Case Report

JPIS Journal of Periodontal & Implant Science

J Periodontal Implant Sci 2010;40:283-288 • doi: 10.5051/jpis.2010.40.6.283

Incomplete bone formation after sinus augmentation: A case report on radiological findings by computerized tomography at follow-up

Kyung-Shil Lee[1], Young-Hyuk Kwon[1,2], Yeek Herr[1,2], Seung-Il Shin[1], Ji-Yeon Lee[1], Jong-Hyuk Chung[1,2]*

[1]Department of Periodontology, Kyung Hee University School of Dentistry, Seoul, Korea
[2]Institute of Oral Biology, Kyung Hee University School of Dentistry, Seoul, Korea

Purpose: The aim of this case report is to present a case of incomplete bone formation after sinus augmentation.
Methods: A patient having alveolar bone resorption of the maxillary posterior edentulous region and advanced pneumatization of the maxillary sinus was treated with sinus elevation using deproteinized bovine bone in the Department of Periodontology, Kyung Hee University School of Dentistry and re-evaluated with computed tomography (CT) follow-up.
Results: Even though there were no significant findings or abnormal radiolucency on the panoramic radiograph, incomplete bone formation in the central portion of the augmented sinus was found fortuitously in the CT scan. The CT scan revealed peri-implant radiolucency in the apical portion of the implant placed in the augmented maxillary sinus. Nevertheless, the dental implants placed in the grafted sinus still functioned well at over 15 months follow-up.
Conclusions: The result of this case suggests that patients who received maxillary sinus augmentation may experience incomplete bone formation. It is possible that 1) osteoconductive graft material with poor osteogenic potential, 2) overpacking of graft material that restricts the blood supply, and 3) bone microbial contamination may cause the appearance of incomplete bone formation after sinus augmentation. Further studies are needed to elucidate the mechanism of this unexpected result and care must be taken to prevent it.

Keywords: Bone formation, Computed tomography, Maxillary sinus.

INTRODUCTION

Alveolar bone resorption in maxillary posterior edentulous region and advanced pneumatization of the maxillary sinus can result in a lack of bone support for dental implants, leaving only a thin wall of bone between the maxillary sinus and oral cavity. When this area does not offer adequate conditions for anchoring, long-term maintenance of dental implants is hard to achieve and a bone graft is required.

The placement and integration of dental implants in such patients requires augmentation of the maxillary sinus. The classic procedure for maxillary sinus augmentation was first introduced by Boyne and James [1]. The periosteal membrane of the sinus mucosa that adheres to the maxillary sinus floor has few elastic fibers. Thus, separation of this sinus membrane is relatively simple and has become a standard method with good results [2,3]. Numerous clinical studies have reported the clinical outcomes of placing implants in the augmented maxillary sinus. The insertion of dental implants in combination with maxillary sinus floor elevation is a predictable

Received: Jul. 23, 2010; **Accepted:** Oct. 12, 2010
***Correspondence:** Jong-Hyuk Chung
Department of Periodontology & Institute of Oral Biology, Kyung Hee University School of Dentistry, 1 Hoegi-dong, Dongdaemun-gu, Seoul 130-701, Korea
E-mail: chungjh@khu.ac.kr, Tel: +82-2-958-9380, Fax: +82-2-958-9387

pISSN 2093-2278
eISSN 2093-2286

JPIS Journal of Periodontal & Implant Science

treatment method showing high implant survival rates and low incidences of surgical complications [4]. However, it sometimes leads to complications due to anatomical structure, infections, iatrogenic factors, or other unknown factors. Therefore, pre- and post-operative evaluation of the maxillary sinus is very important. However, there has been limited availability of data on this procedure based on computed tomography (CT).

This case report describes a 53-year-old male patient who received maxillary sinus augmentation and implant installation with a staged approach. Although the patient had no subjective symptoms and there was no abnormal radiolucency on the panoramic radiograph, incomplete bone formation in the central portion of the augmented sinus was found fortuitously in the CT scan.

CASE DESCRIPTION

A 53-year-old male patient who was in good systemic condition visited the Department of Periodontology, Kyung Hee University School of Dentistry with the chief complaints of pain and gingival bleeding in the upper right 1st molar (#16) area. The upper right 2nd molar (#17) area was in an edentulous state (Fig. 1). Even though he was treated with non-surgical/surgical periodontal therapy, extraction of #16 was inevitable. The residual bone height was between 2 to 4 mm (Fig. 2). Augmentation of the maxillary sinus was scheduled to be conducted with a diagnostic stent 3 months after the extraction of #16, followed by placement of two dental implants 6 months after the augmentation of the maxillary sinus (Fig. 3). The maxillary sinus was clinically healthy. The sinus membrane was elevated from a lateral approach and the sinus was grafted with deproteinized bovine bone (DBB; Bio-Oss, Geistlich Pharma AG, Wolhusen, Switzerland) (Fig. 4). Prophylactic antibiotics (amoxicillin 500 mg, Chong Kun Dang Pharm., Seoul, Korea) were prescribed three times a day for 14 days and 0.12% chlorhexidine solution (Hexamedine, Bukwang Pharm., Seoul, Korea) was also prescribed twice a day for the first 2 weeks to prevent infection of the surgical wound. Healing was uneventful and there was no infection or other post-surgical complications during the healing period.

After a healing period of 6 months, a two stage implant surgery was planned (Fig. 5). Full thickness flap reflection under local anesthesia was followed by placement of two dental implants (Replace Select tapered HA, Nobel Biocare, Göteborg,

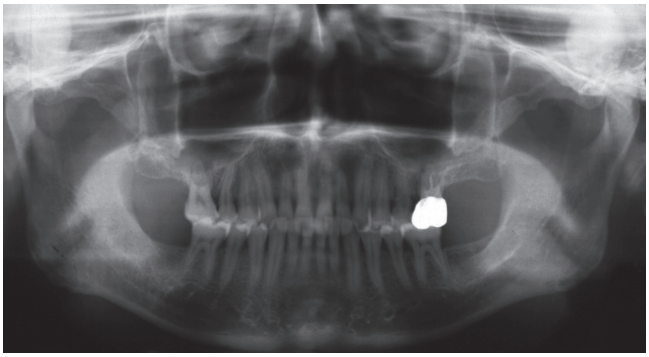

Figure 1. Panoramic radiograph at first visit.

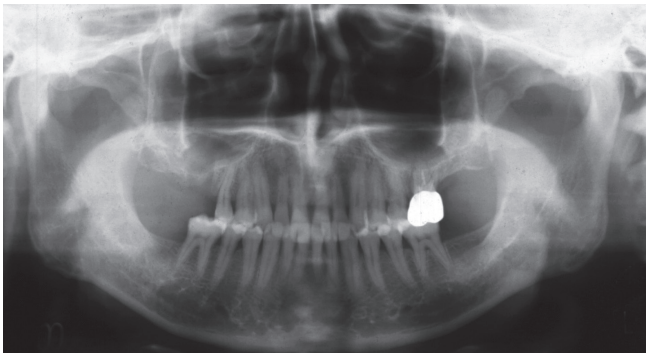

Figure 2. After extraction of #16, marked alveolar bone resorption and pneumatization of the maxillary sinus is visible.

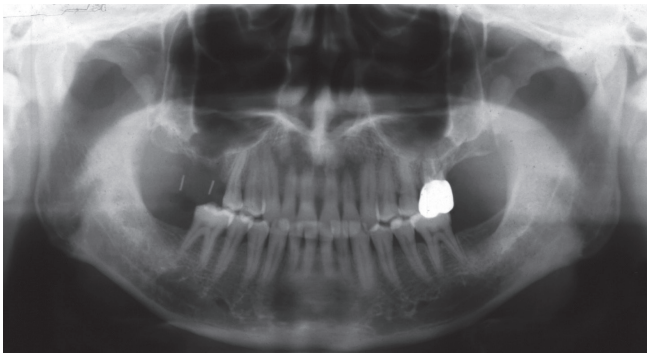

Figure 3. Diagnostic stent for the implant placement at #16i and 17i.

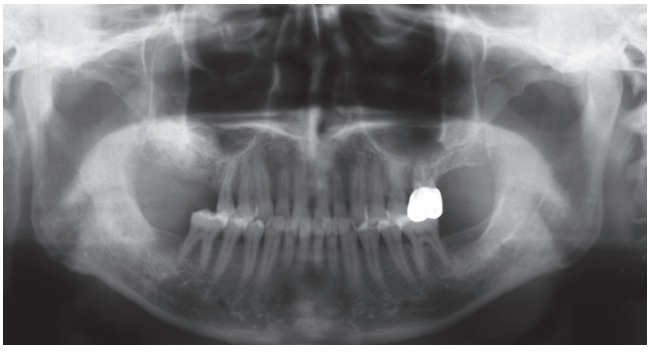

Figure 4. Maxillary sinus augmentation was performed.

Sweden) with a diameter of 4.3 mm and length of 13 mm in the site of #16i and #17i (Fig. 6). Both antibiotics and analgesics were administered for seven days, and mouth rinse with 0.12% chlorhexidine was also recommended for the following two weeks. No complications occurred after implant installation.

The second implant surgery was performed 6 months later (Fig. 7) and the implants were first loaded 2 months after the second surgery. Final prosthetic loading was initiated 13 months after the first implant surgery (Fig. 8).

The implants placed in the augmented sinus were clinically healthy and the implant-supported restorations had been functioning successfully at 17 months after initial loading. Unexpectedly, the patient visited the dental clinic with the chief complaints of pain on biting in the upper right 2nd premolar (#15) since he had eaten hard food 3 days earlier. The #15 tooth was diagnosed as cracked and endodontic therapy was required. During endodontic therapy, a CT scan was taken to locate the buccal canal of the tooth. Peri-implant radiolucency in the apical portion of the implant placed in the augmented maxillary sinus was found by accident in the CT scan although a conventional (panoramic) radiograph revealed no signs of peri-implant radiolucency (Fig. 9). This was after a healing period of 32 months since sinus augmentation. The fortuitously discovered radiolucent portion can be described as incomplete bone formation or bone cavity in the augmented maxillary sinus. Nevertheless, the dental implants that

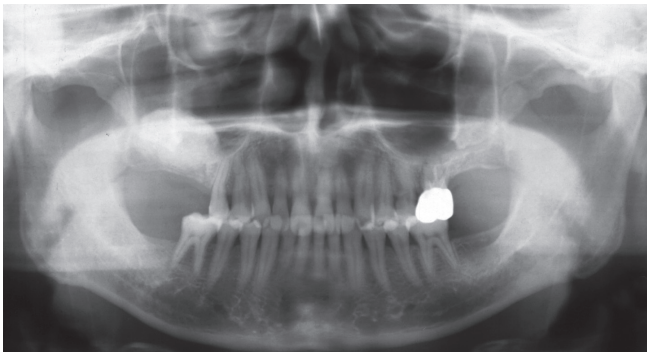

Figure 5. Radiopacity of the augmented sinus had increased at 7 months after the operation.

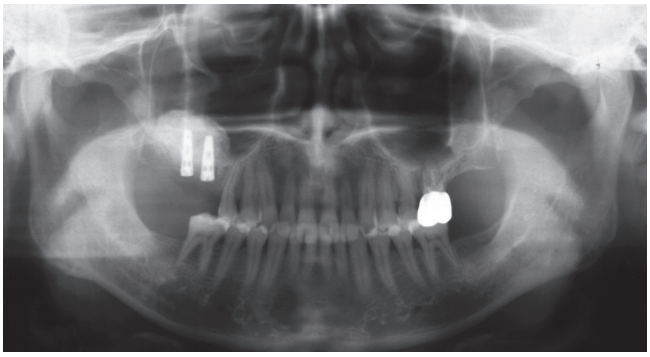

Figure 6. First implant surgery on #16i and 17i was performed.

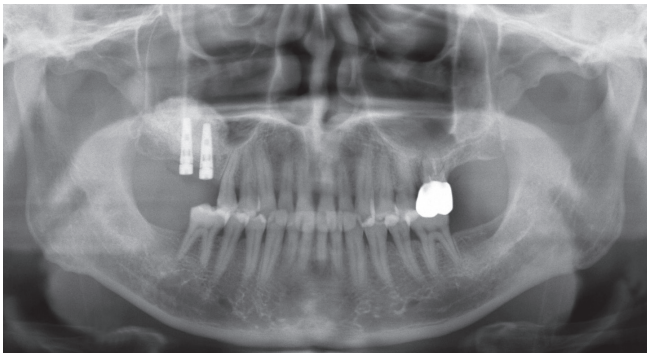

Figure 7. Second implant surgery on #16i and 17i was performed 6 months after the first implant surgery.

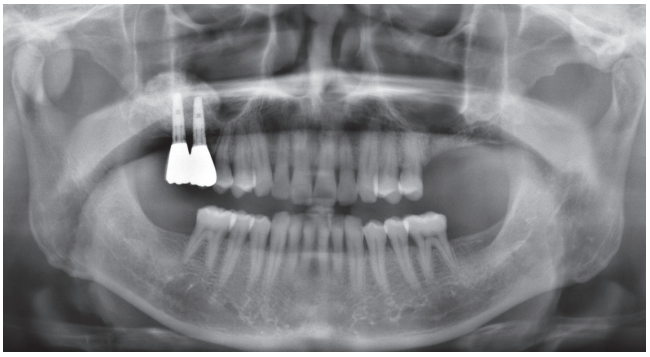

Figure 8. Final prosthetic loading was initiated 13 months after the first implant surgery.

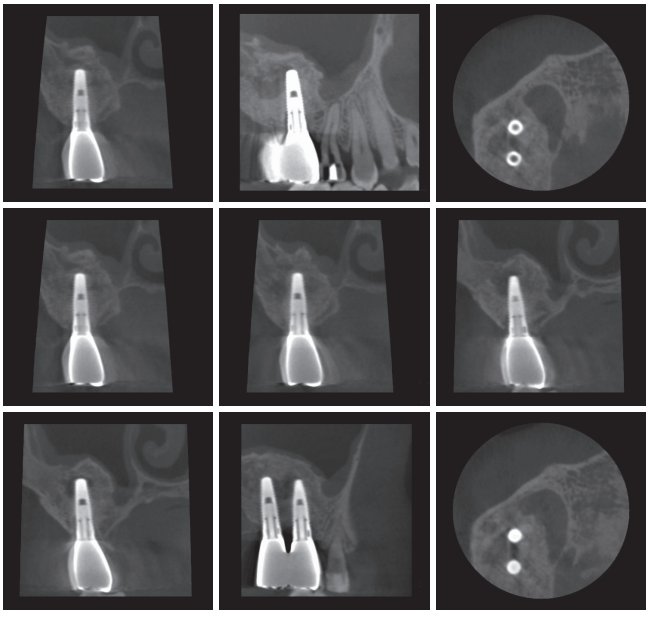

Figure 9. Bone cavity in #16i and 17i area was found in the computed tomography scan (32 months after the sinus augmentation).

JPIS Journal of Periodontal & Implant Science

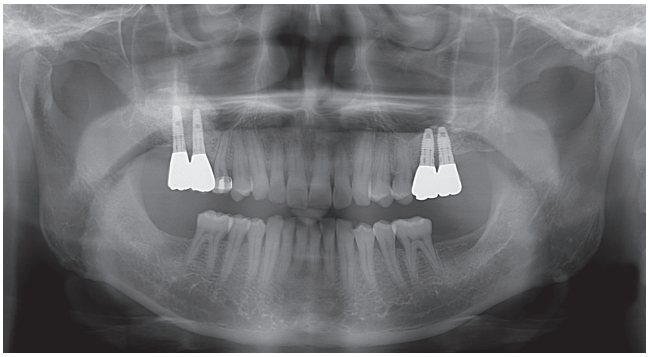

Figure 10. Panoramic radiograph of the most recent visit.

were placed in the grafted sinus had been functioning well after prosthetic loading for more than 60 months and no enlargement of the bone cavity was found in follow-up radiographic views (Fig. 10). The patient has had no subjective symptoms such as discomfort or pain in the #16i and 17i area and has been receiving follow-up care on a regular basis.

DISCUSSION

This study presents the fortuitous discovery of incomplete bone formation (a bone cavity) in the central portion of the maxillary sinus after sinus augmentation using DBB.

Although sinus augmentation is very predictable [5] and complications caused by sinus graft are very rare, clinicians have observed various types of complications, such as perforation of the sinus membrane, excessive bleeding, infection of the grafted sinus, and failure of bone formation during and after sinus augmentation procedures [6-9]. Among these complications, incomplete bone formation of the grafted sinus is not common and the reason for this phenomenon has not yet been determined.

Several causes of incomplete bone formation can be suggested. First, the graft material used in augmentation was solely DBB, which is a cell-free grafting material with osteoconductive properties [10-13]. Cells possessing osteogenic potential are rich in residual host bone and elevated sinus membrane, whereas osteogenic potential of the graft is poor [1,14]. Therefore, new bone originates from the maxillary bone and progresses towards the augmented area [15,16]. The area of newly mineralized bone on the sinus floor is expected to be larger in the vicinity of the residual host bone [17]. Busenlechner et al. [16] reported the relative portion of newly formed bone after sinus augmentation with DBB in a minipig model study. In that study, with increasing distance from the host bone, the relative portion of newly formed bone declined from 38±13.3% at a 0-1 mm distance to 6.6±7% at a 4-5 mm distance. Fuerst et al. [14] and Roldan et al. [15] have also described the inhomogeneous distribution of bone and biomaterials within the augmented sinus in analysis by focusing on selected regions. The addition of autogenous bone, which contains bone-derived progenitor cells and osteoblasts, to bone substitutes is thought to enhance new bone formation [14]. In several animal model studies, e.g. in sheep [18] and in monkeys [19-21], the percentage of newly formed bone was increased by adding autogenous bone to bone substitutes. Experimental studies have shown that culture expanded autogenous bone-derived cells (ABC) added to cell-free grafting materials also enhanced the percentage of bone newly formed in critical-size defects of the rodent calvaria, and the dog and sheep mandible [22-25]. ABC possess an osteogenic potential and therefore increase bone formation in regions with a low number of bone-forming cells [23]. It can be speculated that supplementation of bovine bone mineral (BBM) with ABC may be recommended in cases where bony consolidation is complicated by the large volume of the grafting material or the poor regenerative potential of the host bone. If we had added autogenous bone to cell-free DBB during the sinus graft, more prominent bone formation could have been achieved.

Second, overpacking of graft material could restrict the blood supply. Rosenberg [26] and Garrett et al. [27] suggested packing the bone graft loosely. Loose packing of the graft can create better interparticulate spacing, which facilitates more rapid vascularization and more abundant bone formation. In contrast, tightly packed particles allow cellular and vascular access only to the outside layer of particles [28].

Third, Verdugo et al. [29] reported that bone contamination by specific pathogens could impair osteogenesis and induce greater bone loss in regenerative procedures. Similarly, Choukroun et al. [30] reported the accidental discovery of bubble-like lacunae in the grafted maxillary sinus when a sinus lift was performed with graft material without a 0.5% metronidazole solution. In that study, the formation of bubble-like lacunae within the graft was hypothesized to have resulted from anaerobic contamination after sinus grafting: the "septic theory." This "septic theory" suggests that grafted bone contamination by anaerobic bacteria could possibly induce problems with healing. They suggested the local use of a very small quantity of metronidazole (10 mg) as a sterile solution incorporated into the sinus bone graft.

Fourth, whether the healing period was long enough should also be considered. Hanisch et al. [31] reported that newly formed bone after sinus augmentation procedures using an allogenic-xenogenic bone graft in the grafted area at 12 months (20.7±8.3%) was significantly higher than at 6 months (8.1±3.0%), but it still remained lower than the volume of residual bone. In other words, the mineralization process of an

allogenic-xenogenic sinus graft requires more than 12 months. According to Nkenke and Stelzle [32], healing periods after simultaneous implant placement ranged from 2 to 10 months. In staged approaches, healing periods for the graft material from 3 to 13 months were chosen. After implant placement, additional healing periods of up to 10 months were reported. In the present study, the healing period between sinus elevation and implant placement was 6 months, and the implant was loaded 8 months after the implant placement. Therefore, the healing period of the present case was long enough.

As the placement of endosseous implants has become the treatment of choice for restoring function and reconstructing edentulous areas, the number of patients having surgical complications is also on the rise. In this case report, we described one of these complications: the incomplete formation of maxillary sinus bone after sinus augmentation. As we have discussed above, it is possible that 1) osteoconductive graft material with poor osteogenic potential, 2) overpacking of graft material that restricts the blood supply, or 3) bone microbial contamination may cause the appearance of incomplete bone formation after sinus augmentation. Although the irregular appearance of the augmented maxillary sinus does not preclude implant placement and the success rate of implants placed in the subsinus area is very similar to that of implants placed in other regions [5,30,33], there is still lack of sound scientific data about whether the heterogeneity can be considered as a suitable condition for implant placement and survival. Further studies are needed to elucidate the mechanism of this unexpected result and care has to be taken to prevent it.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Boyne PJ, James RA. Grafting of the maxillary sinus floor with autogenous marrow and bone. J Oral Surg 1980;38:613-6.
2. Peleg M, Chaushu G, Mazor Z, Ardekian L, Bakoon M. Radiological findings of the post-sinus lift maxillary sinus: a computerized tomography follow-up. J Periodontol 1999;70:1564-73.
3. Murakami K, Itoh T, Watanabe S, Naito T, Yokota M. Periodontal and computer tomography scanning evaluation of endosseous implants in conjunction with sinus lift procedure. A 6-case series. J Periodontol 1999;70:1254-9.
4. Pjetursson BE, Tan WC, Zwahlen M, Lang NP. A systematic review of the success of sinus floor elevation and survival of implants inserted in combination with sinus floor elevation. J Clin Periodontol 2008;35:216-40.
5. Wallace SS, Froum SJ. Effect of maxillary sinus augmentation on the survival of endosseous dental implants. A systematic review. Ann Periodontol 2003;8:328-43.
6. Mardinger O, Nissan J, Chaushu G. Sinus floor augmentation with simultaneous implant placement in the severely atrophic maxilla: technical problems and complications. J Periodontol 2007;78:1872-7.
7. Barone A, Santini S, Sbordone L, Crespi R, Covani U. A clinical study of the outcomes and complications associated with maxillary sinus augmentation. Int J Oral Maxillofac Implants 2006;21:81-5.
8. Schwartz-Arad D, Herzberg R, Dolev E. The prevalence of surgical complications of the sinus graft procedure and their impact on implant survival. J Periodontol 2004;75:511-6.
9. Zijderveld SA, van den Bergh JP, Schulten EA, ten Bruggenkate CM. Anatomical and surgical findings and complications in 100 consecutive maxillary sinus floor elevation procedures. J Oral Maxillofac Surg 2008;66:1426-38.
10. Hallman M, Sennerby L, Zetterqvist L, Lundgren S. A 3-year prospective follow-up study of implant-supported fixed prostheses in patients subjected to maxillary sinus floor augmentation with a 80:20 mixture of deproteinized bovine bone and autogenous bone clinical, radiographic and resonance frequency analysis. Int J Oral Maxillofac Surg 2005;34:273-80.
11. Hallman M, Cederlund A, Lindskog S, Lundgren S, Sennerby L. A clinical histologic study of bovine hydroxyapatite in combination with autogenous bone and fibrin glue for maxillary sinus floor augmentation: results after 6 to 8 months of healing. Clin Oral Implants Res 2001;12:135-43.
12. Skoglund A, Hising P, Young C. A clinical and histologic examination in humans of the osseous response to implanted natural bone mineral. Int J Oral Maxillofac Implants 1997;12:194-9.
13. Yildirim M, Spiekermann H, Biesterfeld S, Edelhoff D. Maxillary sinus augmentation using xenogenic bone substitute material Bio-Oss in combination with venous blood: a histologic and histomorphometric study in humans. Clin Oral Implants Res 2000;11:217-29.
14. Fuerst G, Tangl S, Gruber R, Gahleitner A, Sanroman F, Watzek G. Bone formation following sinus grafting with autogenous bone-derived cells and bovine bone mineral in minipigs: preliminary findings. Clin Oral Implants Res 2004;15:733-40.
15. Roldan JC, Jepsen S, Schmidt C, Knuppel H, Rueger DC, Acil Y, et al. Sinus floor augmentation with simultaneous

JPIS Journal of Periodontal & Implant Science

placement of dental implants in the presence of platelet-rich plasma or recombinant human bone morphogenetic protein-7. Clin Oral Implants Res 2004;15:716-23.
16. Busenlechner D, Huber CD, Vasak C, Dobsak A, Gruber R, Watzek G. Sinus augmentation analysis revised: the gradient of graft consolidation. Clin Oral Implants Res 2009; 20:1078-83.
17. Quinones CR, Hurzeler MB, Schupbach P, Kirsch A, Blum P, Caffesse RG, et al. Maxillary sinus augmentation using different grafting materials and osseointegrated dental implants in monkeys. Part II. Evaluation of porous hydroxyapatite as a grafting material. Clin Oral Implants Res 1997; 8:487-96.
18. Haas R, Donath K, Fodinger M, Watzek G. Bovine hydroxyapatite for maxillary sinus grafting: comparative histomorphometric findings in sheep. Clin Oral Implants Res 1998; 9:107-16.
19. Margolin MD, Cogan AG, Taylor M, Buck D, McAllister TN, Toth C, et al. Maxillary sinus augmentation in the nonhuman primate: a comparative radiographic and histologic study between recombinant human osteogenic protein-1 and natural bone mineral. J Periodontol 1998;69: 911-9.
20. Hurzeler MB, Quinones CR, Kirsch A, Gloker C, Schupbach P, Strub JR, et al. Maxillary sinus augmentation using different grafting materials and dental implants in monkeys. Part I. Evaluation of anorganic bovine-derived bone matrix. Clin Oral Implants Res 1997;8:476-86.
21. Hurzeler MB, Quinones CR, Kirsch A, Schupbach P, Krausse A, Strub JR, et al. Maxillary sinus augmentation using different grafting materials and dental implants in monkeys. Part III. Evaluation of autogenous bone combined with porous hydroxyapatite. Clin Oral Implants Res 1997;8:401-11.
22. Bruder SP, Kurth AA, Shea M, Hayes WC, Jaiswal N, Kadiyala S. Bone regeneration by implantation of purified, culture-expanded human mesenchymal stem cells. J Orthop Res 1998;16:155-62.
23. Schliephake H, Knebel JW, Aufderheide M, Tauscher M. Use of cultivated osteoprogenitor cells to increase bone formation in segmental mandibular defects: an experimental pilot study in sheep. Int J Oral Maxillofac Surg 2001;30:531-7.
24. Kon E, Muraglia A, Corsi A, Bianco P, Marcacci M, Martin I, et al. Autologous bone marrow stromal cells loaded onto porous hydroxyapatite ceramic accelerate bone repair in critical-size defects of sheep long bones. J Biomed Mater Res 2000;49:328-37.
25. De Kok IJ, Peter SJ, Archambault M, van den Bos C, Kadiyala S, Aukhil I, et al. Investigation of allogeneic mesenchymal stem cell-based alveolar bone formation: preliminary findings. Clin Oral Implants Res 2003;14:481-9.
26. Rosenberg MM. Free osseous tissue autografts as a predictable procedure. J Periodontol 1971;42:195-209.
27. Garrett S, Loos B, Chamberlain D, Egelberg J. Treatment of intraosseous periodontal defects with a combined adjunctive therapy of citric acid conditioning, bone grafting, and placement of collagenous membranes. J Clin Periodontol 1988;15:383-9.
28. Vastardis S, Yukna RA, Mayer ET, Atkinson BL. Periodontal regeneration with peptide-enhanced anorganic bone matrix in particulate and putty form in dogs. J Periodontol 2005;76:1690-6.
29. Verdugo F, Castillo A, Moragues MD, Ponton J. Bone microbial contamination influences autogenous grafting in sinus augmentation. J Periodontol 2009;80:1355-64.
30. Choukroun J, Simonpieri A, Del Corso M, Mazor Z, Sammartino G, Dohan Ehrenfest DM. Controlling systematic perioperative anaerobic contamination during sinus-lift procedures by using metronidazole: an innovative approach. Implant Dent 2008;17:257-70.
31. Hanisch O, Lozada JL, Holmes RE, Calhoun CJ, Kan JY, Spiekermann H. Maxillary sinus augmentation prior to placement of endosseous implants: a histomorphometric analysis. Int J Oral Maxillofac Implants 1999;14:329-36.
32. Nkenke E, Stelzle F. Clinical outcomes of sinus floor augmentation for implant placement using autogenous bone or bone substitutes: a systematic review. Clin Oral Implants Res 2009;20 Suppl 4:124-33.
33. Raghoebar GM, Timmenga NM, Reintsema H, Stegenga B, Vissink A. Maxillary bone grafting for insertion of endosseous implants: results after 12-124 months. Clin Oral Implants Res 2001;12:279-86.