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Tooth Derived Bone Material - A Hope from Hopeless

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Abstract

Tooth-derived bone graft material, rich in bone growth factors and bone morphogenic proteins (BMPs), has become a practical substitute for bone grafting. It can also be used as a carrier for growth factors and stem cells. Autogenous-tooth bone grafting technique is significant as this grafting material has excellent bone regeneration capacity and relatively fewer chances of antigenicity, genetic diseases, and disease transmission. This article discusses a broad overview of the properties, procedures, and uses of tooth-derived regenerative bone grafting.

Keywords: BMPs, Alloplast, Xenograft

Introduction

In dentistry, one of the most common procedures performed is tooth extraction. In most cases, it has been well documented that it can induce significant dimensional changes in the alveolar ridge. Maintaining alveolar bone volume is a prerequisite for ideal functional restorations and esthetics.[1]

Bone graft materials are widely used to reconstruct bony defects. There are four bone graft materials: autograft, allograft, alloplast, and xenograft. The use of different bone graft materials depends on clinical applications, the volume of deficiencies, and evidence-based studies.[2] Above all, autografts are known to be the gold standard due to their osteoinductivity, osteoconductivity, and osteogenecity.[3]

Although autogenous bone is considered the gold standard among graft materials, donor site morbidity may be an associated problem. Allogenic, xenogenic, and alloplastic graft materials have been used as alternatives, but they have several drawbacks compared with autologous grafts, such as decreased function, the potential risk of infectious disease, an unsatisfactory resorption pattern, a prolonged healing time, and high cost. [4]

The tooth is increasingly captivating attention as a material for alveolar bone regeneration.[5] The auto tooth bone graft material is a system that treats patients by manufacturing bone graft material from their own extracted teeth. It has first been introduced by the Korea Tooth Bank Centre and has satisfied many clinicians and patients with its osteoconduction as well as osteoinduction capacity.[6]

Properties of autogenous tooth bone graft

The human tooth is a substantial source of stem cells, matrix, trace metal ions, and growth factors.[7] Teeth and bones share many similarities. Teeth, cartilages, nerves, and maxillofacial bones all embryologically originated in the neural crest, sharing identical origins.[8-11] Based on osteoinduction, osteoconduction, and osteogenesis potentials through growth factors in tooth and similar histogenesis between tooth and bone, a novel bone graft material can be developed using the inorganic and organic components of an extracted tooth.[12]

The tooth has a much lower fat content and no marrow compared to bone, which makes it easier to be changed into graft material .[13] Dentin is one such material that can be attempted as bone graft material.[14] Human dentin autograft was reported in 2003 as the first clinical case (Murata et al., 2003), while human bone autograft was done in 1820. There was a long-long time lag between the autografts of dentin and bone.[15]

Although the tissue structures of dentin and bone are different, the chemical composition of dentin is very similar to that of bone. i. e. the ratio of the organic and inorganic contents is similar (70% of mineral, 20% collagen, and 10% body fluids by weight). Dentin also contains some growth factors common to the bone, namely, insulin-like growth factor–II, bone morphogenetic protein (BMP), and transforming growth factor-beta.[16]They also contain varieties of proteins that are similar to bone, namely, Osteopontin, bone sialoproteins, dentin sialoproteins, osterix, and osteocalcin due to which it was considered as an effective alternative bone grafting material.[17]

A raw tooth cannot easily induce new bone formation because of its high mineral content, crystallinity, and low porosity, which may interfere with vascular and mesenchymal cells' migration, attachment, and proliferation. The osteogenic capacity of a demineralized tooth was verified as early as 1967, and it has been generally accepted that autogenous and allogenic demineralized teeth are osteoinductive or osteoconductive graft materials.[17,18] Yeomans and Urist first evidenced the autogenous demineralized dentin matrix (DDM). According to Urist, BMP presents in DDM, and bone is a significant stimulant to osteoinductive property.

Moreover, it was shown to have BMP stimulating cartilage and bone formation, differentiating undifferentiated mesenchymal stem cells into chondrocytes and osteogenic cells.[19,20] Non collagenous proteins of dentin are recognized to be involved in bone calcification, such as osteocalcin, Osteonectin, phosphoprotein, and sialoprotein.[21,22] Dentin-matrix-derived BMP is not the same as bone matrix-derived BMP, but they are very similar and exhibit the same type of action in the body.[23]

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Murata et al. found that DDM does not inhibit BMP-2 activity and shows a better release profile of BMP-2; thus, human recycled DDM is a unique, absorbable matrix with osteoinduction ability. Therefore, DDM should be considered an effective graft material carrier of BMP-2 and a scaffold for bone-forming cells.[15]

According to the biochemical and histo morphometric analysis of bone and cartilage induced by human DDM and BMP-2, researchers observed that human DDM of vital teeth origin induced bone and cartilage and that BMP-2 also enhances and accelerates bone formation in the DDM carrier system.[24] Carvalho et al. investigated the osteopromotive property of autogenous DDM and concluded that normal bone regeneration with minimal inflammation-causing no hindrance to bone formation.[25]

From Extraction to Grafting, Particulate dentin

Kim et al. are the pioneers who developed the technology of making bone graft materials using autogenous tooth after partial demineralization and freezing–drying and commercialized it domestically and internationally.[26,27] The solid apatite of external teeth can protect the internal organic part for a long so teeth can have an enormous amount of organic components even though they have been left for a long time after being extracted. Suppose the organic component of teeth is released slowly through a suitable demineralization process, and stem cells, growth factors, and BMP are seeded inside the teeth. In that case, an excellent bone healing effect can be expected.[28]

1. To prepare graft select teeth: Teeth without root canal fillings, which have been extracted due to advanced periodontal bone loss or other reasons, such as wisdom teeth extraction or orthodontic indications, can be used.

2. Restorations like crowns and fillings should be cut off or removed. Carious lesions and discolored dentin, or remnants of periodontal ligament (PDL) and calculus should be reduced by tungsten bur immediately after extraction. In the case of multi-rooted teeth, roots could be split.

3. Place the teeth into the sterile grinding chamber of the grinder. Before that, clean the teeth, including crown and root dentin, and dry using an air syringe.

4. The dentin grinder can grind the roots in 3 seconds. Use the grinding chamber's vibrating movement to sieve particles smaller than 1,200µm into a lower chamber that collects particles between 300µm and 1,200µm.

5. Particles fall into a waste drawer smaller than 300µm. For bone grafting, this fine particulate is not considered an efficient size. This grinding and sorting protocol is repeated to grind the remaining teeth particles left in the grinding chamber, collecting particles between 300µm and 1,200µm.

6. In a small sterile glass container, the particulate dentin from the drawer is immersed in basic alcohol for 10 minutes. The basic alcohol cleanser contains 0.5M of NaOH and 30% alcohol (v/v) for defatting and dissolving all organic debris, bacteria, and toxins of the dentin particulate.

7. All the organic debris from dentin particulate, including dentin tubules, dissolves due to the efficiency of the cleanser. After 10 minutes of cleanser treatment, the scanning electron microscope (SEM) picture shows open and clean tubules.

8. After pouring the basic alcohol cleanser into sterile phosphate-buffered saline (PBS), the particulate is washed twice. The PBS is decanted, leaving wet particulate dentin ready to graft into alveolar bone defects, freshly extracted sockets, or in procedures involving augmenting the maxillary sinus.

The process from tooth extraction up to grafting takes approximately 15-20 minutes. It should be noted that the volume of the particulate dentin is more than twice the

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original root volume. Alternatively, to produce dry, bacteria-free particulate autologous dentin that can serve for immediate or future grafting procedures, the wet particulate can be put on a hot plate (140ºC) for 5 minutes.[29]

Various Forms of Autogenous Tooth Bone Graft Material

There are two types of autogenous tooth bone graft materials: block and powder. The block type of graft material shows osteoinduction capacity through blood wettability and osteoconduction capacity through space maintenance capability and creeping substitution. The powder type is supplied based on various sizes of particles, porosity, blood wettability, osteoconduction, osteoinduction, and creeping substitution abilities. Both types can be used to preserve the extraction socket, Esthetic restoration of the alveolar bone, restoration of the perforated sinus membrane, and augmentation of early implant stabilization. Thus, autogenous tooth bone graft material is beneficial in clinical situations due to different available forms which can be availed for various clinical situations. Furthermore, it supports brilliant bone regeneration through osteoinduction and osteoconduction capability and minimizes foreign body reactions due to genetic homogeneity.[30]

Clinical Application of Autogenous Tooth Bone Graft Material

Autogenous tooth bone graft material has a lot of clinical applications. Since it is autogenous, the risk of immune reaction is eliminated. It can be used for guided tissue regeneration, tooth socket preservation, ridge augmentation, sinus bone graft and grafts in tumor resections, cyst enucleation, etc.[31,32] Kim et al. used autogenous tooth bone powder and block in a socket immediately after tooth extraction. They concluded good healing of the socket when absorbed after 3.5 months which was taken up for implant placement.[33]

Kim et al. reported a case of ridge augmentation where he used autogenous DDM. The results were pretty acceptable.[34] Nilsson et al. said that an appropriate carrier is needed for the BMPs and growth factors to be incorporated as bone grafts. At the same time, others opined that DDM could be a carrier of exogenous BMP and growth factors and have an osteoinductive effect.[35]

Lee et al. concluded after comparing the efficiency of autogenous DDM and other bone graft materials used in sinus bone graft surgeries; after four 4 months of healing, there was the favourable bone formation, but autogenous DDM revealed a faster rate and superior quality of bone formation.[36]Similar results were obtained by Jeong et al. in 2011 while carrying out maxillary sinus augmentation using auto-tooth bone graft material.[37]

Chang et al. in 2014, performed a guided bone regeneration (GBR) followed by implant placement and prosthetic restoration. The results showed no significant marginal bone loss difference radiographically immediately after GBR, implant placement, and prosthesis delivery.[38] Autogenous tooth bone graft can be used as potent graft material after tumor resections, traumatic injuries, large cyst enucleations, traumatic injuries, large cyst enucleation, etc., to prevent pathological fractures of the remaining bone.[14]

Conclusion

Autogenous DDM has shown potential applications in bone substitutes and scaffolds. The advantage is its low morbidity, easy handling, and great radiopacity and enhances bone-remodelling capabilities. Also, there is the absence of antigenicity. This makes it a safe and effective bone graft material. Autogenous DDM was also suggested to be an ideal scaffold for stem cells and

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bone growth factors, endodontic, and tooth restorative materials.[39] The selection of graft material depends on the defect or surgical procedure, autogenous tooth-derived bone material can be considered an alternative to other bone grafts due to its properties, autogenous origin, clinical and histological results.

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