A promising new particulate graft material: a case study

The body wants to heal

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The notion of post-extraction bone preservation and early placement of dental implants is not new, having been mentioned in 2003 [1]. Early placement and the use of recently developed synthetic graft materials have yielded enhanced host regeneration [2]. After twelve years and over 2,000 successful grafts using exactly the same protocol in post-extraction bone preservation the authors [4,5] have found consistent benefits when working in harmony with the host's healing process. Others [3] have also successfully used newer alloplasts. The surgical protocol involves a three-week post-extraction soft-tissue healing period followed by delayed immediate implant placement with a simultaneous synthetic (alloplastic) biphasic particulate graft without a traditional membrane.

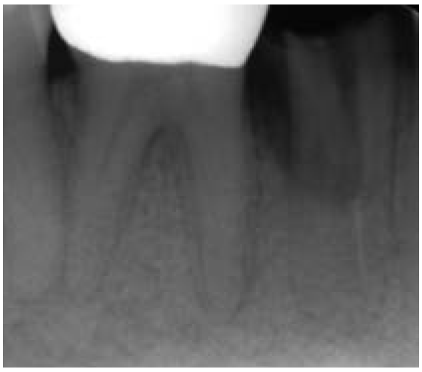
Case description

The patient was a 45-year-old smoker (five cigarettes a day), a non-diabetic, who presented with a root fracture in tooth 45 due to forces acting on a cast post-retained crown. The crown had been unsuccessfully re-cemented by the referring dentist a few times; at presentation, the distal area of the fractured root exhibited bone loss (Fig. 1) consistent with the case history.

Timing is of the essence; whenever a tooth – especially a diseased or fractured one – is removed, the ridge dimensions will be affected by modelling during the healing period, causing shrinkage by up to 50 per cent [1], with a significant percentage of this loss occurring in the first four weeks.

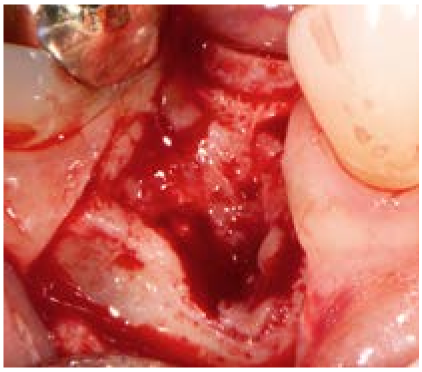
Following atraumatic root removal using periotomes and the dissection of multi-rooted teeth to reduce host bone loss, the site was allowed to heal for three weeks. This period allows for the overgrowth of the soft tissue to an adequate level prior to the onset of the modelling of the underlying hard tissue (Fig. 2).

A site-specific flap was raised that preserved the papillae near the adjacent teeth. The flap must be raised carefully, as the tissue may still be vulnerable after this brief healing period. As expected, the patient exhibited distal and buccal bone loss with extensive granulation tissue (Fig. 3), which had to be very aggressively removed using hand curettes. This type of preparation is critical whenever there is extensive granulation tissue.



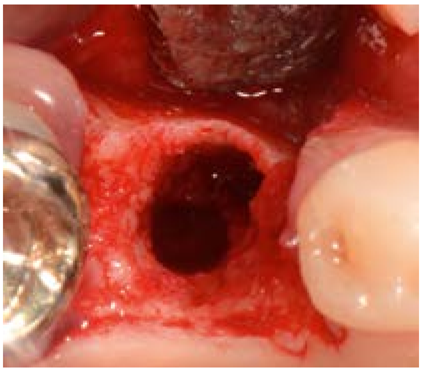
1 I Radiograph. Split root and resultant bone loss.

2 I Site 45 three weeks after extraction.



3 I Site-specific flap preserving the papillae. Bone loss due to split root.

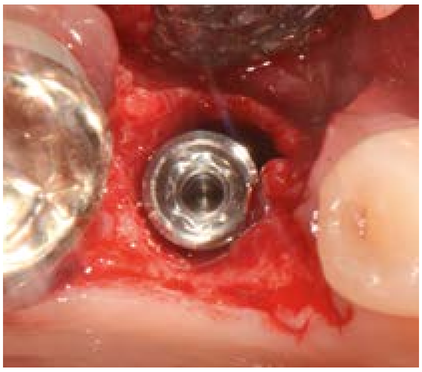
4 I Radiograph. Creating the osteotomy.



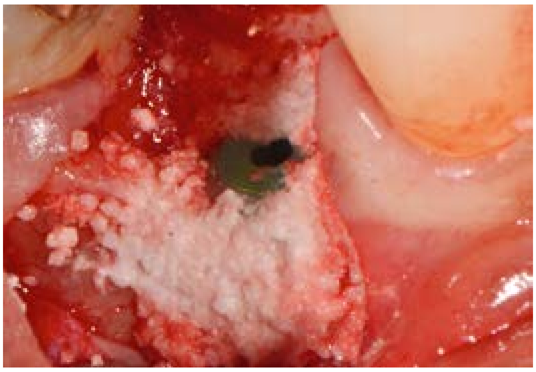
5 I The osteotomy is repositioned lingually.

6 I Dio BioTite-H SM implant.

7 I Dio BioTite-H SM implant in situ. Buccal bone shortage.



8 I Implant placed in optimized position, ready for grafting. Osstell ISQ reading of 53.

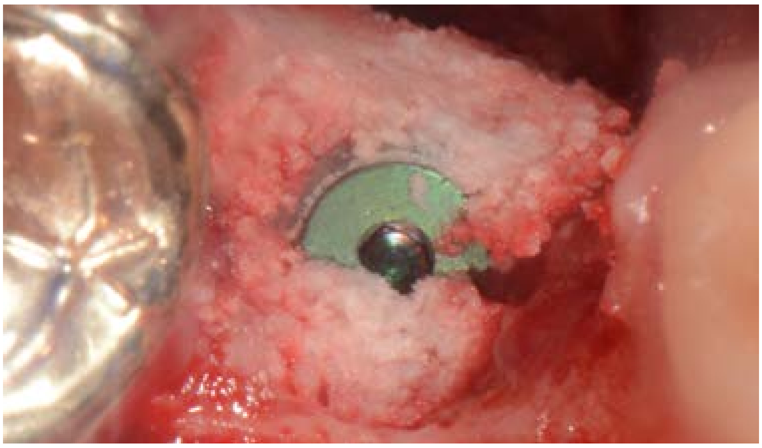


9 I Buccal graft with EthOss to regenerate bone.

The osteotomy was prepared in the clean site using an externally irrigated (saline) Dio SM implant kit (Dio Implant Corporation, Busan, Korea) (Fig. 4). This osteotomy did not follow the root but was placed slightly lingually, optimizing the final implant position for subsequent restoration (Fig. 5). A thin buccal plate was also noted when the flap was raised. If the periosteal blood supply is interrupted, as was the case here, the plate may be compromised (the blood supply to the periodontal ligament ceases at extraction). Without particulate grafts, further bone will be lost.

The implant (BioTite-H SM, 4.5 x 10 mm; Dio Implant System Co., Busan, Korea), which was coated with hydroxyapatite nanoparticles (Fig. 6), was inserted at a torque of 35 Nm using an implant driver and a hand ratchet. The implant was inserted to the level of the adjacent bone, showing the extent of the buccal defect (Fig. 7). The view from above showed the buccolingual position for restoration and the space between the buccal plate and the implant that had to be grafted (Fig. 8). The Osstell ISQ reading (Osstell, Göteborg, Sweden) was 53.

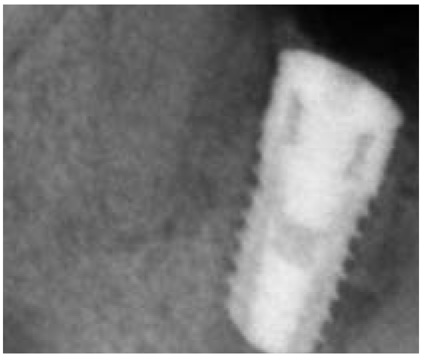
Once the bleeding had spontaneously abated, the case was grafted. The particulate grafting material was a new product, EthOss (Regenamed, London, UK), a mix of beta-tricalcium phosphate



10 I Grafting site viewed from above.

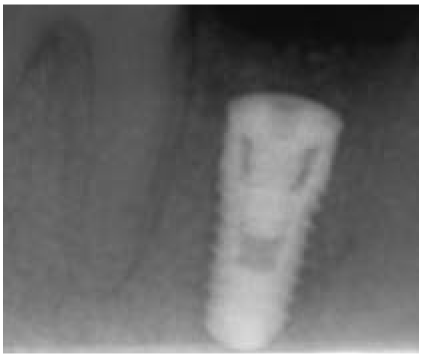
(β-TCP, 65 %) and calcium sulphate ($CaSO_4$, 35 %). It was prepared according to the manufacturer's instructions by adding saline to the syringe carrier and wetting the particulate powder, then extruding the excess fluid by compressing into a sterile gauze.

The resultant paste was then packed around the implant (Fig. 9) and inside the bone defect then allowed to "set" (facilitated by the $CaSO_4$ component). This "setting" [14] occurs after 2–3 minutes; care must be taken not to over-pack the site (Fig. 10) in order not to cover the implant. Over-packing makes

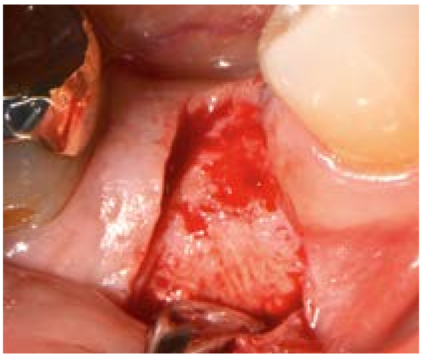


11 I Radiograph. Implant and graft.

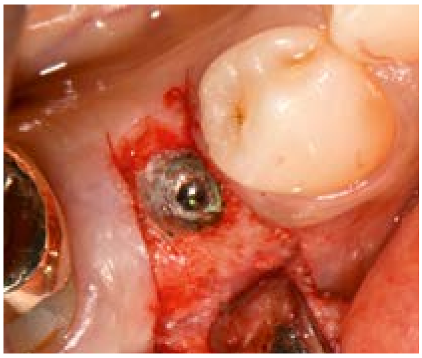
12a and b I Good soft-tissue healing at ten weeks and repair of the ridge.



13 I Radiograph ten weeks after placement showing increased bone level.



14 I Flap raised to show newly regenerated bone at ten weeks.



15 I Site of the core sample.

tension-free closure of the flap more difficult; due to the characteristics of the material, the procedure described here is sufficient for optimal results. This can also be seen on a radiograph of the site that shows the level of the grafting material (Fig. 11).

The flap was then closed using tension-free Vicryl 4.0 sutures (Ethicon, Somerville, NJ, USA). The sutures were removed after a five-day healing period. The biocompatible and bacteriostatic nature of the material [11,12] ensures a good healing response with no host reaction. No traditional membranes (collagen or similar) have been used in the twelve-year period backed by research [5,10]. The authors feel that membranes may inhibit the healing process, not merely by restricting the critical periosteal blood supply vital for angiogenesis

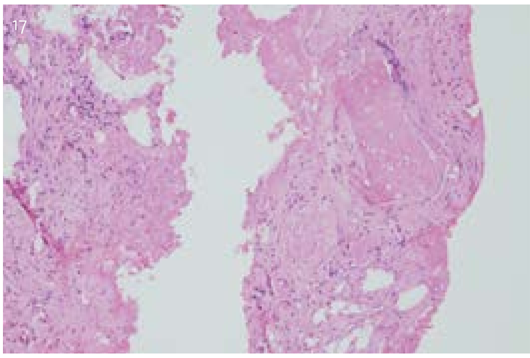
16 I Core sample taken above the implant to gain access, sent for histological analysis.

but also by affecting periosteal induction of bone morphogenetic proteins (BMP) such as stromal cell-derived factors [2].

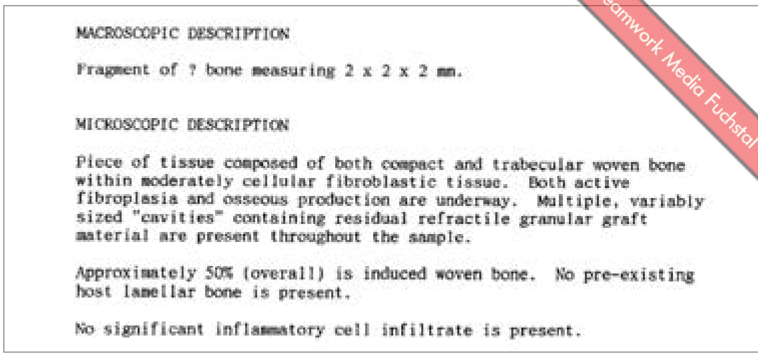
The routine osseointegration and bone regeneration period is ten weeks even in cases where only low primary stability has been attained. It has been shown [15] that earlier loading leads to a secondary "spike" in bone metabolism with functional remodelling.

Healing was uneventful, and both the dimensions and the attached gingiva were retained (Figs. 12a and b). Another flap was needed to access the implant cover screw, which can be a problem due to the extensive bone regeneration associated with these materials, as seen on the ten-week radiograph (Fig. 13).

A site-specific flap was therefore raised, again preserving the adjacent papillae and exposing the new bone formed during the ten weeks of regeneration. This appeared to be true bone, with blood vessels rupturing as the flap was retracted (Fig. 14). The area above the cover screw had 3 mm of new bone covering it despite attempts not to cover it with graft material, which enabled a core sample to be taken (Fig. 15) and demonstrating 3–4 mm of new buccal plate width above the implant. The sample was taken using a 2 mm trephine (Stoma Instruments, Emmingen, Germany) (Fig. 16) and sent



17 I Histological testing by Dr C. Mangham.



MACROSCOPIC DESCRIPTION

Fragment of ? bone measuring 2 x 2 x 2 mm.

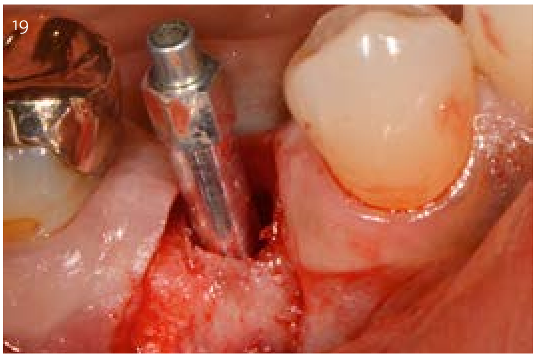
MICROSCOPIC DESCRIPTION

Piece of tissue composed of both compact and trabecular woven bone within moderately cellular fibroblastic tissue. Both active fibroplasia and osseous production are underway. Multiple, variably sized "cavities" containing residual refractile granular graft material are present throughout the sample.

Approximately 50% (overall) is induced woven bone. No pre-existing host lamellar bone is present.

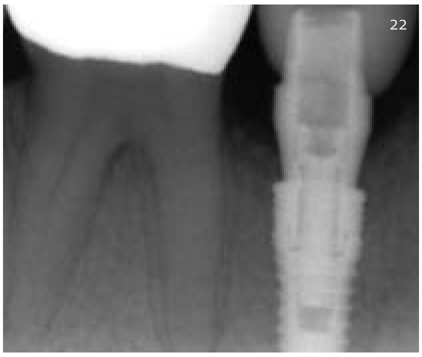
No significant inflammatory cell infiltrate is present.

18 I Histology report, Robert Jones and Anges Hunt Orthopaedic Hospital, UK.



19 I
Osstell peg seated to read the loading ISQ.

20 I
Osstell meter reading at initial loading.



21 I
After six months of loading.

22 I
Radiograph.

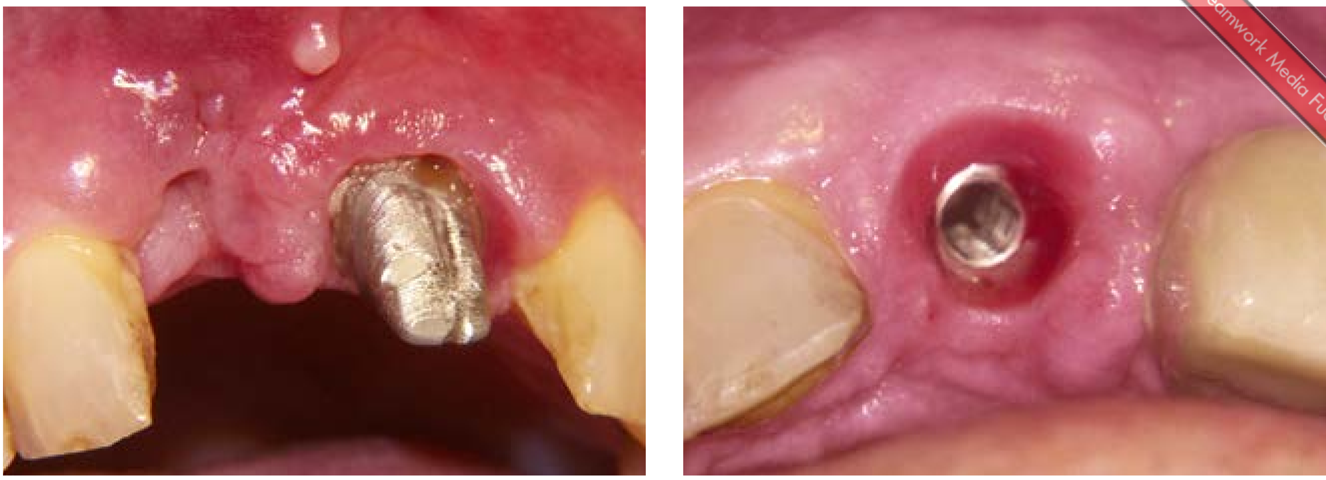
to the Robert Jones and Agnes Hunt Orthopaedic Hospital (Shropshire, UK) for histologic evaluation.

H&E staining was performed by *Dr C. Mangham*, showing new bone formation with residual β-TCP particles, osteogenic cells and connective tissue (Fig. 17). This also allowed an assessment of the new woven bone at ten weeks, which was 50 per cent (Fig. 18), indicating some possible host up-regulation [16]. There was a reduced relative amount of connective tissue, in line with what is expected in grafted sites [8].

A loaded Osstell ISQ reading was recorded; and the new regenerated height of the ridge can be assessed by the depth of the Osstell peg (Type 49; Osstell, Göteborg, Sweden) (Fig. 19). The reading was taken above the peg and was 80 (Fig. 20), a very high reading that may have been a result of the reduced connective-tissue component.

A healing cap was fitted and the flap sutured in place using 5.0 Vicryl Rapide (Ethicon, Somerville, NJ, USA) and allowed to heal for a week, applying Gengigel for improved soft-tissue healing. The implant was then restored with a Dio abutment (SACN 4845 T; Dio Implant System Co., Busan, Korea) torqued to 35 Nm. An IPS e.max crown (Ivoclar Vivadent, Schaan, Liechtenstein) was then delivered using Premier Implant Cement (Premier Dental, PA, USA), making sure to remove all excess at the gel phase.

The patient returned for review at six months; everything appeared satisfactory, both functionally and aesthetically, with adequate attached gingiva (Fig. 21), which is vital for the long-term stability of the implant. Radiographically, the situation was very stable, as the β-TCP was further converted to host bone (Fig. 22); absorption is completed at 9–16 months, dependent on host physiology.



23a and b I A similar case, same protocol, showing no profile loss, at baseline and after seven years of loading.

Both the preservation and restoration of the supporting hard tissue for the dental implant and the ridge profile were achieved on a reduced timescale while at the same time reducing patient trauma.

The procedure described benefits patients and dentists alike, leading to increased acceptance of our treatment protocol that requires neither foreign matter nor harvested autologous material.

Discussion

Alloplastic particulate graft materials for bone regeneration have been around for over 130 years. But it was not until the 1980s [7] that they were beginning to be more fully understood. The optimization of the β-TCP particles in the biphasic EthOss, in line with the present protocol with regard to porosity, size and shape, may have promoted host up-regulation in the regenerative process [2]. The material acts as a scaffold for regeneration and is fully absorbed after 9–16 months, depending on host physiology [9], by host macrophages and osteoclasts (often seen inside the residual β-TCP particles histologically) [13]. In the long term, all that remains is regenerated bone, which can "turn over" normally as natural bone would, hence this is true regeneration with no residual foreign matter [5].

The use of bacteriostatic $CaSO_4$ [12] to stabilize the graft may increase the turnover of mesenchymal cells to osteoblasts, improving the quality of the regenerated bone [6] as seen in cores samples, even in less favourable positions as in this case study. The biphasic nature of the EthOss – where the $CaSO_4$ element absorbs more rapidly, at three to six weeks (depending on host physiology) after serving an initial soft-tissue cell-occlusive function then allowing for larger interparticle spaces – improved vascular ingrowth. This ingrowth coupled with the fact that a traditional membrane is not required [9,10] improves angiogenesis and thereby bone regeneration.

The authors believe that the presence of foreign hydroxyapatite (HA), whether of bovine origin or synthetic, reduces the host bone content [8]. It has been noted over a ten-year period that it is not critical for the preservation of the ridge profile where an implant has been placed and loaded (Figs. 23a and b). This case had been presented in EDI Journal in 2011 [4] and has been loaded for seven years with no loss of profile, despite issues with the adjacent central incisor.

Conclusion

The materials described, used according to the authors' protocol, have shown consistent, impressive results over an extended period, with the benefit of reduced surgery and associated patient trauma. Working within the timing of host healing with sympathetic materials could be a key to tissue preservation as experienced here.

Further animal studies (including comparative, autogenous bone and bottle-graft materials) are currently being undertaken by the authors in an attempt to further improve our understanding of these interesting materials and their properties.

To find the list of references visit the web (www.teamwork-media.de). Follow the link "Literaturverzeichnis" in the left sidebar.

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