

FIGURE 2. Patient 2: A 41-year-old man with severe periodontal disease. A, Oral findings at the initial examination. B, Orthopantomograph at the initial examination. Significant absorption of the alveolar bones was found. C, Orthopantomograph 10 months after the surgery. Almost-normal chewing function has been obtained for the replanted tooth. D, Orthopantomograph 3 years and 4 months after the surgery as well as 1 year and 1 month after the implant placement. All the implants survived. E, Oral findings 8 years and 1 month after the surgery as well as 5 years and 4 months after the implant placement. Almost-normal chewing function has been maintained.

maxillary bones. In the implant treatment, to maintain the condition for a long period, the larger the comparison (comparison of the alveolar roots) between the length of the section buried in the bone and the length exposed on the buccal side (in other words, the larger the ratio of the length of the section buried in the bone), the more advantageous it will be. It is believed that a bone width of approximately 13 mm is sufficient for burying implants deeply.

On the other hand, no detailed data are available on how fast the bone is augmented and thickened after endoscopic surgery of the maxillary sinus floor. A simple x-ray and CT scan after 6 months to a year confirmed the augmentation of bones of thin density. Subsequently, they gradually changed to bones of thick density. Furthermore, on the basis of the results at this time wherein the success rates of implants placed less than 2 years ago and that of more than 2 years ago were 48% and 97%, respectively, thus yielding a clear difference. It is believed that it requires 2 years or more to harden bones. Therefore, it is believed that implant placements should be performed at least 2 years after endoscopic surgery for maxillary sinus lift. On the other hand, because chewing is possible with replanted teeth until that time, this does not interrupt the eating habits of these patients. On the basis of the fact that the period for replanting teeth to the fall out due to root resorption is 4 years and 1 month on average, it is possible to obtain sufficient thickness and hardness during this time. In other words, a replanted tooth acts as a scaffold for bone regeneration and augmentation while simultaneously acting as a temporary abutment tooth until implant treatment.

With respect to the bone resorption after surgery, it has been reported that up to 20 to 60% in the conventional surgery for maxillary sinus lift was used in bone transplantation.⁵⁻⁸ However, with our endoscopic surgery for maxillary sinus lift, bones may be augmented and thickened as time goes by, but they will never be absorbed.⁴ Furthermore, in the patients in which 3 years or more had passed, it was observed that the bones were so hardened and augmented that drilling for implants became difficult; also, from this perspective, it is believed that this is a more effective method than the conventional surgery for maxillary sinus lift.

As previously mentioned, we have reported on the series of regenerative medicine therapy, endoscopic surgery for maxillary sinus lift, and implant treatment to be performed a few years later

as well as the effectiveness thereof for patients with severe periodontal disease. It is believed that this method is an extremely effective treatment method that tremendously improves the quality of life of the patients diagnosed with severe periodontal disease who were told that the only treatment possible was forming a complete denture. It is believed that if the transplantation of teeth from other persons becomes possible in the future, then those patients who are currently forced to wear complete dentures due to the difficulty of implant treatment may also recover an almost-normal chewing function.

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Treatment Outcomes of Implants Performed After Regenerative Treatment of Absorbed Alveolar Bone Due to the Severe Periodontal Disease and Endoscopic Surgery for Maxillary Sinus Lift Without Bone Grafts

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Objective: We have developed a regenerative medicine therapy for the alveolar bone and endoscopic surgery for maxillary sinus lift without bone grafts, in patients experiencing severe periodontal disease with significant absorption of the maxillary alveolar bone, in which more than 10 mm of bone thickness in the maxillary bone was attained, with satisfactory results. The objective of this study was to examine the treatment outcomes of implants that were performed after these therapies.

Participants and Methods: The participants were 36 patients with severe periodontal disease, who cannot be cured with any other treatments except the extirpation of all teeth. The 36 patients are all patients who underwent regenerative treatment of the alveolar bone through tooth replantation and transplantation of the iliac cancellous bone (the bone marrow) as well as endoscopic surgery for maxillary sinus lift from May 2003 to July 2007 in our clinic. A total of 120 implants were placed in these patients when the replanted teeth fell out because of root resorption, and the success rate was examined.

Results: The success rates of the implants were 16 of 33 (48%) in the group when surveyed less than 2 years after the surgery and 84 of 87 (96.5%) in the group when surveyed more than 2 years

after the surgery. A statistically significant difference was found between the 2 groups (Chi-squared test, $P < 0.001$).

Conclusions and Considerations: It was believed that it takes approximately 2 years for the bones in the maxillary sinus floor, augmented through endoscopic surgery for maxillary sinus lift, to attain the thickness and hardness required for implant placement. Therefore, although the implant treatment should be performed later than 2 years after surgery, chewing is possible during this period, with the replanted teeth that were used for regenerative treatment of the alveolar bone. It is believed that this is an extremely effective treatment method to improve the patients' quality of life.

Key Words: Implant, endoscopic surgery, maxillary sinus lift, tooth replantation, regenerative treatment

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We formed a medical team comprised of dentists, plastic surgeons, and otolaryngologists, and we developed a regenerative medicine therapy for the alveolar bone¹⁻³ and endoscopic surgery for maxillary sinus lift⁴ for severe periodontal disease with significant absorption of the maxillary alveolar bone, resulting in general satisfaction in recovery of chewing function. The greatest advantage in using these 2 treatment methods was that vertical augmentation of the bone width of the maxilla by 10 to 15 mm was made possible. Performing tooth replantation is one of the important key points in these treatment methods. Replanted teeth made it possible to obtain 10 mm or more thickness of the maxillary bones without failure by acting as a scaffold for the regeneration and augmentation of neonatal bones. Implants cannot act as a scaffold because the bone marrow cannot regenerate the new alveolar bone around the artificial materials.¹⁻⁴

On the other hand, replanted teeth fall out in a few years owing to root resorption due to ankylosis because they lack periodontal ligaments and directly adhere to the bone. In this article, the result of the implant treatment performed after the fallout of the replanted teeth is reported.

MATERIALS AND METHODS

Regenerative Medicine Therapy for the Alveolar Bone

First, a dentist removes all the loose teeth caused by severe periodontal disease to perform root canal treatment. The gum is incised at the alveolar crest to create a gingival flap by detaching



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under the periosteum while simultaneously developing a wide operative field. Upon the complete removal of the infected tissues and scar tissues caused by the periodontal disease, the socket is lightly drilled using a bar and the tooth is replanted in that location by driving lightly using a hammer. During this work, the root of the replanted tooth is exposed in the maxillary sinus on the maxillary side. Subsequently, a plastic surgeon transplants finely crushed iliac cancellous bone (bone marrow) in the surroundings of the replanted tooth on the buccal side and sutures the gingival flap while extending it.

The ilium survives, and, at the stage when the replanted tooth is fixed 3 to 4 months after the surgery, the superstructure is sufficiently attached to allow the patient to start chewing.¹

Endoscopic Surgery of Maxillary Sinus Lift

An otolaryngologist, who is skilled in internal endoscopic surgery, endoscopically undertakes every operation. Because the root of the replanted tooth is exposed in the maxillary sinus, drainage pathway to the maxillary sinus is first widely opened in the inferior nasal meatus to prevent dental sinusitis. Subsequently, an endoscope and forceps are inserted into the maxillary sinus through this drainage pathway to remove the bottom half of the maxillary sinus membrane, including the floor section of the maxillary sinus. After the surgery, the bone on the maxillary sinus floor is gradually augmented and thickened as a defense reaction against the removal of the membrane. The augmented width ranged from 2.7 to 15.4 mm (7.6 mm, on average).⁴

Implant Placement

An implant may be placed as needed during the stage in which the replanted tooth falls out because of root resorption. Implants of a length as long as possible are used, depending on the augmented thickness of the bone.

Participants and Results

The participants were 36 patients in which both regenerative medicine therapy for the alveolar bone and endoscopic surgery for the maxillary sinus lift were performed on for severe periodontal disease, which could not be cured with any other treatments except the extirpation of all teeth, from May 2003 to July 2007 in our clinic (14 men and 22 women; 29–69 y [46.2, on average]).

The survival period of the 145 replanted teeth placed in these patients until they fell out was 2 months to 10 years and 8 months (4 y and 1 mo, on average). In total, 120 implants were placed after the fallout of the replanted teeth, among which 33 implants were performed less than 2 years after the surgery, whereas 87 implants were performed more than 2 years after the surgery.

The implant success rate was 16 of 33 (48%) in the group who underwent surgery less than 2 years ago, whereas it was 84 of 87 (97%) in the group who underwent surgery more than 2 years ago. A statistically significant difference was found between the groups using a *t* test. Furthermore, in the patients in which 3 years or more had passed, it was observed that the bones augmented during the drilling of the implants had become very solid.

Patient 1: A 44-Year-Old Man With Severe Periodontal Disease and Right Odontogenic Maxillary Sinusitis

He lost many teeth because of severe periodontal disease and was told, by physicians from other clinics he had visited, that the only treatment possible was to remove all his remaining teeth and replace them with a complete denture, which prompted him to visit our clinic (Kiyokawa Dental and Oral Surgery Clinic). At the first consultation, although 5 teeth in the right maxilla and 4 teeth in the mandibular anterior teeth region were found, all of them

were already loose (Fig. 1A). Significant absorption in the entire region of the maxillary alveolar bone and right odontogenic maxillary sinusitis, ranging from the right maxillary sinus to the ethmoid sinus, was found on orthopantomograph and computed tomographic (CT) scan (Fig. 1B, C).

For this patient, regenerative medicine therapy for the alveolar bone, through tooth replantation and transplantation of the iliac cancellous bone (bone marrow), and endoscopic surgery for maxillary sinus lift were performed. Upon doing so, because only 4 teeth survived in the maxilla, the teeth in the mandible were transplanted in the maxilla and the implants were placed in the mandible that became an edentulous jaw. Abutment preparation was performed 4 months after the surgery for the transplanted teeth in the maxilla and the implants in the mandible to start chewing by attaching a prosthesis. Root resorption of the maxillary replanted tooth was found on an orthopantomograph 1 year and 11 months after the surgery (Fig. 1D). The bone augmentation in the maxillary sinus floor, 7 mm on the right and 6.5 mm on the left, and the healed right maxillary ethmoiditis were confirmed on a frontal plane CT scan (Fig. 1E).

Because 2 maxillary transplanted teeth had fallen out 2 years and 1 month after the surgery, 5 implants were placed, all of which survived. Although it is now 2 years and 11 months after the surgery as well as 10 months after the placement of the implants, near-normal chewing function has been maintained (Fig. 1F–H). Additional implants will be placed in association with the falling out of the remaining replanted teeth in the future.

Patient 2: A 41-Year-Old Man With Severe Periodontal Disease

The maxillary and mandibular alveolar bones were significantly absorbed because of severe periodontal disease, and he visited our clinic after finding us on the Internet. Almost all his teeth were already loose at the initial consultation (Fig. 2A), and a significant absorption of the alveolar bone was found through orthopantomography (Fig. 2B).

This method was implemented on this patient, and a successful recovery of the chewing function was obtained (Fig. 2C). Bone augmentation in the maxillary sinus floor, 9.6 mm on the right and 7.7 mm on the left, was confirmed through CT 1 year and 4 months after the surgery. Because most of the transplanted teeth had fallen out 2 years and 4 months after the surgery, implants were placed, all of which survived. Although it is now 8 years and 2 months after the surgery as well as 4 years and 6 months after the placement of the implants, almost-normal chewing function has been maintained (Fig. 2D, E). Additional implants will be placed in association with the falling out of the remaining replanted teeth in the future.

Considerations

For patients in which the alveolar bone was significantly absorbed and every tooth was loose because severe periodontal disease, it was believed that the only treatment possible was the extraction of normal teeth and a complete denture. With the development of regenerative medicine therapy for the alveolar bone, we have made it possible to recover the chewing function using replanted teeth and the regeneration of the alveolar bone in the vertical direction (buccal side) by approximately 3 to 5 mm within 3 to 4 months.^{1–3}

Furthermore, the development of endoscopic surgery for maxillary sinus lift, which does not require bone transplantation to the maxillary sinus floor, made it possible to elevate the maxillary sinus floor by 7.6 mm, on average.⁴ Although it is believed that the reason why the removal of the maxillary sinus membrane allows augmentation and thickening of bones is because, to some vital

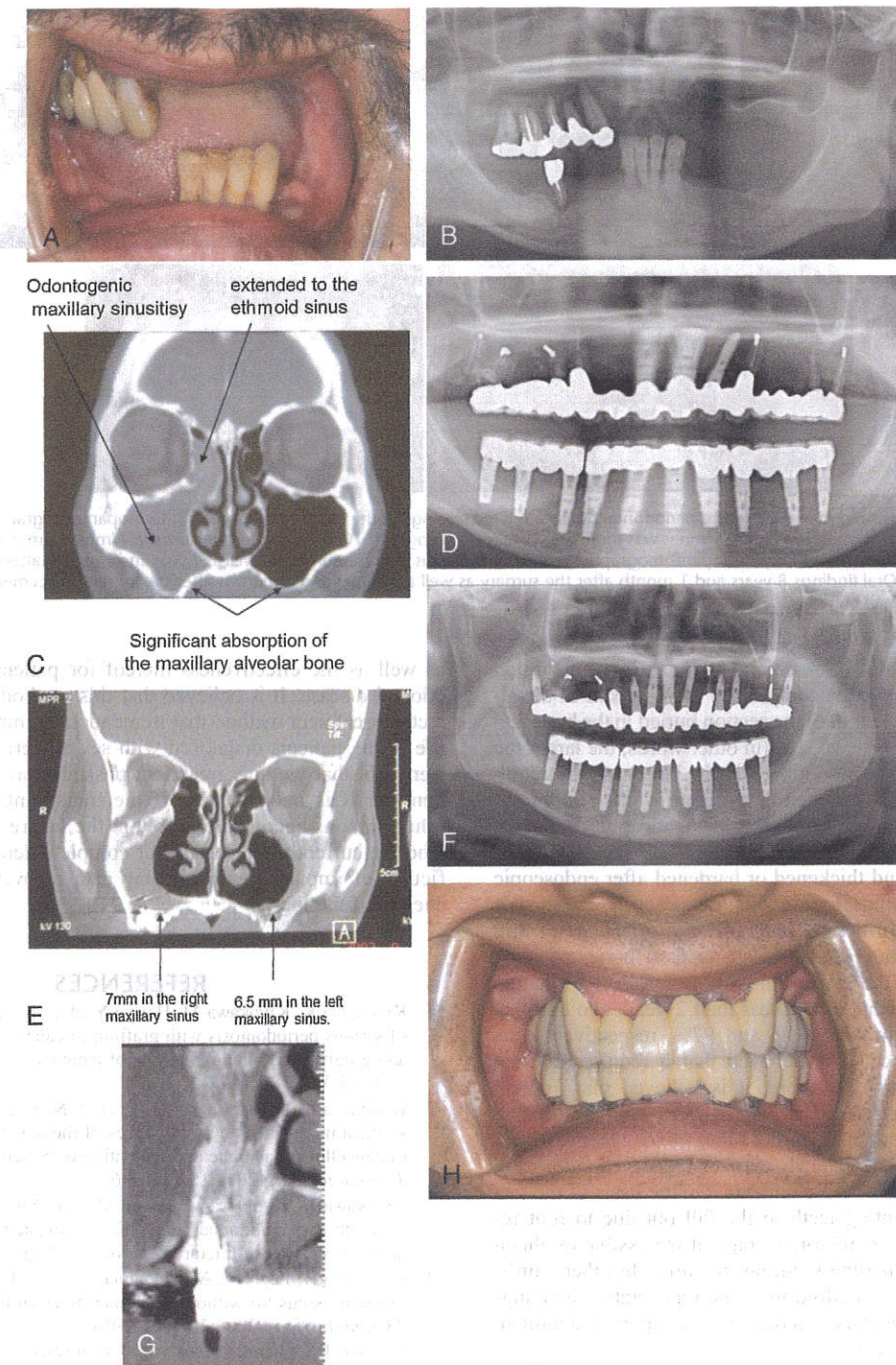


FIGURE 1. Patient 1: A 44-year-old man with severe periodontal disease and tooth loss. A, Oral findings at the initial examination. B, Orthopantomograph before the surgery. C, Coronal CT scan before the surgery. Significant absorption of the maxillary alveolar bone and odontogenic maxillary sinusitis extended to the ethmoid sinus were found on the right side. D, Orthopantomograph 1 year and 11 months after the surgery. Root resorption has started on the replanted tooth in the upper jaw (arrow). E, Computed tomographic scan 1 year and 11 months after the surgery. Bone augmentation was found: 7 mm in the right maxillary sinus and 6.5 mm in the left maxillary sinus. F, Orthopantomograph 2 years and 11 months after the surgery as well as 10 months after the implant placement. Five implants have been placed on the maxillary sinus floor (arrow). Furthermore, 4 replanted teeth still remain functional. G, Computed tomographic scan 2 years and 11 months after the surgery as well as 10 months after the implant placement. The implants were completely buried under the augmented bones. H, Oral findings 2 years and 11 months after the surgery as well as 10 months after the implant placement. Almost-normal chewing function has been maintained.

defense reaction, its mechanism is unknown. However, this fact has been long known in otolaryngology.

Assuming that the thickness of the original bone in the maxillary sinus floor that remained without absorption is approximately 2 mm, the thickness of the bone regenerated on the buccal

side due to regenerative medicine therapy for the alveolar bone is approximately 3 mm^{1,3} and the thickness of the bone augmented in the maxillary sinus floor due to the endoscopic surgery for maxillary sinus lift is approximately 8 mm,⁴ meaning that a total of approximately 13-mm bone width was obtained in the overall