# Histologic evaluation of a threaded hydroxyapatite-coated root-form implant located at a dehisced maxillary site and retrieved from a human subject: A clinical report

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This clinical report describes the microscopic analysis of a threaded hydroxyapatite-coated root-form implant retrieved from an 89-year-old subject after 10 months of service. The implant was never loaded and was removed because it was nonrestorable. Clinically, the buccal area of the implant was covered by soft tissue, whereas the palatal side was covered by bone. Light microscopic evaluation revealed tight contact between hydroxyapatite and bone with no sign of coating dissolution. Osteocytes were present, and Haversian canals were in close proximity to the implant surface. The buccal side of the implant demonstrated mild to moderate inflammatory infiltrate and signs of hydroxyapatite coating dissolution. These observations suggest that hydroxyapatite coatings can resist degradation in contact with bone but may be more prone to dissolution in contact with soft tissue. (J Prosthet Dent 2002;87:140-4.)

Titanium and titanium alloy dental implants have become a valid treatment modality for the totally[1,2] or partially[3,4] edentulous patient. Reports of more rapid or advanced osseointegration of hydroxyapatite (HA)-coated titanium or titanium alloy implants[5-9] have generated interest in the solubility and longevity of the coating after the implants are placed. It has been reported that the HA coating is prone to dissolution.[10-13] However, histologic observations from osseointegrated HA-coated implants retrieved from humans have failed to demonstrate HA dissolution.[14-19]

It has been hypothesized that the HA coating in contact with a nonbony surface may be prone to dissolution.[7,17,20-22] Ogiso et al[22] implanted HA-coated dental implants in dogs, creating a dehiscence on one side of the implants. Histologic evaluation revealed dissolution of the coating toward the dehisced side. Matsui[7] reported comparable observations in a similar animal study with dogs. Piatelli[17,21] evaluated implants retrieved from human subjects and suggested that HA coating in contact with biologic fluids may initiate resorption of the coating.

The exact consequence of an HA-coated implant opposed by soft tissue instead of bone is unknown. This clinical report presents the results of a histologic evaluation of an HA-coated root-form titanium implant retrieved from a human subject. The implant was opposed partially by bone and partially by soft tissue.

## CLINICAL REPORT

An 89-year-old man presented at the Center for Prosthodontics and Implant Dentistry, Loma Linda University, to receive an implant-supported, screw-retained fixed partial denture for the maxillary left canine to first molar (Fig. 1). Ten months previously, 3 threaded HA-coated root-form implants (Steri-Oss; Nobel Biocare USA, Yorba Linda, Calif.) had been placed by a private practitioner to replace the maxillary left canine, second premolar, and first molar. The implant in the maxillary left canine area appeared to be positioned too far buccally to be restorable. A decision was made to replace that implant with another in a more favorable position. Before implant retrieval, the area around the existing implant was probed at 6 locations: distal-palatal, mid-palatal, mesio-palatal, mesio-buccal, mid-buccal, and distal-buccal. The healing abutment was removed, a cover screw was placed, and a periapical radiograph was taken (Fig. 2).

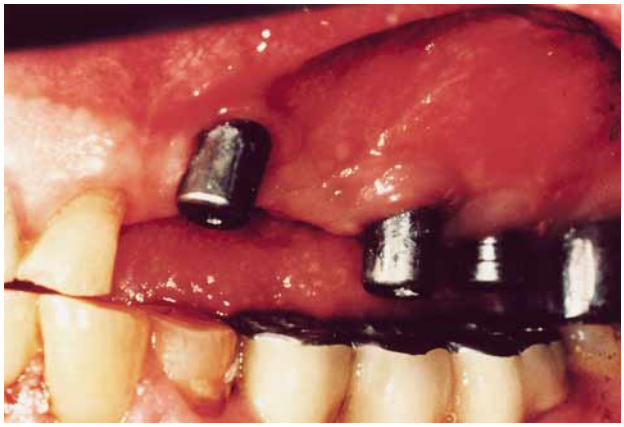

**Fig. 1.** Implant placed too far buccally in area of maxillary left canine. Note lack of keratinized tissue in buccal area.

A full-thickness buccal-palatal flap was reflected around the implant (Fig. 3). The implant was removed with a 4-mm internal diameter trephine bur (ACE

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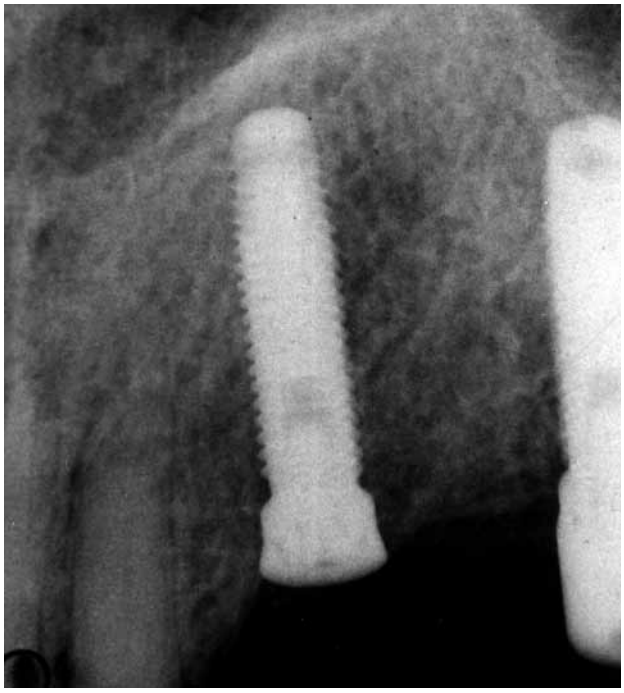

**Fig. 2.** Periapical radiograph shows no peri-implant radiolucency.

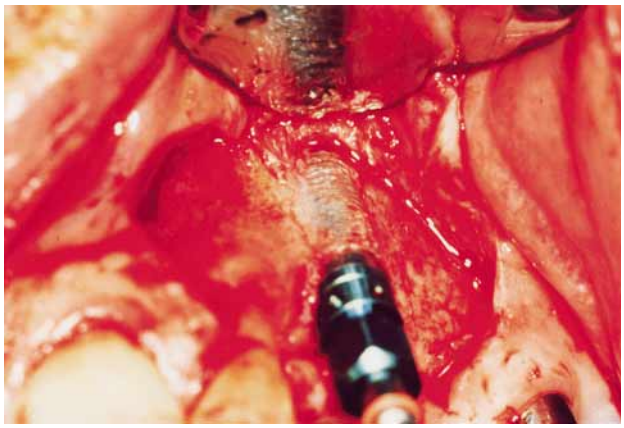

**Fig. 3.** Buccal surface of implant appears not covered by bone after full-thickness flap reflection.

Surgical Supply Co, Brockton, Mass.) and immediately placed in 10% buffered formalin. A new HA-coated threaded root-form implant (Steri-Oss; Nobel Biocare USA) was placed in a more favorable position. On the appropriate form released by the Institutional Review Board at Loma Linda University, the subject gave his informed consent for histologic evaluation of the retrieved implant.

The implant was dehydrated through ascending concentrations of ethanol and transferred to acetone. The specimen was then infiltrated with methyl methacrylate monomer and later with polymethyl methacrylate. Subsequently, the retrieved implant was

**Fig. 4.** Histologic overview of retrieved implant (original magnification × 2).

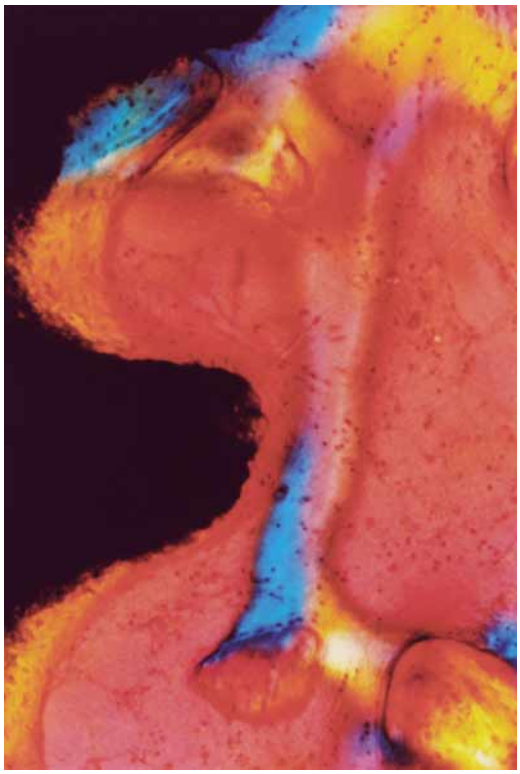

**Fig. 5.** View of implant surface toward bony surface (polarized light). Note lack of HA at tips of threads (original magnification × 10).

embedded in polymethyl methacrylate for undercalcified sectioning after vacuum bench polymerization and hardening in a heated vacuum oven. Five serial sections were obtained with a diamond wafering blade affixed to a low-speed saw. The sections were ground, if necessary, and stained with toluidine blue/basic fuchsin mixture at 50°C.

*Clinical findings.* Probing depths around the implant were as follows: 3 mm at distal-palatal, mid-palatal, mesio-palatal, and mesio-buccal; 4 mm at

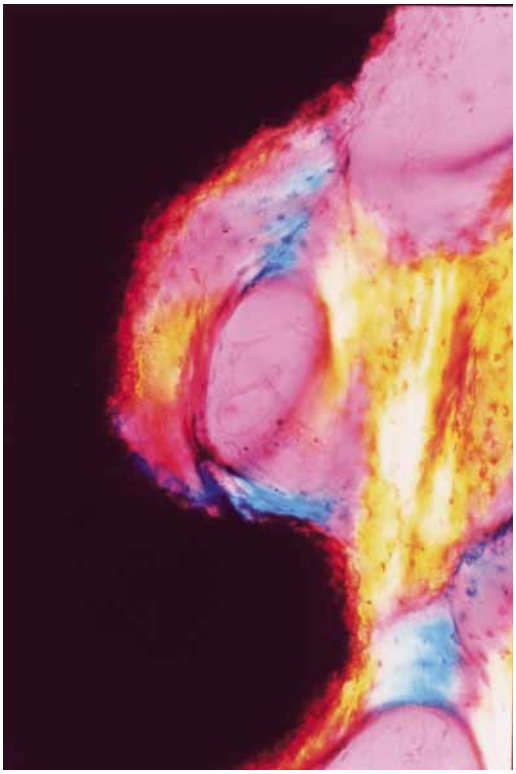

**Fig. 6.** Presence of Haversian canals in close proximity to implant surface emphasizes remodeling activity of bone around implant (polarized light; original magnification × 10).

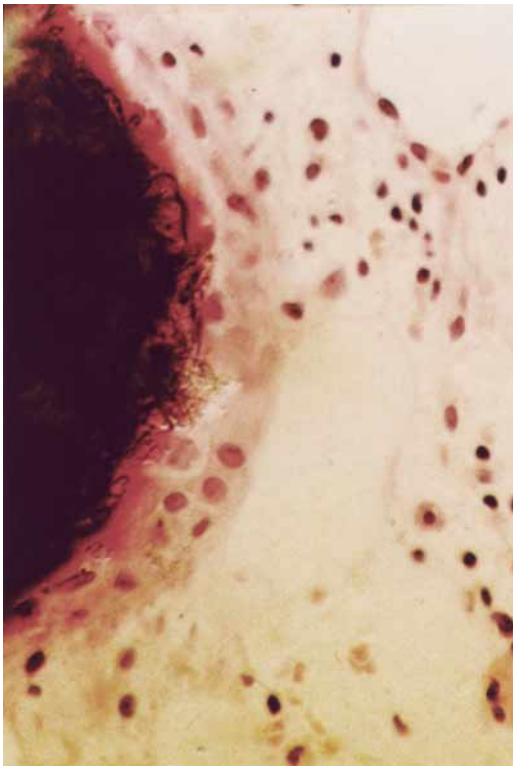

**Fig. 7.** Area of retrieved implant at buccal side. Figure represents area of potential HA resorption associated with large and sometimes multinucleated cells. Cells were consistent with macrophages and osteoclasts (original magnification × 40).

mid-buccal; and 5 mm at distal-buccal. There was bleeding on probing on the buccal side and a total lack of keratinized tissue at the buccal surface. On flap reflection, a 9 mm bony dehiscence along the buccal surface of the implant was observed (Fig. 3). Soft tissue appeared to be adhered to the buccal surface. The implant was clinically immobile. On retrieval, it appeared well attached to the palatal bony area. The area healed uneventfully after implant retrieval.

*Radiographic findings.* A periapical radiograph suggested osseointegration with the surrounding bone, with no sign of peri-implant radiolucency (Fig. 2).

*Histologic findings.* The implant appeared to be surrounded by mature trabecular bone (Fig. 4), with tight contact between HA and bone. The bone on the palatal aspect of the implant appeared mature and healthy with osteocytes present. Excellent trabecular bone remodeling could be observed close to the implant (Figs. 5 and 6). The HA coating was present with no signs of active resorption. The tips of the implant threads were denuded of the HA coating, and the exposed metal surface was in close contact with bone (Fig. 5). On the buccal side of the implant, which was in contact with soft tissue, large and sometimes multinucleated cells were observed (Fig. 7). These cells were consistent with macrophages and osteoclasts. A mild-to-moderate inflammatory cell infiltrate was observed, as were indentations and focal regions of HA loss (Fig. 8).

## DISCUSSION

The histologic findings for the current specimen are in agreement with previous reports.[14-19] They demonstrate that the HA coating may not be susceptible to dissolution in contact with bone. The presence of Haversian canals[20,23,24] (Fig. 6) in close proximity to the bony surface implies a remodeling activity.[25,26] The bone was in tight contact with the HA surface, as reported previously,[16,17] supporting the theory that a special kind of bonding mechanism[27] may exist between the coating surface and the bone.

The absence of HA at the tips of the threads in the current specimen is consistent with what HA-coated implants typically demonstrate after retrieval.[20,28] It has been reported that the friction forces during implant placement result in mechanical detachment of the coating at these areas.[29] It seems unlikely that a resorptive process is responsible for this phenomenon since the lack of HA has been selectively identified at the tips of the threads.

The current specimen provides histologic support for the hypothesis that the HA coating in contact with

**Fig. 8.** Indentations along implant surface *(arrow)* and mild inflammatory cell infiltrate suggest focal loss of HA (original magnification × 20).

a nonbony surface may be prone to dissolution.[7,17,20-22] The indentations along the coating surface (Fig. 8), the presence of macrophages, and the inflammatory process on the dehisced surface of the implant (Fig. 7) could be perceived as an active resorptive process of the HA. It appears that the use of titanium noncoated implants in areas with a bony dehiscence[30,31] may be advantageous. Further research is needed to validate this hypothesis.

The lack of keratinized tissue on the buccal surface may have caused mechanical trauma through friction of the soft tissue on the rough surface of the coating. On the other hand, lack of keratinized tissue has been associated with increased bleeding tendency[32] and peri-implant probing depth[33] around noncoated threaded implants. It is unclear whether the inflammatory process in the current specimen was the result of a mechanical trauma or an active resorptive process of the coating.

The observations reported in this article should be interpreted cautiously, as only one specimen was examined. It is unknown, for example, whether the soft tissue apposition resulted in the inflammatory process or the inflammatory process enhanced further deposition of soft tissue. It should also be mentioned that due to the lack of specific staining, it was impossible to differentiate osteoclasts from macrophages. Despite these limitations, these observations offer useful information given the scarcity of literature on clinically osseointegrated dental implants retrieved from humans. Typically, implants retrieved from humans have already failed, which means that no information about the bone-to-implant contact can be obtained.

## SUMMARY

The histologic evaluation of a single HA-coated root form implant retrieved from a human subject has been described. Clinical, radiographic, and histologic findings support the idea that the HA coating is not prone to dissolution in contact with bone. In contact with a nonbony surface, however, the coating may initiate an inflammatory reaction and active resorptive process.

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## REFERENCES

1. Adell R, Lekholm U, Rockler B, Branemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 1981;10:387-416.
2. Cox JF, Zarb GA. The longitudinal clinical efficacy of osseointegrated dental implants: a 3-year report. Int J Oral Maxillofac Implants 1987;2:91-100.
3. Jemt T, Lekholm U, Adell R. Osseointegration in the treatment of partially edentulous patients: a preliminary study on 876 consecutively placed fixtures. Int J Oral Maxillofac Implants 1989;4:211-7.
4. van Steenberghe D. A retrospective multicenter evaluation of the survival rate of osseointegrated fixtures supporting fixed partial prostheses in the treatment of partial edentulism. J Prosthet Dent 1989;61:217-23.
5. Iamoni F, Rasperini G, Trisi P, Simion M. Histomorphometric analysis of a half hydroxyapatite-coated implant in humans: a pilot study. Int J Oral Maxillofac Implants 1999;14:729-35.
6. Hayashi K, Uenoyama K, Matsuguchi N, Sugioka Y. Quantitative analysis of in vivo tissue responses to titanium-oxide- and hydroxyapatite-coated titanium alloy. J Biomed Mater Res 1991;25:515-23.
7. Matsui Y, Ohno K, Mitchi K, Yamagata K. Experimental study of high-velocity flame-sprayed hydroxyapatite coated and non-coated titanium implants. Int J Oral Maxillofac Implants 1994;9:397-404.
8. Gottlander M, Johansson CB, Albrektsson T. Short- and long-term animal studies with a plasma-sprayed calcium phosphate-coated implant. Clin Oral Implants Res 1997;8:345-51.
9. Oonishi H, Yamamoto M, Ishimaru H, Tsuji E, Kushitani S, Aono M, et al. The effect of hydroxyapatite coating on bone growth into porous titanium alloy implants. J Bone Joint Surg Br 1989;71:213-6.
10. Dhert WJ, Klein CP, Jansen JA, van der Velde EA, Vriesde RC, Rozing PM, et al. A histological and histomorphometrical investigation of fluorapatite, magnesiumwhitlockite, and hydroxyapatite plasma-sprayed coatings in goats. J Biomed Mater Res 1993;27:127-38.
11. Klein CP, Patka P, Wolke JG, de Blieck-Hogervorst JM, de Groot K. Long-term in vivo study of plasma-sprayed coatings on titanium alloys of tetracalcium phosphate, hydroxyapatite and alfa-tricalcium phosphate. Biomaterials 1994;15:146-50.
12. Caulier H, van der Waerden JP, Paquay YC, Wolke JG, Kalk W, Naert I, et al. Effect of calcium phosphate (Ca-P) coatings on trabecular bone response: a histological study. J Biomed Mater Res 1995;29:1061-9.
13. Gross KA, Berndt CC, Goldschlag DD, Iacono VJ. In vitro changes of hydroxyapatite coatings. Int J Oral Maxillofac Implants 1997;12:589-97.
14. Rohrer MD, Bulard RA, Patterson MK Jr. Maxillary and mandibular titanium implants 1 year after surgery: histologic examination in a cadaver. Int J Oral Maxillofac Implants 1995;10:466-73.

15. Piattelli A, Trisi P. Microscopic and chemical analysis of bone-hydroxyapatite interface in a human retrieved implant. A case report. J Periodontol 1993;64:906-9.
16. Piattelli A, Scarano A, Di Alberti L, Piattelli M. Bone-hydroxyapatite interface in retrieved hydroxyapatite-coated titanium implants: a clinical and histologic report. Int J Oral Maxillofac Implants 1999;14:233-8.
17. Piattelli A, Trisi P. A light and laser scanning microscopy study of bone/hydroxyapatite-coated titanium implants interface: histochemical evidence of unmineralized material in humans. J Biomed Mater Res 1994;28:529-36.
18. Block MS, Kent JN. Cylindrical HA-coated implants—8-year observations. Compendium 1993;14(Suppl 15):S526-32; quiz S565-6.
19. Steflik DE, Parr GR, Singh BB, Lake FT, Sisk AL, Howell FV, et al. Light microscopic and scanning electron microscopic analyses of dental implants retrieved from humans. J Oral Implantol 1994;20:8-24.
20. Hardy DC, Frayssinet P, Bonel G, Authom T, Le Naelou SA, Delince PE. Two-year outcome of hydroxyapatite-coated prostheses. Two femoral prostheses retrieved at autopsy. Acta Orthop Scand 1994;65:253-7.
21. Piattelli A, Cordioli GP, Trisi P, Passi P, Favero GA, Meffert RM. Light and confocal laser scanning microscopic evaluation of hydroxyapatite resorption patterns in medullary and cortical bone. Int J Oral Maxillofac Implants 1993;8:309-15.
22. Ogiso M, Yamashita Y, Matsumoto T. The process of physical weakening and dissolution of the HA-coated implant in bone and soft tissue. J Dent Res 1998;77:1426-34.
23. Benjamin LS, Block MS. Histologic evaluation of a retrieved human HA-coated subperiosteal implant: report of a case. Int J Oral Maxillofac Implants 1989;4:63-6.
24. Bauer TW, Geesink RC, Zimmerman R, McMahon JT. Hydroxyapatite-coated femoral stems. Histological analysis of components retrieved at autopsy. J Bone Joint Surg Am 1991;73:1439-52.
25. Steflik DE, Corpe RS, Lake FT, Sisk AL, Parr GR, Hanes PJ. Composite morphology of the bone and associated support-tissue interfaces to osseointegrated dental implants: TEM and HVEM analyses. Int J Oral Maxillofac Implants 1997;12:443-53.
26. De Lange GL, De Putter C, De Wijs FL. Histological and ultrastructural appearance of the hydroxyapatite-bone interface. J Biomed Mater Res 1990;24:829-45.
27. Tracy BM, Doremus RH. Direct electron microscopy studies of the bone-hydroxyapatite interface. J Biomed Mater Res 1984;18:719-26.
28. Rosenlicht JL, Tarnow DP. Human histologic evidence of integration of functionally loaded hydroxyapatite-coated implants placed simultaneously with sinus augmentation: a case report 2 1/2 years postplacement. J Oral Implantol 1999;25:7-10.
29. Edmonds RM, Yukna RA, Moses RL. Evaluation of the surface integrity of hydroxyapatite-coated threaded dental implants after insertion. Implant Dent 1996;5:273-8.
30. Dahlin C, Lekholm U, Lindhe A. Membrane-induced bone augmentation at titanium implants. A report on ten fixtures followed from 1 to 3 years after loading. Int J Periodontics Restorative Dent 1991;11:273-81.
31. Palmer RM, Floyd PD, Palmer PJ, Smith BJ, Johansson CB, Albrektsson T. Healing of implant dehiscence defects with and without expanded polytetrafluoroethylene membranes: a controlled clinical and histological study. Clin Oral Implants Res 1994;5:98-104.
32. Apse P, Zarb GA, Schmitt A, Lewis DW. The longitudinal effectiveness of osseointegrated dental implants. The Toronto Study: peri-implant mucosal response. Int J Periodontics Restorative Dent 1991;11:94-111.
33. Bragger U, Burgin WB, Hammerle CH, Lang NP. Associations between clinical parameters assessed around implants and teeth. Clin Oral Implants Res 1997;8:412-21.

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