An immediate-delayed socket grafting procedure

Helping the host regenerate hard and soft tissues

MINAS LEVENTIS[1,2], PETER FAIRBAIRN[1,3], ANNETTE LINDNER[4]

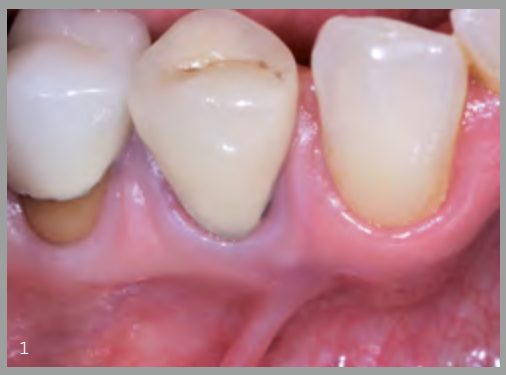
This case report highlights the use of a bioactive in situ hardening synthetic resorbable bone substitute composed of beta tri-calcium phosphate (β-TCP) and calcium sulfate (CS) for alveolar ridge preservation, following a modified immediate-delayed socket grafting technique. Both the staged approach along with the biological and biomechanical properties of the grafting material helped the host to regenerate vital bone and newly-formed thick keratinized soft tissues, thus minimizing the complexity of the procedures and leading to a predictable and successful outcome.

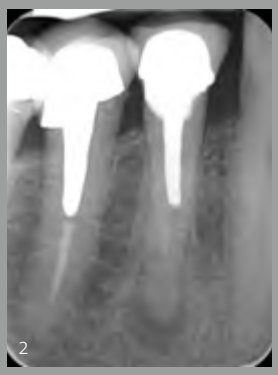
Case report

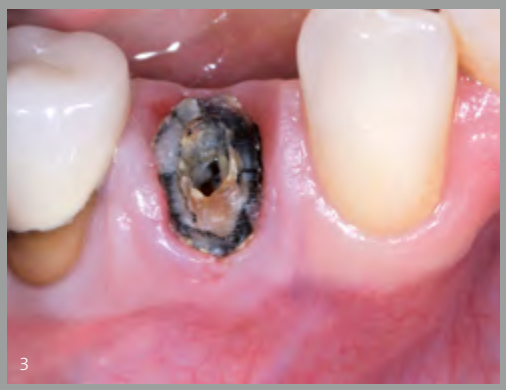
A 63-year-old female patient, non-smoker, with non-contributory medical history, presented with a non-conservable mandibular right first premolar due to extensive caries and periapical pathology (Figs. 1 and 2). After thorough clinical and radiological examination, a delayed implant placement treatment was proposed. The treatment plan involved:

- extraction of the failing tooth,
- alveolar ridge preservation with grafting of the socket six weeks after extraction,
- implant placement four months after grafting,
- uncovering of the implant three months after placement and subsequent loading with a final screw-retained crown.

The extraction was performed under local anaesthesia without raising a flap. Firstly, the crown was removed using forceps and the decayed root was carefully mobilized







1 I Initial clinical view.
2 I Initial x-ray.
3 I Clinical view of the decayed root after removing the crown.

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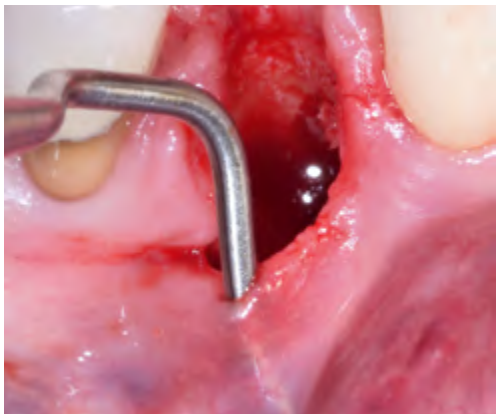
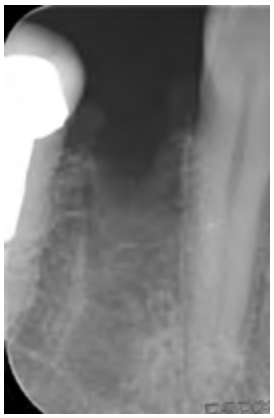
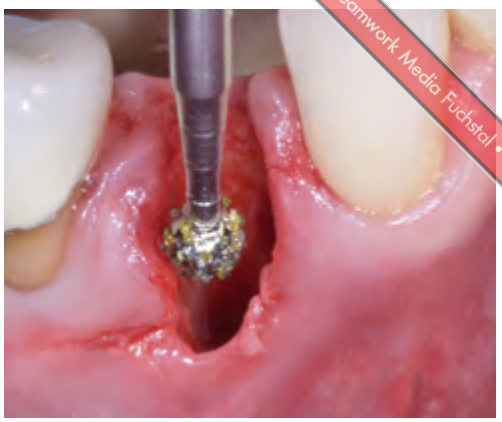


4 I The post-extraction site; note the loss of the buccal plate and the thin buccal soft tissues.



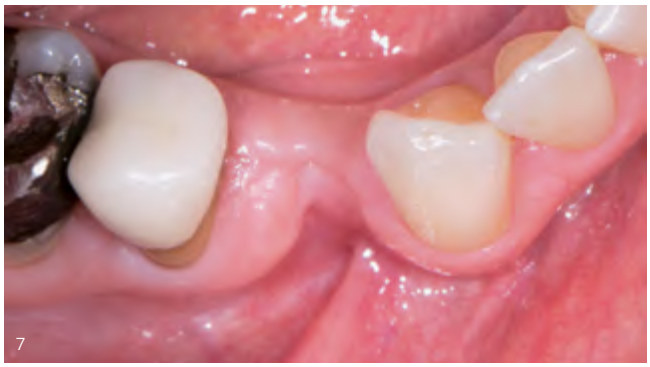
5 I Periapical x-ray immediately post-extraction.



6 I Debridement of the socket using EthOss degranulation burs.

and removed, using periotomes and thin elevators in order to minimize the injury of the surrounding soft and hard tissues (Fig. 3). However, due to the extensive caries and the non-favourable anatomy of the root, the extraction was very difficult, which resulted in complete loss of the thin buccal bone plate and loss of the buccal keratinized soft tissues crestally (Figs. 4 and 5). Thus, the socket was thoroughly curetted and debrided of any soft tissues, using Lucas hand bone curettes and degranulation burs (EthOss EK Strauss Degranulation Bur Kit, EthOss Regeneration Ltd, Silsden, UK), followed by rinsing with sterile saline (Fig. 6). The post-extraction site was then allowed to heal by secondary intention.

After six weeks, the site was covered by newly-formed soft tissues, while the complete loss of the buccal plate during the extraction resulted in severe atrophy of the ridge in the horizontal dimension (Fig. 7). Under local anaesthesia, a site-specific papillae-sparing full thickness flap was raised using vertical releasing incisions, without including the papillae of the adjacent teeth (Fig. 8) as described by *Greenstein* and *Tarnow* [1]. After flap elevation, all granulation tissue was removed and the socket was grafted utilizing a self-hardening fully resorbable synthetic bone grafting material (EthOss, EthOss Regeneration Ltd, Silsden, UK), consisting of β-TCP (65 %) and CS (35 %), as described by the authors in a previous publication [2]. No barrier membranes were used (Figs. 9 and 10).



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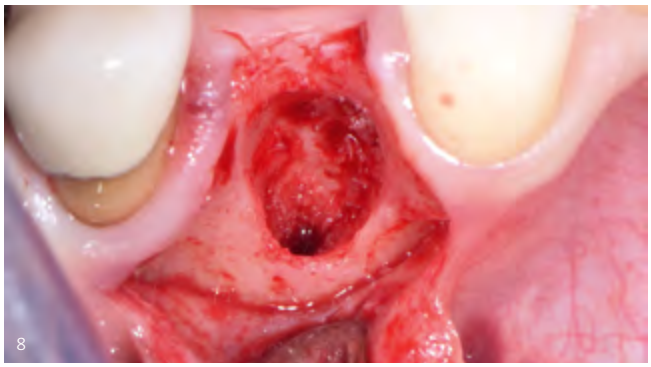

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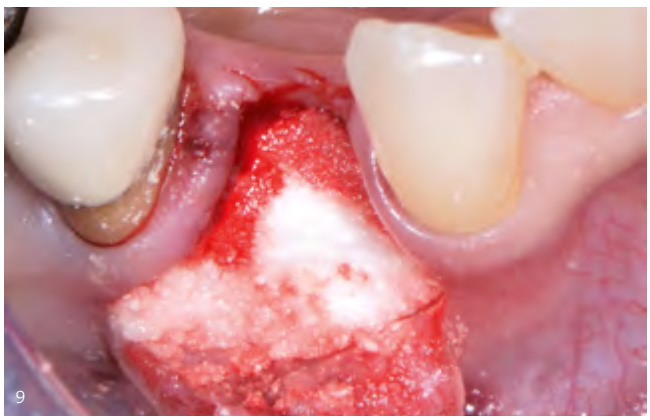

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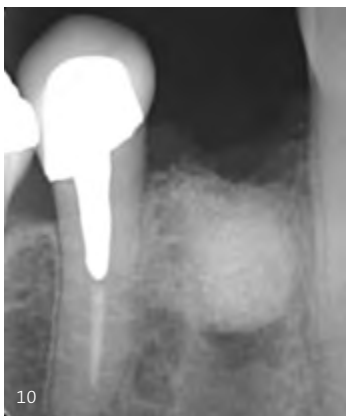

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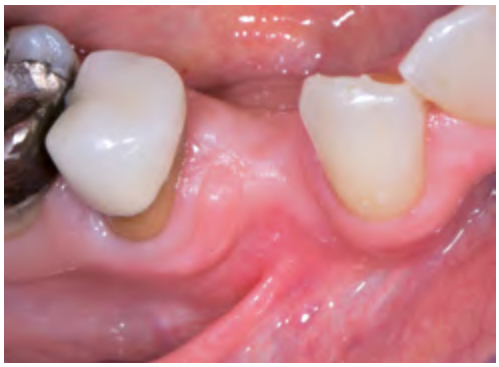
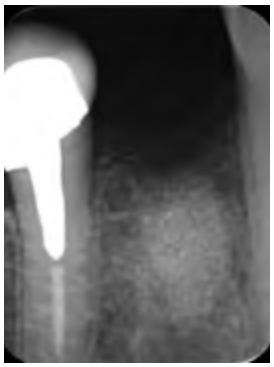
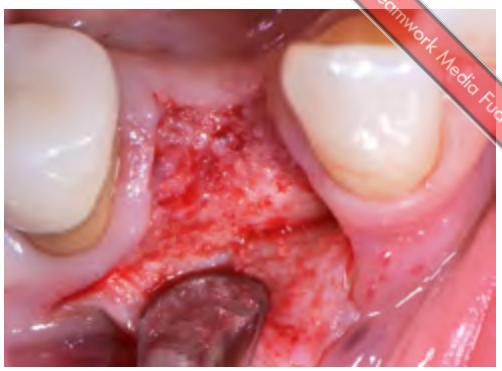
7 I Clinical view six weeks after the extraction. The host already regenerated soft tissues to cover the socket.
8 I Site specific papillae-sparing flap to expose the socket. Note the lack of buccal bone.
9 I The socket was grafted with β-TCP/CS (EthOss). No membranes were used.
10 I Periapical x-ray post-op.



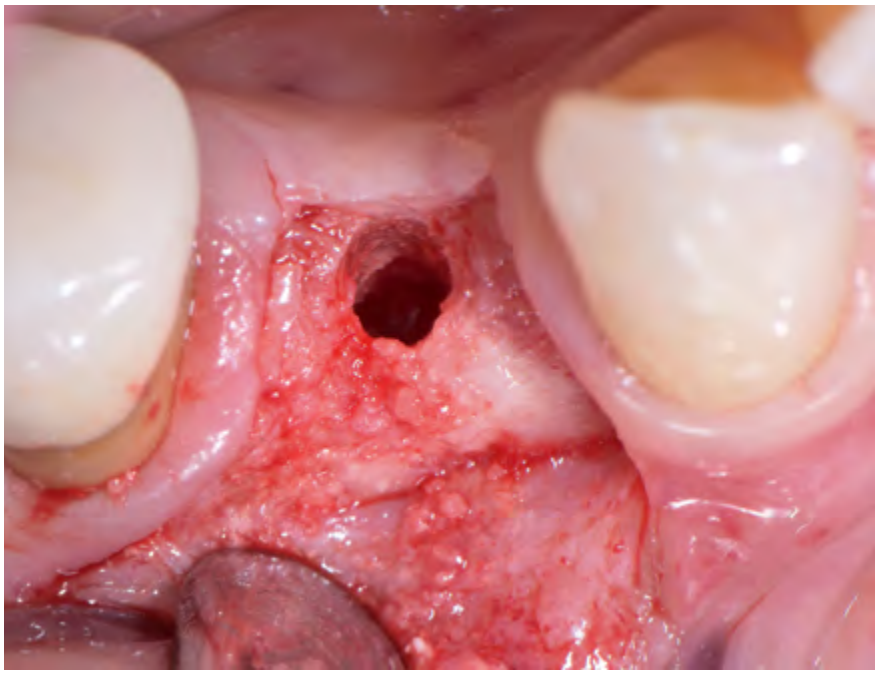
11 I Clinical view four months post-op.



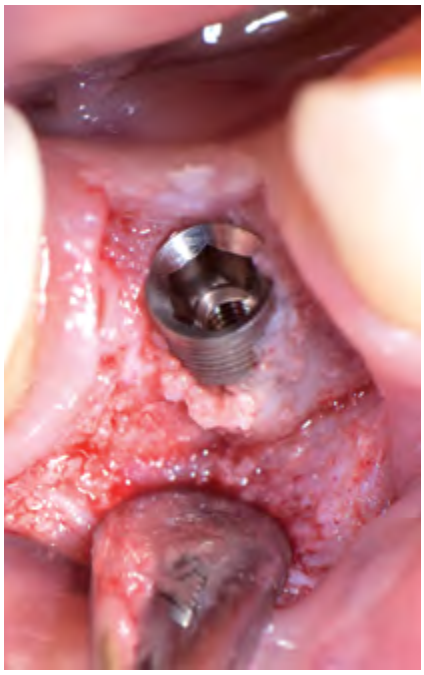
12 I Periapical x-ray four months post-op.



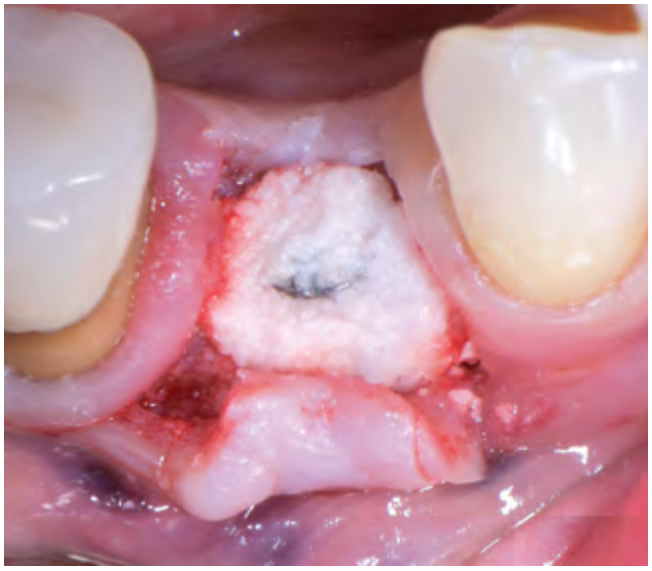
13 I Adequate regeneration of hard tissues at re-entry four months post-op.



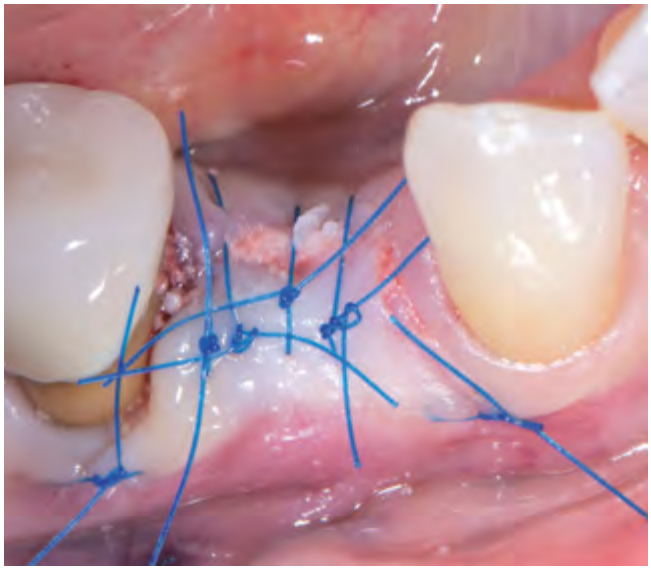
14 I The only way to evaluate the quality of the regenerated bone is to harvest a trephine bone biopsy. The bone sample was harvested from the centre of the regenerated site, so there is no old bone there, just newly-formed regenerated hard tissue.



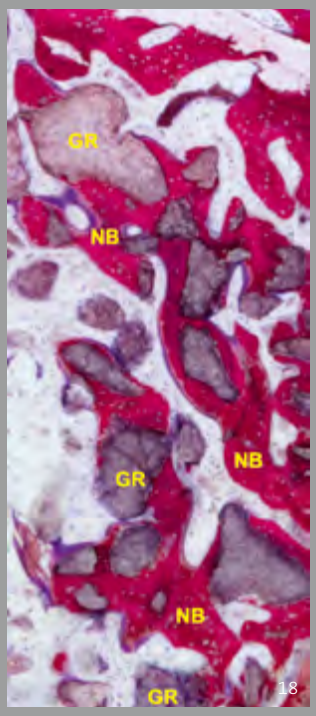
15 I Implant placed at the correct 3D positioning.



16 I Additional veneer grafting with EthOss.



17 I Repositioning and suturing of the full-thickness flap.



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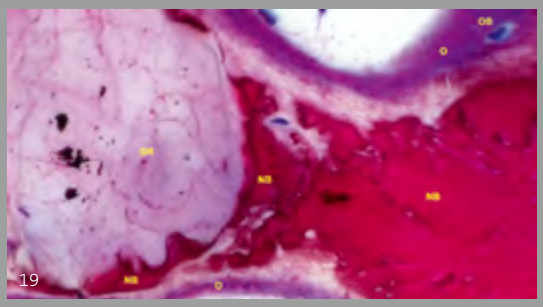

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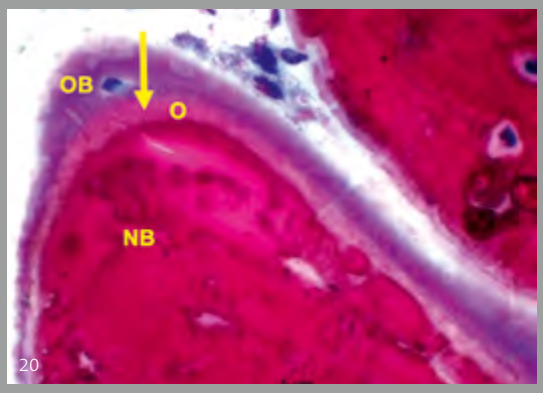

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18 I Histological analysis of the sample showing pronounced bone regeneration. Dense trabecular network of new bone (NB) with tightly integrated EthOss granules (GR). Undecalcified ground section; stain azure II/ pararosaniline staining, original magnification x50.

19 I Regenerated bone (NB) in contact to a dissolving EthOss granule (GR). Osteoblasts (OB) form osteoid (O). Connective tissue shows no signs of inflammation. Undecalcified ground section; stain azure II/ pararosaniline staining, original magnification x400.

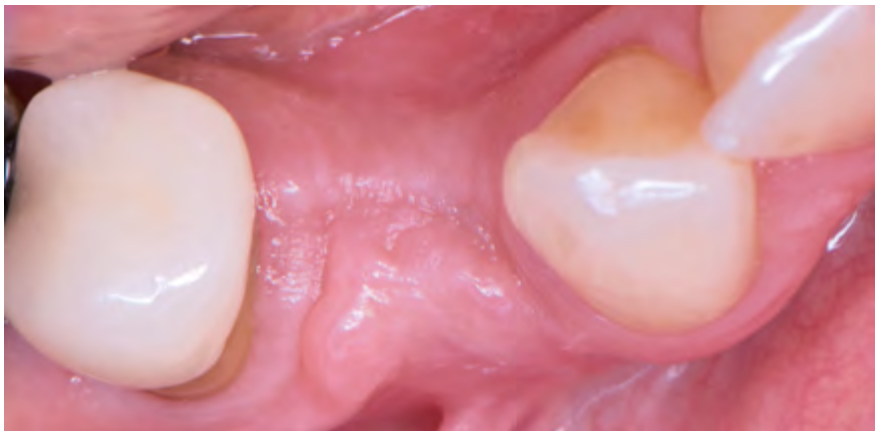
20 I Osteoblasts (OB) form osteoid (O). In some areas, a brighter space (arrow) between blue osteoid and red new bone can be observed. This might be a sign of different calcification stages in bone formation. Undecalcified ground section; stain azure II/ pararosaniline staining, original magnification x630.

The mucoperiosteal flap was repositioned and sutured without tension with 5-0 sutures (Prolene, Ethicon, Johnson & Johnson, Somerville, NJ, USA). Antibiotic therapy consisting of 500 mg amoxicillin every eight hours for five days was prescribed. The sutures were removed after a week. The patient did not wear any prosthesis during the healing period.

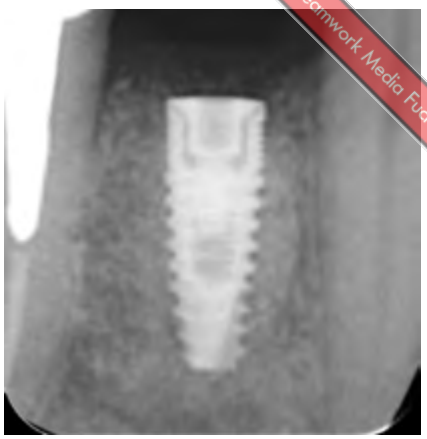
The post-operative healing was uneventful. After four months, the architecture and the dimensions of the ridge were adequately restored and the site was covered with keratinized epithelium (Fig. 11). A periapical x-ray at this point in time showed the consolidation of the grafting material, resulting in bone regeneration at the site (Fig. 12). A site-specific full thickness flap was elevated revealing that the grafted area was filled with regenerated hard tissue (Fig. 13). Prior to implant placement, a bone core biopsy was taken (Fig. 14) with a depth of 7 mm from the centre of the site using a trephine drill with a diameter of 2.3 mm (Komet Inc., Lemgo, Germany). Following the harvesting of the bone sample, the preparation of the bony bed was completed and a 3.75 mm x 10 mm tapered implant (Paltop Advanced Plus, Paltop Dental Solutions Ltd, Israel) was placed at the optimal position (Fig. 15). After placing the cover screw, the site was again grafted with a small amount of EthOss to cover the exposed implant threads buccally (Fig. 16). Again, no barrier membranes were used. After releasing the periosteum, the flap was repositioned and sutured tension-free using the same kind of sutures as in the previous procedure (Fig. 17). There was no need for a frenectomy, as the adjacent frenum was not applying any tension to the site when mobilizing and pulling the patient's lower lip. Antibiotic therapy consisting of 3 g amoxicillin one hour pre-operatively and 500 mg amoxicillin every eight hours for five days post-operatively was prescribed. The sutures were removed after an uneventful seven-day healing period.

The trephine bur with the bone biopsy inside was fixed in 4 % formalin for five days, rinsed in water and dehydrated in serial steps of ethanol (70 %, 80 %, 90 %, 100 %), remaining for one day in each concentration. The specimen was then infiltrated, embedded and polymerized in resin (Technovit 9100, Heraeus Kulzer, Wehrheim, Germany) according to the manufacturer's instructions. After polymerization, the sample was cut in 500 µm sections using a precision cutting machine Secotom 50 (Stuers, Ballerup, Denmark). The sections were mounted on acrylic slides (Maertin, Freiburg, Germany) and grounded to a final thickness of approximately 60 µm on a rotating grinding plate (Stuers, Ballerup, Denmark), and subsequently stained with Azur II and Pararosaniline (Merck, Darmstadt, Germany), which allowed for a differentiation between graft granules, pre-existing and newly formed bone. Imaging was performed with an Axio Imager M1 microscope equipped with a digital AxioCam HRc (Carl Zeiss, Göttingen, Germany). Histologically the analyzed biopsy contained newly-formed bone, residual grafting material, and vascularized uninflamed connective tissue. No necrosis or foreign body reactions were detected. The graft particles were surrounded and in contact with trabecular bone, while active osteoblasts forming osteoid could be identified, demonstrating persistent osteogenesis (Figs. 18 to 20).

After three months, the healing was uneventful (Figs. 21 and 22) and a small



21 I Clinical view three months after implant placement.



22 I Periapical x-ray three months after implant placement.

crestal incision was utilized to expose the implant and a healing abutment placed. The patient had to travel and came back three months later for the restoration of the implant. At this point of time, clinical examination revealed that the ridge was adequately reconstructed, with increased bulk and thickening of the keratinized soft tissues (Fig. 23). The secondary stability of the implant was measured by resonance frequency analysis (Penguin^{RFA}, Integration Diagnostics Sweden AB, Göteborg, Sweden). An ISQ (Implant Stability Quotient) value of 75 was recorded, demonstrating high stability (Fig. 24). An open-tray impression was taken and the final screw-retained crown was fitted and torqued at 35 Ncm, resulting in a successful outcome, regarding aesthetics and function (Figs. 25 and 26).

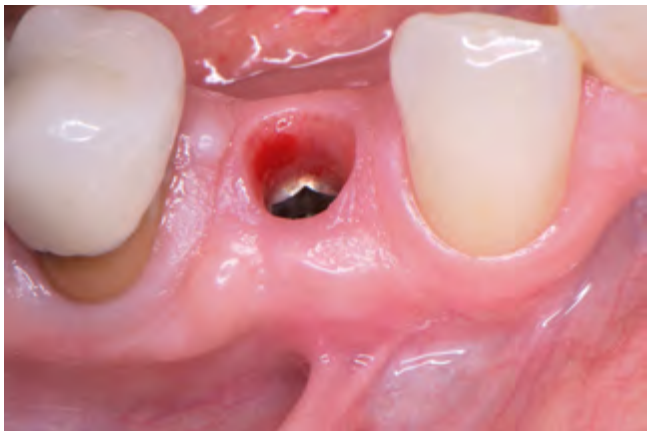
Discussion

The atrophic changes of the alveolar ridge that are triggered by tooth extraction are extensively documented in animal and human studies, describing that horizontal bone loss of 29 to 63 per cent and vertical bone loss of 11 to 22 per cent can be observed during the first six months after tooth removal [3,4]. Grafting the post-extraction sockets at the time of tooth extraction with a bone grafting material constitutes a predictable and reliable way to limit the resorption of the alveolar ridge. Such alveolar ridge preservation measures involve the use of a wide variety of bone grafts, barrier membranes and biologically active materials, and many different surgical techniques and protocols have been proposed [5,6]. When placing a grafting material into a socket immediately after extraction, a clinical decision has to be made as to whether the site will heal under secondary intention or a flap will be raised and advanced to cover the grafted socket. The clinician has to decide which approach is preferable. The first approach involves the risk of the biomaterial being washed out in the oral environment, while the second method may lead to distortion of the vestibule and the coronal displacement of the buccal keratinized gingivae. This iatrogenic loss of the buccal keratinized soft tissues will alter the soft tissue profile of the site and may influence in a negative way the health status of the supporting tissues around the dental implants [7].

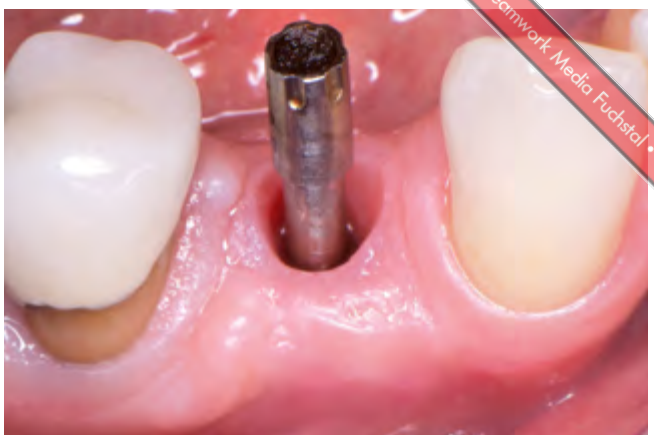
For the above-mentioned reasons, in the presented case an immediate-delayed socket grafting was performed and the socket was filled with the biomaterial not immediately after the extraction, but six weeks later. Although an additional clinical step was added in the overall treatment, it is of great clinical importance that the six-week healing period after the extraction enabled the production of adequate newly formed keratinized tissues, achieving tension-free primary closure and protection of the socket graft throughout the healing and regeneration phases. Moreover, as the graft was not placed immediately into the socket, the risk of an infection and graft loss may be decreased.

In a recent systematic review of randomized controlled clinical trials analyzing the outcomes of flapless socket grafting, *Jambhekar* et al. [8] reported that after a minimum healing period of twelve weeks, sockets filled with synthetic biomaterials had the maximum amount of vital bone (45.53 %) and the least amount of remnant graft material (13.67 %) compared to xenografts and allografts. The histological findings of the present case are in accordance with the above findings as pronounced regeneration of vital bone and small amounts of dissolving graft particles were observed four months after the socket grafting procedure.

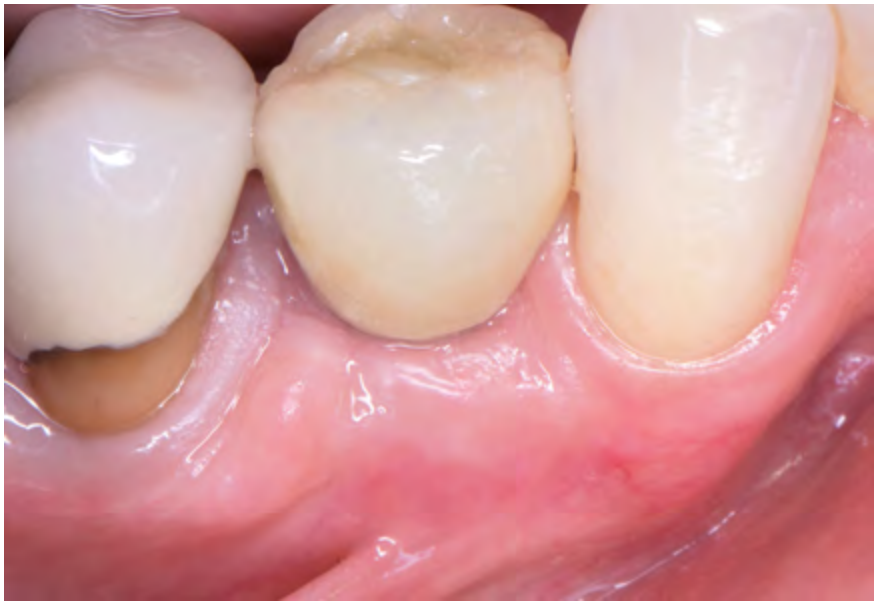
In the presented case, a synthetic fully resorbable grafting material (EthOss) consisting of β-TCP (65 %) and CS (35 %) was used in order to preserve the alveolar ridge and enhance the regeneration of high quality vital bone, as shown in preclinical and clinical studies published by the authors [9–15]. The bioactive β-TCP element, apart from being osteoconductive, shows an osteoinductive potential which might further improve host regeneration of bone in the healing process [16–18]. The CS element is bacteriostatic and produces an in situ self-hardening grafting material that doesn't need additional stabilization with the use of collagen membranes or other meshes. In this way, the CS acts as an "integrated barrier membrane", halting the ingrowth of soft tissue during the early phases of bone regeneration. Both CS and β-TCP are fully resorbable bone



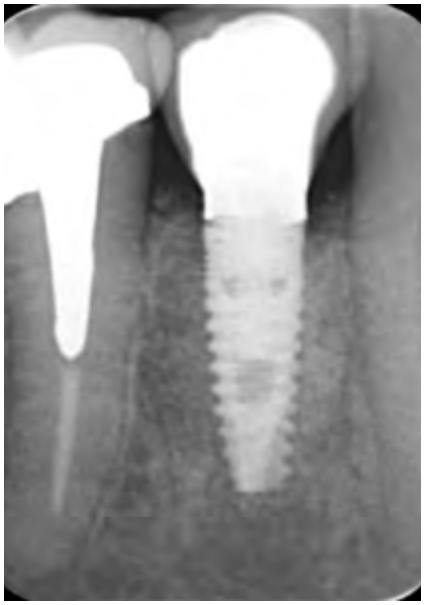
23 I Maturation of the soft tissues. Note the zone of thick keratinized soft tissues that have been regenerated by the host to cover the reconstructed high quality bone around the implant.



24 I ISQ measurement revealing high secondary stability of the implant.



25 I Final result.



26 I Periapical x-ray after fitting the screw-retained implant crown. The grafting material is turning over, being replaced by the regenerated bone.

substitutes, leading to the fast regeneration of vital host bone without the long-term presence of residual graft particles. The CS element will resorb over a three-to-six-week period, thus creating a vascular porosity in the β-TCP scaffold for improved vascular ingrowth and angiogenesis, while the β-TCP element resorbs by hydrolysis and enzymatic and phagocytic processes, usually over a period of 9 to 16 months.

In the presented case, the self-hardening bioactive β-TCP/CS bone graft was covered only with the mucoperiosteal flap. Periosteum has an immense osteogenetic potential and plays a pivotal role in bone graft incorporation, healing and remodeling, as it contains multipotent mesenchymal stem cells that are capable of differentiating into bone and cartilage, and provides a source of blood vessels and growth factors [19,20].

Conclusion

A modified immediate-delayed socket grafting approach using a bioactive self-hardening fully resorbable synthetic grafting material resulted in successful clinical, radiological and histological results. The spontaneous soft tissue healing after the extraction, and the thick keratinized soft tissues that the host regenerated to cover the reconstructed high quality bone around the implant were key factors for the success of the presented treatment modality.

The references are available at www.teamwork-media.de/literatur

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