

Histologic evaluation of a hydroxyapatite onlay bone graft retrieved after 9 years: A clinical report

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Because of the limited observations of published studies, the condition of hydroxyapatite after a long period of intraoral function remains a concern. This clinical report describes the histologic evaluation of a 9 year-old hydroxyapatite specimen retrieved from a human subject. The residual hydroxyapatite particles showed no sign of resorption, and tight contact with the surrounding bone was observed. (J Prosthet Dent 2002;87:481-4.)

A variety of methods and materials have been used for alveolar ridge augmentation. The use of hydroxyapatite (HA) as an onlay bone graft material has been studied in both humans¹⁻⁴ and animals⁵⁻²⁰ with the use of light microscopy. A majority of the animal studies found bone formation within the graft material^{5-8,10-13,16-20}; others reported the formation of connective tissue.^{6,9,14} The same is true of histologic specimens retrieved from humans (Table I). The majority of investigations on this subject reported evidence of bone formation,²¹⁻³⁴ whereas others reported the formation of connective tissue surrounding the HA particles.^{22,35,36} What determines the type of tissue that will develop is unknown. Several studies have shown that immobility of the HA particles during the initial healing period is a crucial factor.^{6,37} It has been suggested that mobile particles induce connective tissue formation and immobile particles foster bone growth.

Different theories on the mechanism by which bone develops within the graft material have been proposed. One theory is that early vascularization is followed by the formation of connective tissue^{6,7,9,33} in the space around the HA particles while bone is gradually inserted in the area.^{6,7,9,33,38} The term *non-induced creeping substitution* has been proposed^{38,39} to describe the phenomenon of an osteoconductive material promoting the gradual formation of bone. The exact mechanism of bone formation in these situations remains unknown. Several studies have demonstrated

that bone starts to grow from the recipient bone site^{6,9,22,24-28} and eventually occupies a large proportion of the graft material, leaving the remote part of the HA particles surrounded by soft tissue.^{22,24,26}

Several authors have suggested that HA is prone to intraoral degradation or dissolution,^{8,20,24,30-42} but others have failed to show any sign of resorption.^{11,12,19,22,23,28-35} Because of the limited observations of published studies, the condition of HA after a long period of intraoral function remains a concern. This clinical report describes the histologic evaluation of a 9 year-old HA specimen retrieved from a human subject.

CLINICAL REPORT

A 52 year-old female presented at the Center for Prosthodontics and Implant Dentistry in September 1999 for the fabrication of a maxillary complete denture. Clinical examination revealed that a bone graft performed 9 years previously in the area of the maxillary right first molar and premolar would likely compromise the success of the planned denture. The bone graft had been performed in a private practice, and hydroxyapatite (Interpore 200; Interpore International, Irvine, Calif.) had been used as the graft material.

The patient had expressed dissatisfaction with previously fabricated maxillary complete dentures because of pain during function in the area around the graft. After various treatment options were presented and discussed, it was decided that the graft material should be removed before the new maxillary complete denture was fabricated. Excision of the material was performed under local anesthesia. Full-thickness buccal and palatal flaps were reflected (Fig. 1). The bone graft was removed and immediately placed in 10% formalin solution.

The specimen was fixed in 10% buffered formalin, dehydrated in alcohol, and embedded in special resin (Technovit 7200 VLC; Kulzer, Wehrheim, Germany).

This study was supported by Nobel Biocare.

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Table I. Human histology reports on hydroxyapatite used as an onlay bone graft

Reference	Form of HA graft (n)	Histologic findings	Location	Time in place
Beirne et al ³⁵	Particulate (4)	Connective tissue around HA particles. Mild inflammatory response/multinuclear cells present in proximity to graft.	Mandible	3-6 months
Piecuch ²¹	Particulate (1)	Bone in combination with connective tissue around graft material.	Mandible	6 months
Beirne et al ³⁶	Particulate (5)	Connective tissue around graft with no bone formation.	Mandible	3-13 months
Tio et al ²²	Block (1)	No evidence of ossification; infection had preceded. No foreign body reaction.	Mandible	1 week
Tio et al ²²	Particulate (1)	16% of grafted area was filled with bone. Ossification more intense at bone/graft interface. No foreign body reaction.	Mandible	6 months
Wolford et al ²³	Block (15)	Bone ingrowth. Bone at 18% (range: 6.7-31%) of grafted area. No inflammation or foreign body reaction.	Orthognathic sites	4.7-16.4 months
Donath et al ²⁴	Particulate (1)	Bone formation close to recipient site; connective tissue close to mucosal surface. Particles had border of dissolution.	Mandible	1 year
Page and Laskin ²⁵	Particulate (1)	New bone formation in proximity to recipient bony surface; soft tissue close to vestibular site. No inflammatory reaction.	Mandible	10 months
Chao and Poon ²⁶	Particulate (2)	Bone formation in proximity to recipient bony surface; soft tissue close to mucosa. No sign of inflammation.	Mandible	6 and 12 months
el Deeb et al ²⁷	Particulate (2)	Bone formation around particles; soft tissue close to mucosal surface.	Not reported	7-16 weeks
el Deeb et al ²⁷	Block (1)	Bone formation up to half of graft; soft tissue present close to mucosal surface. Infection had preceded.	Not reported	14 months
Holmes et al ²⁸	Particulate (17)	Bone ingrowth within graft material; soft tissue close to external surface. Bone present at 18% within grafted area.	Orthognathic sites	7-16.4 months
Hupp and McKenna ²⁹	Block (15)	Bone ingrowth within graft; up to 40% of grafted area filled with bone. No sign of graft resorption.	Mandible	1-28 months
Salyer and Hall ³⁰	Block (7)	20-30% of grafted areas filled with bone. No sign of HA resorption.	Orthognathic sites	3-10 months
Davis et al ³¹	Particulate (1)	HA was mixed with autogenous bone when implanted. No sign of graft material resorption, new bone grew within grafted area.	Mandible	7 months
Hjoering-Hansen et al ³²	Block (18)	Bone formation that gradually penetrated graft material. Tight contact between HA and newly formed bone.	Mandible or maxilla	3-36 months
Nunes et al ³³	Particulate (9)	60% of grafted area was filled with bone. No sign of HA resorption.	Mandible or maxilla	14-30 months
Ayers et al ³⁴	Block (17)	New bone formation. Early specimens had minimal bone formation that became gradually more enhanced in older specimens.	Orthognathic sites	4 months to 11 years
Current report	Particulate (1)	Bone formation in tight contact with HA in notable number of areas. Histomorphometry: 18% bone, 54% soft tissue, 28% HA.	Maxilla	9 years

Initial midaxial sections of 200 μm were made with a cutting-grinding system (Exact Technologies; Oklahoma City, Okla.). The sections were ground to 40 to 50 μm and used unstained for histomorphometric analysis and light fluorescent microscopy.^{40,41} The histomorphometric analysis was performed on a Macintosh computer with use of the public domain

NIH Image program (developed at the US National Institutes of Health).

No clinical signs of pathosis were identified in the area around the graft, and no pain or discomfort was elicited upon palpitation. After flap reflection, the graft material appeared solid and well adapted to the recipient bony surface.



Fig. 1. Upon flap reflection, graft material appeared to have solid consistency. *Long arrow* identifies graft material after flap reflection; *short arrow* identifies vestibular area.

The grafted area appeared to have a mixture of bone, soft tissue, and residual graft particles. Cancellous bone with HA interlocked in a network of trabeculae was present in the specimen (Fig. 2); the bone appeared to have grown around the HA particles (Figs. 2 and 3). Along the surface of the residual particles, tight contact between the HA and bone was observed (Fig. 3). No signs of HA resorption—the presence of osteoclasts, multinuclear cells, or inflammation around the residual graft particles—were seen. Histomorphometric evaluation revealed that bone represented 18%, connective tissue 54%, and residual graft particles 28% of the grafted area.

DISCUSSION

It has been suggested that degradation and/or resorption of the graft material occurs after HA is implanted.^{8,20,24,42-44} Histologic evaluation of the current specimen 9 years after implantation revealed HA graft particles with no sign of active resorption. Tight contact between HA particles and the surrounding bone, observed in this study and reported by other authors,^{6,10,11,13,16,18,19,28,32-34} highlights the biocompatibility of HA as a graft material.

Soft tissue irritation and partial exposure of HA particles have been reported,^{4,7,27,29} along with histologic signs of inflammation at the graft area close to the mucosal surface.^{27,29} For the patient described above, discomfort was associated with complete denture function. Despite the histologic evidence of bone formation, the use of hydroxyapatite as a graft material in preprosthetic surgery on completely edentulous patients should be evaluated cautiously because of these clinical limitations. Nevertheless, if dental implants are included in the treatment plan, they should provide enough support for the prosthesis; or if a fixed partial denture is planned and bone grafting is performed in the area of the pontics, mucosal irrita-

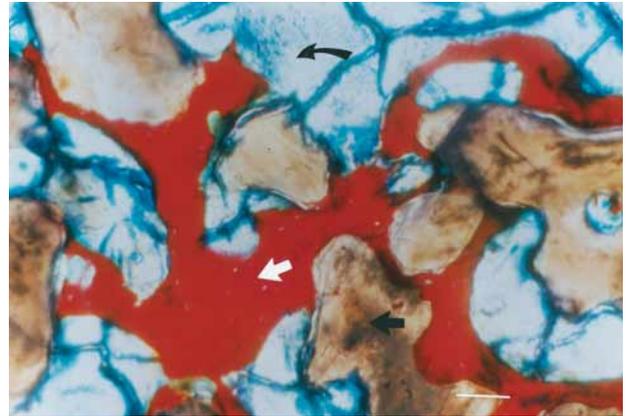


Fig. 2. Graft particles appeared to be interconnected with bone. *Straight black arrow* identifies residual graft material, *white arrow* identifies bone, and *curved black arrow* identifies connective tissue (*white line* represents 160 μm ; original magnification $\times 10$).



Fig. 3. Tight contact between HA particles and bone. *Straight black arrow* identifies residual graft material, *white arrow* identifies bone, and *curved black arrow* identifies connective tissue (*white line* represents 80 μm ; original magnification $\times 20$).

tion may not be a significant risk when HA is used as an onlay graft material.

SUMMARY

For the patient described in this report, alveolar ridge augmentation performed with hydroxyapatite appeared to provide a mixture of bone and soft tissue. Nine years after graft placement, the residual HA particles showed no sign of resorption, and tight contact with the surrounding bone was observed.

We thank Nobel Biocare for providing funding assistance for the histologic analysis of the specimen; Hari Prasad BS, MDT, for his technical assistance during the histologic processing; and Dr Dimitris Tatakis for his cooperation during the microscopic observations and his overall guidance and contribution.

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0022-3913/2002/\$35.00 + 0. 10/1/122961

doi:10.1067/mpr.2002.122961