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Case Report

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Improving Clinical Results in Veterinary Osseous Grafting

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Abstract

Veterinary dentistry and oral surgery is beginning to incorporate osseous graft material and techniques into their everyday dental clinical practices. Autogenous, allogenic, xenografts and synthetics are all part of a new armamentarium to improve clinical results and achieve osseous reconstruction either to preserve anatomical ridge contours or support implants placed to replace teeth extracted or previously missing.

Clinicians and researchers have been exploring the use of calcium sulphate (CS) for over 100 years. in orthopedic, spinal arthrodesis , and maxillofacial surgery. Calcium sulphate is an inexpensive, easy to use material that offers many advantages as a predictable and significant bone regeneration substrate.

Keywords: Osseous graft; Dentistry; Surgery; Bone

Introduction

Morbidity, time and expense with autografts has generated an abundance of alternative materials. Alternatives range from the simple, such as calcium sulphate and calcium phosphate to the complex that contain allografts, Bone morphogenic proteins (BMP) and other agents [1].

Clinicians and researchers have been exploring the use of calcium sulphate (CS) for over 100 years in orthopedic, spinal arthrodesis, and maxillofacial surgery [2,3]. Calcium sulphate is a simple inexpensive material that offers many advantages as a predictable and significant bone regeneration substrate. Calcium sulphate was first used as a filler for bone defects by Dreesman in 1892 [4]. Studies undertaken in the 1950s demonstrated that CS is an effective resorbable material for filling bone defects and retaining bone grafts. It was reported that it was rapidly resorbed, caused no inflammation, minimal foreign body response and resulted in normal regenerated bone, with no measurable rise in serum calcium levels [5-8].

Calcium sulphate has proven to be very versatile in bone repair and can be used alone as a defect filler or as a barrier over other graft material to prevent soft tissue ingrowth into the underlying graft material. The ability of CS to be easily absorbable makes it a good delivery vehicle for bio-materials such as growth factors, osteogenic factors and antibiotics [9]. Currently it is utilized to regenerate empty extraction sockets and to treat dehiscence's and fenestrations. Calcium sulphate is also being utilized in oral surgery techniques, such as filling cysts, defect repair after removal of impacted teeth, periodontal defects, and as barrier membranes [10].

Calcium sulphate as a graft material

Use of calcium sulphate is not new in dentistry and has been reported in the literature almost 50 years [11]. The material resorbed fairly quickly when placed as an osseous graft material and had mixed results when compared to autogenous, allograft and xenograft materials [12]. It did show promise as a barrier to prevent soft tissue ingrowth into osseous graft material or clot that occupying the extraction socket and was reported in the literature as an early membrane in periodontal procedures [13]. The benefit of its use as a membrane was its biodegradability, eliminating the need for a 2nd surgery to retrieve the membrane at the surgical site [14]. Additionally, calcium sulphate has also be used as a carrier for allograft materials to form a hard setting putty that would allow molding of the area to be restored via osseous grafting, tenting the tissue [15]. In the biphasic form, the clinical benefits have been reported to be equivalent to autogenous bone grafts and may be an appropriate alternative to conventional graft materials [16].

Hydroxyapatite (HA)

Synthetic graft materials were explored in the aim to find less expensive materials for osseous grafting and compatibility to the hosts native bone. Numerous studies had been reported using hydroxyapatite as a surface treatment on dental implants when press-fit implants were being used. As press-fit implants have predominately most of their load in shear due to the load being parallel to the implants surface, surface treatment was required to allow the native bone to "fuse" to the implant and transmit loading forces. Hydroxyapatite fit the required parameters needed. Early problems with these HA coatings related to the low level of crystallinity causing resorption of the material over time, leading to higher levels of crystallinity to maintain the HA being used on implants. Fortunately, low crystallinity HA made an ideal graft material as it would remain long enough to maintain the space being filled by the graft and allow complete replacement of the HA by native bone over time (6-8 months) [17].

As with calcium sulphate, HA when combined with other materials augments the desired properties of the individual components while minimizing or eliminating undesired properties such as resorption rate, tissue ingrowth, site adaptability and host bone stimulation (conversion of the graft) [18].

Composite graft materials

Bond Apatite® (BA) is a composite graft, that combines 2/3 biphasic calcium sulfate and 1/3 hydroxyapatite (HA) granules of different sizes and shapes. No additives, polymers or other chemicals are contained in the mix, so there is no alteration to the chemical structure of the calcium sulfate. The ratio (2:1) of Biphasic Calcium Sulfate and HA in a specific particle size distribution takes advantage of each components properties. The calcium sulfate component acts as a short-range space maintainer scaffold which completely degrades in relation to the bone formation rate in 4-10 weeks. While the HA acts as a long term space maintainer designed to slow down the overall resorption of the graft.

The bioactivity and the graft transformation into vital bone are due to the biphasic calcium sulfate component of the graft. The overall structure of Bond Apatite® has micro porous (1-10µm) and macro porous (50-500µm) structure. The initial surface porosity is about 40 percent, but as the calcium sulfate completely degrades over time, it creates more space for the new bone to be formed as the graft is converted to native bone. The graft porosity and its hygroscopic ability will allow seepage of the patients blood into the graft immediately following placement.

The product is supplied in an all-in-one dual-chamber pre-filled syringe containing the granulated powder in one chamber and physiological saline in the other chamber. Mixing the powder component with the liquid in the driver results in a viscous material those are suitable for injection into the graft site. Setting time is approximately 3-5 minutes. The material once mixed and injected into the site is moldable and hardens instantly in the presence of blood or saliva. It is recommended not to over-compress the material into the site as cement expansion may lead to patient discomfort. Following placement of the mixed material a piece of dry gauze is placed over the material at the treatment site and pressed firmly for 3 seconds to wick any residual liquid and to compact the cement. The flap is then closed with sutures.

Due to the grafts properties use of a membrane is not required as long as primary closure can be achieved. Leaving the material exposed will result in material volume loss decreasing the clinical results desired. But, a gap of 1-3 mm is not an issue as soft tissue will migrate rapidly over it and the gap will close in a few days. Use of a membrane recommended in large defects in which soft tissue stabilization cannot be ensured or in socket preservation procedure when a flap was not reflected and the material is completely exposed to the oral environment. In those cases, a protective barrier is required over the graft to prevent volume loss.

Bond Apatite® may be used in a wide variety of osseous defects, including medium and large size defects such as dehiscence, fenestration cases, periodontal bone defects, extraction socket augmentation, filling of bony defects pre-implant placement, or simultaneously with implant placement, filling a void post cyst removal, and ridge augmentations.

3-D Bond™ graft material is graft binder cement made of pure biphasic calcium sulphate. It is available in a syringe and following mixing with a liquid is directly injected into the site or can be mixed with other graft materials as a binder or as a barrier membrane over other materials. This graft was developed for smaller applications (socket augmentation) that have some bony wall support.

Radiographically, the appearance is completely different compared to other graft materials which appear radiopaque to their constant presence in the grafted site. Initially BA and 3-D Bond appears radiopaque, gradually a radiolucent appearance takes place reflecting the graft transformation into new formed osteoid before its calcification and integration with the surrounding bone becomes evident. After 4-8 weeks the majority of the grafted site will appear radiolucent while spots remain reflecting the presence of the HA particles. Within 12-16 weeks radiopacity comparable to adjacent native bone takes place with the appearance of a natural trabecular form. New osteoid has already calcified.

Clinical Case Series

Case 1

A female spayed 7 year old Basset Hound presented with a complicated crown fracture of the left maxillary fourth pre-molar (#208). A full thickness mucoperiosteal flap was elevated. The fractured tooth was sectioned and extracted. Following site debridement, bone cement, Bond Apatite (a) was prepared in its pre-mixed syringe and delivered to the extraction site. Primary closure was achieved and sutures placed.

Results

At 8 weeks post-surgery, the tissue had completely healed with maintenance of the alveolar ridge. The bone cement has completely filled the empty sockets and re-established the alveolar crest contours (Figures 1-3).

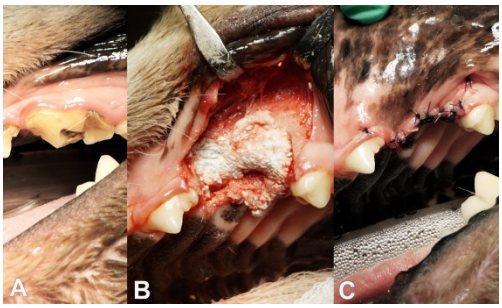

Figure 1: Complicated crown fracture of the left maxillary fourth pre-molar (#208) (A), molded the bone cement in the prepared site to achieve normal anatomical contours to the ridge (B), primary closure and placement of sutures (C).

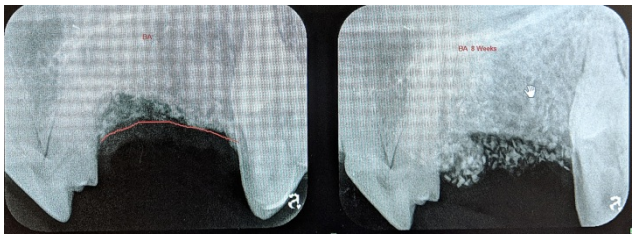

Figure 2: Radiograph of the graft placed to rebuild the maxillary defect at the time of surgery (Left) 8 week radiograph demonstrating a radiolucent appearance reflecting the graft transformation into new formed osteoid before its calcification (Right).

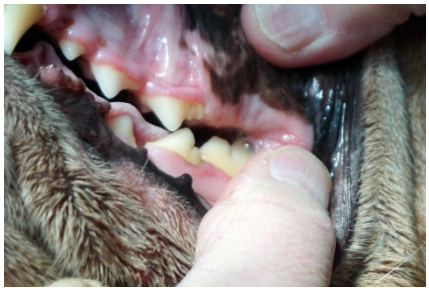

Figure 3: Completely healed thick keratinized gingiva at 8 weeks post grafting and maintenance of the ridge contour.

Case 2

A male neutered 6 year old feline domestic long hair (DLH) presented with a non-restorable left maxillary canine fracture (#204) that was extracted and prepped for an immediate implant placement. The surgical site was prepared following extraction with the Densah drill (b) compacting drilling bone protocol. Following implant placement a gap was noted between the implant and prepared site on the mesial and distal. Calcium sulphate with hydroxyapatite bone cement was utilized to fill the voids and to add to the crest to minimize resorption during the healing phase. Primary closure was achieved and the site closed with sutures.

Results

The 6 month re-entry to expose the implant to initiate the restorative phase confirmed soft and hard tissue health absent of any inflammatory reaction. The implant site demonstrated implant stability and ridge maintenance. There was no evidence of any graft particulate indicating complete conversion of graft to native bone. Radiograph confirmed complete osseointegration (Figures 4-6).

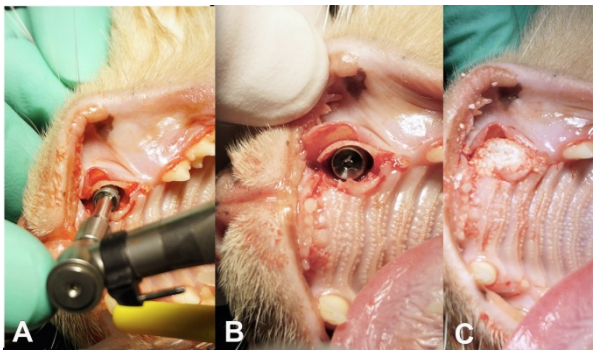

Figure 4: Surgical site demonstrating implant placement into the prepared osteotomy (A) notice the bony voids on mesial and distal following implant placement (B), placement of bone cement to fill the gaps and cover the implant prior to site closure (C).

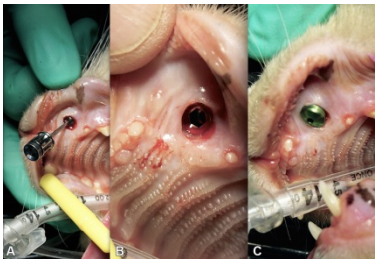

Figure 5: Re-entry of the site at 6 months to begin the restorative process of the implant (a), after the cover screw was removed, healthy tissue and excellent emergence profile was noted. (b) A healing abutment was placed into the uncovered implant to maintain the health tissue profile (c).

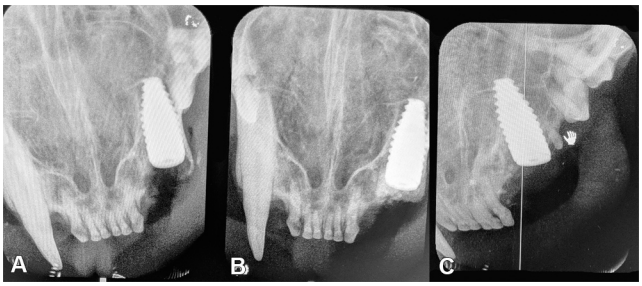

Figure 6: Radiographs of the implant immediately following placement and site grafting (A, B), radiograph at 6 months post implant placement demonstrating maintenance of the bone around the implant (C).

Case 3

A 2 year old male neutered Siberian Husky that was treated for facial edema at the left sub orbital area, and referred to our clinic for a complete oral examination and dental X-rays under general anesthetic. Marked inflammatory tissue was noted with two draining fistulas apical to the attached gingiva in the alveolar mucosa at the left maxillary fourth pre-molar (#208) site. (Figure 7 Left) Dental radiographs revealed a generalized radiolucency associated with the roots of fourth pre-molar, molar one, and molar two (208, 209, 210) (Figure 8). Also present was generalized osteolytic, sclerotic bone, and a generalized irregular trabecular pattern.

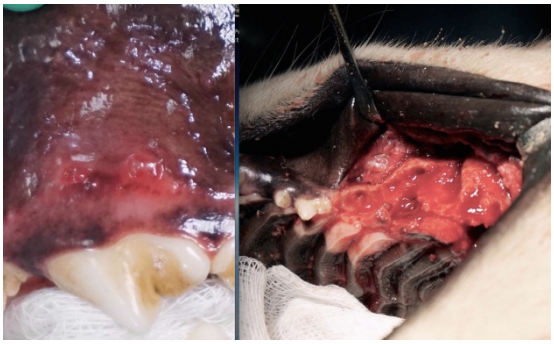

Figure 7: Draining fistulas at gingival and mucosal margin (Left), extraction sites with radical debridement (Right).

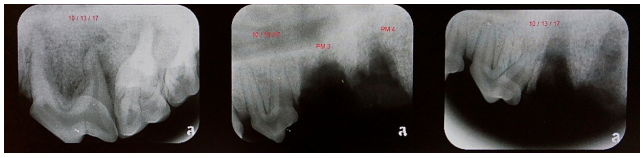

Figure 8: Initial radiographic presentation (Left), radiographic presentation immediately following surgical extractions and bone debridement (Middle and Right).

Treatment consisted of extraction of all the affected teeth and radical surgical debridement of the surgical extraction sites. Surgical debridement not only removes poorly vascularized infected bone, but also delivers well vascularized tissue to the affected bone facilitating the healing process and allowing antibiotics to reach the target areas. The surgical defect was filled with calcium sulphate (Bond Apatite). (Figure 9 Left) Tissue and bone samples were submitted for histopathological analysis which diagnosed osteomyelitis.

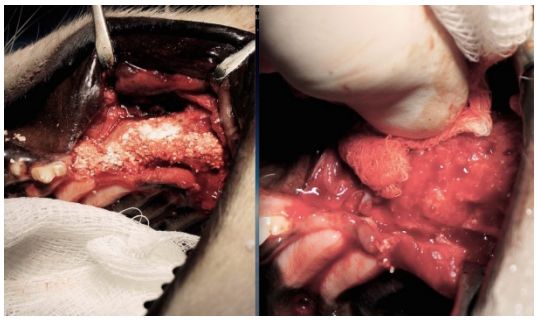

Figure 9: Bond Apatite graft to support the maxillary defect (Left), re-entry at 9 weeks (Right). Note the well vascularized remodeling bone.

Results

Surgical re-entry at 9 weeks demonstrated vascularized bone in the grafted defect restoring ridge contours and no evidence visually of the calcium sulphate placed at surgery (Figure 9 Right). Radiographs at 9 weeks demonstrated excellent graft and ridge maintenance and normal remodeling presentation of the calcium sulphate with HA placed at surgery (Figure 10). The surgical site at 6 months confirmed thick keratinized tissue and stability of ridge contours (Figure 11).

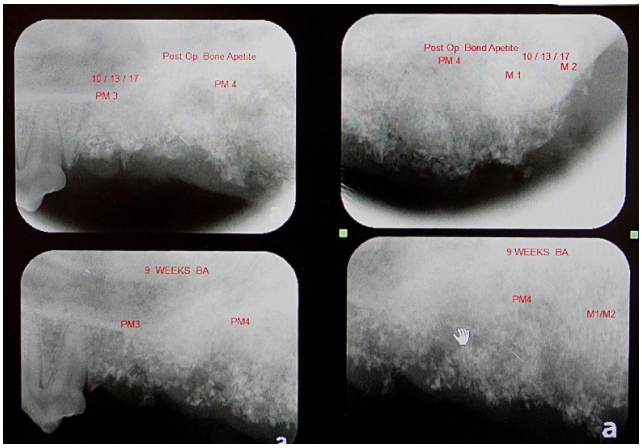

Figure 10: Immediately following Bond Apatite graft placement (Top) and radiographs 9 weeks post-op surgery (bottom).

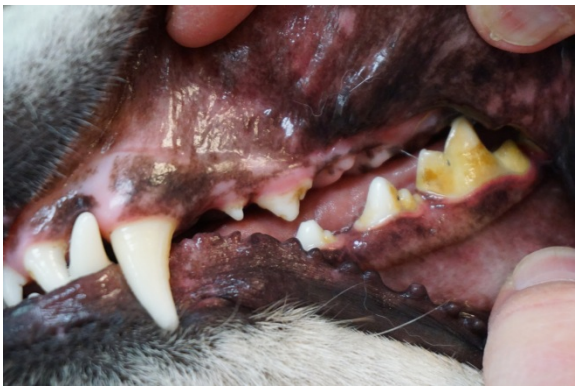

Figure 11: Surgical site 6 months post surgical demonstrating restoration of ridge contour with excellent soft tissue healing and minimal bone loss.

Discussion

Veterinary dentistry and oral surgery incorporates various biomaterials to augment extraction sockets and to rebuild extensive bony deficiencies. Current augmentation materials to enhance bone healing include; autogenous grafts, xenografts, allografts, synthetics, blocks of bone and putties. The cases presented demonstrate how bone cements are easy to use, minimally invasive, require less surgical time to place while gaining complete functionality.

Bond Apatite and 3-D bond are the next generation calcium sulphate bone grafting materials following the clinical track record of over 100 years of use as a graft material. The graft material is delivered with a self-contained self-mixing syringe injected directly into the surgical site. Bond Apatite is a slower resorbing material due to the

addition of HA granule matrix and idea for larger bone defects that require longer space maintenance during the regeneration process.

3-D Bond has complete resorption in 4 to10 weeks and is recommended when smaller bone deficiencies such as socket grafting with bony wall support is desired.

The clinical cases presented support the latest research data utilizing next generation bone cements (Bond Apatite and 3-D Bond). Radiographic appearance studies demonstrate the maintenance of the alveolar ridge and reconstruction of the normal bony anatomy of larger defects. Additionally, the cements are biocompatible while supporting development of keratinized gingival tissue with minimal inflammation.

Surgical grafting procedures are simplified using this protocol with healing periods are reduced to 12 weeks. Bone graft placement is reduced to place, press and close with primary soft tissue closure. In most cases no protective graft membrane is required. When primary closure is not achievable and the gap is greater then 1-3mm placement of a resorbable membrane is recommended to prevent volume loss during healing.

Conclusion

This case series demonstrates the clinical and biological advantage of the new Biphasic Calcium Sulfate bone graft substrate. Additionally the product exhibits ease of use, adaptability to the site, radiographic bone integrity and excellent support of keratinized tissue with no dimensional alterations [19].

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