Alveolar ridge preservation: Particulate dentin of extracted teeth are optimal for immediate grafting of extracted site

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Conflict of interest: IB is co founder of SDG procedure and has interest in Kometabio inc.

Abstract:
The healing process of a tooth extraction site results in significant changes of alveolar ridge contour caused by alveolar bone loss, most of it, during 3-4 months after extraction. It is therefore strongly indicated to graft the extracted site with biocompatible or bioactive bone grafts. Most of the synthetic allogeneic and xenografts preserve the alveolar ridge during the repair phase and then it resorbs during the remodeling phase, thus, achieving only a partial ridge restoration. In recent years, a novel procedure was developed where the extracted tooth is transformed into immediate graft that preserves best the alveolar ridge for many years. This happens because the autologous dentin undergoes ankyloses with newly formed bone thatis biologically connected to the host bone this way restoring a functional connectivity between host bone and dentin particles.

INTRODUCTION:

The healing process of a tooth extraction site results in significant changes of alveolar ridge contour caused by alveolar bone loss, significantly greater on the buccal aspect than on the lingual or palatal (Pietrokovski and Massler, 1967). It seems therefore, that an accelerated bone loss takes place during the first three months after tooth extraction, ensuing in reduction of 50% of the width of alveolar ridge within 12 months (Schropp et al., 2003). Moreover, tissues loss due to remodeling continues for many years although in a slower pace. The labial bone wall thickness has been identified as the most critical factor influencing bone resorption, especially it is critical in the frontal and premolar area of the jaw, in the region of the thin buccal lamella. It is reasonable to assume that the greater resorption of the buccal plates of alveolar ridge proceeds since most of this bone is formed during tooth eruption.

The rapid significant changes of the ridge contour including the soft mucosal tissues are key in determining the esthetic and functional deficiencies. Also, prosthetic reconstruction using dental implants will often not be possible, because of deficient alveolar ridge. There is sufficient compelling evidence that immediate grafting of the extraction sockets by various ridge preservation techniques including the placement of graft materials and/or the use of occlusive membranes prevents alveolar bone loss at the repair phase of wound healing (Horowitz et al., 2012; Nevins et al., 2006). Socket preservation techniques for ridge preservation utilizing different biomaterials and/or barrier membranes often result in better maintenance of tissue volumes, although the inevitable biological process of post-extraction bone resorption and bone remodeling cannot be stopped (Chappuis et al., 2017). We have shown that the best results in minimizing resorption in such cases can be achieved using autologous dentin grafts that interact differently than non-autologous grafts (Binderman et al., 2014; Kosinski, 2017).

In fact, tooth dentin and cementum, being similar in their mineral and protein composition to membranous bone, are instructive to osteogenic cells by directly depositing new bone matrix on their surfaces resulting in ankylosed dentin-bone interfaces. Such ankylosed interface happens when avulsed teeth are re-implanted back into their sockets (Andersson et al., 1984; Andersson, 2010; Andreasen and Raven, 1972) or when extracted teeth are processed immediately after being extracted into a particulate dentin graft that is inserted into freshly extracted socket, in same patient (Binderman, et al., 2014; Kosinski, 2017; Valdec et al., 2017).

The alveolar bone, during its initial healing phase will react a lot better to the ankyloses process than it would to osseointegration only. Recent clinical results show optimal alveolar ridge contour preservation of over 5 years post-surgery when de-coronation of ankylosed teeth is

performed (Malmgren, 2013; Filippi et al., 2001). In a recent study, a case series was reported where a technique in which the extraction socket was augmented with autologous, particulated mineralized dentin that was placed immediately after tooth extraction (Valdec et al., 2017; Schwarz et al., 2016; Binderman et al., 2014). In all cases, patients exhibited a stable volume of soft and hard tissues and good osseointegration of titanium implants, having been placed in this augmented socket (Valdec et al., 2017; Binderman et al., 2014). Here, we describe the efficacy and safety of the Smart Dentin Grinder (SDG) procedure for ridge preservation after extraction of teeth. Preservation of alveolar ridge effectiveness is not only important for implant supported prosthesis, but also to restore or augment surgically produced defects, like of impacted teeth or support dehiscent root surfaces of periodontally involved teeth. In fact, since every tooth extraction induces loss of alveolar bone, it is indicated to process the extracted tooth into a particulate graft whenever possible, in order to preserve the alveolar bone.

THE CLINICAL PROCEDURE:

(a) Why the SDG is a safe procedure?

The SDG procedure (Smart Dentin GrinderTM) that was developed by Kometabio company is indicated only for the same patient's teeth. The extracted tooth is usually covered with a biofilm of bacteria, toxins and soft tissue such as periodontal ligament on its root surfaces. In addition, the tooth crown in many instances contains foreign materials such as cements, filling materials and metal based ceramic crowns. In many treated teeth root canals are filled with Gutta Percha and cementing materials. In some cases the root canal is infected by bacteria. After extraction, all the foreign materials, polymeric, cements, metallic, ceramic and root canal filling should be thoroughly removed using a bur, drill or piezo knifes. This will usually take a minute or two and is performed by the dentist or his auxiliary. At the same time, the 'shaving' of the organic coat of the root surfaces that includes the periodontal ligament tissue and the bacterial biofilm is easily removed by a tungsten carbide burr, drill and water.

At the end of this phase (2 minutes) we achieve a very clean surface of tooth structure that consists of of dentin. At this phase the thin layer of cementum is usually removed and most of the enamel. Before placing the teeth into the sterile grinder chamber they should be thoroughly dried by air flow syringe. The grinding and sorting process into specific particulate usually takes 1minute. The grinding of the tooth takes 3 seconds and vibration for sorting of the ground particles takes 20 seconds. More than 90% of the particulate accumulates in special 'chamber drawer' that contains particulate 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. In the next step, the particulate is poured into a sterile small glass container. A chemical cleanser that consists of 0.5M NaOH and 20% ethanol is poured in to cover the particulate. Some gentle shaking will help 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, virues and more even inside the tubules.

After 10 minutes the cleanser is decanted by absorbing the liquid onto a sterile gauze. The PBS solution which is Phosphate Buffer Saline is poured into the dish for 3 minutes with gentle shaking. The PBS will wash out the remanences of the cleanser and will lower the pH back to physiological pH of 7.2. Those treatment times were optimized to achieve complete removal of all organic substances from the particulate surfaces. Now, the PBS is absorbed into a sterile gauze and the slightly wet particulate is ready to be grafted. At this point it is possible that few bacteria can survive the cleansing procedure, however, these bacteria are the patient's bacteria. It is today common knowledge that the oral bacterial environment is normally protective for the patient. The dentist should be aware about the bacterial biofilm that is concentrated in the gingival crevice and produce growth of anaerobic bacterial environment.

(b) Why SDG is an effective procedure?

Dentin, cementum and membranous bones (mandible and maxilla) develop from a unique embryonic neural crest cell populations. It is therefore inevitable that dentin and membranous bone consists of similar molecular cues and structures.

These tissues consist of hydroxyapatite mineral (HA) that is deposited on and between type I collagen molecules, inside fibers as well as extrafibrillar HA, surrounding these collagen fibers. In addition, the non collagen fraction of glycoproteins, although being only a small fraction of the matrix volume, are vastly important in regulating mineralization, attraction of osteoprogenitor cells and instructive molecules like BMP.

These make this matrix very bioactive and most important in initiating regeneration of bone or repair of cementum and dentin. Interestingly, the mineral of adult dentin and bone matrix is protecting the organic molecular structures from being invaded by macromolecules and bacteria. 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.

The root ankyloses is a biological repair process where the root cementum and dentin surfaces are attractant to osteogenic cells that attach to root surface through integrin-RGD covalent biological attachment.

Then, the dentin and cementum matrices are instructing local cells to differentiate into active osteoblasts that secrete mineralized matrix directly on dentin and cementum surfaces. This creates an ankyloses interface which cements the newly formed bone to dentin surface. At the remodeling phase the osteoclasts do not distinguish between bone and dentin matrices because dentin and bone have same embryonal origin.

It is evident that extracted teeth that are processed as described above are instructive to the osteogenic environment in the fresh socket and therefore new bone is deposited directly on the dentin particulate surfaces, leading to ankylosed interfaces between new bone and dentin particles. In fact, this process creates hard tissues (bone-dentin) connectivity that restores the alveolar ridge and preserves it for many years.

(C) Clinical cases:

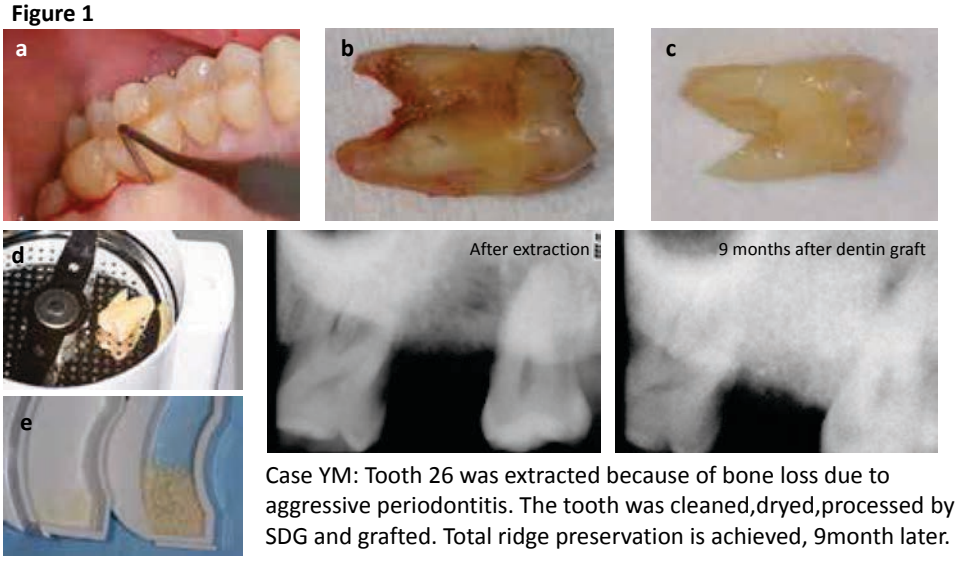
Extraction of teeth is an everyday practice of every general practitioner dentist. One third of teeth are extracted because of advancement of bone loss due to periodontal diseases. Most of these teeth are without any prosthetic or endodontic treatments. However, majority of extractions are performed of teeth that are either root canal treated and have different prosthetic reconstruc-

tions. The prosthetic devices in the tooth crown should be cut out, usually by tungsten carbide. In many cases roots volume is enough to convert into particulate, since the particulate dentin recovered from the roots by SDG procedure will result in 2-3 times the volume of the roots. When teeth are endodontically treated, the dentist should evaluate whether after removing the root canal filling, he will be left with usefull amount of dentin graft. It should be noted that 10% of extractions consist of wisdom teeth. When impacted wisdom teeth or other are extracted it is a must to graft the large defects in order to restore the alveolar ridge. The SDG procedure does it best.

Here, we present everyday cases in general dental practice. Case YM **(Figure1)** is a young adult that his tooth 26 has a local progressive periodontal bone loss.

Figure 1 shows that the extracted tooth is a naïve tooth with no dental treatment. It shows that during 15-20 minutes, the dentist or his assistant is converting the extracted tooth into an autologous particulate that grafted the extraction site. On follow up, the bone ankylosed to dentin produces a very stable alveolar ridge that otherwise would be resorbed during 3-6 months after extraction. This grafted site preserves the alveolar ridge both functionally and esthetically. It can be utilized as a site for implant insertion after 3 month in the maxillary posterior region, changing it from D3 bone into D1 bone.

Figure 1

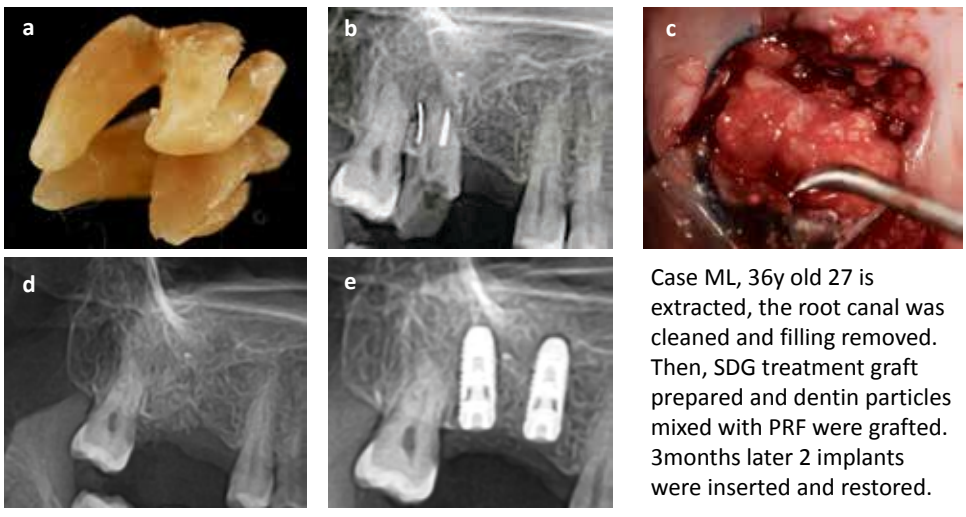


Case YM: Tooth 26 was extracted because of bone loss due to aggressive periodontitis. The tooth was cleaned,dryed,processed by SDG and grafted. Total ridge preservation is achieved, 9month later.

Figure 2 shows a case (ML) where a molar tooth with a root canal filling was extracted. In this case, the crown was discarded and the root canal filling was removed and the roots underwent the SDG procedure. In this case you will find that the extraction site and even some of the sinus (see **Figure 2e**, arrow) was filled with dentin graft. Here, two implants were inserted 3-4 month after grafting.

Also, in this case the dentin particulate was mixed with PRF before grafting, thus, producing a possibility of 'sticky bone' that could be molded into a geometry that fits the restoration of the ridge **(Figure2c)**.

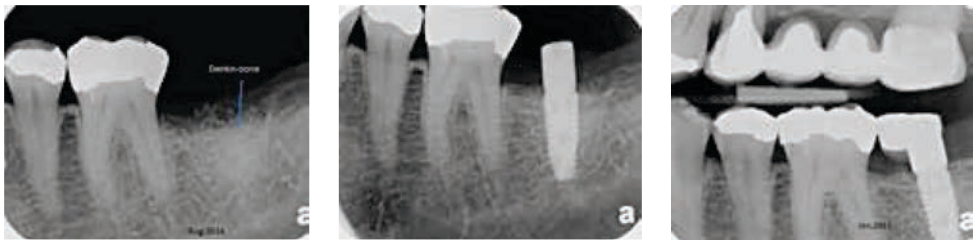
Figure 2



Case ML, 36y old 27 is extracted, the root canal was cleaned and filling removed. Then, SDG treatment graft prepared and dentin particles mixed with PRF were grafted. 3months later 2 implants were inserted and restored.

Figure 3 shows a simple case that shows that the extracted root was capable to preserve the alveolar ridge and build a solid bone-dentine structure that was adequate for implant-prosthetic restoration, after 2-3 months.

Figure 3

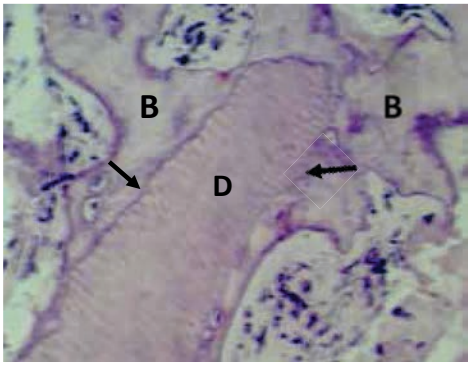


In fact, **Figure 4** shows an x-ray taken 4 years after grafting dentin particulate of a single molar and reconstructing with implants and prosthetic device. The bone level next to implants was perfectly stable.

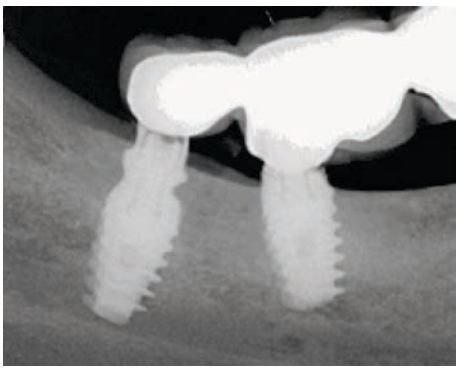
A bone biopsy taken before placing the implants shows most viable mineralized bone deposited directly on the dentine surface, termed as ankyloses.

This is achieved only by autologous dentin as was described before in re-implanting of avulsed teeth and autotransplantations.

Figure 4



Biopsy taken 2months after grafting just before implant insertion in the lower jaw. D = dentin particulate. B+ newly formed bone ankylosed to dentin. Arrows show ankyloses interface.



Four years after implant insertions and prosthetic reconstruction in dentin grafted socket augmentation by SDG procedure. No vertical resorption at implant interface.

DISCUSSION

The use of scaffolds for preserving or reconstructing the alveolar bone ridge became a frequent surgical procedure. Bone grafts usually undergo extensive remodeling and resorption during the first year after surgery, which may affect the feasibility of an effective rehabilitation. Some authors 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 lower resorption than low-density grafts. It seems therefore, that autogenic dentin like membranous bone are optimal for long standing preservation of augmented alveolar bone ridge. Autologous dentin and cementum undergo ankyloses when re-implanted back into the osteogenic socket.

Clinical studies of follow-up cases of re-implanted avulsed teeth or auto transplanted teeth from one site into surgical 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 onto dentin or cementum. This biological attachment is termed by clinicians as ankyloses. It is important to note that such biological interface be-

tween dentine or cementum mineralized matrices and the newly deposited mineralized bone matrix is creating a functional biological connectivity that allows remodeling of all mineralized tissue in most physiological pattern. 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 suggested to decoronate ankylosed teeth and this way to preserve the alveolar ridge. This concept of biological ankyloses happens when autologous extracted teeth are undergoing an SDG process and re-implanted back into extraction sites and/or are used for grafting alveolar bone defects, deficiency or in sinus augmentation procedures.

Also, recent clinical findings suggest that dentin grafts of extraction sockets in the esthetic zone preserves best the buccal plate. Recent study from Zurich university (Valdec et al., 2017) that used the same concept of grafting of particulate mineralized dentin found it safe and effective in preserving the alveolar ridge in the esthetic zone.

In conclusion, the extracted tooth is not anymore a medical waste, since in most cases it is the patient tissue that can be transformed immediately into a graft that will preserve the alveolar ridge and restore functionctional and esthetic reconstructive prosthesis.

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