upper bridge is fitted, restoring masticatory function almost to its original level. C, Computed tomographic findings 1 year 4 months after surgery. Approximately 7.6 mm on the right and 7.7 mm on the left of regenerated bone (arrow) observed on the maxillary sinus floor.

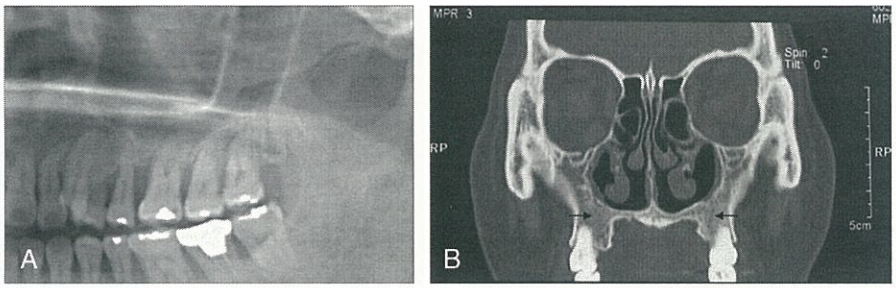

FIGURE 6. Patient 2: 58-year-old woman. A, Preoperative orthopantomogram. Marked bone absorption observed in the left maxillary molar regions. B, Computed tomographic findings 1 year 10 months after surgery. Bone regeneration of 12.0 mm on the right and 13.3 mm on the left (arrow) observed in molar region of the maxillary sinus floor.

prepared and temporary crowns were fitted. However, masticatory function could not be restored owing to the severe anterior overbite (Fig. 7D). To treat this, we performed a Le Fort I osteotomy of the maxilla and sagittal splitting and genioplasty of the mandible 8 months after the initial surgery. At this time, regeneration of the maxillary sinus floor bone from the site of the Le Fort I osteotomy was confirmed by both macroscopic examination and palpation. Palpation indicated the regeneration of firm bone in the maxillary sinus floor, and teeth that had protruded into the maxillary sinus floor after the initial operation were now completely embedded in the bone up to the root apex. However, at the time of endoscopic excision of the mucous membrane, excision in parts of the right molar region had been insufficient; hence, bone regeneration here was less than at other sites, and 2 to 3 mm of some dental roots remained exposed in the maxillary sinus. In other words, the effectiveness of our method was confirmed by macroscopic comparison of areas of sufficient and insufficient mucous membrane excision (hereafter referred to as a half-side test; Fig. 7E). Computed tomographic scans taken 1 year 7 months after the initial operation showed maxillary sinus floor bone regeneration of 10.9 mm but only 2.7 mm of the regenerated bone in the right molar region (Fig. 7F). The postoperative course after the second operation was satisfactory. At 2 years 3 months after the first operation and 1 year 7 months after the second operation, masticatory function was satisfactory (Fig. 7G), and a marked improvement in facial configuration has been obtained (Figs. 7H, I).

DISCUSSION

The only treatment commonly used for severe periodontitis with marked absorption of alveolar bone is extraction of all loose teeth followed by fitting of dentures. However, because absorption of alveolar bone results in extremely low alveolar crests, fitting of dentures often results in poor stability and restoration of sufficient masticatory function cannot be expected. Furthermore, because the jaw bone itself, including alveolar bone, has no vertical thickness, implants are not feasible. In such cases, maxillary sinus lift with iliac bone grafts is widely performed to increase bone thickness and allow implant placement. However, postoperative problems reported with this method include operative invasiveness of making an incision in the anterior portion of the oral cavity floor, fenestration of the anterior wall of the maxilla, absorption of grafted bone, and development of paranasal sinusitis.[15–21]

We developed a regeneration treatment for cases of severe periodontitis using autogenous tooth and cancellous iliac bone (bone marrow) grafts, which has provided almost satisfactory results.[14]

However, one significant problem with this method was the exposure of some of the dental roots, including the root apex, in the maxillary sinus after grafting teeth to the maxilla. This poses a risk for odontogenic maxillary sinusitis. To solve this problem, we arranged for an otolaryngologist to perform a maxillary sinus drainage procedure, which provided the impetus to develop this endoscopic maxillary sinus lift procedure. Until 15 to 20 years ago, many radical maxillary sinus operations were performed in which all the mucous membrane of the maxillary sinus was excised. It was common knowledge among otolaryngologists that narrowing of the maxillary sinus occurred after excision of the mucous membrane because of ossification (Fig. 1). This past experience indicating that sufficient bone could be regenerated by simply excising the mucous membrane, without grafting iliac or other bone to the maxillary sinus floor, was the driving force behind the development of our new method.

There are no reports on research into the mechanisms that could cause regeneration and thickening of bone in the maxillary sinus after excision of the mucous membrane. The kind of bone regenerated and the degree of regeneration possible are also unclear. Among the cases in which we conducted a CT a year or more after surgery, we observed a mean thickening of the maxillary sinus floor bone of 7.6 mm, but bone density was slightly lower than the surrounding bone. However, in one case (patient 3) in which we performed a Le Fort I osteotomy 8 months after surgery, maxillary sinus floor bone thickening was confirmed in a half-side test using both macroscopic examination and palpation. In this case, because endoscopic excision of the mucous membrane was insufficient in parts of the right molar region, approximately 2 to 3 mm of grafted teeth and dental roots protruded into the maxillary sinus. However, in other areas where the mucous membrane was completely excised, all of the dental roots up to the root apex were embedded in firm bone. The CT findings previously mentioned and the random half-side test results suggest that the mechanism for embedding of the dental roots in the bone could involve the growth of granulation tissue across the maxillary sinus floor where mucous membrane had been excised, with granulation tissue changing into bone for a period of several months (Figs. 2C, D). Conversely, in areas where mucous membrane excision was insufficient, it is possible that rapid epithelialization of the mucous membrane occurred before the protruding dental root could become embedded in granulation tissue, resulting in incomplete embedding up to the root apex. We are confident that the half-side test results clearly show the usefulness of this procedure.

Our observations suggest that maxillary sinus floor bone thickening stops when the mucous membrane becomes epithelialized. Consequently, to obtain bone growth of sufficient thickness using this procedure, it is essential to delay epithelialization by thoroughly excising the mucous membrane in the lower half of the maxillary sinus. Performing endoscopic excision of the mucous membrane from a drainage opening in the inferior nasal meatus

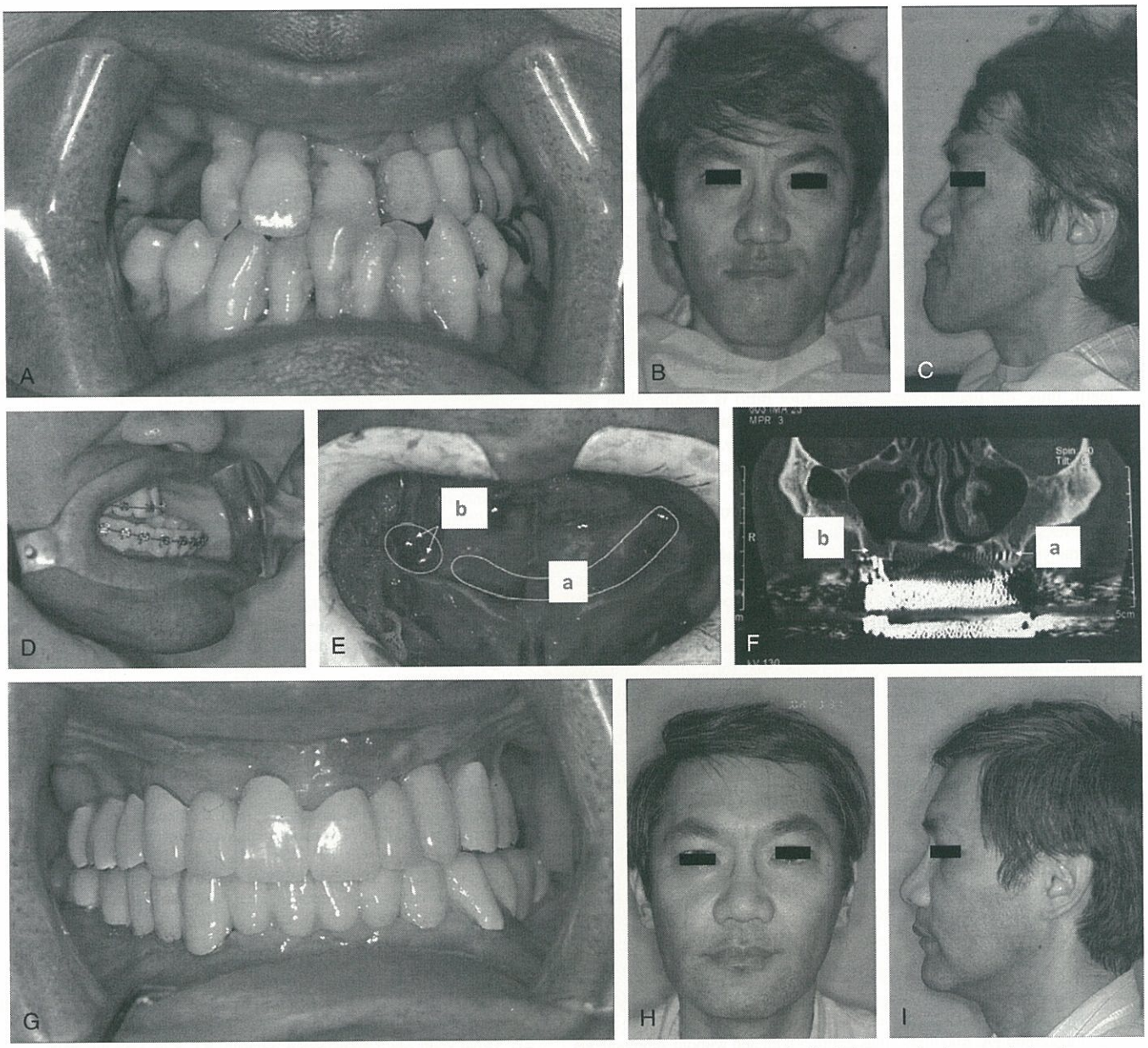

FIGURE 7. Patient 3: 44-year-old man. A, Preoperative oral cavity findings. Loosening of all of the teeth observed due to severe periodontitis. B, Preoperative facial configuration (frontal view). C, Preoperative facial configuration (lateral view). Severe mandibular protraction and anterior overbite observed. D, Findings during teeth preparation and fitting of a temporary upper bridge 4 months after surgery. Masticatory problems due to severe anterior overbite observed. E, Intraoperative findings during the second operation (Le Fort I osteotomy). Maxillary sinus floor bone regeneration confirmed by macroscopic examination and palpation (arrow a). Protrusion of approximately 2 to 3 mm of the roots of 2 teeth due to insufficient excision of mucous membrane in the right molar region (arrow b). F, Computed tomographic findings 1 year 7 months after surgery. Regenerated maxillary sinus floor bone was approximately 10.9-mm thick on the left side (arrow a) and approximately 2.7-mm thick on the right side (arrow b). G, Oral cavity findings 2 years 3 months after the initial surgery and 1 year 7 months after the second operation. Satisfactory masticatory function restored and maintained. H, Facial configuration (frontal view) 2 years 3 months after the initial surgery and 1 year 7 months after the second operation. I, Facial configuration (lateral view) 2 years 3 months after the initial surgery and 1 year 7 months after the second operation.

requires a little practice, but resourceful use of surgical instruments by an otolaryngologist experienced in endoscopic surgery certainly makes it possible.

The greatest advantage of this procedure is that it is minimally invasive compared with the conventional sinus lift procedure,[1–13] which requires an approach from a vestibular mucosal incision, fenestration of the anterior wall of the maxilla and bone graft. In our patients, bone grew to a mean thickness of 7.6 mm, almost the same as that obtained with the conventional procedure, for equally favorable results. Furthermore, because there is already a large

drainage hole to the nasal cavity, there is almost no risk of developing postoperative paranasal sinusitis or chronic pain.

In cases where this procedure was used with the regenerative therapy[14] we developed, the dental roots of teeth grafted into the maxilla became embedded in regenerated alveolar bone on the oral cavity side (lower) and in bone regenerated after sinus mucous membrane excision on the maxillary sinus side (upper). Consequently, the dental roots were almost completely embedded in the bone (Fig. 2D). After the commencement of mastication after the fitting of a bridge, the most important factor determining whether the biting force of the grafted teeth is maintained for an extended period is the ratio of the length of the teeth protruding into the oral cavity to the length of the teeth embedded in the bone (dental crown–dental root ratio). The smaller the ratio, the stronger the biting force of the grafted teeth. By combining our procedure with regenerative therapy, bone is regenerated both upward and downward around the dental roots of the grafted teeth; thus, the dental crown–dental root ratio is smaller than that achieved with the previous sinus lift procedure in which bone regeneration occurs in an upward direction only. As a result of this upward and downward bone regenerations, the bonding strength of the grafted teeth means that there are no problems with intermaxillary fixation of grafted teeth after osteotomy, as is clearly demonstrated in patient 3 (Fig. 7). Even if the teeth are lost after several years because of absorption of the dental root range,[22–24] sufficient bone thickness remains to permit placement of implants.

Consequently, patients who previously could only be treated with the fitting of dentures can maintain close to normal masticatory function for approximately 5 to 6 years with grafted teeth and then approximately another 10 years with implants, for a total of approximately 15 years. It is probable that this would have a significant influence on patients' quality of life.

We are currently considering adopting a procedure for the allotransplantation of teeth in the near future. If this becomes possible, our method could be used simultaneously with alveolar bone regeneration therapy for edentulous cases already using dentures in the same way as for cases with surviving teeth. This would dramatically increase the number of patients for whom the procedure is suitable. People who experience pain when they chew because of ill-fitting dentures could once again enjoy the pleasure of chewing with their own teeth.

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