Simple Preservation of a Maxillary Extraction Socket Using Beta-tricalcium Phosphate with Type I Collagen: Preliminary Clinical and Histomorphometric Observations

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ABSTRACT

Alveolar atrophy following tooth extraction remains a challenge for future dental implant placement. Immediate implant placement and postextraction alveolar preservation are 2 methods that are used to prevent significant postextraction bone loss. In this article, we report the management of a maxillary tooth extraction socket using an alveolar preservation technique involving placement of a cone of beta-tricalcium phosphate (ß-TCP) combined with type I collagen without the use of barrier membranes or flap surgery. Clinical examination revealed solid new bone formation 9 months after the procedure. At the time of implant placement, histomorphometric analysis of the biopsied bone showed that it contained 62.6% mineralized bone, 21.1% bone marrow and 16.3% residual ß-TCP graft. The healed bone was able to support subsequent dental implant placement and loading.

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After tooth extraction, the residual alveolar ridge generally provides limited bone volume because of ongoing, progressive bone resorption.[1] Healing events within postextraction sockets reduce the dimensions of the socket over time.[2] A reduction of about 50% in both horizontal and vertical directions has been observed over 12 months, with two-thirds of the reduction occurring in the first 3 months.[3] The rate and pattern of bone resorption may be altered if pathologic and traumatic processes have damaged 1 or more of the bony walls of the socket. In these circumstances, fibrous tissue will likely occupy part of the socket, preventing normal healing and osseous regeneration.[3] These morphologic changes may affect the successful placement and osseointegration of dental implants.

When considering ways to preserve adequate bone volume, clinicians frequently ask whether filling bone defects, such as alveolar postextraction sockets, with resorbable osteoconductive materials is warranted.[4–6] Although autogenous bone is still considered

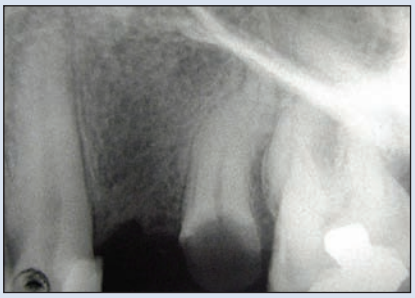

Figure 1a: Periapical radiograph of deteriorated left maxillary second premolar before extraction.

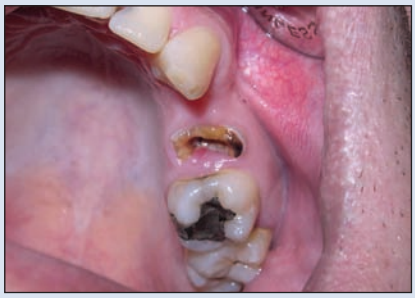

Figure 1b: Remnant of the maxillary second premolar structure with extensive coronal destruction.

Figure 1c: Determination of the crestal alveolar bone level before socket preservation.

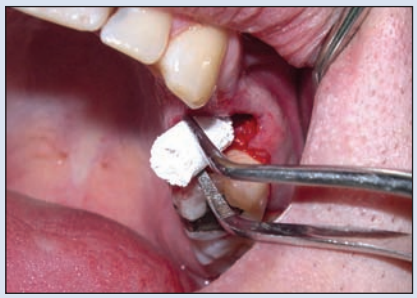

Figure 1d: Placement of ß-TCP combined with type I collagen (RTR Cone) at the extraction site.

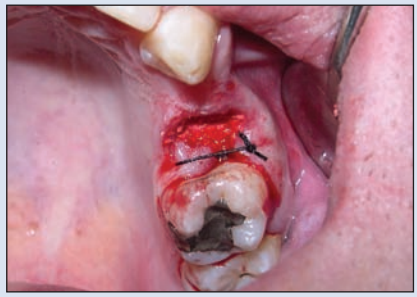

Figure 1e: ß-TCP combined with type I collagen implant secured with a single suture without a barrier membrane or mucoperiosteal flap.

the gold standard for grafting procedures, limitations, such as donor site morbidity from bone graft harvesting techniques,[7] have stimulated the search for suitable synthetic grafting materials. Although barrier membranes may be used to guide bone regeneration, wound dehiscence may lead to early exposure and infection of the membrane followed by reduction in the volume and quality of bone.[8,9]

Beta-tricalcium phosphate (β-TCP), a synthetic alloplastic material, has been used for bone regeneration in a variety of surgical procedures with satisfactory clinical and histologic results in both animal models[10,11] and human trials.[12,13] β-TCP may be a suitable bone substitute that will biodegrade and be replaced by newly mineralizing bone tissue without fibrous tissue proliferation.[12] Bony regeneration has been reported in cases where β-TCP was used without a barrier membrane in patients undergoing sinus floor elevation and mandibular cyst removal.[12] It is also possible to combine β-TCP with platelet-rich plasma, other growth factors or collagen to potentially accelerate the process of bone regeneration.[14,15]

There have been no reports on the use of β-TCP combined with type I collagen for postextraction socket preservation without the use of a barrier membrane or mucoperiosteal flap to cover the implanted material. The purpose of this article is to present clinical, radiographic, histologic and histomorphometric results for a patient treated with β-TCP in combination with type I collagen for alveolar preservation before dental implant placement.

Case Report

A 28-year-old healthy male non-smoker with good oral hygiene required the extraction of a left maxillary second premolar (tooth 25) before placement of a dental implant for prosthodontic rehabilitation (**Fig. 1a**). The tooth had to be extracted as it was severely broken down (**Fig. 1b**). The alveolar preservation protocol was approved by the institution's ethical review board and written informed consent was obtained from the patient after the risks and benefits were explained to him.

After administration of local anesthesia, an intrasulcular incision was made to raise a distal papilla and marginal gingiva. This exposed the marginal bone to allow visualization and measurement of the alveolar bone level (**Fig. 1c**). Extraction of the tooth was performed using a straight elevator and forceps without the elevation of flaps. After extraction of the tooth, the socket was thoroughly curetted. β-TCP with type I collagen (RTR Cone, Septodont, Saint-Maur-des-Fossés, France) was placed in the alveolar socket occupying the space from

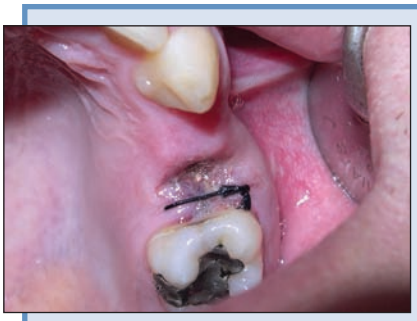

Figure 2a: At 5 days following placement of ß-TCP combined with type I collagen in the alveolar socket, the socket opening is covered with fibrin.

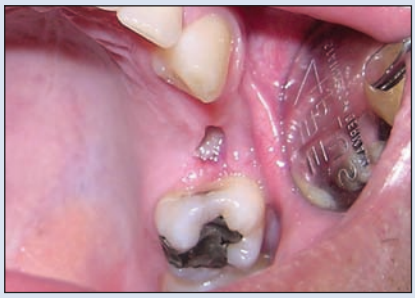

Figure 2b: At 7 days, the extraction socket is covered with healing gingival tissue.

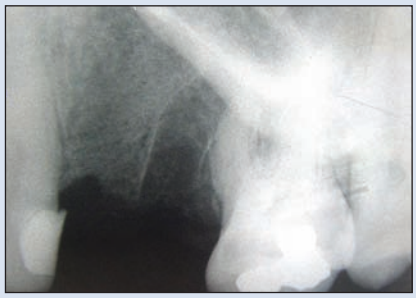

Figure 2c: Periapical radiograph taken 7 days after insertion of ß-TCP combined with type I collagen.

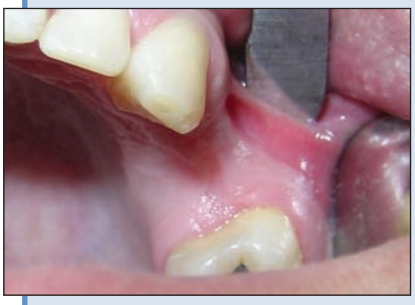

Figure 2d: The postextraction healed gingival wound 4 months after alveolar socket preservation.

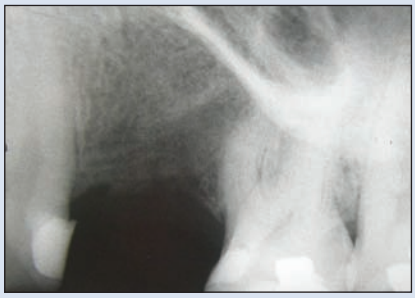

Figure 2e: Periapical radiograph taken 9 months following socket preservation showing complete bone fill of the socket.

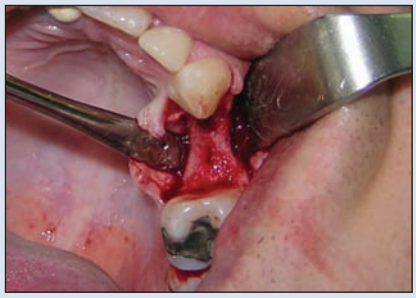

Figure 2f: Exposure of the alveolar bone for dental implant placement 9 months after alveolar socket preservation. Newly formed bone is solid and there are no visible signs of particles.

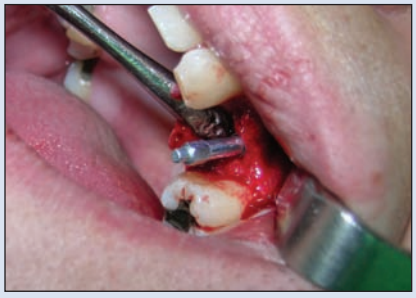

Figure 2g: Test of implant position in the preservation area. No reduction in vertical bone height was recorded when the 9-month measurements were made and subsequently compared with baseline measurements at tooth extraction.

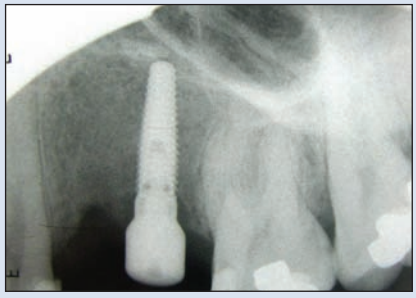

Figure 2h: Titanium implant immediately after placement, positioned within the bone of the healed socket 9 months postextraction.

the crest of the alveolus to the apex of the socket (**Fig. 1d**). The socket was filled with the alloplastic material, but not covered with any barrier membrane or mucoperiosteal flap. The distobuccal and palatal papillae and attached gingiva at the extraction site were stabilized with a single interrupted suture to reduce the opening of the socket and the amount of exposed material (**Fig. 1e**). The patient was prescribed a course of antibiotic and pain medications with postoperative instructions for 7 days, at which point the suture was removed.

The patient was examined at 3, 5 and 7 days, then at 4 and 9 months postoperatively; radiographs were taken at 1 week, 4 months and 9 months following placement of the alloplastic material (**Figs. 2a–2e**). After 9 months, a trephine, 2 mm in diameter and 6 mm in length, was used to collect a bone sample from the treated extraction socket during dental implant placement (**Figs. 2f** to **2h**).

The bone biopsy specimen was prepared for nondecalcified histologic and histomorphometric analysis. It was cut and polished to a thickness of 45 µm using a

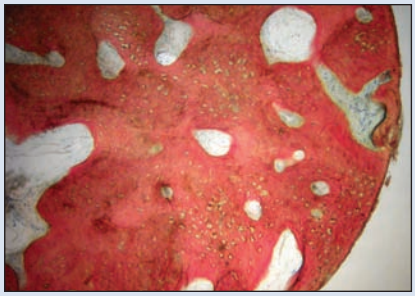

Figure 3a: Photomicrograph of a biopsy core taken 9 months after placement of ß-TCP combined with type I collagen (RTR Cone) without a barrier membrane. Good trabecular connectivity with large, irregular lacunae of the young mineralized bone and bone marrow can be seen. ×40 magnification. Stevenel's blue and Van Gieson's picro fuchsin staining.

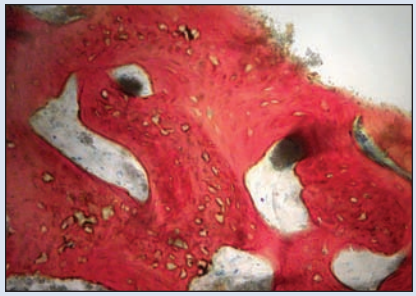

Figure 3b: High-power image of a biopsy core taken 9 months after socket preservation. Residual ß-TCP and various sizes of dispersed particles are being incorporated into new bone. Large irregular lacunae appear to include ß-TCP. ×200 magnification. Stevenel's blue and Van Gieson's picro fuchsin stain.

cutting–grinding system (Exakt Technologies, Oklahoma City, Okla.) and stained with Stevenel's blue and Van Gieson's picro fuchsin. The parameters evaluated included the total area of the core, the percentage of new bone formation, the percentage of residual graft and the percentage of fibrous tissue. All parameters were evaluated by analyzing digital images in the NIH Image Program (National Institutes of Health, Bethesda, Md).

Clinically, healing was uneventful. By the seventh day, the socket was completely covered with gingiva. During the 9 months of observation, no loss of material, no signs of infection, exudation or fistula formation at the area of the extraction and ridge preservation wound were noted. Measurement of the alveolar ridge on the day of implant placement revealed slight horizontal bone resorption, but no change in the vertical dimension of the alveolar ridge. The buccopalatal dimension of the alveolar socket was 12 mm before RTR Cone placement and 10 mm after 9 months. The alveolar crestal bone level was 3 mm below the cementoenamel junction of the mesial aspect of the left first molar before RTR Cone placement and 9 months following the placement. Clinically, no particles of material were visible and the bone was found to be smooth and solid when prepared for implant insertion (**Fig. 2f**).

Radiographically, by the fourth month of follow-up, the alveolar socket appeared to be filled with radiodense bone tissue except for the most cervical portion of the alveolus. By 9 months postextraction, the cervical radiolucency had disappeared and uniform radiodense bone was found throughout the healing extraction socket (**Fig. 2e**).

Histologically, a great deal of active new bone formation was noted (**Fig. 3a**). This was apparent throughout the biopsy core (**Fig. 3b**) as large, irregular lacunae with active osteoblastic rimming. In some areas, new bone deposition was associated with residual β-TCP particles. It appeared that resorbing β-TCP was present as dispersed particles. No residual collagen was noted in proximity to the β-TCP, and no fibrous tissue or inflammatory cellular infiltration was observed. Histomorphometric analysis showed the composition of the sample to be 62.6% mineralized new bone, 21.1% bone marrow and 16.3% residual β-TCP graft.

Implant placement and postoperative healing were uneventful. At follow-up 18 months after prosthodontic treatment and loading, the implant was stable and surrounded with healthy tissue. There were no complaints or complications during this period of observation.

Discussion

There are several reasons to consider preservation of the alveolar socket immediately following tooth extraction. One reason for placing a graft of a synthetic biomaterial is to stabilize the coagulum within the socket and avoid possible reduction of the hard tissue volume required for bone regeneration. Although vertical bone resorption can be expected as part of the physiologic pattern of bone healing after tooth extraction,[3] in our patient no reduction in the vertical dimension of the alveolar ridge had occurred 9 months after tooth extraction. The ridge width (12 mm) did not change either.

Another reason for placing a graft into an extraction socket is to provide a scaffold for the in-growth of cellular and vascular components to form new bone of acceptable quality and quantity. In our patient, the total

volume of newly formed bone was 83.67% including both mineralized bone and bone marrow when β-TCP with type I collagen was used without a barrier membrane or mucoperiosteal flap.

The results in this case show that β-TCP particles in the extraction socket are osteoconductive. When particles of β-TCP are mixed with the blood clot and surrounded by the bony walls of the alveolar socket, osteogenic cells, including undifferentiated mesenchymal stem cells, start migrating from the existing bone surface between and over the surface of the particles, stimulated mostly by an adhesive glycoprotein, fibronectine, a component of the forming blood clot.[12,13] In addition, type I collagen combined with β-TCP promotes osteogenesis by supporting osteoblastic differentiation and proliferation.[16,17] Type I collagen has been shown to accelerate the healing process in bone defects in animals.[16] Complete bone healing was noted in animals after 3 months, whereas defects in the control group took 5 months to fill with new bone. The combination of β-TCP and type I collagen in an integrated structure, such as an RTR Cone as used in our study, has demonstrated osteoconductivity, which facilitates bone formation.[15]

Significant resorption of the β-TCP particles is expected 3–6 months after placement.[10] At 9 months after alveolar socket preservation, the small residual amount of β-TCP graft did not compromise placement of the osseointegrated dental implant. Moreover, β-TCP particles become well incorporated into new bone formation creating a dense cancellous network. This may improve the biologic ability to withstand loading forces transmitted by implants placed in that site. Biodegradation of β-TCP occurs by both osteoclastic activity and chemical dissolution by tissue fluids.[18] β-TCP is a highly porous material and dissolved β-TCP particles can be incorporated into the newly mineralized bone and the lacunar–canalicular system of osteocytes[19] as well as into the bone marrow or marginal osteoid.

An important factor in this case is that neither a barrier membrane nor a mucoperiosteal flap was used to cover the alveolar postextraction socket filled with synthetic material. Instead, the β-TCP in combination with type I collagen was left uncovered to heal spontaneously. At 7 days, the process of epithelialization was complete and the socket was covered without clinical complications. Several possible mechanisms may explain the apparent blockade of fibrous tissue ingrowth into the porous structure of the β-TCP granules: inhibition of fibroblastic proliferation by β-TCP and its metabolites during dissolution of β-TCP particles[20]; a local decrease in pH during dissolution of material[13]; or direct chemical bonding of β-TCP with bone through a reaction between calcium ions in the β-TCP particle and carboxyl groups in the collagen polypeptide chains.[15,19]

This case report suggests that a cone of biomaterial, composed of β-TCP combined with type I collagen, can prevent alveolar crest resorption following tooth extraction without the use of a barrier membrane or a mucoperiosteal flap. Formation of new bone of acceptable quality and quantity permitted the placement of an osseointegrated dental implant. Further study of this material and this protocol is needed and a case series is currently underway.

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