Histologic Evaluation of a 9-year-old Hydroxyapatite-coated Cylindric Implant Placed in Conjunction with a Subantral Augmentation Procedure: A Case Report

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The histologic examination of dental implants retrieved from humans provides a unique opportunity to evaluate the bone-implant interface. This case report presents a clinical, radiographic, and histologic evaluation of a cylindrical hydroxyapatite- (HA) coated implant retrieved from the posterior maxillary area of a patient after 9 years after placement. The implant had been placed in conjunction with a subantral augmentation procedure with HA as the graft material. Clinical examination revealed an immobile implant with no sign of pathosis. Radiographic examination indicated close proximity of the bone to the implant surface without evidence of radiolucency. Histologically, because of tissue destruction during implant retrieval, only the apical portion of the implant was available for examination under light microscopy, and it appeared to be integrated with the surrounding bone; 45.9% of the surface of the implant had close bone apposition at the interface. There was no evidence of dissolution of the HA coating and the bone appeared to be in immediate contact with the coating. Residual graft particles were present and in close proximity with the implant surface. These observations suggest that the subantral augmentation procedure performed simultaneously with the placement of an HA-coated implant with HA as the graft material apparently resulted in osseointegration between the implant and the surrounding bone. The implant was maintained without complication for 9 years. (INT J ORAL MAXILLOFAC IMPLANTS 2001;16:737–741)

Key words: *dental implants, hydroxyapatites, osseointegration, sinus augmentation*

Dental implants offer a predictable treatment modality for totally or partially edentulous patients.[1,2] Since the introduction of sinus grafting techniques,[3,4] implant placement and prosthetic rehabilitation of the resorbed posterior maxilla has become a valid treatment option.[5–7]

A variety of grafting materials have been used to augment the antral space, including autografts harvested extraorally[3–5,8,9] or intraorally,[9–11] demineralized freeze dried bone powder,[5] hydroxyapatite (HA),[5–7,10,12–15] and combinations of these.[5–7,10,13,14] Regardless of the type of graft used, the sinus augmentation procedure has been proposed as a 2-stage procedure, wherein the bone grafting is performed and the implants are placed later, after a healing period of 6 to 12 months[3–6,10–12,16]; or as a 1-stage procedure, wherein the implants are placed simultaneously with the bone grafting procedure.[5,13] The 1-stage approach has the benefit of reducing the total length of treatment time and the number of surgical interventions. There is controversy regarding the implant survival rate when the 1- and 2-stage approaches are compared. Some authors have shown similar implant survival rates between the 2 techniques,[5,6] while others have demonstrated greater predictability with the 2-stage approach.[14,15]

This article provides a histologic and histomorphometric analysis of a 9-year-old HA-coated cylindric implant that was placed simultaneously with a subantral augmentation procedure (1-stage approach) in which HA was used as a grafting material.

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CASE REPORT

A 52-year-old female patient presented at the Center for Prosthodontics and Implant Dentistry, Loma Linda University, in November 1999 for the fabrication of a conventional maxillary complete denture. Upon clinical examination, a root-form implant was identified in the area of the maxillary right first molar. The patient reported discomfort in the area when using her existing maxillary complete denture. The area around the platform of the implant appeared clinically irritated.

The implant was an HA-coated cylindric implant (Integral, Sulzer Calcitek, Carlsbad, CA) that had been placed in June 1990 in a private practice in conjunction with a subantral augmentation procedure. Hydroxyapatite (Interpore 200, Interpore International, Irvine, CA) had been used during the subantral augmentation. Given the patient's dissatisfaction with the previously fabricated maxillary complete dentures because of pain in the area around the implant platform, the decision was made to remove the implant before the fabrication of a new maxillary complete denture. Removal of the implant was done under local anesthesia. A periapical radiograph was taken before the implant was removed (Fig 1). Surgical removal of the implant was performed in October 1999. Full-thickness buccal and palatal flaps were reflected. The mobility of the implant was evaluated manually (bidigital using the handles of 2 instruments). The implant was removed using a 4-mm internal-diameter trephine bur (ACE Surgical Supply, Brockton, MA) and immediately placed in 10% buffered formalin.

Histologic Processing and Analysis

The implant was sectioned in half longitudinally and immediately dehydrated with a graded series of alcohols for 9 days. Following dehydration, the specimens were infiltrated with a light-curing embedding resin (Technovit 7200 VLC, Kulzer, Germany). Following 19 days of infiltration with constant shaking at normal atmospheric pressure, the specimen was embedded and polymerized by 450 nm light, with the temperature of the specimens never exceeding 40°C. The specimen was then prepared using the cutting/grinding method of Donath and Breuner.[17,18]

The specimen was cut to a thickness of 150 µm with an EXAKT cutting/grinding system (EXAKT Apparatebau, Norderstedt, Germany). The slides were then polished to a thickness of 50 µm using the EXAKT microgrinding system followed by alumina polishing paste. The slides were stained with Stevenel's blue and Van Gieson's picro fuchsin. Two slides from the retrieved implant were available for analysis.

The bone-to-implant contact (BIC) percentage was measured on digitized images of the apical section of the implant. Analysis was performed on a Macintosh computer using the public domain NIH Image program (developed at the U.S. National Institutes of Health and available on the Internet at http://rsb.info.nih.gov/nih-image/). The coronal portion of the implant, where the relationship of the implant to the surrounding tissue could not be identified (possibly destroyed during retrieval), was excluded from the measurements.

Clinical Evaluation

Initial clinical examination revealed that the implant was immobile when assessed manually, with probing depths of 3 to 4 mm. Soft tissue around the implant appeared irritated because of the friction of the tissue around the implant platform during function with the existing maxillary complete denture.

Upon flap reflection (retrieval surgery), no sign of pathosis was seen around the implant. The bone appeared well integrated with the implant; however, the bone level was located 3 mm apically to the implant platform. Upon implant removal, the surrounding bone appeared well attached to the implant surface.

Radiographic Evaluation

Radiographic examination (Fig 1) suggested close implant contact with the surrounding bone. No evidence of peri-implant radiolucency was noted.

Histologic and Histomorphometric Evaluation

The apical portion of the implant was preserved during retrieval and evaluated under light microscopy (Fig 2). The implant surface appeared to be in contact with either bone or connective tissue (Fig 3a). The HA coating had a uniform thickness regardless of its contact with bone or connective tissue (Fig 3b). The residual graft particles appeared to be in close contact with the implant surface; however, there was always bone (Figs 3b and 3c) or connective tissue (Fig 3d) between the graft particles and the implant surface. No contact between the residual graft material and the implant surface was observed. The vent area of the implant appeared to have almost 100% BIC (Fig 4), with bone lining nearly the entire internal vent surface. No sign of inflammation or resorption of either the coating or the residual HA graft material was seen.

Histomorphometric analysis was performed only at the apical portion of the implant that was not damaged during retrieval. Bone-to-implant contact

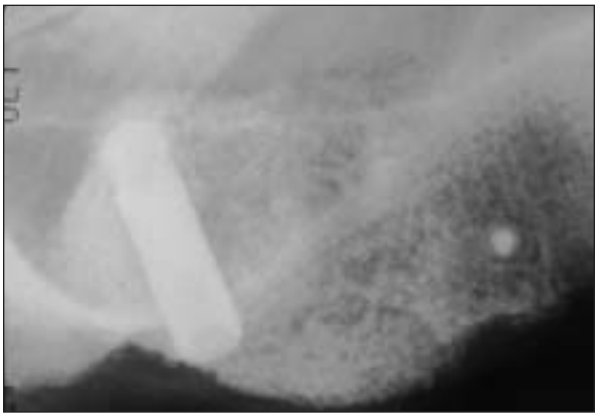

Fig 1 Periapical radiograph before implant retrieval.

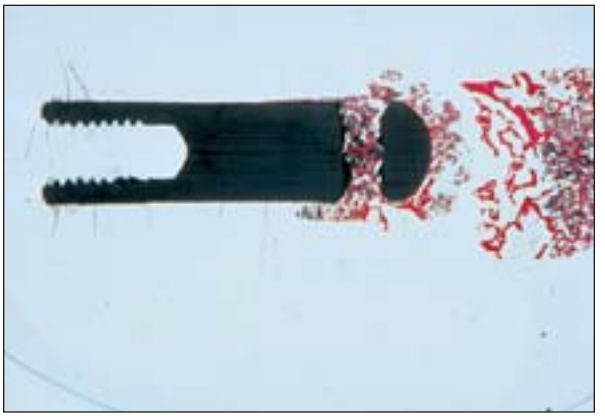

Fig 2 Histologic overview (original magnification ×1.5).

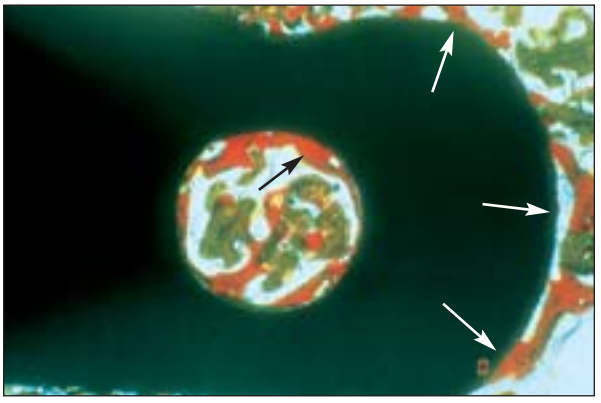

Fig 3a The HA coating *(white arrows)* appeared to have a uniform thickness. Bone *(black arrow)* and connective tissue are in contact with the implant surface at the apical area of the implant (original magnification ×4).

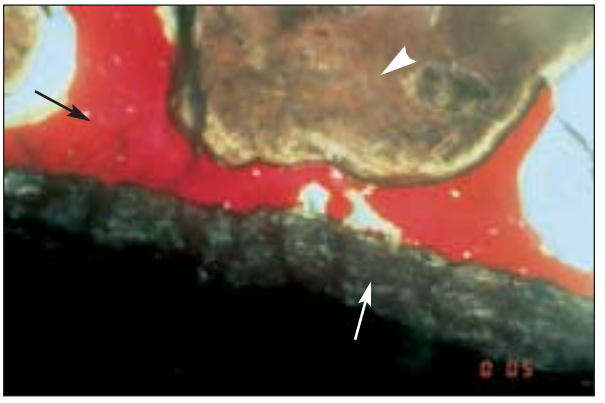

Fig 3b Bone *(black arrow)* was in direct contact with the HA coating *(white arrow)* and with residual graft material *(white arrowhead)* (original magnification ×20).

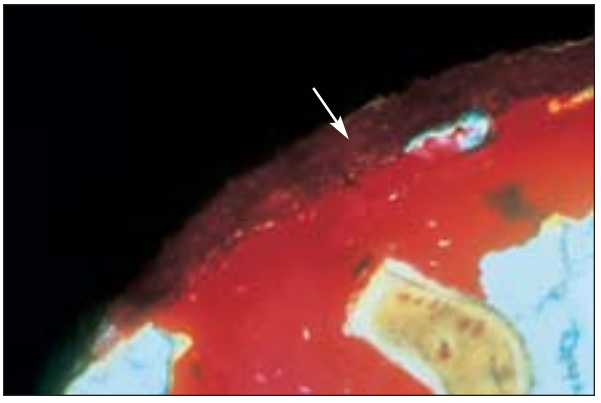

Fig 3c Uniform coating thickness *(white arrow)* and tight contact with the bone could be observed (original magnification ×20).

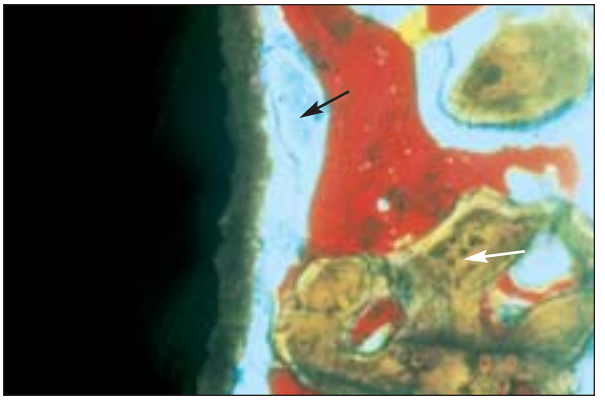

Fig 3d Connective tissue *(black arrow)* surrounded the implant in some areas. Notice the tight contact of the bone with the residual HA particles *(white arrow)* (original magnification ×10).

Fig 4 The internal vent area appeared to have almost 100% bone-to-implant contact. Bone *(black arrows)* lined the vent surface, with residual HA material *(white arrows)* in the middle being in tight contact with the surrounding bone. Bony islands connected the graft particles (original magnification ×20).

was observed at 45.9% of the implant surface, while 54.1% of the implant surface was in contact with soft tissue.

DISCUSSION

The significance of the current case report is that it provides histologic evidence in a human subject that HA-coated implants placed simultaneously with a subantral augmentation procedure in which HA had been used as a graft material have the potential to achieve and maintain osseointegration. The potential of HA graft material to induce bone formation when placed in the maxillary sinus has been demonstrated[7,10,12,14,15]; however, few investigations have provided histologic evidence that implants placed with a 1-stage approach can actually become osseointegrated.

Hürzeler and coworkers[14] and Quinones and associates,[15] in a series of animal studies in monkeys, demonstrated the potential of implants to become osseointegrated when placed simultaneously with a subantral augmentation procedure using HA. In addition, Wetzel and colleagues[19] in another animal study demonstrated 25% BIC when implants were placed simultaneously with maxillary sinus grafting. Hydroxyapatite had also been used as a grafting material in that study. Haas and coworkers,[20] in an animal study done in sheep, demonstrated that 1-stage sinus grafting and implant placement resulted in osseointegration of the implants in the maxillary sinus. At 6 months after implantation, 34.7% BIC was observed when inorganic bovine mineral had been used as a grafting material and 35.5% BIC when autogenous bone had been used. In agreement with findings from the current specimen, enhanced bone formation was observed at the apical portion of the implants (along the vent area), and the residual mineral particles had no direct contact with the implant surface. Bone or connective tissue was intervening between the implant surface and the residual mineral particles.

In a clinical case report, Rosenlicht and Tarnow[21] 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 maxillary sinus grafting, and demineralized freeze-dried allograft mixed with anorganic bovine mineral had been used as a grafting material.

Despite currently available evidence that implants placed using the 1-stage approach have the potential to osseointegrate, there are some limitations to this treatment modality. Blomqvist and coworkers[22] demonstrated that the 2-stage approach offers the opportunity for prosthetically better implant placement. The 1-stage approach obligates the surgeon to achieve primary stability with the bone that is available during that surgery. However, optimal prosthetic reconstruction may require placement of the implant at an area different from that area where the bone initially exists. Triplett and Schow[9] stated that the 2-stage approach should be preferred, because it offers the potential for better implant placement.

An interesting observation regarding the current specimen was the fact that after 9 years the HA coating had a uniform thickness, with no sign of dissolution or degradation. In vitro studies have demonstrated that dissolution of the HA coating can occur.[23,24] It has also been reported that HA coatings may be susceptible to dissolution when they are not in contact with bone.[25,26] In the current specimen, the coating lacked contact with bone in some areas (Fig 3d). Nevertheless, no sign of resorption was observed. This has also been shown in other clinical case reports[27,28] in which implants had been under function for relatively short periods of time (0.5 to 3 years) before retrieval. Proussaefs and associates[29] published a case report in which 2 HA-coated root-form implants demonstrated 79% and 84% BIC after being in function for 7 years. Similarly, Proussaefs and coworkers[30] demonstrated no signs of coating degradation or dissolution in HA-coated implants retrieved after being in function for up to 11 years. In the few clinical case reports where dissolution of the coating was observed, infection of the area had occurred.[31,32]

In summary, this case report demonstrated that an HA-coated cylindric implant placed simultaneously with subantral augmentation performed using HA as a graft material, appeared to be osseointegrated 9 years post-placement. In the apical portion available for histologic examination, the HA coating had a uniform thickness, with no sign of resorption.

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