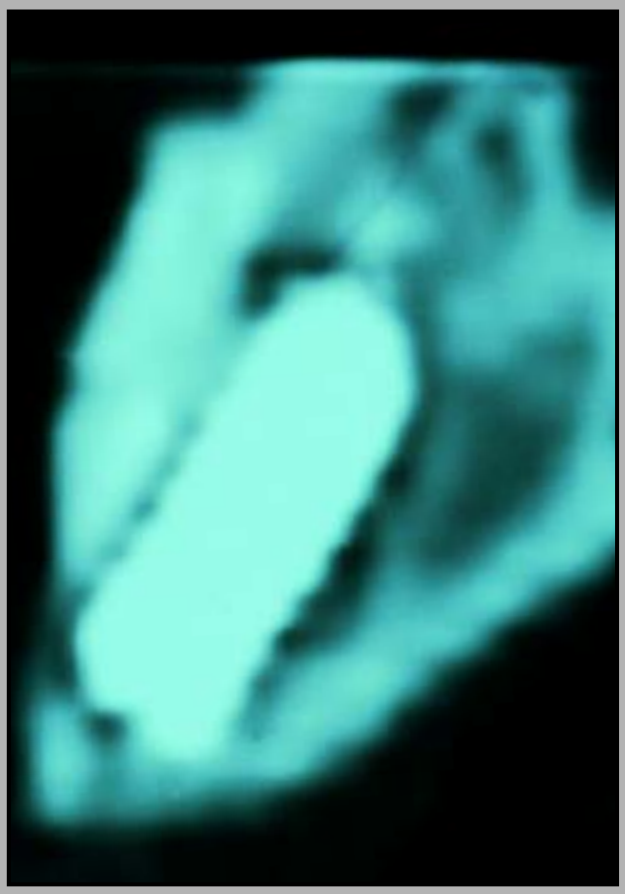
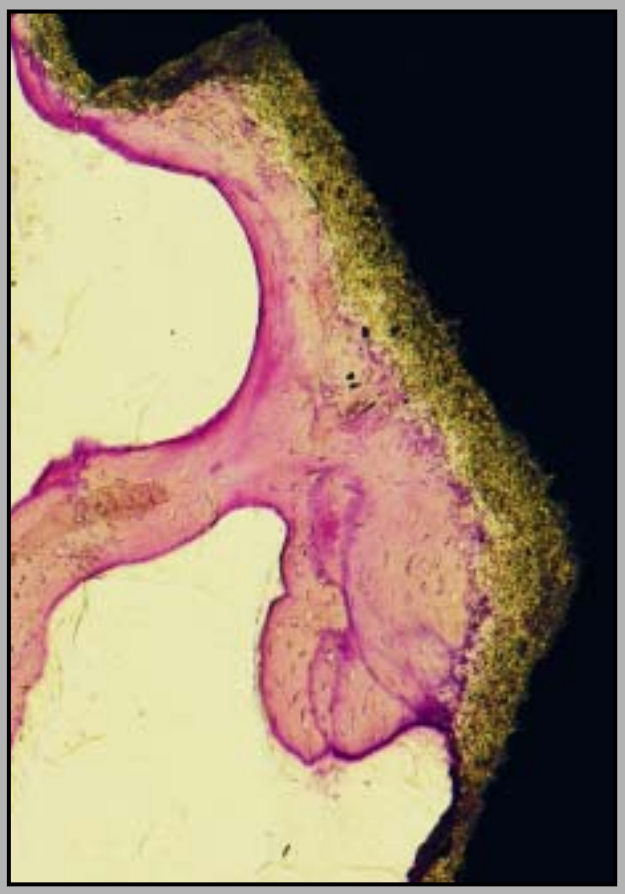
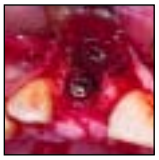




A 6-Year Unloaded Hydroxyapatite-Coated Dental Implant Placed into an Extraction Socket in Conjunction with Nonresorbable Hydroxyapatite Grafting Material: Histologic Evaluation



*Girolamo Stellino, MD, DDS**
*Luca Landi, DDS***

A submerged hydroxyapatite (HA)-coated implant placed into a fresh extraction socket in conjunction with a nonresorbable HA graft was harvested after 6 years of unloaded healing. The implant and surrounding bone were processed for histologic analysis. The HA coating appeared to be stable and homogenous. An excellent bone-to-implant contact could be found along the entire implant length. No signs of HA resorption or detachment were found. The HA graft was still recognizable histologically around the apical third of the implant. Light microscopy revealed a good osteoconductive ability of the HA particles, which did not show any signs of remodeling or resorption. These findings suggest that HA-coated implants may be able to maintain optimal osseointegration over time, even in the absence of loading. (Int J Periodontics Restorative Dent 2002;22:575–581.)

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Osseointegration of titanium implants starts a few weeks after surgical placement in the alveolar bone and is completed in 4 to 6 months.[1] Rigid fixation of the implants is a prerequisite to achieve structural and functional contact between titanium and bone.[2] This phenomenon is influenced by several parameters, such as alveolar bone quality, surgical trauma, systemic and local factors, biomechanical loading conditions, and implant surface characteristics.[3] It has been shown that after osseointegration is established, optimal loading may significantly quantitatively and qualitatively improve the bone-to-implant contact by dissipating occlusal stresses in the anchoring bone.[1] Conversely, absence of mechanical stimulation may induce bone atrophy, with reduction of osseointegration.[4,5]

Hydroxyapatite (HA) coating has been shown to increase bone-to-implant contact only during the early stages of healing, without any further advantage in the long-term osseointegration rate compared to commercially pure titanium.[6] An HA-enhanced surface is able to improve

shear and tensile strength at the bone-implant interface.[7] However, several disadvantages should be considered when HA-coated implants are contemplated in oral rehabilitation. Coating dissolution and detachment from the titanium surface have been described histologically in humans[8] and animals.[9,10] Exposure of the HA porous surface to the oral cavity, because of marginal bone loss, may increase plaque accumulation and hence initiate periimplantitis.[11] HA-coated implants have also been placed into fresh extraction sockets with success rates comparable to those placed in edentulous ridges.[12] When the gap between the implant body and the socket is too wide, the use of a regenerative material, with or without a cell-occlusive barrier, is advocated.[12,13]

This report presents the histologic analysis of an HA-coated implant placed immediately after tooth extraction in conjunction with HA grafting material and left submerged and unloaded for about 6 years.

Case report

A 35-year-old man presented with a submerged implant that had been placed about 6 years before to replace the maxillary left central incisor. Clinically, no signs of infection were present, and radiographically, no radiolucency could be detected around the implant (Fig 1). The authors were able to obtain information regarding the implant history by contacting the clinician who had performed the implant surgery. The HA-coated implant (Sustain, Lifecore) had been placed immediately after extraction of the central incisor. The residual space was grafted with nonresorbable HA (Interpore 450, Interpore) so that the implant was completely submerged. No membrane was used, and primary closure was achieved. The patient provided a computed tomographic (CT) scan in which implant position and the grafting material were clearly identifiable (Fig 2). The implant was judged to be nonrestorable because of the extremely apical position. The treatment plan included implant removal and residual socket preservation to place, after healing, a new and prosthetically driven implant.

Implant harvesting

Under local anesthesia, an access flap was designed. The implant appeared to be completely submerged in a bone-like tissue containing diffuse HA particles. Once the coronal bone was removed, the implant was found to be clinically immobile. At this point, using a 4-mm-diameter trephine bur, the implant and surrounding bone were harvested (Figs 3 and 4). The biopsy (Fig 5) was immediately immersed in a 10% formaldehyde buffered fixation solution. The residual defect was grafted with demineralized freeze-dried bone allograft (LifeNet) and covered with a resorbable barrier membrane (Guidor). Primary closure was achieved with tension-free sutures.

Histology

The biopsy was processed according to the technique of Donath and Breuner[14] for undecalcified specimens. Briefly, after fixation for about 10 days, the specimen was dehydrated in an ascending series of alcohol rinses, washed, and then embedded in Technovit 7200 VLC resin (Heraeus Kulzer) and polymerized. The specimen was then sectioned to about 250 μm and ground to a final thickness of about 60 μm (Exakt). The two sections obtained were mounted on a glass slide and stained with hematoxylin-eosin for light microscopic evaluation (Zeiss).

The HA-coated implant appeared to be well-integrated with surrounding alveolar bone (Fig 6). Because of the trephine bur's action, only one side of the implant could be used for osseointegration evaluation. No signs of fibrous or granulation tissue could be detected between the implant surface and bone. The HA coating

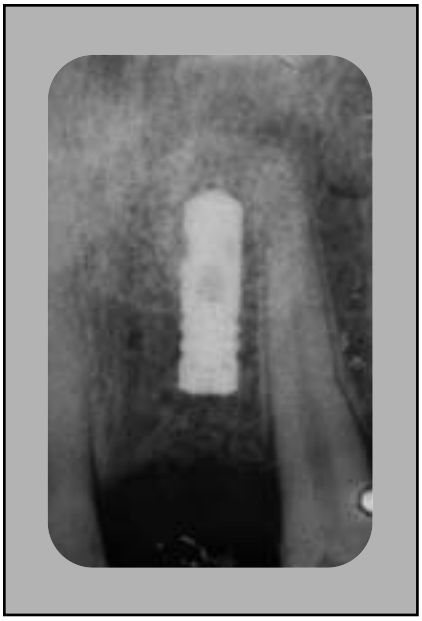

Fig 1 (left) *Periapical radiograph taken during the initial evaluation. Implant in position of maxillary left central incisor shows no sign of periimplant radiolucency. Note the unfavorable position of the implant with respect to the cementoenamel junction of the adjacent teeth.*

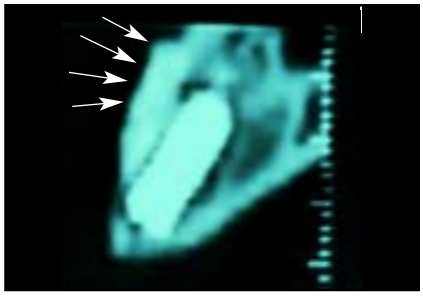

Fig 2 (right) *CT scan of the area of the maxillary incisor. The HA graft appears as a dense and radiopaque area outside the envelope of basal bone* (arrows). *The coronal aspect of the implant is completely covered by bone.*

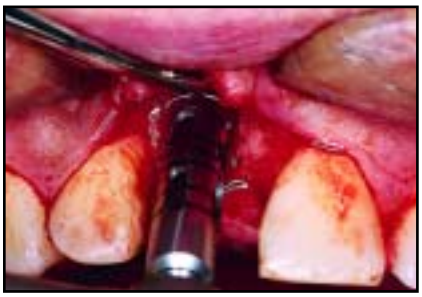

Fig 3 (left) *Full-thickness flap is elevated, and 4-mm trephine bur is used to remove the osseointegrated implant together with the surrounding bone.*

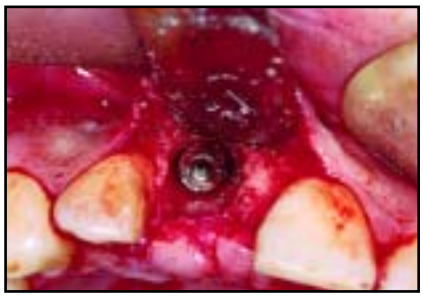

Fig 4 (right) *Implant in situ after trephine bur action and just before removal. Care was taken not to damage the adjacent teeth or perforate the buccal cortical plate.*

Fig 5 (left) *Ten-mm-long implant just after harvesting. Note the retained alveolar bone covering the implant body.*

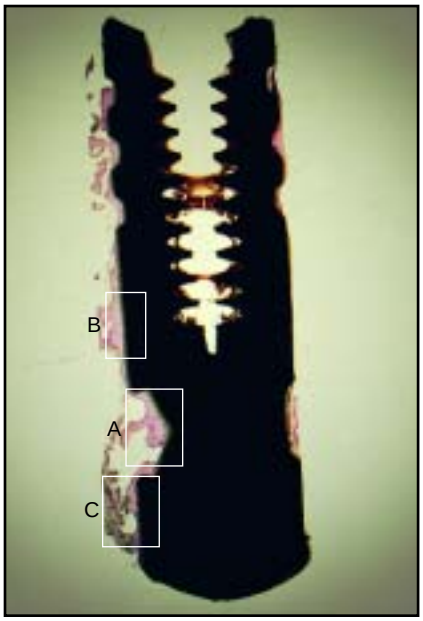

Fig 6 (right) *Photomicrograph shows the implant body and the surrounding bone at low magnification. Bone was harvested predominantly on one side of the implant (hematoxylin-eosin stain; original magnification × 40).*

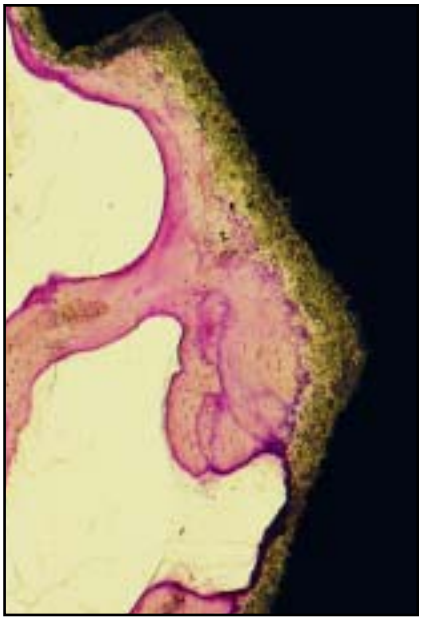

Fig 7 *Area* A *from Fig 6. The HA coating appears to be rather homogenous. Alveolar bone is in intimate contact with the surface coating, with no signs of fibrous tissue interposition (hematoxylin-eosin stain; original magnification × 100).*

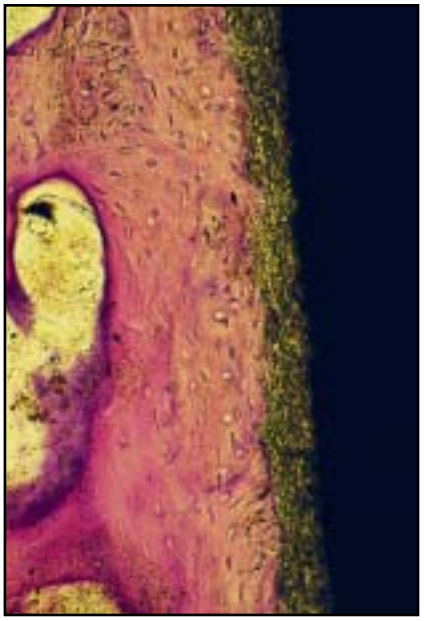

Fig 8 *Area* B *from Fig 6. Alveolar bone appears lamellar in nature, with a number of osteocytes populating the lacunae. The coating layer seems to be coalesced with surrounding bone. No macrophage or giant cell activity is detectable (hematoxylin-eosin stain; original magnification × 100).*

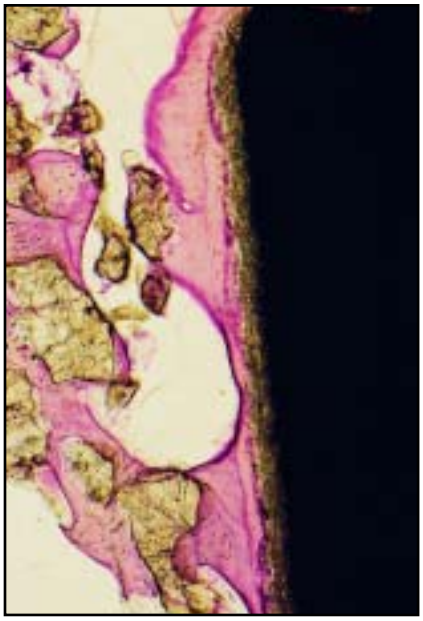

Fig 9 *Apical third of the implant body, as indicated by area* C *in Fig 6. HA particles are clearly identifiable. Note the intimate contact between alveolar bone and graft particles. No signs of inflammatory infiltrate or fibrous encapsulation are evident. The sharp geometry of the particles may suggest that no remodeling of the graft is taking place (hematoxylin-eosin stain; original magnification × 100).*

appeared to be rather homogenous in thickness along the entire implant perimeter. At higher magnification, the HA coating was in intimate contact with alveolar bone (Fig 7). No signs of coating detachment or HA particle dissolution could be noticed. No macrophages or giant cells were detectable at the periphery of the implant coating (Fig 8). The alveolar bone was lamellar in nature, with lacunae populated by osteocytes and marrow spaces. Apical to the implant body, residual fragments of HA grafting material were clearly identifiable (Fig 9). The particles were closely related to the implant and embedded in a bone matrix, without any fibrous tissue encapsulation. No inflammatory infiltrate could be seen, and the sharp geometry of the particles suggested that no remodeling of the fragments had taken place.

Discussion

HA-coated implants are safely and successfully used in a number of clinical applications.[15] A porous surface may be able to reduce healing time, allowing faster bone deposition at the implant surface.[16] Furthermore, it may determine a better initial implant stability, increase the amount of osseointegration,[9] and enhance load-stress distribution to the surrounding bone.[10]

In our retrieved implant, the HA coating appeared to be rather stable, without any sign of disintegration or dissolution along the entire implant length. The thickness of the coating seemed to be homogenous, in accordance with previous findings.[17] Unlike those findings, we were not able to document any evidence of giant cell activity or HA fragments dispersed in the periimplant tissue. Several factors may have produced such a stable profile for this HA coating.

First, the quality of the coating may have been of high crystallinity. This may significantly reduce HA surface dissolution and eliminate the presence of molten particles of amorphous compounds in the surrounding tissues.[9,10,18,19] Second, the periimplant bone appeared to be cortical in nature. This might have reduced or eliminated the resorption of HA, as shown in pigs.[20] Third, the absence of loading for about 6 years might have been responsible for maintaining the coating's macrostructure integrity. However, the influence of section thickness on the histologic interpretation of the specimen must be acknowledged. We analyzed two consecutive sections of about 60 μm, and, although not ideal for histomorphometric evaluation, they may still allow identification of giant cells because of their large average size (30 to 50 μm).[21]

It has been shown that the absence of mechanical stimuli may induce bone atrophy in the skeleton as well as at the implant-bone interface.[1,4,5] High coating crystallinity, in fact, while reducing chemical dissolution of amorphous compounds, may weaken the strength resistance of the HA surface to biomechanical bending forces, causing delamination and detachment of the coating layer.[22] Because of the absence of loading, atrophy of the periimplant bone[1,4,5] might have been expected. On the contrary, there was a perfect and intimate relationship between the implant surface and alveolar bone. This may suggest that a porous coating, such as HA, even in the absence of any mechanical stimuli, is able to maintain optimal osseointegration over time. This is in agreement with findings in a canine model for other types of roughened implant surfaces.[23] That study did not find any difference in terms of bone-to-implant contact between loaded and unloaded implants up to 15 months. This may be partially explained by the biologic activity induced by an HA-enhanced surface, which by itself may promote bone formation.

Our findings may be of interest when a sleeping implant has to be retrieved and used to rescue a failing implant-supported rehabilitation. In those instances, the ability of such an implant to withstand mechanical loading may be questionable. Our report documents how a sleeping, nonloaded implant can maintain its osseointegration and still be considered for prosthetic restoration, even after a long period.

HA-regenerated bone, present at the apical third of the implant body, appeared to be similar to native bone with normal structural

features. This confirms the findings of an earlier animal study.[24] In that dog model, implants placed into extraction sockets and grafted with HA and barrier membranes healed and osseointegrated with surrounding bone with a higher bone-to-implant contact compared to those placed with a barrier membrane alone. However, the nonresorbable nature of the graft and the persistence of such a high concentration of HA particles after 6 years should be carefully evaluated. It is not known if such a composite bony structure will be able to respond physiologically to loading conditions. HA particles may not be able to undergo any resorption or remodeling according to the functional needs of the load-bearing bone and may affect long-term implant success. Further investigations may be warranted to shed more light on the ability of HA-regenerated bone to sustain functional osseointegration with loaded endosseous implants over time.

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