

Histologic evaluation of a 12-year-old threaded hydroxyapatite-coated implant placed in conjunction with subantral augmentation procedure: A clinical report

Periklis Proussaefs, DDS, MS,^a Henry-Savajol Olivier, DDS,^b and Jaime Lozada, DDS^c
Loma Linda University, Loma Linda, Calif

This clinical report presents a histologic evaluation of a threaded hydroxyapatite-coated root-form implant retrieved from the posterior maxillary area of a patient after being in function for 12 years. The implant had been placed in conjunction with subantral augmentation. Histologically, the portion of the implant that was examined under light microscopy appeared to be integrated with the surrounding bone; 74.3% of the surface of the implant had close bone apposition at the interface. The residual graft particles were present and in close proximity to the implant surface. These observations suggest that subantral augmentation procedure performed simultaneously with the placement of a hydroxyapatite-coated implant by using hydroxyapatite as a graft material may result in osseointegration between the implant and the surrounding bone that can be maintained under long-term function. (J Prosthet Dent 2004;92:17-22.)

Dental implants offer a predictable treatment modality for the completely or partially edentulous patient.^{1,2} With the introduction of subantral augmentation procedure (SAP),^{3,4} implant placement, and prosthetic, rehabilitation of the resorbed posterior maxilla has become a valid treatment option.⁵⁻⁷

Several materials and techniques have been introduced when performing the SAP.⁸⁻²⁹ A number of authors have reported the use of autogenous bone grafts harvested extraorally^{3-5,8-11,28,29} or intraorally,^{5-7,11-15,26} demineralized freeze-dried bone powder,^{5,27} hydroxyapatite,^{5-7,13,15-18,23,24} inorganic bovine mineral,^{21,22,25,27,28} and combinations of these.^{5-7,13,18,20,22,25,26} Regardless of the type of graft used, the sinus augmentation procedure has been proposed as a 2-stage procedure, in which the bone grafting is performed and the implants are placed after a healing period that lasts from 6 to 12 months,^{3-6,13,16,21,23,24} or as a single-stage procedure (simultaneous approach), in which the implants are inserted simultaneously with the bone grafting procedure.^{5-10,12,14,15,22,26,27-29} The simultaneous approach has the benefit of reducing the total length of the treatment and the amount of surgical interventions. However, there is controversy regarding the implant survival rate with the simultaneous approach. Some authors have shown a similar implant survival rate in the 2-stage and the simultaneous approach techniques,^{5,6} while others have demonstrated the 2-stage approach to be more favorable.^{1,18,19}

Histologic evidence from animal studies¹⁹ and results from a clinical study²⁶ have indicated the use of

hydroxyapatite (HA)-coated implants when performing an SAP. Even though both laboratory studies^{30,31} and clinical reports^{32,33} have indicated insufficient stability of the HA coating, histologic reports from humans demonstrated no alteration of the HA coating under long-term function.³⁴⁻³⁷ A bonding mechanism has been suggested for the intimate contact between bone and HA-coated implants.³⁸

Animal studies have demonstrated the potential of dental implants to become osseointegrated when placed in conjunction with SAP.^{17-19,27} However, histologic evidence in humans is limited. An implant is typically retrieved after failure; thus, it provides little information regarding bone-implant interface. In limited situations implants are indicated for retrieval after becoming clinically osseointegrated. Few articles have provided histologic evidence in humans regarding the potential of dental implants to become osseointegrated when placed in conjunction with SAP.^{38,39}

The purpose of this paper is to present the histologic and histomorphometric analysis of a 12-year-old HA-coated threaded root-form implant placed simultaneously with SAP where HA was used as a grafting material.

CLINICAL REPORT

A 74-year-old man presented at the Center for Prosthodontics and Implant Dentistry of Loma Linda University for restoration of partial edentulism in the area of the left maxillary premolars and first molar. Upon clinical examination, 3 root form implants were identified in the area of the maxillary left premolars and the first molar. Implants in the area of the second premolar and first molar were placed in 1991 in conjunction with an SAP at the same Center. Hydroxyapatite (Interpore 200; Interpore Cross International, Irvine,

^aAssistant Professor, Graduate Program in Implant Dentistry. Private practice, Santa Clarita, Calif.

^bPostdoctoral student, Graduate Program in Implant Dentistry.

^cProfessor and Director, Graduate Program in Implant Dentistry.

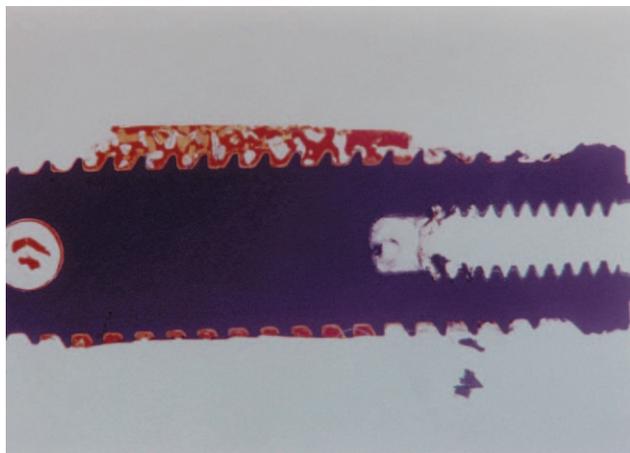


Fig. 1. Histologic overview (original magnification $\times 2$).

Calif) was used as graft material during the SAP. Maxillary bone height below the maxillary sinus in the area of the maxillary left first molar was 4 mm before the SAP. The implant in the area of the left maxillary first premolar was located within the patient's alveolus and not in the maxillary sinus. The patient was previously restored with an implant-supported screw-retained fixed partial denture. Clinical examination revealed that the implant in the area of the left maxillary first molar had been placed too far buccally, compromising esthetics and hygiene. The implant in the area of the left maxillary first premolar was failing because of excessive bone loss. After discussing different treatment options, the decision was made to remove the failing implant and misaligned implant in the area of the left maxillary first molar and place new dental implants.

The implants to be removed were HA-coated threaded root-form implants (Steri-Oss; Nobel Biocare, Yorba Linda, Calif). Implant removal was performed under local anesthesia. Periapical and panoramic radiographs were made prior to implant retrieval. Full-thickness buccal and palatal flaps were reflected. The mobility of the implants was evaluated manually (bidigitally, using the handles of 2 instruments). The failing implant in the area of the left maxillary first premolar was considered mobile, while the implant in the area of the left maxillary first molar had no sign of mobility. The implant in the region of the left maxillary first molar was removed using a 4-mm internal diameter trephine bur (ACE Surgical Supply Co, Brockton, Mass) and immediately placed in 10% buffered formalin. This implant received histologic and histomorphometric analysis.

Histologic processing and analysis

The implant was sectioned in half and immediately dehydrated with a graded series of alcohols for 9 days. Following dehydration, the specimens were infiltrated with a light-polymerizing embedding resin (Technovit 7200 VLC; Heraeus Kulzer, South Bend, Ind).



Fig. 2. HA coating appeared to have uniform thickness. Bone is in contact with implant surface along majority of implant surface (original magnification $\times 4$). Gray lining along implant surface is HA coating, bone is stained red, and residual graft material is stained brown.

Following 19 days of infiltration with constant shaking at normal atmospheric pressure, the specimen was embedded and polymerized using a 450-nm light (9W/71 blue; Osram Dulux, München, Germany) with the temperature of the specimens never exceeding 40°C. The specimen was then prepared by the Donath cutting/grinding method.^{40,41}

The specimen was cut to a thickness of 150 μm on a cutting/grinding system (EXAKT Apparatebau, Norderstedt, Germany). Following this, the specimens were polished to a thickness of 50 μm using the EXAKT microgrinding system. The specimens were stained with Stevenel's blue and Van Gieson's picro fuchsin. Two specimens from the retrieved implant were available for analysis.

Osseointegration (%) was measured on digitized images. Analysis was performed on a computer (Macintosh G4; Apple, Cupertino, Calif) using public domain software (NIH Image program; National Institutes of Health, Bethesda, Md). This method has been used in previous studies.³⁴⁻³⁷ The coronal portion of the implant, where the relation of the implant with the surrounding tissue could not be identified (possibly destroyed during retrieval), was excluded from the measurements.

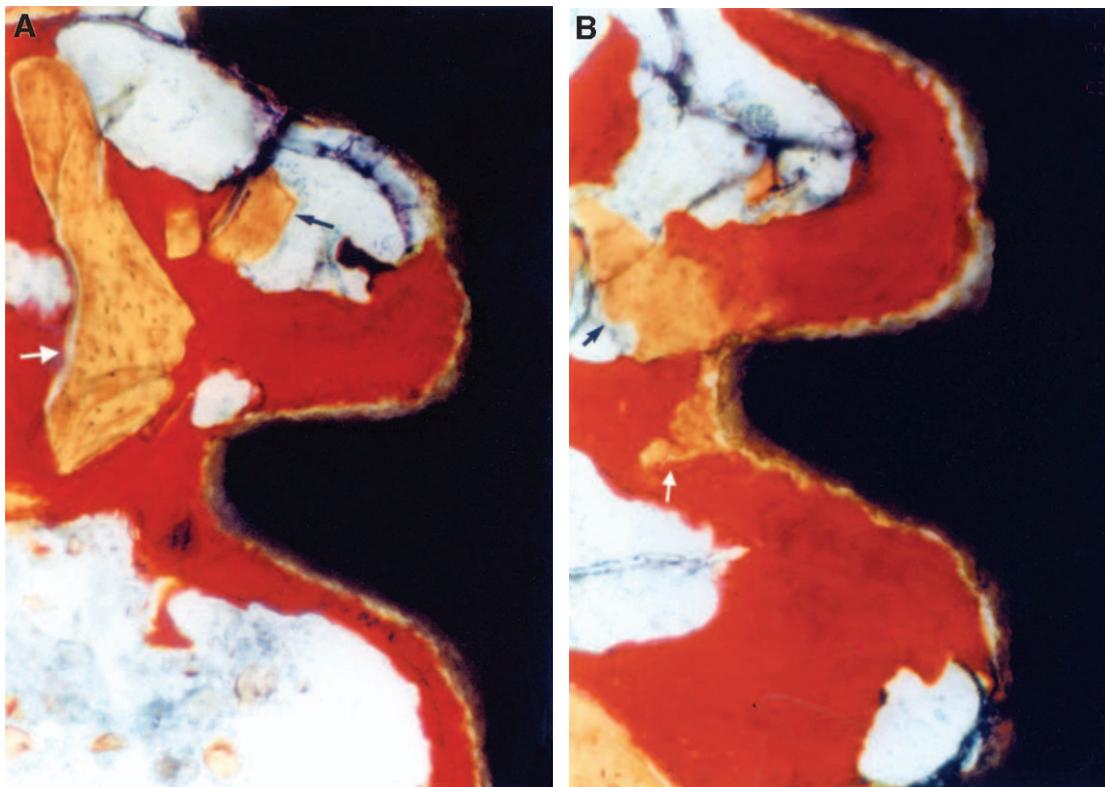


Fig. 3. **A**, Bone appeared in direct contact with HA coating and with residual graft material (arrows). In majority of specimens, residual graft material had 70- to 100- μ m distance from implant surface, while bone was present between residual graft particles and implant surface. **B**, In some instances, residual graft material (arrows) was in direct contact with HA coating. Notice uniform thickness of HA coating (original magnification $\times 20$). Gray lining along implant surface is HA coating, newly formed bone is stained red, and residual HA graft material is stained brown.

Clinical evaluation

Initial clinical examination revealed that the implant in the area of the left maxillary first molar was immobile when assessed manually with probing depths of 3 to 4 mm. Upon flap reflection (retrieval surgery), no sign of pathosis was seen around the implant. The bone appeared well integrated with the implant. The bone level was located 1 to 2 mm apically to the implant platform. Upon implant removal, the surrounding bone appeared well attached to the implant surface.

Radiographic evaluation

Radiographic examination suggested osseointegration with the surrounding bone. No evidence of peri-implant radiolucency was noted.

Histologic and histomorphometric evaluation

The portion of the implant preserved during retrieval was evaluated under light microscopy (Fig. 1). The implant surface appeared to be in contact with either bone or connective tissue (Fig. 2). The HA coating was structurally intact regardless of its contact with bone or connective tissue (Figs. 3 and 4). The residual graft particles appeared in close contact with the implant

surface (Figs. 3 and 4). In the majority of the specimens, there was bone (Fig. 3, A) between the graft particles and the implant surface. In some areas, residual graft particles were in direct contact with the HA coating (Fig. 3, B and Fig 4). No sign of inflammation or resorption of either the coating or the residual HA graft material was observed.

Histomorphometric analysis was performed at the portion of the implant that was not damaged during retrieval. Bone-to-implant contact was observed at 74.3% of the implant surface. Bone appeared to be in tight contact with the implant surface. Based on measurements of the distance between the tips of the threads in these specimens and the manufacturer-stated distance of 0.63 mm, it was possible to calculate the thickness of the coating remaining. The thickness was calculated to be approximately 50 μ m, equal to the original thickness purported by the manufacturer.

DISCUSSION

Placement of dental implants in conjunction with SAP has been supported by numerous clinical studies.^{5,7,8,10,12,14,15,26,29} Blomqvist et al¹⁴ reported an 82% survival rate for 314 implants placed in 49 patients,

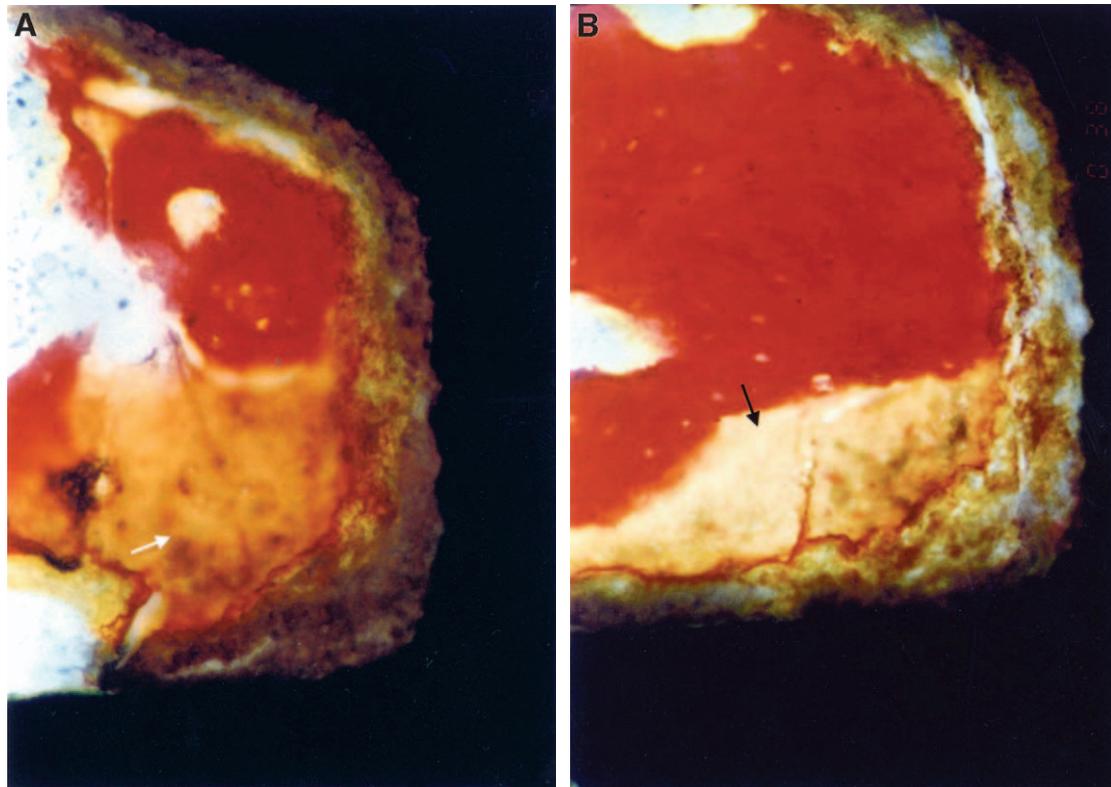


Fig 4. **A**, Under higher magnification, residual graft material (*white arrow*) is in direct contact with HA coating (*gray lining* along implant surface). **B**, Bone (stained *red*) appears in direct contact with HA coating and residual graft material (*black arrow*) (original magnification $\times 20$).

with a follow-up period of 3 to 49 months. Khoury¹⁵ reported a 94% survival rate for 476 implants placed in conjunction with 216 SAPs, with a follow-up of 2 to 6 years. Peleg et al²⁶ reported a 100% survival rate for 160 HA-coated implants placed in conjunction with 63 SAPs, with a follow-up of 2 to 4 years. However, clinical studies cannot provide information regarding bone-to-implant contact. This knowledge can be obtained from either animal studies or clinical reports involving retrieved dental implants. The current clinical report provided histologic evidence that HA-coated implants placed simultaneously with SAP may have the potential to achieve and maintain osseointegration under long-term function.

The potential of the HA graft material to induce bone formation when placed in the maxillary sinus has been demonstrated.^{7,13,16-19} However, few reports^{17-19,27,28} have provided histologic evidence that implants placed using the simultaneous approach can actually become osseointegrated. Quinones et al,¹⁷ Hurzeler et al,¹⁸ and Quinones et al,¹⁹ in a series of animal studies in monkeys, demonstrated the potential of implants to become osseointegrated when placed simultaneously with SAP when HA was used as a graft. In another animal study, Wetzel et al²⁷ demonstrated 25% bone-to-implant contact when implants were placed simultaneously with the maxillary sinus grafting. HA was used

as a grafting material in that study. In an animal study involving sheep, Haas et al²⁸ demonstrated that simultaneous sinus grafting and implant placement resulted in osseointegration of the implants into the maxillary sinus. Six months after implantation, 34.7% bone-to-implant contact was observed when inorganic bovine mineral had been used as a grafting material, and 35.5% when autogenous bone had been used.

Rosenlicht and Tarnow,³⁹ in a clinical report, demonstrated osseointegration of an HA-coated implant retrieved from the maxillary sinus after being in function for 2.5 years. The implant placement had been performed simultaneously with the maxillary sinus grafting, and demineralized freeze-dried allograft mixed with inorganic bovine mineral had been used as a grafting material. Proussaefs and Lozada³⁷ demonstrated 45.9% bone-to-implant contact from an implant retrieved from a patient after being in function for 9 years. The implant had been placed in conjunction with SAP, as in the present report.

In the current report, bone-to-implant contact was 74.3%. This is above the previously reported bone-to-implant contacts when implants are placed in conjunction with SAP.^{37,39} Even though conclusions cannot be made from a single clinical report, well controlled animal²⁴ and human²¹ studies have indicated that the degree of bone maturation is an ongoing process. The

percentage of bone-to-implant contact increases over time as a result of the remodeling process in response to the functional loading. It could be suggested that the high degree of bone-to-implant contact in the present report was the result of a chronic maturation and remodeling process of the bone around the implant and the residual graft particles.

An interesting observation in the current specimen was the fact that after 12 years the HA coating had a uniform thickness with no sign of dissolution or degradation, an observation made in other clinical reports.³⁴⁻³⁷ In vitro studies have demonstrated that dissolution of the HA coating can occur.^{30,31} In the few clinical reports where dissolution of the coating was observed, infection of the area had previously occurred.^{32,33}

In the current clinical report, residual HA graft particles were in direct contact with the implant surface in some areas (Fig. 3, B and Fig 4). This is a unique observation, because previously published histologic reports from both animal studies^{17-19,27,28} and human studies^{34-37,39} indicated the presence of newly formed bone between the residual graft material and implant surface. Direct contact of residual HA particles with the implant surface had not been observed in any of these studies. The clinical significance of this observation is unknown.

It should be noted that all of the previously mentioned should be cautiously interpreted, as they are based on a single clinical report. They are important, however, because of the paucity of long-term human data. With time, as more such reports are made available, a body of knowledge will be established that will indicate a typical clinical response to this particular form of treatment.

SUMMARY

This clinical report demonstrated that an HA-coated threaded root-form implant placed simultaneously with a subantral augmentation procedure performed by using HA as a graft material appeared to be osseointegrated 12 years after placement. The HA coating had a uniform thickness with no sign of resorption. Residual HA particles were in direct contact with the implant surface in some areas.

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Reprint requests to:

DR PERIKLIS PROUSSAEFS
 CENTER FOR PROSTHODONTICS AND IMPLANT DENTISTRY
 SCHOOL OF DENTISTRY
 LOMA LINDA UNIVERSITY
 LOMA LINDA, CA 92350
 FAX: 909-558-4803
 E-MAIL: pproussaef@hotmail.com

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