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Update

Use of Autogenous Dentin as Graft Material in Oral Surgery

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ABSTRACT

Dimensional changes in alveolar height and width occur after tooth extraction, which leads to reduced function for patients and makes it difficult for professionals to place dental implants. To minimize such bone loss, a variety of grafting materials are used, among which autogenous grafts stand out for their ability to foster osteogenesis, osteoconduction and osteoinduction. The use of dentin as an autogenous graft material appeared in the professional literature for the first time in 2010, demonstrating that this material can be an effective therapeutic alternative to other graft materials, as it fosters osteoconduction and osteoinduction, and leads to new bone formation in 46-87% of the area treated with an autogenous dentin graft 3 months after use. The latest systematic review, published in 2018, concluded that implants placed in regenerated areas where dentin was used as graft material were observed to have survival rates of 97.7% after one year, suggesting this new material can be an effective alternative offering promising results, although further research is needed in this regard.

KEYWORDS

Autogenous dentin; Autologous graft; Demineralized human dentin.

INTRODUCTION

Tooth extractions result in a reduction in alveolar crestal bone dimensions, which varies among individuals and tooth location, and may be greater when such extractions are motivated by periodontal pathology or are owed to the presence of endodontic lesions[1]. This reduction or loss of bone occurs horizontally (width) on the order of 5-7 mm during the first 12 months, and vertically (height), with an average loss of 1.67-2.03 mm during the first 3 months. Loss in width is greater in the vestibular cortical bone, and loss in height is greater in the jaw than in the maxilla[2,3].

Such bone loss entails functional alterations and decreased alveolar volume, with consequent difficulty in retention of prostheses or placement of implants. Therefore, preventative methods have been discussed in the literature, including regenerative procedures for alveolar preservation, or the immediate placement of implants[2-4].

Alveolar ridge preservation techniques were described in 2013 as a procedure which is performed at the time of extraction with the aim of minimizing bone reabsorption and maximizing bone formation in the alveolar ridge[5].

In the last Osteology Consensus Report in 2012, the indications for alveolar preservation were established. On the one hand, the goal is to preserve hard and soft tissue while additionally preserving crestal bone volume to optimize functional and aesthetic outcomes, as well as to ultimately simplify post-extraction and alveolar preservation procedures. To achieve these objectives, various authors recommend seeking to achieve primary wound closure following biomaterial placement by using biomaterials with low reabsorption rates[6].

As for the ideal properties of the biomaterial, its osteoconductive properties are noteworthy; namely, the material's ability to serve as scaffolding for bone regeneration, as well as its ability to foster osteoinduction (ability to promote the recruitment of bone-forming cells), and osteogenesis (ability to induce cells contained in the graft material to promote bone regeneration)[7-11], each type of graft possessing different properties, as shown in Table[8].

Human dentin and bone are mineralized tissues with a similar chemical composition, and once demineralized, their composition is comprised of 95% type I collagen and non-collagen proteins. These proteins include Insulin-like growth factor 1 (IGF-1), insulin growth factor 2 (IGF-2), transforming growth factor-beta (TGF-beta), and bone morphogenetic proteins (BMPs), which are molecules that induce bone formation in several experimental animals (rats, rabbits). For these reasons, the demineralized dentin matrix is defined as an acid-insoluble and bioabsorbable molecule, constituting a bound collagen matrix inducing bone formation[9].

According to several studies[9], human dentin can be classified into three groups according to the degree of demineralization; nondemineralized dentin (calcified dentin), partially demineralized dentin matrix (70% decalcified) and demineralized dentin matrix, the latter being biocompatible and osteoinductive given its similarity to the demineralized bone matrix.

Human dentin is composed of 70% inorganic content with 4 types of calcium phosphates (hydroxyapatite, tricalcium phosphate, octacalcium phosphate and amorphous calcium phosphate), which give the tooth osteoconductive properties, making it a biocompatible graft material. Hydroxyapatite in dentin comes in the form of low crystalline calcium phosphate, which makes it easier to degrade by osteoclasts, thus lending it good osteoconductive properties[10].

Another 20% of its composition is organic, 90% of which is a type I collagen network while 10% is comprised of non-collagenous proteins (osteocalcin, sialoprotein, and phosphoprotein, which are involved in bone calcification) and growth factors (bone morphogenetic proteins: BMPs, LIM and insulin-like growth factor, which give the tooth osteoinductive properties). In vitro studies show that proteins extracted from dentin affect the proliferation and differentiation of osteoprogenitor cells, such as TGF-B and other factors,

Table. Graft types and their properties[8].

Type	Graft	Osteoconduction	Osteoinduction	Osteogenesis	Advantages	Drawbacks
Bone	Autograft	YES	YES	YES	"Gold standard". Best results. Good percentage of bone volume and mineralization	Associated morbidity Limited availability
	Autograft	YES	YES	NO	Available in various formats	Worse results than autogenous bone
Dentin	Autograft	YES	YES	NO	Good compatibility and bone formation	Limited availability
Biomaterials	Bovine hydroxyapatite	YES	YES	NO	Some osteoinductive capacity. Combinable with autogenous bone	Not completely reabsorbed
Ceramic	Tricalcium phosphate	YES	NO	NO	Good biocompatibility. Good bone formation	Not completely reabsorbed
Composites	Various combinations	-	-	-	Allows combining the advantages of each component	

which can influence the development, remodeling, and regeneration of mineralized tissues. The remaining 10% is water[7, 11].

The first known use of dentin as an autogenous graft was in 2010, with Kim et al.[11] being the first authors to describe the procedure by suggesting the use of extracted teeth as graft material, given that they possess suitable physical properties (density, roughness and homogeneity) and chemistry (calcium/phosphate composition similar to human bone in the cortical region). In addition, dentin is a biocompatible material, stimulating the formation of bone tissue, is well-accepted by the host and is capable of integrating completely into the newly formed bone[12, 13].

Concerning the use of human dentin as an autograft for alveolar preservation, one of the techniques described in the literature is to perform an atraumatic extraction, remove the pulp from the tooth extracted with endodontic files, and the enamel and cement using rotary instruments, divide the root into several fragments, and then crush them to obtain a particle size of 0.25-2 mm, which when mixed with blood from the patient's tooth socket is then introduced into the socket under controlled pressure, covering it with a fibrin sponge and a cross stitch[14].

The objective of this study is to examine the current state of dentin use as an autogenous graft in various oral surgery procedures.

LABORATORY ANIMAL STUDIES

A study using demineralized, artificially perforated human dentin matrices in 6 iliac crest defects in sheep, sacrificing 3 sheep at two months and 3 at four months, showed new bone formation at the edges of the demineralized dentin block at 2 months, but not within the material. However, there was bone formation within the dentin block at 4 months, where excellent bone regeneration was observed. This study confirmed that BMP-2 produced better osteoinduction in porous materials than in non-porous materials, as pores measuring 300 micrometers in diameter allowed infiltration of bone-forming cells and osteoclasts. Dentin scaffolding with artificial perforations showed angiogenesis by the formation of new capillaries and development of existing ones, in addition to better diffusion of oxygen and other nutrients[15].

Demineralized human dentin matrix has also been used as graft material in the sockets of 32 rats, performing a histological, morphometric and immunohistochemical analysis at 3, 7, 14 and 21 days after surgery, resulting in an increase in the expression of vascular endothelial growth factor (VEGF), which is the most important proangiogenic factor in physiological and pathological neovascularization processes[19]. Another study that used demineralized human dentin matrix in the alveoli in 16 rats showed an increase in osteoblast differentiation by producing an increase in BMP-2 and BMP-4 and demonstrated that the matrix acts as scaffolding for osteoblastic differentiation[20]. Along this line, another study conducted in rats comparing human demineralized dentin injection and human demineralized dentin mixed with BMPs demonstrated that the demineralized human dentin matrix accelerated BMP-2 activity, acting as scaffolding for this growth factor and accelerating bone and cartilage formation, suggesting its use as scaffolding material for bone-forming cells[16].

A systematic review of dentin processing methods in tissue bone engineering shows that the demineralization process of dentin increases osteoinduction and decreases antigenicity, this being the motive for using human demineralized dentin matrix in all human and animal studies since 2008, since the demineralization process prevents the denaturalization of proteins in order to preserve growth factors and proteins involved in osteoinduction. In addition, the studies conclude that the ideal particle size to promote bone regeneration is 75-500 micrometers in diameter[17].

HUMAN STUDIES

Dentin as autogenous graft material was described by Kim et al.[11] in 2010, when the team performed extractions of 6 permanent teeth in 6 patients, removing the pulp and cement and then crushing them, converting them into granules and using them as graft material for implant placement. At 3 months, coinciding with the second phase, they performed biopsies on their patients, verifying the reabsorption of almost all dentin and the replacement of new bone in 46-87% of grafted material while detecting a large number of inorganic compounds (hydroxyapatite, tricalcium beta phosphate, amorphous calcium phosphate and octacalcium phosphate), similar in both dentine and bone.

Six years later, Kim et al. published the results of marginal bone loss in 10 implants placed in 5 patients (after having lost one subject who left the study) after having placed an implant in the jaw and the rest in the jawbone. In all patients, dentin implants were placed as graft material, the second phase was performed at 3 months, and at 5 months the definitive prosthesis was placed. Measurements of marginal bone loss in the palatine, vestibular and the width of alveolar crest were compared by first performing initial Cone Beam Computed Tomography (CBCT), a CBCT following implant placement surgery, another CBCT after placement of the prosthesis, and the final one at 5 years. They showed that autogenous dentin appeared to maintain bone volume as periimplantary bone underwent less reabsorption, with 1 mm marginal bone loss at 6 years, and the other four cases suffered no marginal bone loss. However, they concluded their study by highlighting that more studies with larger sample sizes and a longer follow-up period were needed[12]. Valdec et al.[14] described a protocol for an alveolar preservation technique using particulate autogenous dentin, including 4 patients undergoing extraction of anterosuperior teeth, removing the pulp from 3 of them and the endodontic filling in one, removing cement and enamel with high-speed drills, splitting the dentin with a bone grinder and mixing it with the patient's autogenous blood, sealing the socket with a free graft of the palate obtained using a circular scalpel. At 4 months they placed the implant and took a sample for histological analysis (where autogenous dentin can be seen surrounded by vital bone, with the presence of osteoblasts, and without signs of infection or necrosis) in addition to performing a CBCT.

Lee et al.[18] performed extractions of 29 teeth in 9 patients, turning them into blocks or dentin granules, then using them in combination with xenograft, allograft or synthetic bone in 11 locations and uniquely in 2 locations for the placement of 26 implants (24 in maxilla and 2 in jaw), 9 implants in 3 patients placed simultaneously with performing the graft, and 17 implants in 6 patients after a period of 6-9 months. The histology showed rapid formation and stable bone structure, which coincides with the outcomes reported by other authors, such as Kim et al. There were no complications, such as suture infection or dehiscence, and proper healing resulted. However, it was a heterogeneous study in terms of the type of graft material used, with a short follow-up time, and no pre- and post-regenerative procedure assessments were performed.

Other authors, such as Jeong et al.[19], also used autogenous dentin from extracted teeth, alone or in combination with other materials as graft material for the realization of breast lifts. One hundred (100) implants were placed in 51 patients, immediately placing 76 implants at the time of the mastopexy, and 24 post-procedure implants. These authors used dentin as a single graft material, or mixed with autogenous bone (tuberosity), synthetic bone, or xenograft (Bio-oss, Biocera). They performed a biopsy 3-6 months after the breast lift procedure on the 27 patients in which only dentin was used as graft material for the placement of 38 implants, and observed dentin tubules, osteoblasts and osteoclasts around the graft material, with adequate bone formation (46-87% at 6 months) thanks to its osteoconductive and osteoinductive properties. An implant survival rate of 78% was obtained, demonstrating that this grafting material could also be suitable for mastopexy.

Autogenous dentin has been used in the form of block grafts for subsequent implant placement. Kim et al.[20] placed 14 implants simultaneously with the block grafts and 15 following them. In the later histological analysis, the union of implant and gum, osteocytes embedded in the matrix of demineralized dentin, and osteoclasts reabsorbing the matrix were observed, as well as the formation of new osteoid tissue and vascular invasion within the fibrous tissue. These authors recommended that, in the use of autogenous dentin in the form of blocks, better results can be obtained when used in association with some biomaterial in the form of granules. They also published a report on a series of 15 cases in which 23 implants were placed in molars, in 1 patient in the form of a block, and in the rest in the form of granules. A 31-month follow-up was carried out. They performed biopsies at 2 months during the second phase and 4 months after placement of the autogenous dentin, detecting areas of osteoconduction at 2 months through the direct binding of the bone formation zones, as well as regions of fibrous and bone tissue being introduced into the region of reabsorption of the graft material. At 4 months, the graft material was replaced with neoformed bone, detecting dense, well-vascularized tissue, while concluding that, although autogenous dentin showed rapid healing and closure and did not induce immune reactions, more studies were needed to evaluate this material over the long term[21].

Comparing the use of autogenous dentin as a single graft material with the use of bovine xenograft as a single graft material to assess differences between them, Pang et al.[22] published a randomized clinical trial in which they placed 21 implants while performing regeneration with autogenous dentin, and 12 implants in which they performed bone regeneration with bovine xenograft (Bio-oss) for the regeneration of vertical defects in the vestibular bone. They performed the regeneration procedure within 2-4 weeks of extraction, and at 6 months performed a biopsy in both groups. Proper healing occurred in both groups without postoperative infection or suture dehiscence. There were no statistically significant differences in vertical bone gain or primary stability of implants. In histological analysis, the percentage of new bone formed, as well as the percentage of residual grafted material, were similar in both groups.

Kabir et al.[23] published a clinical case study in which, following the extraction of the third upper right molar, the researchers pulverized it and used it as a graft material in the post-extraction socket to assess alveolar preservation, performing clinical and radiographic controls at the time of extraction and at 3 and 12 months, showing replacement of the demineralized dentin matrix with new bone tissue. The Micro

Computed Tomography (micro-CT) scan showed new bone with trabecular structure at 12 months without remnants of dentin matrix, thus suggesting this material as a possible autogenous graft for other types of procedure apart from breast lifts or placement of dental implants.

In 2018, Gual-Vaqués et al.[24] published a systematic review of 6 studies on humans analyzing implant stability using the Implant Stability Quotient Index (ISQ). Complications arose, with suture dehiscence being the most common, affecting 29.1% of the cases, and less frequently, hematoma, infection, marginal bone loss (follow-up was performed for only one year). They also record implant survival and failure rates within 6 months of placing the prosthesis, with a 97.7% success rate, analyzing the mineral composition and healing process histologically and histomorphometrically, which suggested dentin is an excellent grafting material, demonstrating new bone formation in 46-87% of locations during a healing period lasting 3-6 months, as well as an abundance of osteoblasts and osteoclasts around the graft material and new bone formation via osteoconduction and osteoinduction processes. This systematic review shows that there are no statistically significant differences between using dentin in granules or blocks, or in using it alone or in combination with other graft materials and shows greater secondary stability than primary stability. The limitations of this systematic review lie in the fact that there are few studies in this regard and in the small sample size analyzed. In addition, there is great variability among the studies (different locations, anatomical considerations, different evaluation methods, different types of surgery), such that more long-term studies are needed with uniform study variables and comprising a larger sample size.

In 2018, Schwarz et al.[25] published a prospective clinical study in which they performed alveolar crest augmentation techniques on 30 patients, using block-shaped autogenous root dentin in 15 cases, and blocks of autogenous bone obtained from the ascending branch in the other 15. In patients where dentin is used as graft material, it was obtained from retained third molars which were extracted and then, by removing the crown and root cement, a root fragment with dentin and pulp was obtained. Autogenous bone blocks were obtained from the retromolar region in the external oblique ridge by combining rotating and piezoelectric tools. Measurements of the alveolar crest were performed before and after the regenerative procedure, and upon revisit for the placement of dental implants at 26 weeks. There was an increase of 5.53 mm in patients where autogenous dentin was used, and 3.93 mm in cases where autogenous bone blocks were used, with less reabsorption observed in the first group. In addition, homogeneous integration of both grafts could be clinically and radiographically observed upon patient revisit, which allowed the placement of implants with good primary stability, with the authors concluding that autogenous dentin appears to be a viable alternative as a graft material for bone width regeneration, but that studies with larger sample size and follow-up time are needed.

In 2019, Canto-Díaz et al.[26] published a split pilot study in 6 patients, in which they perform alveolar preservation with autogenous dentin on the research group and allow convention healing to occur in the control group, sealing both alveoli with a collagen membrane. They performed tooth extractions for periodontal motives, root cavities or non-restorable fractures and placed implants at 16 weeks. For preparation of the dentin graft group, they removed the crowns or fillings of any kind using rotating tools, washed the tooth fragments with saline, and crushed them to obtain a particle size of 300-1200 microns, which was then sterilized for 10 minutes with sodium hydroxide and ethanol, and finally washed with saline solution. After placing collagen membranes on both alveoli, they sutured with 5/0 monofilament and performed a postoperative CBCT at 8 and 16 weeks, detecting lower dimensional contraction of the post-extraction socket among the study group than in the control group at 16 weeks following surgery, and stable and homogeneous densiometric values (Hounsfield units) in both groups in the three regions under study (apical, medial and coronal socket regions), thus suggesting that autogenous dentin is suitable as graft material for alveolar preservation.

The latest review of the use of graft material derived from extracted teeth concludes that the ideal particle size is still controversial, although most authors report using particles between 300-1200 microns, while agreeing that dentine is a promising material owing to its osteoconductive and osteoinductive properties stemming from its similarity to bone[27].

CONCLUSIONS

Although the material of choice in regeneration is autogenous bone, human dentin and bone tissue have a similar chemical composition, such that dentin has begun to be used as a regenerative material in oral surgery.

Autogenous dentin possesses the properties of osteoconduction and osteoinduction, which has led to its use in different regenerative procedures in implantology (alveolar preservation, guided bone regeneration, breast lifts), in isolation or in combination with other materials.

Dentin has been shown to yield good results in terms of bone gain and primary implant stability, and even better results when compared to other materials.

However, studies using a larger sample size are needed, especially with a longer follow-up period in order to confirm the long-term stability of this material.

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