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*Extracted teeth are not a biological waste anymore: they are processed and grafted back to preserve best the alveolar ridge.*

#### Key words:

tooth, biomaterial, graft, bone regeneration, bone biology

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Conflict of interest: IB is co-founder of KometaBio Inc. and developer of the SDG procedure.

#### Introduction:

Tooth extraction, although a difficult decision made by the dentist, is still a traumatic procedure for the patients and they are considered a biological waste. A loss of periodontal support, impacted third molars that trouble the patient and traumatized teeth are among the main reasons for extractions. But, when the extraction procedure is performed even with minimal trauma, ev-

#### Abstract

*Tooth extraction is one of the most widely performed procedures in dentistry, more than 4 million teeth are extracted each year in Poland alone, they are considered a clinical waste and therefore discarded. On the other hand, every dentist is educated to re-implant avulsed teeth into same extraction sockets. The resulting ankylosis of those teeth supports the notion that the fresh socket consists of a large population of osteogenic cells which are attracted by root cementum or dentin resulting in deposition of bone matrix directly on its root surface. Moreover, transplanted teeth in same patients and submerged roots are also undergoing ankyloses and preserve alveolar ridge. It is evident that ankylosed teeth undergo very slow remodeling by osteoclasts and in turn replaced by lamellar bone, thus best preserving the structure of the alveolar ridge. Based on these clinical experiences with ankylosed teeth we have developed a procedure geared for clinical setting that employs freshly extracted teeth, by recycling them into a bacteria-free particulate autogenous mineralized dentin for immediate grafting. A 'Smart Dentin Grinder'<sup>TM</sup> was devised to grind extracted teeth and sort them into a specific size dentin particulate. This novel procedure is indicated in each case where teeth are naïve such as wisdom teeth or decayed and treated that are extracted. The freshly extracted tooth, which is most similar to the structure of autologous cortical bone, offers the type of graft that is very effective to instigate new bone formation in the first stages of the wound healing but also support and maintain the site with strong scaffold characteristics for the long haul. Overall, the extracted tooth should no longer be viewed as waste and should not be discarded. The experiences from thousands of cases that utilize extracted teeth by using the SDG procedure which are undergoing a simple and quick preparation protocol are most effective in regenerating and preserving the esthetic and function of the alveolar ridge for many years. Moreover, the enhanced healing process and the inductive properties of dentin are responsible for the development of bone-dentin solid matrix that allows placement of implants 2-3 months after grafting.*

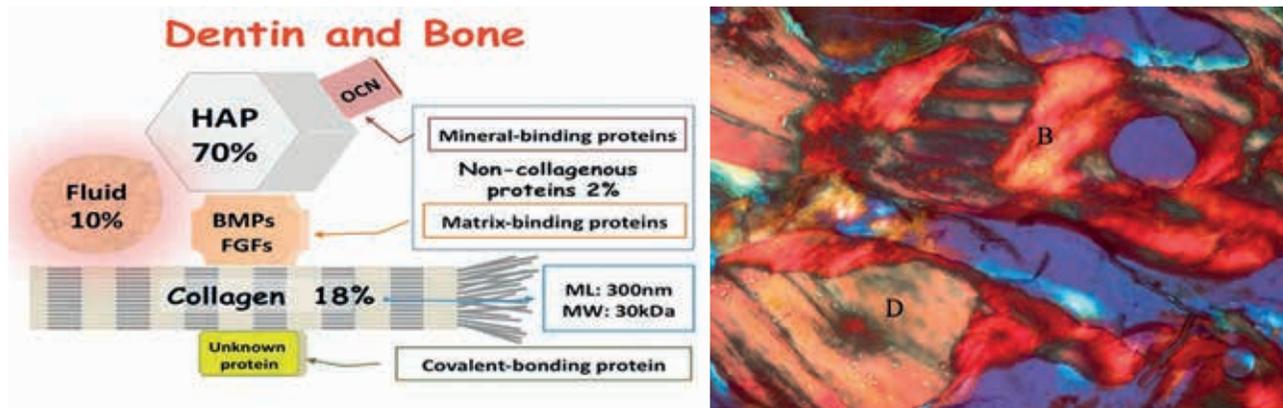


Fig. 1 The similar composition of bone and dentin matrix.

Fig. 2 Core biopsy of grafted dentin in extraction site. Dentin is yellowish-brown surrounded by newly formed lamellar bone (red-purple, B) ankylosed to dentin (D).

idently the buccal alveolar bundle bone loss and alveolar bone ridge remodeling will result in the deterioration of oral esthetics and function. After tooth extraction an accelerated bone loss takes place, ensuing in reduction of 50% of the width of alveolar ridge within 12 months [1]. In frontal and premolar areas where the buccal lamella is thin, the bone loss will lead to buccal bone loss and esthetic defect [2]. Moreover, soft tissue and bone loss due to remodeling continues during lifetime, although in a slower pace. It is reasonable to assume that the greater resorption of the buccal plates following tooth extraction proceeds because most of this alveolar bone is formed during the phase of teeth eruption. The significant changes of the ridge contour including the soft mucosal tissues becomes a major esthetic and functional restoration problem. In fact, a key prerequisite for esthetic outcomes of prosthetic restorations is when adequate three-dimensional (3D) osseous volume of the alveolar ridge, including an intact facial bone wall is of sufficient thickness and height. There is 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 reduces alveolar bone loss at the repair phase of wound healing [3-5]. Nevertheless, it does not prevent the gradual bone loss during the remodeling phase [6-7]. Most of the studies show that biocompatible and osteoconductive materials as well as gingival grafts preserve alveolar bone at the extraction site during the repair phase of wound healing, however, none can completely eliminate the problem because they tend to resorb before the remodeling of woven bone tissue ensues, resulting in less lamellar bone that has a negative impact on esthetics and is a critical causative factor for esthetic implant complications and failures [8,6]. For many years, submerged roots and teeth were documented as a clinical way to preserve the contour of alveolar ridge. Although, the roots were slowly resorbed, they were immediately replaced by lamellar bone, thus, preserving the bone contour at best. Recently, we have developed a unique procedure (SDG procedure) that is transforming the extracted tooth/teeth at chair side into a valuable bioactive tooth dentin particulate that is grafted immediately after their extraction that is best preserving the width and height of alveolar ridge for many years [8-12].

#### A. Why extracted teeth can be utilized as a graft of the extraction site at the same session?

Every dentist and dental student knows that the three mineralized structures that compose the tooth are mature enamel that is

purely hydroxyapatite (HA) without organic matrix while, dentin and cementum consist of organic matrix, mostly type I collagen and some most important non collagenous proteins embedded in HA mineral. From these mineralized tissues dentin volume is more than 85% of the tooth structure. Both dentin and cementum have a very high similarity in their organic and mineral components to membranous cortical bone, since developmentally they originate from the neural crest (Fig. 1). The soft tissues consist of the pulp chamber and remnants of periodontal ligaments (mostly Sharpey fibers) that are easily removed from the extracted teeth both by mechanical means and by dissolving them during preparation of the extracted tooth by a mild cleanser.

Evidently, the autogenic cortical membranous bone is best choice for grafting in an extraction site or augment bone deficiencies in order to achieve most stable alveolar ridge. Nevertheless, harvesting such cortical bone particles from same patient jaws or calvaria cadaver is considered an aggressive surgical procedure. The fact that the extracted tooth dentin mineralized matrix that is same as autogenic cortical bone makes it to be the preferred graft by the clinician. Upon extraction the tooth dentin is available while harvesting cortical bone from the jaw is scarce and needs an additional surgery to harvest it. In fact, it is obvious that avulsed teeth should be re-implanted because they are normally ankylosed (biologically cemented) to residual alveolar bone. It means that the re-implanted root is attracting osteogenic cells that will directly deposit bone on its surfaces (Fig. 2). Although, the roots may undergo slow resorption, it is replaced by new bone, thus, preserving the overall anatomical contour of the alveolar ridge [13-14]. Several clinicians showed that ankylosed roots left in the alveolar bone will preserve the alveolar ridge for many years [15-16]. For many years in the past extracted teeth from one site were implanted into another extraction site (auto transplant). In these cases transplants that underwent ankyloses functioned in similar fashion to re-implanted avulsed teeth [17-18]. Interestingly, a minor percent of failures was described during re-implantation of teeth, despite no measures of sterilization or chemical treatment of the tooth were used.

#### B. The innovative procedure for preparation of dentin graft from extracted teeth (SDG procedure):

Today, thousands of extracted teeth are undergoing cleaning, grinding into particulate and mild but effective cleansing procedure that dissolves the plaque that includes all bacteria, toxins and viruses and makes the tooth dentin particulate ready to

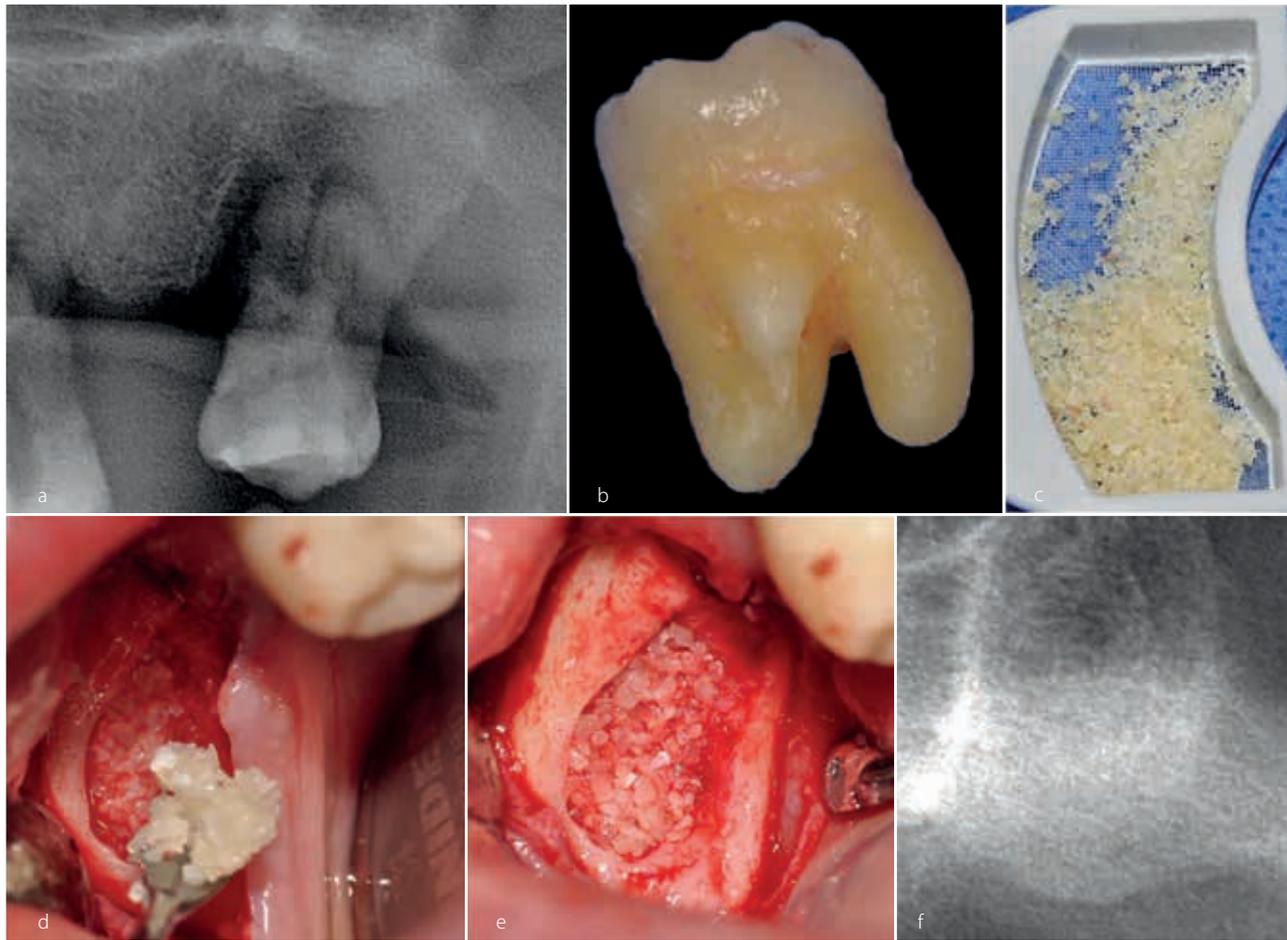


Fig. 3 From extracted tooth up to preserved alveolar ridge.

be grafted into the extraction site and any bone defects or sinus lifting. The SDG procedure takes no more than 15 minutes and makes the graft effective same as autogenic harvested cortical bone. Today, most of extracted teeth are either bacterially contaminated due to periodontal defects, contamination of the pulp or dentin and teeth that are treated by fillings and crowns. In addition, many of extracted teeth are root canal treated teeth. Every extracted tooth where reasonable residual dentin structure vol-

ume that is clean from any foreign materials is available can undergo the SDG procedure and become most effective graft of the extraction site and more. On contrary, impacted and non impacted third molars are virgin teeth that should be processed by the SDG procedure and immediately be grafted at the surgical site which is usually an increased surgical bone defect site. The important criteria is how much residual tooth dentin structure remains, enabling its grafting. Moreover, after thorough research we have



Fig. 4 Extracted teeth with caries and periodontal lesion transformed by SDG procedure into clean and bacteria free graft.

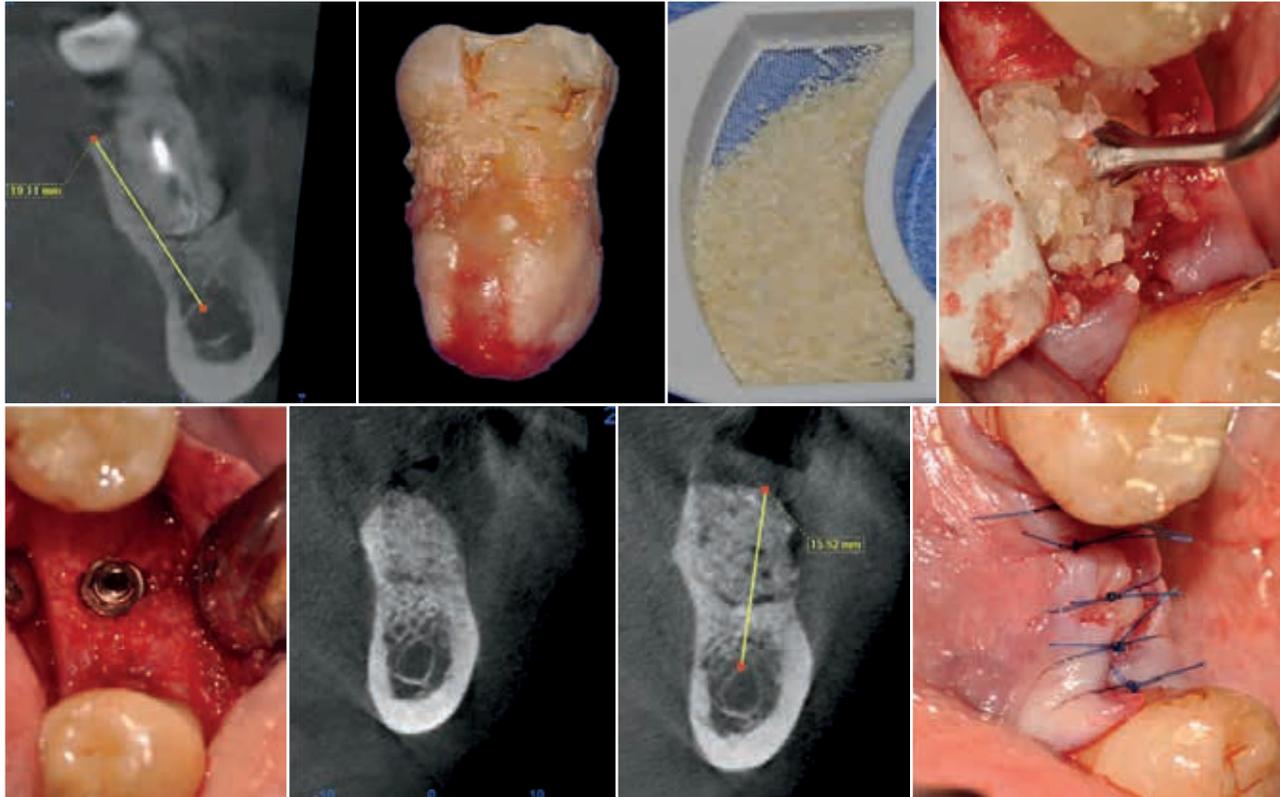


Fig. 5 A case where buccal plate was augmented dentin particulate from extracted molar and membrane of PRF. 4 month after grafting and implant was placed in solid bone-dentin matrix.

recently reduced dramatically the cleansing time process by using a micro ultrasonic cleansing device. It should be noted that since the tooth dentin particulate graft should be grafted in same patient (autogenic), even the survival of few bacteria that come from same patient are not pathogenic. Nevertheless, the patients mouth is never sterile. The vast experience with grafting of tooth dentin that is prepared by the SDG procedure protocol reveals enhanced healing and no complications with regard to bacterial contamination [8].

**C. Cases that present the high qualities of autogenic particulate dentin**

Fig. 3a presents a case where a molar had to be extracted because of periodontal lesions. The molar tooth was extracted and it had no treatments or caries (Fig. 3b). The molar tooth was cleaned, dried and ground by SDG grinder. The result was a more than 2ml of 250-1200 um particulate dentin that included enamel (HA) (Fig. 3c). After 10 minutes of treatment by cleanser and wash by phosphate buffered saline (PBS), the wet particles were placed into extraction site (Fig 3d). Previous to that the extraction site was eradicated of any granulation soft tissue to achieve bony walls of the socket. In this case only part of the particulate was utilized for grafting the extraction site, because particulate volume is 2-3 times the volume of the tooth. The rest was utilized to graft a bone crater. Three month later the bone (Fig. 3e) and the x-ray (Fig. 3e) revealed solid regenerated bone ankylosed to dentin particles, thus, allowing stable implant placement in the upper jaw.

Fig. 4 presents an example where two molar teeth with deteriorated tooth crowns and caries (Fig4b) were cleaned for 2-3 minutes, resulting in natural dentin color roots (Fig. 4c) that were processed by SDG into bacteria free dentin particulate for immediate grafting (Fig. 4d and e). The soft tissue was sutured with minimum tension (Fig. 4f). A temporary bridge was prepared in advance for esthetic reasons (Fig. 4g). This case is an example of

extracted teeth that usually are immediately put in waste. Not any more. Such teeth become 15 minutes after extraction the best autogenic grafting material, same as autogenic cortical membranous bone, that will preserve the esthetics and function of alveolar ridge for many years.

In the next case (Fig. 5) a molar was extracted where no buccal plate was present. The molar was processed by SDG procedure and the particulate was grafted to achieve regeneration of the buccal plate. Here, a membrane was utilized to protected the structure and volume of grafted particulate. In fact, after 3 month a wide and solid ridge was achieved where an implant was placed.

**In conclusion:**

The biological and clinical rationale of utilizing a procedure where shortly after extraction even infected teeth become a tooth dentin graft that is inducing deposition of lamellar bone directly on the grafted dentin particles has clinical advantages for the patients and for the dentist. Bone ankylosed to dentin particles is regenerating solid functional connectivity with surrounding structures and therefore is preserving the alveolar ridge, both its width and height, thus, enabling most esthetic and functional attainable prosthetic restorations. From clinical and animal studies and thousands of completed clinical cases where autogenic tooth graft procedure (SDG) were utilized, a safe and accelerated wound healing, creation of new bone ankylosed to grafted dentin that makes possible to start implant restoration after shorter periods after grafting. The benefits for your patients is tremendous since his tissue can serve best to augment and preserve his alveolar ridge. This procedure is safe and efficient and is in the range of holistic health procedures.

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