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Case Report

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Osseous Veterinary Site Reconstruction Utilizing Autologous Dentin from Extracted Teeth

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Abstract

Following tooth extraction, significant changes of alveolar ridge contour results from alveolar bone loss. Most of the bone loss occurs during the first 3-4 months following extraction. To prevent this, it is strongly recommended to graft the extraction site with a biocompatible and bioactive osseous graft material at the time of extraction. There are many options available for socket grafting each with its own deficiencies. Most of the synthetic and allograft type bone substitutes preserve the alveolar ridge during the repair phase of the wound healing but subsequently resorb during the following remodeling phase and therefore only achieve partial ridge restoration. Xenografts, on the other hand, do not osseointegrate sufficiently and form "islands" of foreign body within the bone structure. Recently a novel procedure was developed where the extracted tooth is immediately processed as autologous graft that preserves the alveolar ridge for many years and is biocompatible to the host site in a highly predictable manner. The procedure also helps to keep treatment costs lower then prepackaged graft materials. Autologous graft particulate, made from the extracted tooth of the patient, undergo ankylosis with the newly formed bone i.e. One in which the exposed alveolar bony wall of the tooth extraction socket and particulate implants create a more natural biological union than other alternatives, hence providing an optimal and a more predictable short and long term clinical outcome.

Keywords: Smart dentin grinder; Autologous particulate dentin graft; Socket preservation; Tooth derived bone graft; Dentin graft; Autologous grafting

Introduction

The healing process of a tooth extraction site results in significant changes to the ridge contour that is the result of alveolar bone loss typically at a larger extent on the labial/buccal than on the lingual/palatal. This is mainly due to the relative osseous density differences [1]. The majority of this accelerated bone loss occurs during the first three months following tooth extraction and gradually slows down over the ensuing months. Bone resorption of such nature may lead to a reduction of as much as 50% in the width of the alveolar ridge within 12 months [2]. Moreover, hard tissue loss due to remodeling continues for many years although at a slower pace. The labial bone wall thickness has been identified as the most critical factor influencing bone resorption. This becomes more critical in the frontal and premolar area of the jaw where typically a thin buccal lamella is present. It is reasonable to assume that resorption of buccal plates of the alveolar ridge is greater since most of this bone is formed during tooth eruption and has a lower density then bone located on the lingual aspect.

Significant changes of the ridge contour, including the soft (mucosal) tissues, are a major cause of esthetic and functional deficiencies. In addition, using dental implants for prosthetic reconstruction will often not be possible due to such deficient alveolar ridge anatomy. There is sufficient compelling evidence that immediate grafting of extraction sockets by various ridge preservation techniques, including the placement of graft materials and/or the use of occlusive membranes, limits or even prevents alveolar bone loss during the repair phase of wound healing [3]. Socket restoration techniques for ridge preservation utilizing different biomaterials and/or barrier membranes often result in better maintenance of tissue volume. Still, the inevitable biological process of post-extraction bone resorption and bone remodeling cannot be stopped due to lack of internal loading within the bone that is transmitted by occlusal loading on teeth or implants that aid in bone maintenance [4]. The best results in minimizing resorption in such cases have been demonstrated by using autologous dentin grafts that interact differently than non-autologous grafts [5,6].

Tooth dentin and cementum, being similar in their mineral and protein composition to membranous bone, are inductive to osteogenic cells by directly depositing new bone matrix on their surfaces resulting in ankylosed dentin-bone interfaces. Such ankylosed interface occurs when avulsed teeth are re-implanted back into their sockets[7-9] or when extracted teeth are processed immediately after being extracted into a particulate dentin graft that is inserted into the freshly extracted socket in the same patient [5,6].

The alveolar bone, during its initial healing phase, reacts more favorably to an ankylosis process than it would to osseointegration only. Recent clinical results show optimal alveolar ridge contour preservation over five years post-surgical follow up when decoronation of ankylosed teeth is performed [10,11]. In a recent study, a series of cases reported a technique in which the extraction socket was restored with autologous, particulated mineralized dentin that was placed immediately after tooth extraction [5,12,13]. In all cases, patients exhibited a stable volume of soft and hard tissues and good osseointegration of titanium implants that were placed in this augmented socket [5,12]. Here in, we describe the efficacy and safety of this technique using the Smart Dentin Grinder (SDG) (KometaBio, Cresskill, NJ) procedure for ridge preservation after extraction of teeth in canine patients.

Adopting an effective protocol for preservation of alveolar ridge is not only important for implant supported prosthesis, but also imperative in order to restore surgically produced defects that may result from removal of impacted teeth or support dehiscent root surfaces of periodontally involved teeth. Since every tooth extraction induces loss of alveolar bone, it is indicated to process the extracted

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tooth into a particulate graft whenever possible in order to preserve the alveolar bone by filling the tooth extraction socket.

The Clinical Procedure

Procedure safety

The SDG procedure (Smart Dentin Grinder™) (Figure 1) was developed by the KometaBio company and is indicated for the same patient's teeth (Dog/Cat) to be used at time of extraction. The extracted tooth is usually covered with a biofilm of bacteria, toxins and soft tissue such as periodontal ligament on its root surfaces. Following extraction, all foreign materials, should be thoroughly removed using a diamond bur in a hand piece. (a) Also, removal of the organic coat of the root surfaces, periodontal ligament bacterial biofilm by "shaving the surfaces of the extracted tooth or teeth is easily achieved by the use of the carbide bur (Figure 2).

Figure 1: Smart Dentin Grinder™ unit (KometaBio).

Figure 2: Stripping the cementum and PDL from the extracted tooth with a dental handpiece and bur.

At the end of this phase (2 minutes) a very clean surface of tooth structure that consists of dentin is achieved. A thin layer of cementum is usually removed and most of the enamel is stripped from the extracted tooth along with any carious tooth structure (Figure 3). Before placing teeth into the sterile grinder chamber they should be thoroughly dried with the air syringe. The grinding and sorting process into specific particulate size takes approximately 1minute. The grinding of the tooth/ teeth takes 3 seconds and vibration for sorting of the ground particles takes 20 seconds. More than 90% of the particulate accumulates in the special 'chamber drawer' that contains particulate of the size of 300-1200 um, the optimal size for achieving an osteogenic interaction at the grafted site. It is noted that the particulate volume will be about 2-3 times more than the volume of the tooth prior to grinding (Figure 4). Next, the particulate is poured into a sterile small glass container and a chemical cleanser consisting of 0.5M NaOH and 20% ethanol is poured in to cover the particulate. Some gentle shaking helps the cleanser solution to wet the particles and penetrate into the dentin tubules. It is important to note, that the cleanser is very effective in dissolving all organic materials, like bacteria, endotoxins and viruses on the particle surface as well as within the dentinal tubules.

Figure 3: Prepared extracted teeth following stripping of cementum from the roots (Left) and inserted into the Smart Dentin Grinder ready to start processing (Right).

Following immersion in the cleanser for 10 minutes, the cleanser is decanted by absorbing the liquid with sterile gauze. A PBS (Phosphate Buffer Saline) solution (b) is poured into the dish and agitated for 3 minutes with gentle shaking. The PBS washes out the remaining cleanser, adjusting the pH back to physiological pH of 7.2. Those treatment times are optimized to achieve complete removal of all organic substances from the particulate surfaces. Next, the PBS is absorbed into sterile gauze and the slightly wet particulate is ready to be grafted (Figure 5). At this stage it is possible that a few bacteria may survive the cleansing procedure, however, these bacteria are the patient's own bacteria. The patient's normal oral bacterial environment is normally protective for the patient. The dentist should be aware the bacterial biofilm that is concentrated in the gingival crevice can produce growth of an anaerobic bacterial environment.

Figure 4: Extracted teeth processed in the Smart Dentin Grinder.

Figure 5: Processed extracted teeth following rehydration demonstrating an increase in volume compared to the dry processed teeth.

Procedure effectiveness

Dentin, cementum and membranous bones (mandible and maxilla) develop from unique embryonic neural crest cell populations. Therefore dentin and membranous bone consists of similar molecular cues and structures. Both of these collagenous tissues are impregnated by hydroxyapatite mineral (HA) that is deposited on and between type I collagen molecules, inside fibers as well as extra fibrillar HA, surrounding these collagen fibers. In addition, the non-collagen fraction of glycoproteins, although being only a small fraction of the matrix volume, is vastly important in regulating mineralization, attraction of osteoprogenitor cells and inductive molecules like BMP.

This makes the matrix very bioactive and most importantly initiating regeneration of bone or repair of cementum and dentin. It is evident that teeth that are extracted by injury, also called avulsed teeth, when re-implanted into their sockets or transplanted teeth, undergo either partial or total ankyloses and may function for many years. Root ankylosis is a biological repair process where the root cementum and dentin surfaces are an attractant to osteogenic cells that attach to root surface through an integrin-RGD covalent biological attachment. Wherein the dentin and cementum matrices are instructing local cells to differentiate into active osteoblast that secrete mineralized matrix directly on dentin and cementum surfaces. This creates an ankylosis interface which cements the newly formed bone to the dentin surface. At the remodeling phase the osteoclasts are unable to distinguish between bone and dentin matrices as both have a similar embryological origin [14].

Extracted teeth that are processed as described above are inductive to the osteogenic environment in the fresh socket and therefore new bone is deposited directly on the dentin particulate surfaces, leading to an ankylosed interface between the new bone and dentin particles. This process creates hard tissues (bone-dentin) connectivity that restores the alveolar ridge and preserves it for many years.

Clinical practicality

The resulting graft material has been shown to produce highly predictable results in animal and human patients over the long-term. The procedure of creating the graft material is not time consuming and only requiring approximately 15 minutes to prepare and processing the extracted teeth. Additionally, treatment costs are minimized versus using packaged osseous graft materials. Typically healing time is also reduced due to the autologous nature of the graft which allows the clinician to complete the restorative and prosthetic procedure faster.

Clinical cases

Extraction of teeth is an everyday practice of veterinary clinicians with most teeth extracted because of advanced bone loss due to prior periodontal disease. In most cases root volume is sufficient to convert into particulate material as dentin recovered from the roots by the SDG procedure will result in 2-3 times the volume of the roots utilized.

Case 1

Two year old F/S Welsh Corgi presented with need for an extraction of a compromised fractured #208 and immediate grafting with autologous dentin prepared from that root.

Results

Bone-Dentin tissue formed from autologous graft of dentin root particulate demonstrated a high stability of the site and ridge at 12 weeks (Figures 6 and 7).

Figure 6: Buccal plate sub-gingival fracture (L), Dentin particulate graft placed in prepared site (C), Site closed with sutures to get primary closure (R).

Figure 7: Extraction site (L), Dentin graft placed (C), 3 month postoperative follow-up (R).

Case 2

Twelve year old F/S GS mix requiring multiple surgical extractions of #s 404;208 with site debridement and dentine autologous graft to augment and support the large maxillary and mandibular defects.

Results

Grafting of autogenous-bone regenerated the normal bony anatomy with dentin autologous particulate supporting exceptional tissue maintenance (Figures 8-12).

Figure 8: Surgical site development #404 (A), dentin autologous graft placed (B), primary closure of the site (C) and tissue maturation at 3 months post-surgery (D).

Figure 9: Radiograph of #404 post extraction site (top L), 4 weeks post dentin grafting (top R) and 3 months follow up demonstrating solid bone-dentin remodeling (bottom).

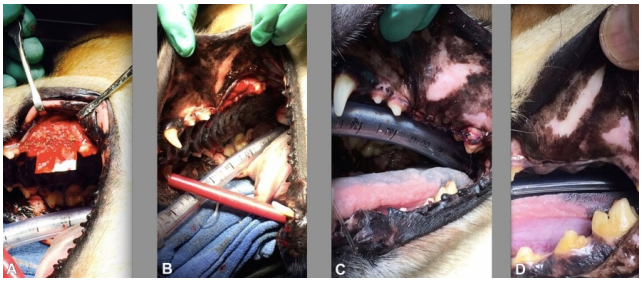

Figure 10: (A) Extraction site #208 and dentin grafting (B) Primary closure (C) Follow up for suture removal and (D) 12 week follow-up demonstrating healing with tissue maintenance.

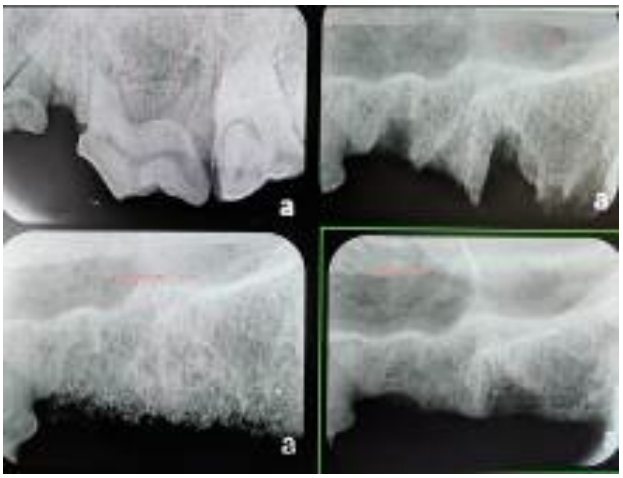

Figure 11: Sequential radiographs of #208 pre extraction (Top Left), post extraction (Top Right), dentin graft placement (Bottom L) and 3 month follow-up (Bottom R).

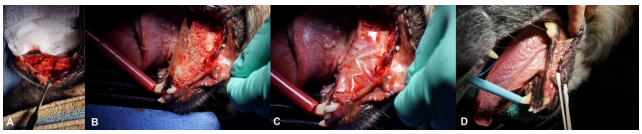

Figure 12: (A) Hemi-mandible surgical site with affected teeth extracted and necrotic bone and tissue debridement (B) Dentin graft filling the defect (C) Protective membrane placed and (D) Site closed with sutures.

Case 3

Twelve year old F/S Husky with advanced periodontal disease and osteomyelitis (confirmed by Histo). Treatment included surgical extraction of the affected teeth and removal of infected and necrotic tissue and bone as well as appropriate antibiotic treatment. Conventional surgical debridement not only removes poorly vascularized (infected) bone but also brings well vascularized tissue to affected bone facilitating the healing process and allowing antibiotics

to reach the target areas. Dentin particulate was placed, filling the entire defect and a BioXclude membrane (Snoasis Medical, Golden, CO) was utilized to provide graft stability and space maintenance needed to obtain ideal bone production.

Results

Serial radiographic study and clinical presentation displaying predictable and exceptional bone-dentin complex maturation and healthy oral mucosa (Figures 13 and 14).

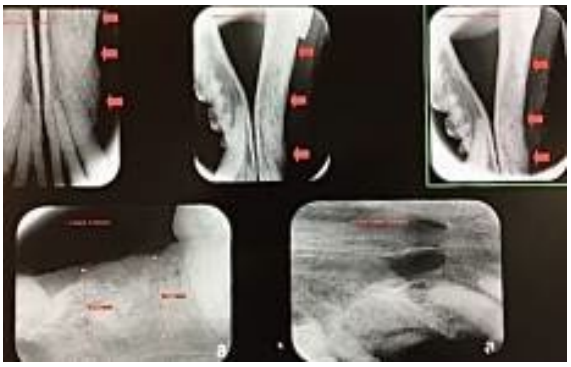

Figure 13: Mandible restored to normal form and function at 9 weeks with demonstrating bone remodeling (Top 3), mandibular buccal view with increased vertical height development and ridge maintenance (Bottom Left) and maxillary Canine (#104) with bone fill at 9 weeks following dentin graft (Bottom Right).

Figure 14: Palatal defect demonstrating necrosis of the hard palate (Left) and buccal fenestration (Right).

Case 4

Eleven year old M/N Akita with a mandibular disto-occlusion (MAL 2) with severe palatal trauma resulting in communication between the oral cavity and the nasal sinus. Substantial loss of palatal bone was secondary to bone necrosis.

Results

Treatment included multiple surgical extractions with debridement and excision of the necrotic palatal bone and tissue. Extracted teeth were cleaned and ground into autologous particulate graft. A Canine Cortical Strut (Calvaria) was prepared and stabilized with 2.0 mm cortical self-tapping screws to rebuild the lost palatal bone. Ossiflex bone membrane Veterinary Transplant Services, Kent, WA) was utilized to close the oral nasal connection. Dentine graft filled the entire maxillary defect. Fascial Lata membrane covered the reconstructed site before primary closure was completed (Figures 15-19).

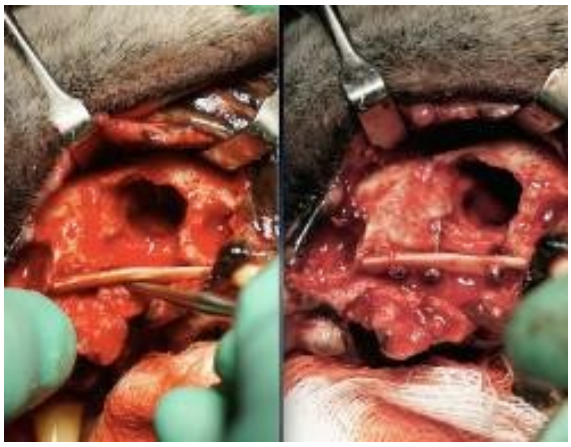

Figure 15: Cortical-cancellous strut stabilized with 3 cortical self-tapping screws. The strut will replace the lost necrotic hard palate and support the dentin particulate graft.

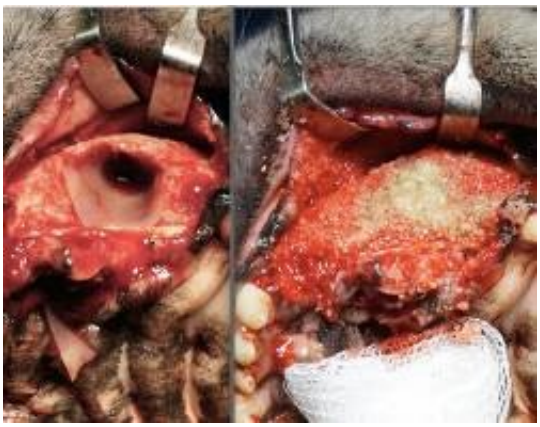

Figure 16: Ossiflex bone membrane "snow cone" shaped and placed into the oral-nasal communication to plug the defect (Left) and dentin graft placed to fill the entire defect (Right).

Figure 17: Fascia Lata membrane placed to support the soft tissue and protect the grafted site (Left) with final closure with mattress and interrupted suture patterns to establish a tension free flap (Right).

Figure 18: 12 Week post-op of the healed site.

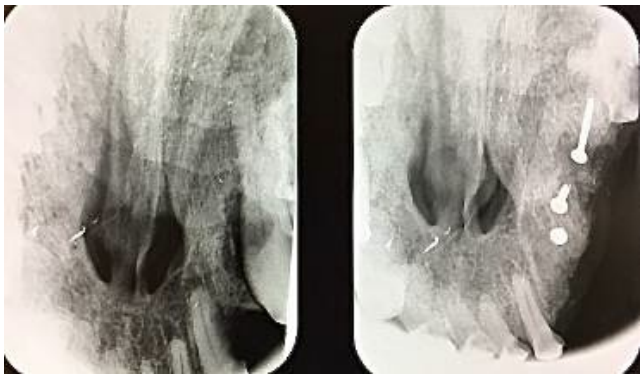

Figure 19: Radiographs demonstrating pre-surgical presentation (Left) and 12 weeks post healing with bone-dentin grafting, showing ridge maintenance (Right).

Discussion

The use of scaffolds for preserving or reconstructing the alveolar ridge or deficient site has become a frequent surgical procedure. Bone grafts usually undergo extensive remodeling and resorption during the first year after surgery. Unfortunately this does not allow woven bone sufficient time to mature into lamellar bone and therefore immature bone will quickly resorb following scaffold resorption. This may affect the feasibility of an effective rehabilitation. Some authors have suggested that graft resorption rate may be dependent on their embryologic origin, since grafts from membranous bone (i.e. calvarial or mandibular grafts) do not resorb as extensively as those from endochondral bone (as iliac crest bone grafts). Bone graft density may also be associated with their resorption, as it has been shown that high density grafts undergo a slower and lower resorption than low density grafts. It seems therefore, that autologous-dentin like membranous bones are optimal for long standing preservation of augmented alveolar bone ridge. Autologous dentin and cementum undergo ankylosis when re-implanted into the extraction socket. During the healing process the dental particulate graft will be invaded and incorporated into a filigree of osseous repair tissue in the alveolar socket. Remodeling of this conglomerate will slowly occur while the graft provides a strong mechanical scaffold for the former extraction defection the dental arcade and mandible. During the dog's lifetime some of the dentine particulate will continue to be present in remodeled cancellous bone that has filled the alveolar socket.

Clinical studies of follow-up cases of re-implanted avulsed teeth or auto transplanted teeth from one site into surgically prepared sockets showed an immediate cellular interaction with dentin or cementum root surfaces that results by cellular biologic attachment to their surfaces, differentiation into osteoblasts and deposition of mineralized matrix directly on to dentin or cementum. This biological attachment is termed an ankylosis. It is important to note that such biologic interface between dentin or cementum mineralized matrices and the newly deposited mineralized bone matrix is creating a functional biological connectivity that allows remodeling of all mineralized tissue. Although, root resorption takes place in a very slow pace, it is replaced by newly formed bone, thus preserving the alveolar ridge.

Malmgren and others have suggested to remove the coronal portion of ankylosed teeth in order to preserve the alveolar ridge [10]. This concept of biological ankylosis of teeth is one the same as what happens to autologous tooth particulate when the tooth undergoes an SDG process and then re-implanted back into the extraction site and/or used for grafting alveolar bone defects and deficiencies. A recent study from Zurich University [12] that used the same concept of grafting of particulate mineralized dentin found it safe and effective in preserving the alveolar ridge.

Conclusion

The extracted tooth in most cases being the patient's own tissue can be transformed immediately into an osseous graft that will preserve the alveolar ridge and restore oral bony deficiencies form and function. This protocol may be utilized instead of synthetic, allograft or xenograft osseous graft materials with better predictable long-term results and lower treatment costs associated with use of these packaged graft materials.

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