Utilization of Biphasic Calcium Sulfate as Socket Preservation Grafting as a Prelude to Implant Placement: A Case Report

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Extraction of the natural tooth may be a prelude to implant placement. This may be done using an immediate placement protocol or require a delayed approach depending on multiple factors that include residual infection related to the failed tooth being extracted, availability of bone to stabilize the implant at placement, or soft tissue issues. Socket preservation is recommended when the delayed approach is selected to create an osseous bed with adequate height and width that can accommodate the implant that is planned.

Key Words: Biphasic calcium sulfate, socket preservation, delayed implant placement

INTRODUCTION

When socket preservation is performed, crestal bone levels are maintained at a higher level than for sockets where grafting was not performed.[1,2] The use of osseous graft materials and guided bone regeneration has demonstrated enhancement of socket healing by (1) potentially modifying the resorption process, (2) yielding preservation of the crestal bone, and (3) limiting resorption potential during healing.[3] In the absence of socket grafting, volumetric bone loss in uncomplicated extraction sockets after 2 years may reach 60% resulting in compromised future implant placement.[4]

Calcium sulfate as a graft material has been used for decades in maxillofacial, plastic, oncologic, and orthopedic surgeries for treatment of osseous defects. Dreesman[4] reported the osteogenic potential of calcium sulfate as a bone graft substitute orthopedically to treat traumatic and tuberous bone deficits. Peltier[5] conducted a thorough literature review of osseous defects treated with calcium sulfate and reported sporadic successful outcomes. Numerous studies including Thomas and Puleo (2009),[6] Thomas et al (2005),[7] Pietrzak and Ronk (2000),[8] Ricci et al (2000),[9] Boden (1999),[10] and Tay et al (1999)[11] reported that calcium sulphate has been consistently found to be highly biocompatible, osteoconductive, and clinically easy to use. Bahn[12] summarized that the material is simple to use, inexpensive, and offers many advantages as a grafting material for osseous fill. Further studies demonstrated that calcium sulfate is resorbable and well tolerated by the tissues, acts primarily as a space filler, restores morphologic contour, and prevents soft tissue ingrowth into defects during the healing phase.[13,14] Stubbs et al[15] confirmed that the osteoconductive properties of calcium sulfate allow for the ingrowth of blood vessels and osteogenic cells Following placement in the bone defect, calcium sulfate completely resorbs over time, leaving behind calcium phosphate deposits that stimulate bone growth. Adverse reactions or failures to heal have not been reported in the literature. Bioresorption studies of calcium sulfate and clinical experience have demonstrated consistent osteoconduction with complete resorption and de novo bone placement. When calcium sulfate is placed in direct contact with viable host bone, new bone growth occurs by apposition to the calcium of the graft material. The resorption period of calcium sulfate depends on graft volume, vascularity of the grafted site, and resorption model.[16] Graft materials in general needs to remain for a suitable time period to facilitate the ingrowth of vascularity (angiogenesis) and eventual conversion to host bone. Calcium sulfate's resorption rate is also dependent on the crystalline structure and the presence of impurities. The resorption rate that is consistent with new bone formation can be controlled using a surgical grade calcium sulfate dihydrate possessing a rigid crystalline structure of known specific size and shape.[17,18] After implantation, the graft's presence can easily be monitored radiographically because of its radiopacity, with it appearing radiolucent at 2–3 weeks and regaining radiopacity at 12 weeks. This reflects the transformation of the material initially into newly formed uncalcified osteoid that gradually turns into calcified de novo bone.

In maxillofacial applications, however, difficulties hardening calcium sulfate in the presence of saliva and bleeding have impeded its routine use. This obstacle was overcome in 2010 by Dr. Amos Yahav, who modified the material's behavior, without changing its chemical structure or enhancing it with additives, by making it biphasic. The biphasic calcium sulfate form allows the calcium sulfate to harden in the presence of saliva and

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blood. As calcium sulfate is a completely resorbable synthetic material with short-term space-maintaining abilities, the biphasic calcium sulfate form can be used as a composite graft in combination with other slow-resorbing bone grafts materials.[19] Bond Apatite (Augma Biomaterials Ltd., Spotswood, New Jersey), an available bone graft material, is a biphasic calcium sulfate composite bone graft cement containing approximately 33% hydroxyapatite in a controlled particle distribution (PSD) medium. The calcium sulfate component resorbs initially, whereas the hydroxyapatite particles with a slower resorption rate allow maintenance of the deficit space for a longer time period.[20] Thus, initially, the defect space is maintained while the host vascularizes the grafted area, and then de novo bone replaces the graft material while preventing undesirable ingrowth of soft tissue into the defect. The hydroxyapatite particles are of various sizes (90 μm to 1 mm) and shapes. The small and medium particles will resorb over 3–6 months, yielding fast bone regeneration for 90% of the grafted site.[21] The remaining 10% of the graft (larger particles of hydroxyapatite) remain for a longer period of time; however, the majority of will resorb by 8 months.[22,23]

Case Presentation

A male patient, 68 years of age, presented with the chief complaint of pain in the maxillary right posterior area related to a fixed 4-unit bridge. Radiographs were taken to evaluate the clinical situation (Figure 1). It was noted that prior endodontic treatment had been performed on the second and third molars (teeth #1 and #2) and second premolar (tooth #4), which were abutments for a 4-unit bridge and a pontic at the first molar site (tooth #3). Marginal breakdown with recurrent caries was noted on the 3 bridge abutments. Periapical pathology was noted on the teeth #2 and #4, with an absence of obturation material in all 3 abutment canals. A large wide post was noted in the palatal canal of tooth #2 with a J-shaped lesion noted radiographically on the mesial aspect of the root, which was indicative of a possible vertical root fracture. The patient was informed that the prognosis for the bridge abutments was guarded, and it was recommended that these teeth be extracted and replaced with an implant-supported restoration. Because of the periapical pathology, immediate implant placement was not recommended. A delayed approach with socket grafting, followed by a healing period before implant placement, was discussed with the patient. The patient agreed to treatment and was scheduled for surgery.

The patient presented, and treatment consent forms were signed. Local anesthetic that included 4% Septocaine with 1:100,000 epinephrine (Septodont, Inc, Louisville, Colo) and 4% Citanest Plain (Dentsply Pharmaceutical, York, Pa; Prilocaine) was administered. The existing fixed bridge was removed, and the recurrent decay noted radiographically was confirmed visually (Figure 2). A crestal incision with sulcular incisions at the abutment teeth was made with a #15 scalpel blade. A Molt periosteal elevator was used to create a full-thickness flap on the buccal aspect of the ridge, and lingual was minimally elevated. The teeth were luxated with 301 and 49 elevators and extracted atraumatically with a maxillary universal forceps. The sockets were curetted to remove any apical pathology that was

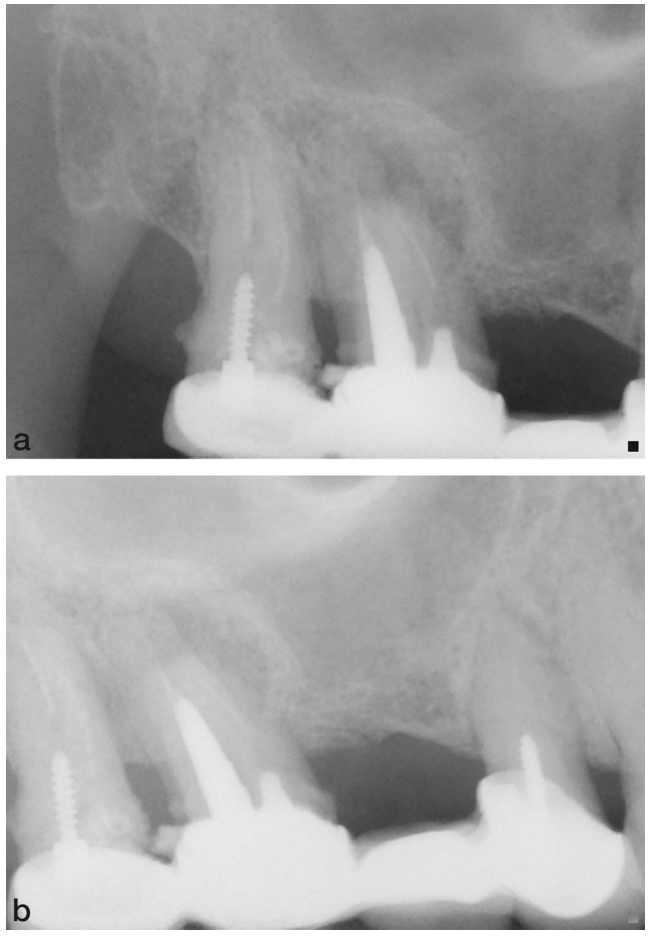


Figure 1. Radiograph demonstrating failure of bridge abutments related to endodontic failure and periodontal bone loss.

associated with the teeth using a Lucas surgical bone curette. The Bond Apatite bone graft cement is activated by placing the syringe in one's dominant hand with a power grip. The other hand is used to apply gentle counter-pressure on the cap to prevent it from coming off the syringe. Then, using the dominant hand, the plunger is advanced in the syringe and moves the first piston to make contact with the second piston; this begins the activation process. The advancement continues until the pistons reach the blue line on the syringe. At this point, remove the cap and dispense the cement into the host site. There is no need to push the material into the apical zone; the presence of voids left apically is acceptable. The compaction of the material at crestal portion of the socket is crucial and is accomplished by placing dry sterile gauze on top of the placed graft material and exerting firm finger pressure followed by additional firm pressure on the gauze with a periosteal elevator. This is performed to properly stabilize the material at the crest level of the socket (Figure 3). No vertical incisions were made to preserve the blood supply to the surrounding tissues. Because of the large area of exposed graft material at the crest of the ridge, a resorbable barrier was placed to protect the underlying biphasic calcium sulfate graft. First a collagen plug (Zimmer Biomet Dental, Palm Beach Gardens, Fla) was placed over the Bond Apatite at the distal

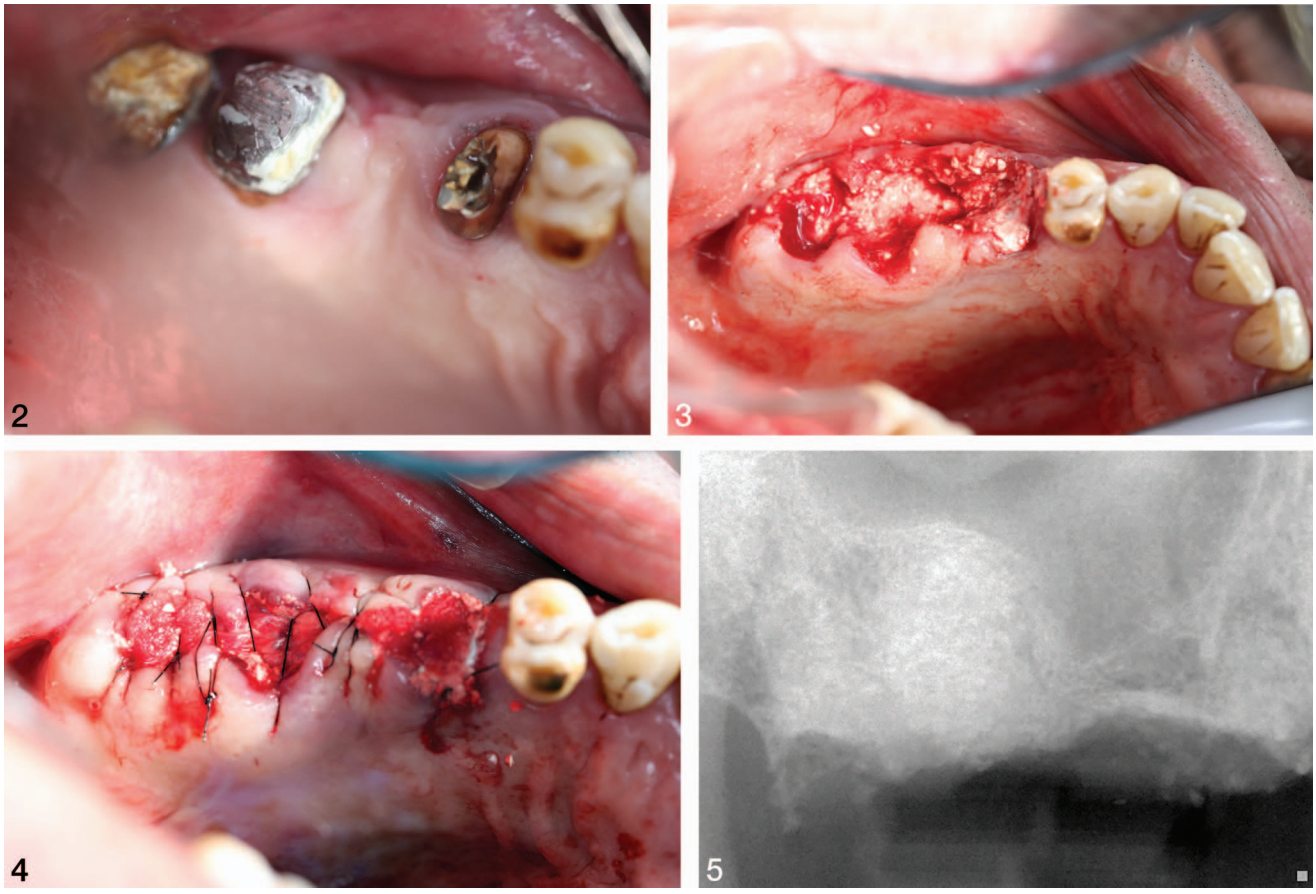


Figure 2–5. Figure 2. The fixed prosthetic bridge was removed in prelude to extraction of the failing abutment teeth. **Figure 3.** Following extraction of the bridge abutment teeth, the extraction sockets were curetted and filled with Bond Apatite. **Figure 4.** Exposed material over 3 mm was covered by a collagen sponge at the mesial aspect and BioXclude at the distal, which was secured in place by sutures to help contain the graft material without primary closure of the soft tissue. **Figure 5.** Radiograph taken immediately following extraction and socket preservation with Bond Apatite, demonstrating initial radiopacity of the graft material.

aspect of the surgical site. Next, a BioXclude (SNOASIS Medical MiMedx Tissue Services, LLC Marietta, Ga), a minimally manipulated allograft amnion chorion tissue membrane, was placed over the surgical site covering the graft material that had been placed. The flap was closed with minimal manipulation with 5-0 nylon suture material (AD Surgical, Sunnyvale, Calif) in an interrupted pattern (Figure 4). Primary closure of the surgical site was not achieved. A radiograph was taken to document the socket grafting (Figure 5).

The patient returned at 2 weeks after surgery for suture removal. The crestal aspect demonstrated partial closure with some minor opening between the buccal and palatal aspects of the flap margins with an absence of soft tissue inflammation (Figure 6). The patient indicated no postoperative issues with pain during the healing period and minor soreness after the surgery that resolved after a few days.

The patient presented at 2 months after surgery for site evaluation and a radiograph was taken (Figure 7). The radiograph demonstrated partial radiolucency of the graft material indicating early replacement with host bone was occurring. At 4 months after surgery, the patient again returned for evaluation, and it was noted that the crest was covered with keratinized tissue that was noninflamed (Figure 8). A divot at each extraction socket was noted but was covered with keratinized tissue. A radiograph was taken to evaluate the graft, and it appeared that the graft had converted to de novo bone as it blended with the surrounding native bone (Figure 9). Local

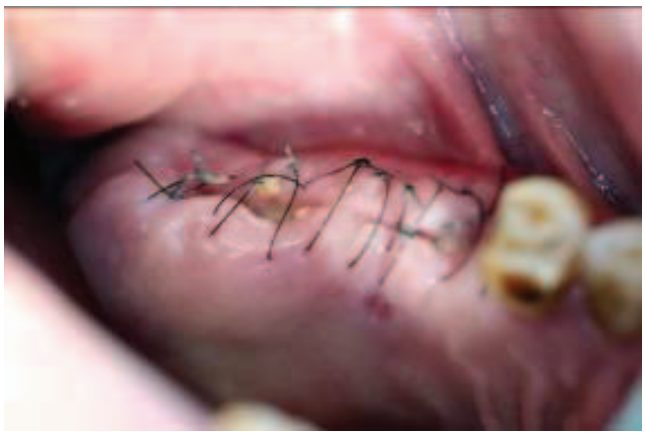


Figure 6. Patient returned at 2 weeks after graft placement for suture removal demonstrating partial closure of the soft tissue over the grafted sockets and an absence of soft tissue inflammation.

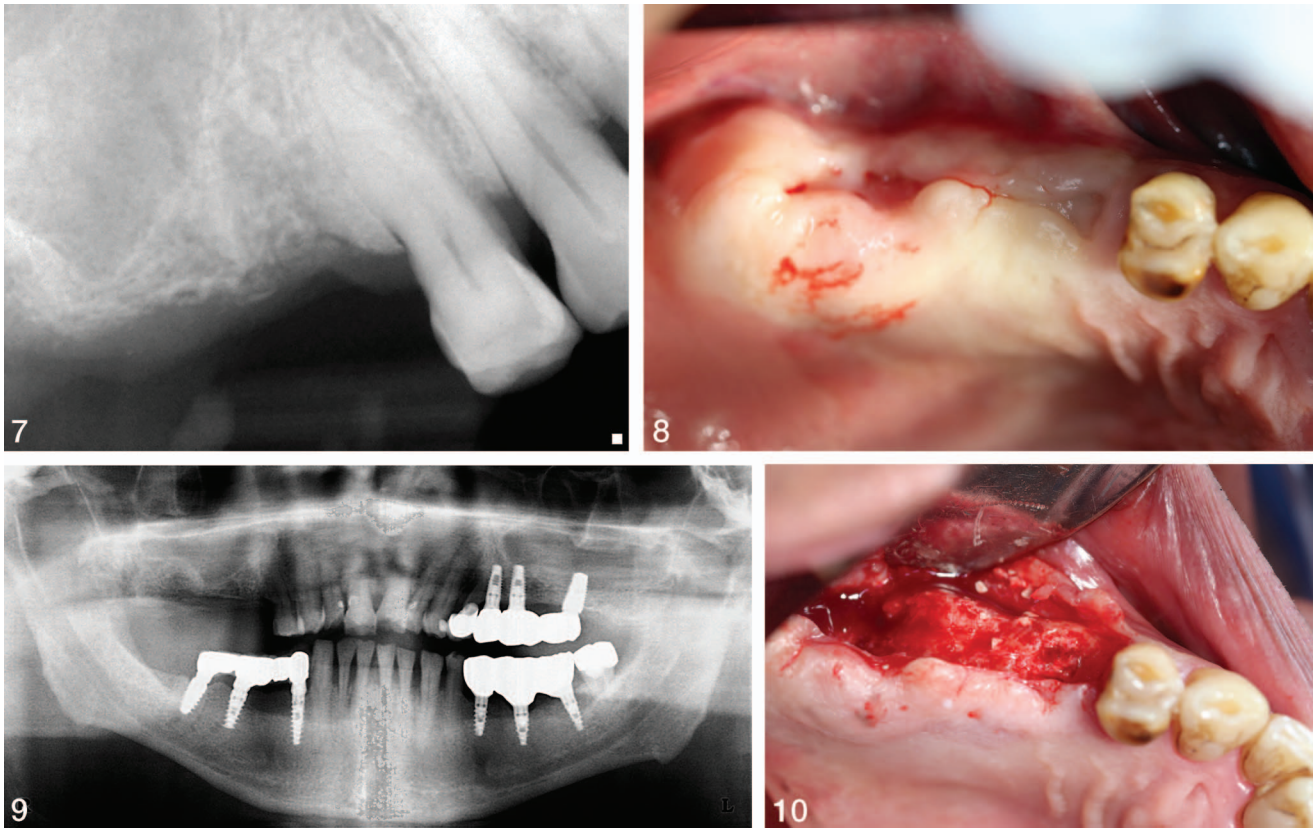


Figure 7–10. Figure 7. Radiographs taken at 2 months after surgery demonstrating partial radiolucency of the graft material placed. **Figure 8.** Patient presentation at 4 months after surgery demonstrating coverage of the sockets by keratinized gingiva and an absence of soft tissue inflammation. **Figure 9.** Radiograph taken at 4 months after surgery to evaluate the organization of the graft material placed for socket preservation. **Figure 10.** Second-stage surgery at 4 months after graft placement following flap elevation demonstrating osseous fill of the extraction sockets and a few residual particles of Bond Apatite remaining.

anesthetic following the same protocol performed at the extraction and socket grafting appointment was accomplished. A crestal incision was made without vertical releasing incisions with a #15 scalpel blade, and a Molt periosteal elevator was used to create a full-thickness flap (Figure 10). Upon flap elevation, the socket grafting was evaluated, and osseous fill of the extraction sockets with a few residual particles of Bond Apatite was noted.

A bone core was taken with a trephine from the mesial site for histologic analysis (Figure 11). The original implant plan was to place an implant at each of the 4 sites, but on preparation of the first molar site with osteotomy burs, it was decided the bone quality at that site was not ideal, and the plan was changed to placement of 3 implants with restoration with a 4-unit fixed bridge. The osteotomies were completed for the 3 sites (previously grafted) to accept implants according to the manufacturers protocol (Figure 12). Implants that were 3.75-mm-diameter in size with 10-mm length (TUFF, Noris Medical, Las Vegas, NV) were placed at the 3 osteotomy sites (second premolar and second and third molars), and the cover screws were placed (Figure 13). Radiographs were taken to document the implants placed, their relationship to adjacent anatomy, and the previously placed healed osseous grafting (Figure 14). The flaps were reapproximated to achieve primary closure and closed with 5-0 nylon sutures in an interrupted pattern, and the patient was dismissed. The core sample taken from the premolar site was sent to the histologist.

Histological Analysis

Specimen examined microscopically at 40× demonstrated residual particles of Bond Apatite (Figure 15; yellow areas on the right side) and young bone in proximity with the particles. At 200× (Figure 16), the pathologist reported residual particles of Bond Apatite (yellow areas on the right side), which were the large hydroxyapatite (HA) particles that remained. No residual remnants of biphasic calcium sulfate remained at this stage, because it was replaced with early host bone. Young bone (blue areas on the right side) in proximity with the particles and fibrous connective tissue (purple areas on the right side) are observable and will ossify over time. The microscopic description reported was of decalcified sections that show two portions of tissue composed of viable bone admixed with bone graft (HA) material and fibrous connective tissue.

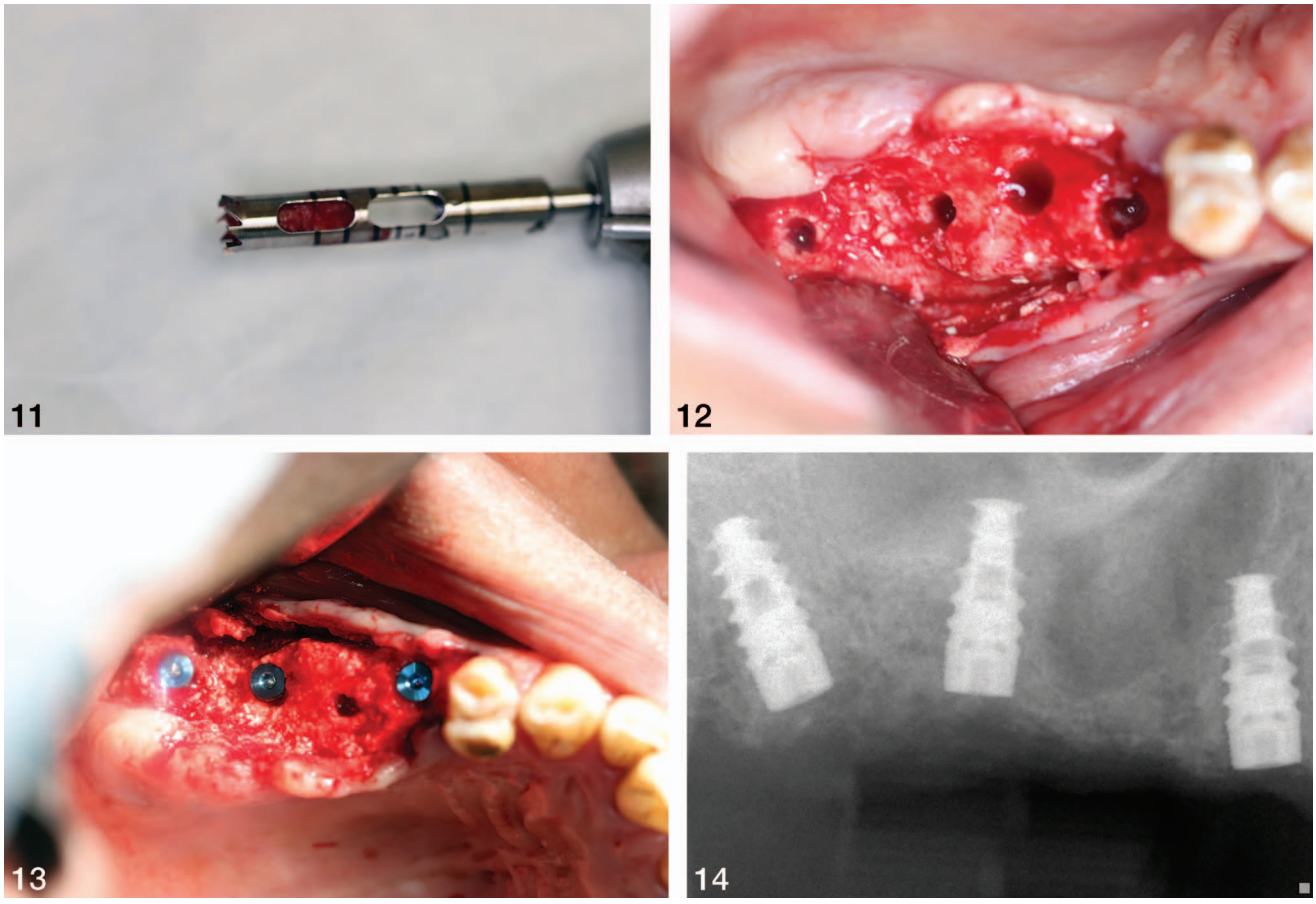


Figure 11–14. Figure 11. Trephine containing the core sample of healed graft material at 4 months after graft placement. **Figure 12.** A core sample of the graft material was removed with a trephine at the planned mesial site and osteotomies prepared at the 3 sites with abandonment of the first molar site due to its bone quality. **Figure 13.** Implants have been placed into the 3 osteotomies and cover screws affixed to the implants. **Figure 14.** Radiograph immediately after implant placement demonstrating bone contact surrounding the implants.

Discussion

Socket grafting is recommended when immediate implant placement cannot be performed, and a delayed approach is selected. Various graft materials are available for socket grafting that include allografts, autografts, xenografts, and some non-biologic materials. These materials present as particles that are typically mixed with either (i) the patient's blood absorbed at the graft site immediately or (ii) peripherally autologous blood drawn, centrifuged, and mixed to form a putty that is placed into the surgical site. Additionally, some products are available as prepared putties that are not necessarily mixed with blood before placement. These 2 graft approaches require primary closure with or without a membrane. If primary closure is not possible, then placement of a nonresorbable membrane is necessary to prevent soft tissue invagination into the of the graft material. There are numerous reports in the literature of exposure of the membranes or postoperative issues that require additional maintenance by the practitioner. There is also scenarios for the potential graft contamination or loss at the crestal aspect because of wash out, salivary contamination, or other factors that can compromise the intended volume of graft.

Biphasic calcium sulfate overcomes the issue of early exposure when primary closure is not possible. The material, when set, has a hard consistency that prevents soft tissue invagination while enabling soft tissue proliferation over its surface. In socket grafting procedures or when at least 2 bony walls exist, the material can be left exposed without primary closure; however, it should be protected by a collagen sponge that should last 7–10 days or until soft tissue proliferation has taken place to bridge the exposed gap. The collagen sponge (plug) should be secured above the graft by suturing to prevent its dislodgment. As such, the graft resists oral dissolution, thereby maintaining volume as resorption and replacement by de novo bone occurs over succeeding months. The question remains, "does biphasic calcium sulfate fully resorb and is it replaced by viable host young bone?" As the histology report for this reported case demonstrates, the graft at 4 months was

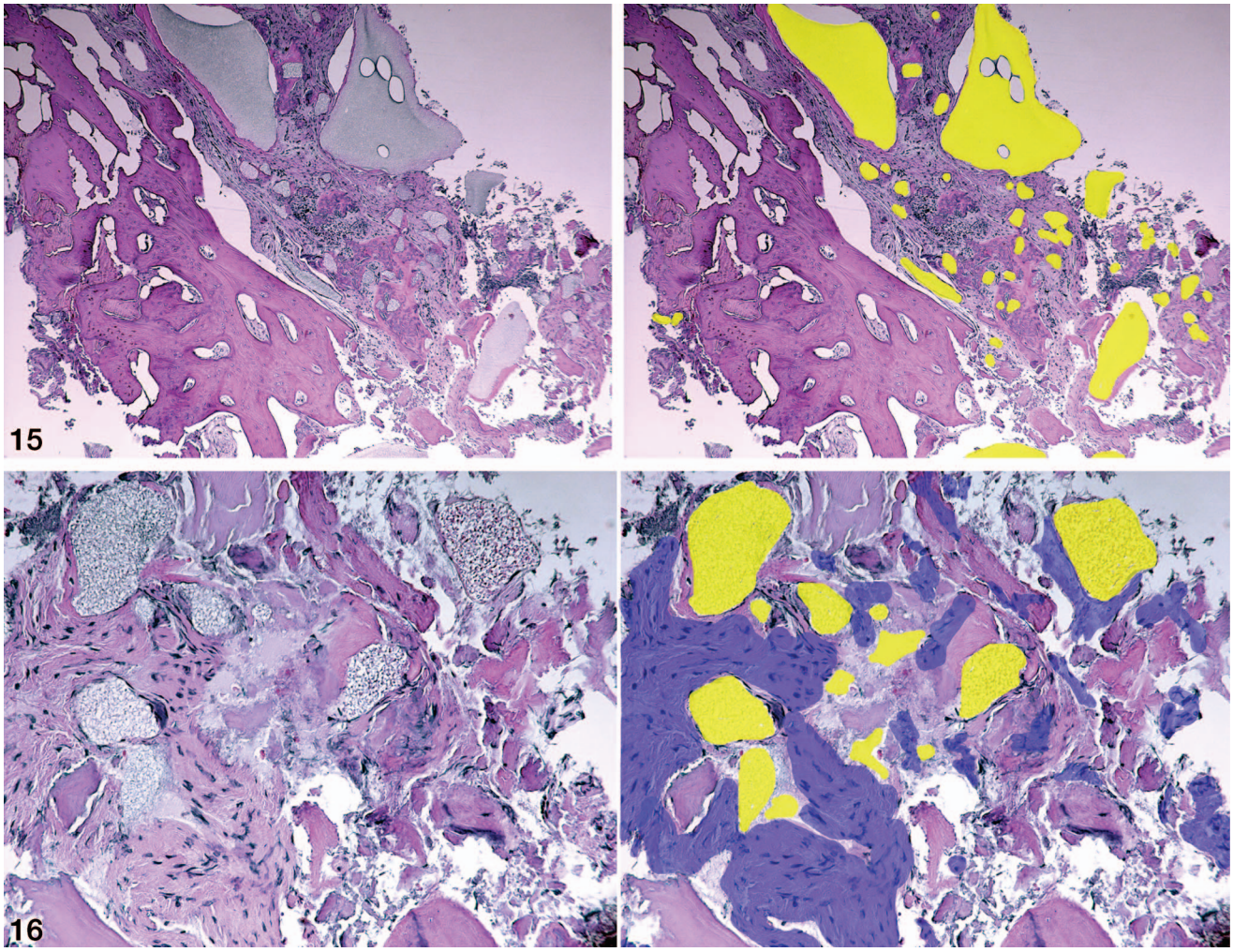
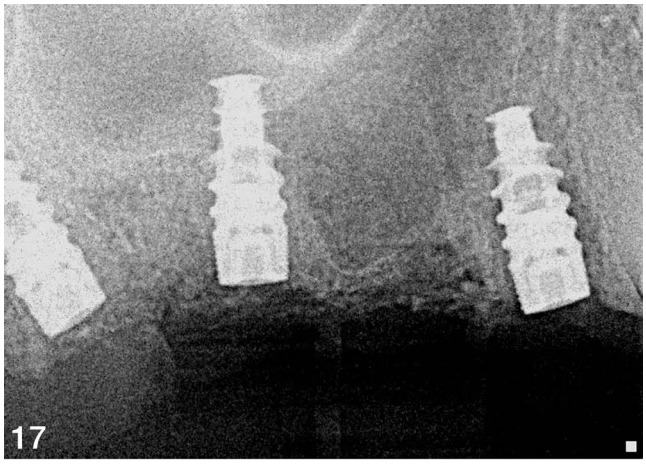


Figure 15–16. Figure 15. Histologic evaluation of the core specimen at 40×, demonstrating residual particles of the HA portion of the Bond Apatite (yellow on right side) and young bone in contact with the particles. **Figure 16.** Microscopic evaluation of the core specimen at 200×, demonstrating residual particles of Bond Apatite (yellow on right side) HA and young bone (blue on right side) in proximity with the particles and fibrous connective tissue (purple on right side).

predominately resorbed with only scattered residual particles present, and young viable bone was noted in proximity with the remaining HA particles. The bulk of the specimen removed for analysis was filled with young active bone with some scattered fibrous connective tissue present. Prior histologic studies have noted that the remaining large HA particles of the Bond Apatite composition and the presence of some fibrous connective tissue is normal at the 4-month postsurgical histologic analysis. Staged implant surgery takes advantage of this phenomena, allowing the graft to convert by 4 months to accommodate and stabilize implant placement in young bone and then continue maturation and organization as the implants undergo integration before the restorative aspects are initiated (Figure 17). At 6 months after implant placement, intimate contact between the grafted sites and implants with an absence of radiographically discernable graft particles was noted (Figure 18).

Conclusion

Biphasic calcium sulfate should be considered as a graft material in those clinical situations where a delayed implant placement approach is selected. The graft material overcomes some of the issues reported with other graft materials while providing a hard setting material that is resorbable while being replaced by host bone and does not require primary site closure. The material is mixed easily in the supplied mixing syringe and expressed into the site being grafted with a minimal learning curve for application intraorally. The hard setting nature of the material prevents displacement during the healing phase and thus preserves the desired volume without the need for site containment with membranes or titanium mesh. Following a typical healing period of 4–6 months, dependent on the graft volume, the site is histologically ready for implant placement. Further improvement in bone density can occur during implant integration before the restorative phase is initiated.



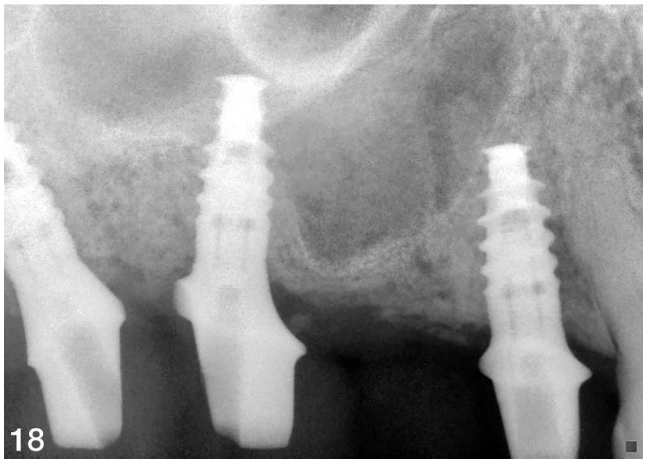


Figure 17–18. Figure 17. Radiograph at 4 months after implant placement and 8 months after graft placement demonstrating bone in contact with the implants and no observable graft particles noted. **Figure 18.** Radiograph at 6 months after implant placement and 10 months after graft placement at insertion of custom abutments demonstrating bone in intimate contact with the implants and an absence of graft particles observable.

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