상악동 거상술의 방사선 및 조직계측학적 평가

박준범
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Radiographic follow-up of sinus augmentation with histomorphometric evaluation

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Abstract

상악 구치부의 부족한 치조골 높이로 인해 골내 임플란트 식립이 어려운 경우가 많다. 상악동 거상술을 통해 이와 같은 어려움을 극복할 수 있다. 부족한 치조골 높이를 가진 세 명의 환자에서, 상악동 거상술 이후 임플란트를 식립하였다. 시상면상과 축면상 분석을 사용해 수술 결과를 분석하였고, 조직계측학적 분석은 방사선학적 결과를 비교하기 위해 사용하였다.
본 연구를 통해 이식재의 가장 외면으로부터 시작하여 내면을 향해 이식재의 성숙이 이루어짐을 알 수 있었으며, 시상면상과 축면상 분석을 사용해 이식 부위에 대한 평가에 이용할 수 있으리라 사료된다.

Key words: radiograpy, sinus floor augmentation, dental implants, histology

I . Introduction

Inadequate alveolar bone height in the posterior maxilla is one of the most common challenges for the placement of endosseous dental implants1. Maxillary sinus augmentation is a well-established technique for functional rehabilitation of partially or completely edentulous patients with severe maxillary atrophy2. Various bone grafting materials have been used in sinus augmentation including autogenous graft3, freeze-dried bone allograft4, xenograft5, and alloplastic material6. Bovine hydroxyapatite is proven to be osteoconductive and biocompatible7, and the results of sinus augmentation with xenografts are well-documented in the literature8.

Dental computed tomography has become an established method for anatomic imaging of the jaws prior to dental implant placement9. It can be utilized not only in the diagnosis and treatment planning stage but also in post-operative assessments4, 10. In this report, radiographic evaluation was used to assess the postoperative results in a sinus augmentation procedure along with the histomorphometric analysis.

II. Case Report

Case 1

A 46-year-old male patient came seeking periodontal evaluation and treatment. The patient had a non-contributory medical history. The clinical examination revealed that the upper right 1st and 2nd molars were missing. Dental implants with simultaneous sinus augmentation were planned after completion of the periodontal treatment. The patient was given a detailed explanation concerning the procedure and an informed consent form was signed.

A high-resolution scanner (SOMATOM sensation 4, Siemens, Germany) equipped with an image reconstruction software package was utilized and slice thickness was set at 2.0 mm for the reconstruction of the images. In the preoperative scan, the cross-sectional and panoramic views were used to measure the remaining alveolar bone height and the thickness of the buccal window (Figs. 1A and 1B). No membrane thickening was noticed in the right maxillary sinus and the average remaining alveolar bone height was 5.8 ± 1.6 mm.

Fig. 1A. 68-year-old female patient with severe bo

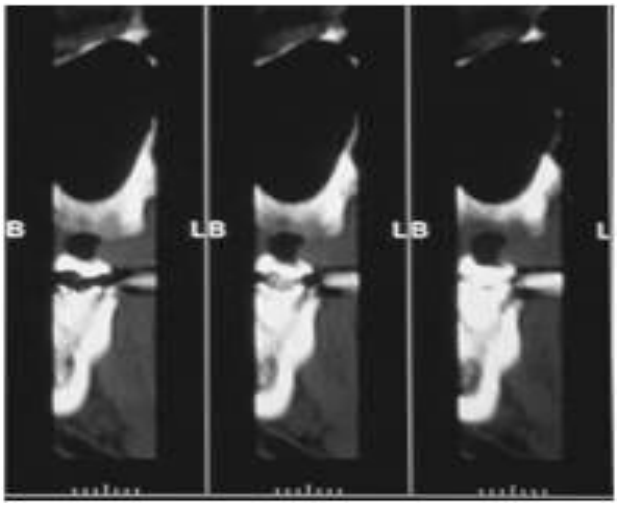

Fig. 1B. Preoperative cross-sectional view.

The patient rinsed with 0.12% chlorhexidine digluconate solution (Hexamedine, Bukwang, Seoul, Korea) before the operation. Following a 2% lidocaine with 1: 100,000 epinephrine local anesthetic injection, a crestal incision was placed and mesiobuccal and distobuccal vertical releasing incisions were placed extending beyond the mucogingival junction. An oval-shaped osteotomy was made on the lateral aspect of the sinus wall using a diamond bur with generous saline irrigation. Elevation of the sinus membrane was performed with curettes to make space for the bone graft. Then, the bony preparation for the endosseous implant fixture sites was performed. A graft of bovine hydroxyapatite (0.25-1.0mm cancellous particle; Bio-Oss®, Geistlich Pharm AG, Wolhusen, Switzerland) was introduced and carefully packed without excessive pressure into the anterior part of the sinus cavity and then into the posterior part. Following graft placement, three implants

(3.8 x 10, 4.3 x 15 and 4.3 x 15 mm; Implantium®, Dentium, Seoul, Korea) were inserted and the remaining sinus space was completely packed with bovine hydroxyapatite. The lateral wall of the sinus was then covered with a membrane (Bio-Gide®, Geistlich Pharma AG) and stabilization of the barrier membrane was achieved. The patient was placed on amoxicillin 500 mg 3/day for 5 days, mefenamic acid 500 mg initially then mefenamic acid 250 mg 4/day for 5 days, and chlorhexidine digluconate 0.12% 3/day for 4 weeks. The sutures were removed and the area was carefully cleaned with 0.12% chlorhexidine digluconate solution 7 days postoperatively.

The condition of the sinus membrane, the maturation of the newly formed tissue, and the presence of any sinus pathology was assessed one month after surgery (Figs. 2A and 2B) The newly formed sinus floor was smooth, showing that there was no perforated area and the average alveolar ridge height was 19.5 ± 0.7 mm. No change of membrane thickness was seen. The center of the graft area was more radiolucent compared with the outer surface.

Fig. 2A. One-month postoperative panoramic view, showing smooth, newly formed sinus floor.

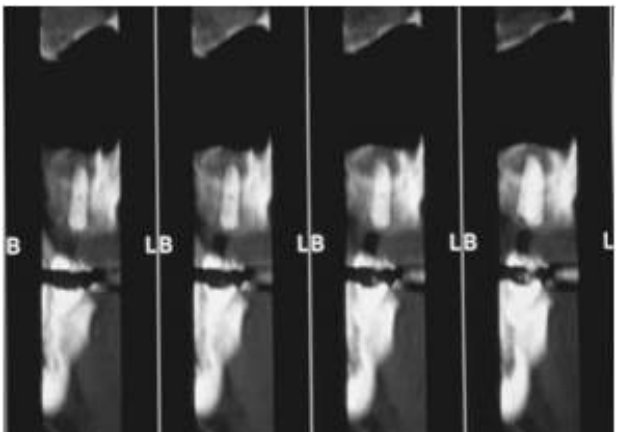

Fig. 2B. One-month postoperative cross-sectional view, showing complete bony coverage of implants.

A second surgery was performed and the final implant-supported crowns were inserted eight months after implant installation. An additional scan was obtained to evaluate the right maxillary molar nine months after the sinus augmentation. The alveolar ridge height at 8 months postoperatively was 18.5 ± 0.7 mm. The grafted sites appeared to be denser than the previous evaluation (Figs. 3A and 3B). However, the center of the graft area was still more radiolucent than the autogenous bone. The axial view shows the differences in the radiopacity more clearly (Fig. 3C). The prosthesis functioned well up to the final evaluation.

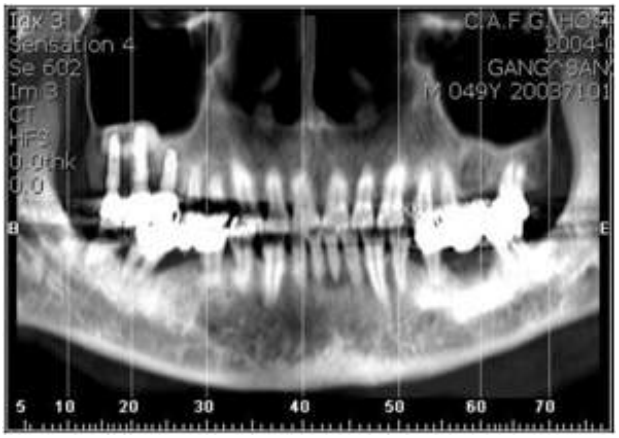

Fig. 3A. Nine-month postoperative panoramic view.

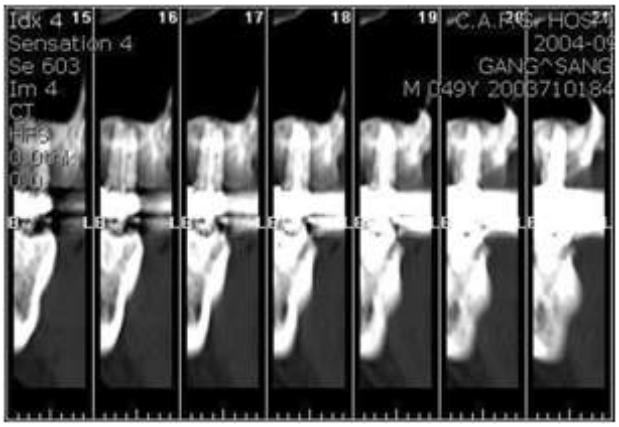

Fig. 3B. Nine-month postoperative cross-sectional view.

Fig. 3C. Nine-month postoperative axial-sectional view.

Case 2

A 49-year-old male presented wanting treatment for the missing teeth in the upper molar areas. The patient did not have any medical conditions that were associated with a compromised healing response. The average residual bone in this patient was 5.0 ± 0.8 mm (Figs. 4A and 4B) and the treatment plan consisted of implant installation with simultaneous augmentation in the right posterior area.

Fig. 4A. Preoperative panoramic view.

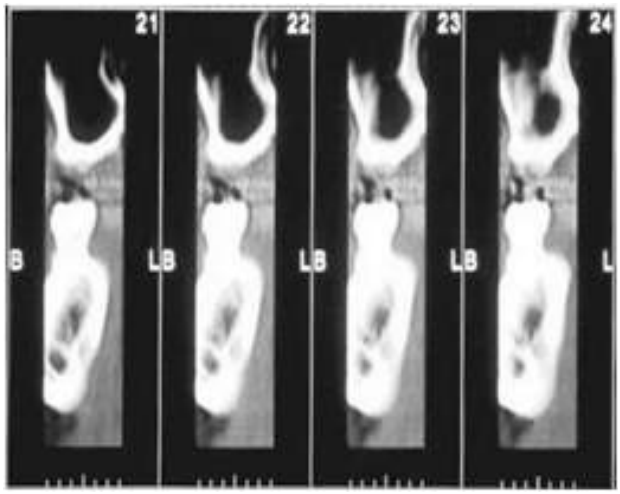

Fig. 4B. Preoperative cross-sectional view.

Prior to surgery the patient rinsed with 0.12% chlorhexidine mouthrinse. Following local anesthetic injection, a full-thickness mucoperiosteal flap was elevated and reflected laterally, exposing the lateral wall of the sinus. An oval-shaped bony window was prepared and the Schneiderian membrane was elevated from the sinus floor. Bovine hydroxyapatite (Bio-Oss®) was introduced and carefully packed into the sinus cavity (Fig. 5A). The lateral wall of the sinus was then covered with an absorbable membrane (Bio-Gide®) (Fig. 5B). Three implants (3.8 x 10, 3.8 x 10 and 3.8 x 10 mm; Implantium®) were placed and the wound was closed with sutures. The patient was placed on the same medication and given the same instructions as the patient in Case 1.

Fig. 5A. Buccal view showing an oval-shaped bony window.

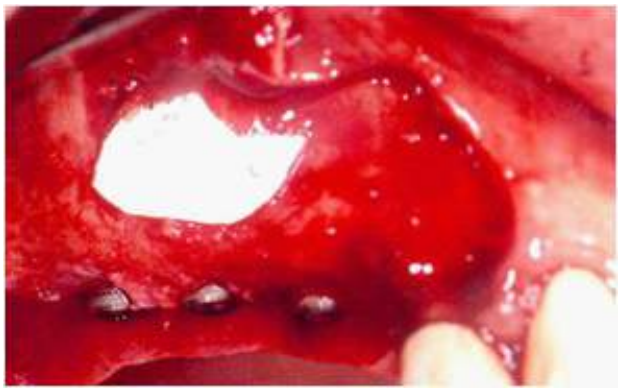

Fig. 5B. An absorbable membrane was applied onto the lateral wall.

Following three months of healing, CT examination was performed to assess the grafted area. The graft area was clearly visible in the radiograph and only the outer surface showed more radiopaque, making the center of the grafted area more radiolucent. The average alveolar ridge height three months postoperatively was 14.7 ± 0.6 mm (Fig. 6A). All implants were fully covered by bone-extending material between 3.5 to 4.0 mm above the apex (mean 4.2 ± 0.6 mm). The palatal apical aspect of all the implants showed complete bony coverage (Fig. 6B). The central area of the graft area had more radiolucent region (Fig. 6C) and the axial view showed some irregularities on the buccal window (Fig. 6D).

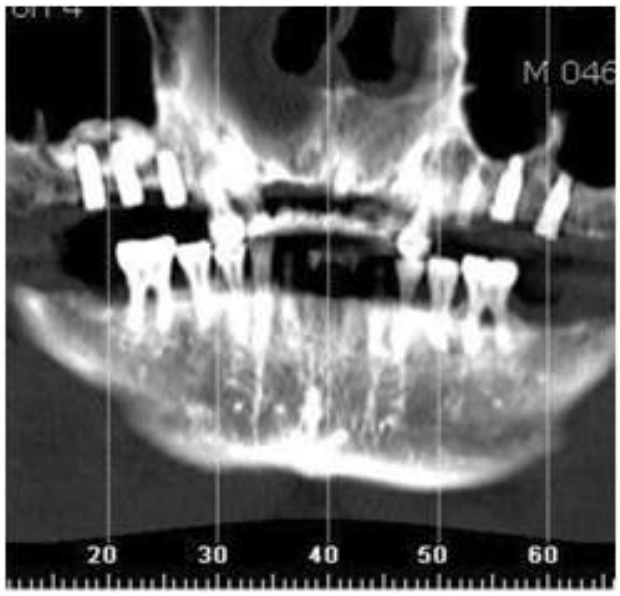

Fig. 6A. Three-month postoperative panoramic view.

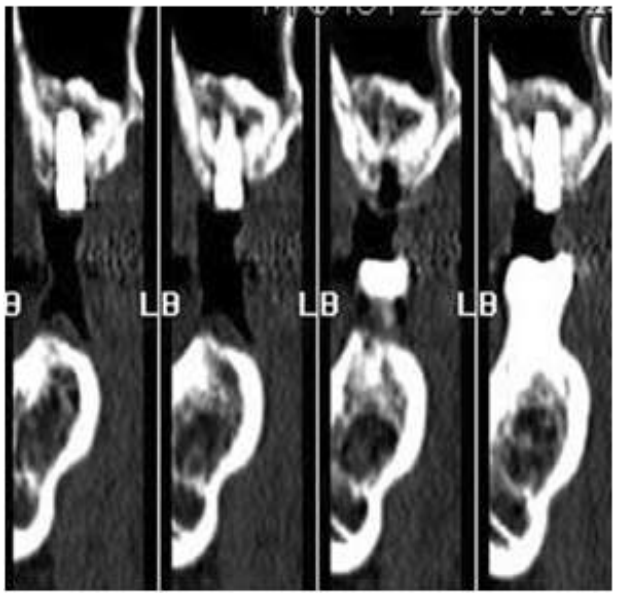

Fig. 6B. Three-month postoperative cross-sectional view.

Fig. 6C. Three-month postoperative axial-sectional view, showing the difference in the radiopacity of the grafted area.

Fig. 6D. Three-month postoperative axial-sectional view, showing some irregularities on the buccal window with limited cortication.

The implants were uncovered and the final implant-supported crowns for upper 1st and 2nd molars were inserted eight months after implant installation. The prosthesis was well in function up to the final follow-up evaluation.

Case 3

A 51-year-old male patient presented for the dental treatment. The patient did not have any medical conditions and was not taking any medications that were associated with a compromised soft healing response. The clinical examination revealed that the upper right 1st and 2nd molars were hopeless. Treatment with sinus augmentation with staged dental implantation was planned after extraction and completion of periodontal treatment. The patient was given detailed explanation concerning the procedure and an informed consent form was signed.

Immediately before the procedure, the patient rinsed with chlorhexidine digluconate solution (Hexamedine). Following local anesthetic injection, a bony window was made and the sinus membrane was elevated from the sinus floor. Deproteinized bovine bone (Bio-Oss®) was placed and the lateral wall of the sinus was covered with a membrane (Bio-Gide®). The stabilization of the

barrier membrane was achieved, and the flap was repositioned with sutures. The patient was placed on the same medication as the patient in Case 1.

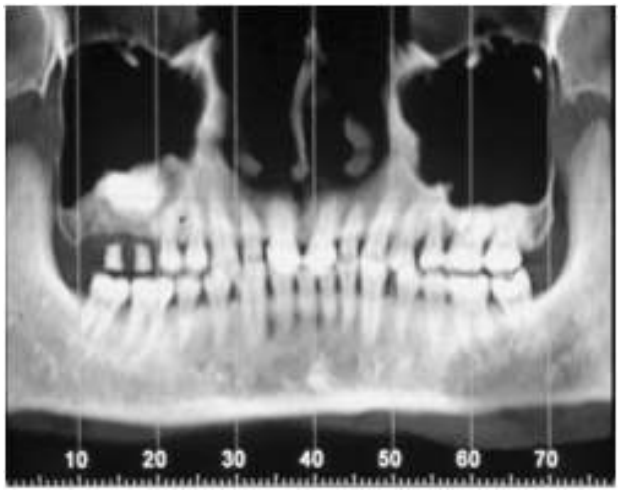

Fig. 7A. A six-month postoperative panoramic view, showing smooth, newly formed sinus floor.

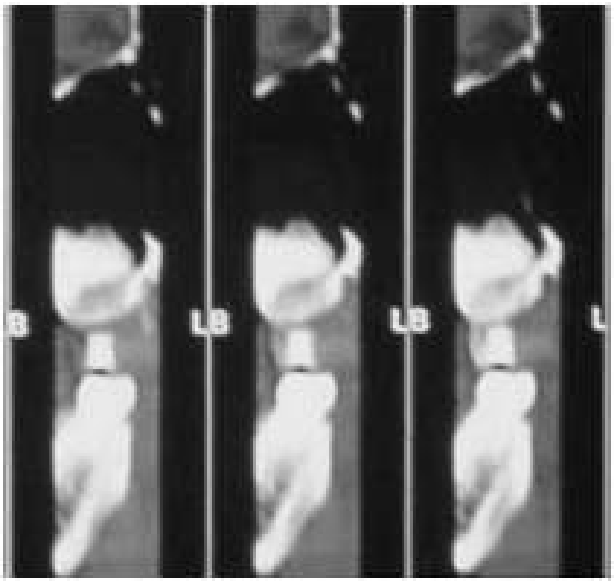

Fig. 7B. A six-month postoperative cross-sectional view.

Following 6 months of healing, CT examination was performed and the grafted area was clearly visible in the radiograph with radiopacity (Figs. 7A and 7B). The alveolar ridge height at 6 months postoperative was 16.7 ± 2.1 mm. The bony preparation of the posterior maxilla was performed using the trephine drill with inner diameter of 2.75 mm (Fig. 8A) and final drill for 3.8 and 4.3 mm implant, respectively. A core of 2.7 x 10 mm was obtained and sent for processing for histologic evaluation. The 3.8 x 12 mm and 4.3 x 12 mm implants (Implantium®) were placed with the insertion torque of 40 Ncm. Retrieved specimens were fixed in 4% paraformaldehyde in phosphate buffer (pH 7.4), decalcified in 10% formic acid, and embedded in paraffin. Subsequently, step-serial sections of the tissue blocks were made perpendicularly to the long axes using a microtome. The most technically satisfactory section was stained with hematoxylin and eosin and the slide was examined under a light microscope (Olympus BX50, Olympus Optical, Osaka, Japan). Computer-assisted histomorphometric measurements of the newly formed bone were obtained using an automated image analysis system (TDI Scope Eye, Seoul, Korea). The ratio of bony tissue was calculated as the bone area divided by the whole area. A histologic view of the biopsy revealed good healing with mature bone (Fig. 8B). The trabecular bone is lamellar, which can be seen under higher magnification, and lacunae with osteocytes were observed in the specimen, and the bone marrow was partly fibrous and partly cellular (Fig. 8C). Evaluation of the core yielded 42.6% of bone tissue.

The final implant-supported crowns for upper 1st and 2nd molars were inserted 9 months after implant installation and the prosthesis was well in function up to the final follow-up evaluation.

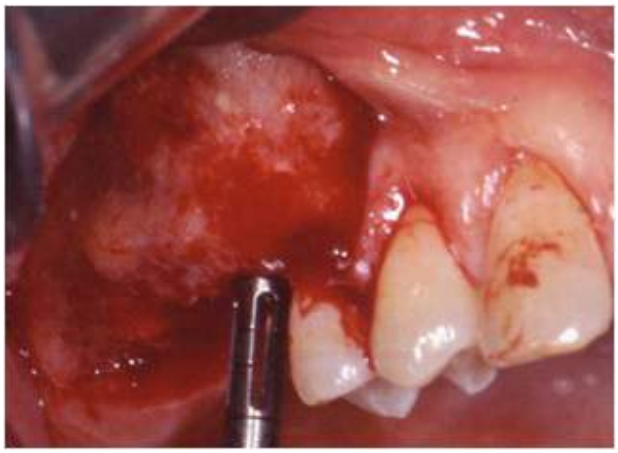

Fig. 8A. The bony preparation was done with the trephine drill with inner diameter. The lateral wall of former buccal window was healed and the graft particles were fully incorporated with the newly formed tissue.

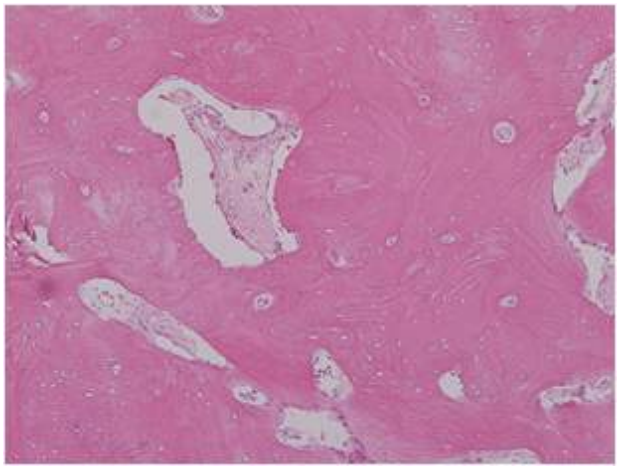

Fig. 8B. Histologic view of biopsy 6 months postoperative, showing good healing with mature bone (original magnification ×20; hematoxylin and eosin).

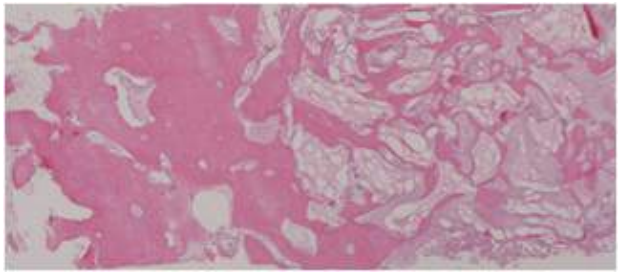

Fig. 8C. Higher magnification from Fig 8B. The trabecular bone showed lamellar configuration and lacunae with osteocytes were observed in the specimen (Original magnification X100; hematoxylin and eosin).

III. Discussion

The height and the width of alveolar bone and the thickness of buccal window were assessed with the sagittal and axial images11. The change of the alveolar height could also be assessed from different time points12. Even though there were no significant changes of alveolar bone height between the two evaluations from the first case, the grafted area seemed to have higher mineral density, which suggests that the area is undergoing the new bone formation and maturation. The osteogenesis seems to start from the outer surface including the Schneiderian membrane. The osteogenic potential of human maxillary sinus Schneiderian membrane was tested with both in vitro and in vivo assays, and the osteogenic potential was shown to be associated with the sinus membrane13.

The axial view gave information about the preoperative thickness of the buccal window and the change of the buccal defect made at the sinus augmentation procedures. The eight-month postoperative axial view revealed some irregularities with limited cortication of the buccal window.

The biopsy showed mature bone with lamellar configuration throughout the specimen and it was hard to distinguish newly formed bone from the pre-existing bone in the decalcified section. The ratio of bony tissue was 42.6% and this value was comparable with the 6-month results (39%)14, and with the 6- to 8-month results (45-50%)15.

The one-stage technique was applied if the residual bone height was greater than 5 mm16. A barrier membrane was applied over the lateral window because it was reported that higher implant survival rates and greater vital bone formation may be achieved17.

This report clearly shows that the maturation of the graft material starts from the most outer surface and moves towards the inner surface, including the Schneiderian membrane. It suggests that a radiograophic evaluation with sagittal and axial view may be used to evaluate the status of maturation of the graft materials.

IV. Conclusion

Three patients with an insufficient alveolar bone height were treated with sinus augmentation. A radiographic evaluation with sagittal and axial views showed that the graft area became more radiopaque as time went on and the biopsy showed that newly formed bone was hard to distinguish from the pre-existing bone in the decalcified section. It suggests that radiographic evaluations with sagittal and axial view may be used to evaluate the status of maturation of the graft materials.

Disclosure

The author claims to have no financial interest in any company or any of the products mentioned in this article.

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