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REVIEW ARTICLE

Tooth Derived Bone Graft Material

[1]Chayanika Bhattacharjya, [2]Srikanth Gadicherla, [3]Abhay Taranath Kamath, [4]Komal Smriti, [5]Kalyana Chakravarthy Pentapati

ABSTRACT

Alveolar bone deficiency is a major postoperative complication in the treatment of traumatic injuries, periodontal diseases and likewise. Hence, alveolar bone repair remains a major hurdle in tissue engineering. Autogenous bone can be well-thought- of as benchmark for bone grafting sans its limitations and complications. In order to overcome these limitations, there is an increased demand of bone graft materials that led to numerous studies on different techniques and materials for bone regeneration over the years. Dentin and bone having same biochemical similarities led to the idea of using it as a bone regenerative material. Demineralized dentin matrix (DDM), an organic material obtained from dentin has been shown to possess osteogenic capacity. Demineralized dentin matrix may prosper in future endodontic world as an apexification material and as a permanent root canal filling material as well. Quick in bone forming as compared to conventional bone graft, this material is a boon to the dental world in this era. This manuscript reviews various studies on different types of DDM as a bone grafting material, and also summarizes the suggested pathway of bone regeneration.

Keywords: Autogenous, Bone, Bone morphogenic protein, Demineralized dentin matrix, Grafting.

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INTRODUCTION

Bone grafting is an age old story for replacement of a missing bone to heal fractures posing significant health risk to patients. Traumatic injuries, tumor resections or periodontal diseases that involve severe bone loss in the oral cavity attract bone grafting. Whether one goes for autograft, allograft, xenograft or alloplast to fill the bony defects, there are their own set of limitations. The requirement of additional surgeries, functional and esthetic problems at the donor site with varying degrees of graft resorption and the limited amount of graft obtained, forced research for an alternative. In order to overcome the relevant shortcomings, numerous substitutions are being tried. Dentin is one such material that can be attempted as a bone graft material. This review paper is an attempt to re-evaluate various studies on different types of demineralized dentin matrix (DDM) that can be used as a bone graft.

[1]Intern, [2,4,5]Associate Professor, [3]Professor and Head

[1-3]Department of Oral and Maxillofacial Surgery, Manipal College of Dental Sciences, Manipal University, Manipal, Karnataka, India

[4]Department of Oral Medicine and Radiology, Manipal College of Dental Sciences, Manipal University, Manipal, Karnataka, India

[5]Department of Public Health Dentistry, Manipal College of Dental Sciences, Manipal University, Manipal, Karnataka, India

Corresponding Author: Kalyana Chakravarthy Pentapati Associate Professor, Department of Public Health Dentistry, Manipal College of Dental Sciences, Manipal University, Manipal, Karnataka India, Phone: +91-9916036303, e-mail: drkalyan81@gmail.com

DENTIN AND BONE

Apart from the fact that dentin and bone share certain similar biochemical properties (80% hydroxyapatite crystals and 20% type I collagen,[1] it contains some growth factors common to bone *viz* insulin like growth factor-II (IGF-II), transforming growth factor (TGF-b), bone morphogenic protein (BMP).[2] Dentin also contains variety of proteins that are common to bone *viz* osteopontin, bone sialoproteins, dentin sialoproteins, osterix, osteocalcin due to which it was considered as an effective alternative bone grafting material.

There are two main types of DDM, autogenous and allogenous DDM. For preparing the dentin derived bone graft, extracted teeth were prepared as described previously.[3] Adult extracted human third molars were obtained and they were then crushed in liquid nitrogen, washed in sodium chloride, 1M (NaCl), demineralized in an acidic medium like acetic acid or hydrochloric acid (pH = 2), then rinsed in cold distilled water and lyophilized to finally get the graft ready to use.[4]

Properties of dentin which are comparable to bone:

Osteoinductive Property

As bone and dentin are proven to possess similar properties, several studies have proved that dentin derived bone substitution induces osteoinduction. Yeomans and Urist first evidenced the regenerative property of autogenous DDM. According to Urist, BMP present in DDM and bone are major stimulants that possess osteoinductive properties.[5] Bessho et al successfully isolated BMP from demineralized bone and dentin of extracted teeth from rabbits. Purified BMP is homogenous and induced bone formation in 3 weeks when implanted in the muscle pouches in wistar rats.[6] Although, dentin

derived BMP was different from bone derived BMP, the mechanism of action remained the same.[7]

According to Boden et al, LIM (constitutes of Lin11, Isl-1 and Mec3 homeodomain protein) minera-lization protein accelerates the differentiation of undifferentiated cells into osteoblasts, hence, induce maturation and bone formation.[8] Wang et al found out that predentin, odontoblasts and the endothelial cells of blood vessels of teeth express LIM.[9] Gomes et al[10] studied the osteoinductive property of autogenous DDM slices in experimental surgical bone defects in rabbits incorporating human amniotic membrane (HAM) with using the guided bone regeneration (GBR) technique. Slices of autogenous DDM induced direct bone formation and were incorporated by the newly formed bone tissue and remodeled. The bone defects healed faster in the autogenous DDM + HAM than HAM group.[10]

Osteoconductive Property of Autogenous DDM

Studies showed that autogenous DDM possessed osteoconductive properties similar to the one present in bone. Bone morphogenic protein besides acting as an osteoinductive material, it also acts as a scaffold for cells to grow into. Kim et al evaluated the surface structures and the physicochemical properties of autogenous tooth bone graft material and was compared with a variety of other bone graft materials. The result showed that the pattern associated with autogenous DDM had a low crystalline structure and is similar to the autogenous cortical bone structure.[11]

Carvalho et al investigated the osteopromotive property of autogenous DDM. In this study, he created 5 mm defect in the buccal bone of mandibular molars of 36 rabbits. These rabbits were divided into four groups, control group (defects remained untreated), PTFE group, PTFE + autogenous DDM group and experimental group (autogenous DDM). Postoperatively the experimental group showed normal bone regeneration with minimal inflammation causing no hindrance to bone formation.[12] Nampo et al used extracted teeth as graft material for alveolar repair and concluded that dentin has high affinity and marked osteoconductive effect on jaw bones.[13]

CLINICAL APPLICATION OF AUTOGENOUS DDM

Tooth derived bone substitutes find a lot of clinical applications. Being autogenous, it eliminates the risk of immune reaction. Kim et al used autogenous tooth derived bone graft along with guided tissue regeneration at the time of implant placement. Histomorphometric analysis of the samples during healing period of 3 to 6 months showed new bone formation in 80 to 86% of the area of interest with excellent bone remodeling.[14]

Another retrospective cohort study (Lee and Kim) evaluated the clinical efficacy of autogenous DDM with a mean follow-up period of 31 months. The results showed that the mean peri-implant marginal bone loss after 1 year implant placement was 0.33 ± 0.63 mm which demonstrated remarkable and acceptable healing property.[15]

Tooth Socket Preservation

The residual alveolar bone get resorbed very rapidly immediately after teeth extraction. This causes difficulty in the seating of prosthesis at a later date or might also be esthetically unpleasant. Hence, alveolar bone preservation after teeth extraction is a common practise these days. Gomes et al conducted a human study in 2006 using autogenous DDM. Twenty-seven lower third molar sockets were selected. The experimental sockets were filled with autogenous DDM and were covered with PTFE membrane. After 90 days, the experimental sockets showed bone formation of the same radiopacity as the surrounding bone. Also, these sockets had shown a faster rate of bone formation as compared to the other groups (control group with no material in the socket and the third group with PTFE in the sockets). It was also proven that the experimental socket had a superior bony architecture.[16]

Kim et al used autogenous tooth bone powder and block in a socket immediately after tooth extraction. They reported good healing of the socket after 3 to 3.5 months which was then taken up for implant placement.[17]

Ridge Augmentation

This is a process of increasing the height or width of alveolar bone in cases of bony deficiency. Bone grafts are added vertically or horizontally on the upper parts or laterally on the residual alveolar ridges respectively. These processes of augmenting the alveolar bone require the use of bone grafts which comes with its own set of complications. For example, bone resorption after grafting or dehiscence of the soft tissues. Therefore, autogenous DDM can be used as an alternative to conventional bone grafts in such cases as well. Kim et al reported a similar case of ridge augmentation where he used autogenous DDM. The results were pretty acceptable.[18]

Nilsson et al[29] said that an appropriate carrier is needed for the BMPs and growth factors to be incorporated as bone grafts while, others opined that DDM by itself can play the role of a carrier of exogenous BMP and growth factors as well as have osteoinductive effect.[19]

Sinus Bone Graft

Pneumatization is a process by which the floor of the maxillary sinuses descend downward in edentulous

maxillary arches. This might complicate the placement of implants at a later date. In order to push the floor of the sinuses upward, surgeries called 'sinus lift' surgeries are performed. In cases of direct method of sinus lift, bone grafts are added to push the schneiderian membrane and bony sinus floor upward.

Previous study on sinus lift using autogenous tooth graft material reported that subjects with autogenous tooth grafts alone or along with other bone graft materials showed implant survival rates of 96.15%. On histomorphological examination, it was found that autogenous tooth graft material showed gradual resorption and eventual bone formation through osteoinduction and osteoconduction.[20]

Lee et al conducted a study to compare the efficiency of autogenous DDM and other bone graft materials used in sinus bone graft surgeries, after a 4 months healing period, all the groups showed favorable bone formation, but autogenous DDM showed a faster rate and superior quality bone formation.[21] Kim et al again performed sinus bone graft surgeries using autogenous DDM, and concluded that this can be used as a sinus bone graft material.[22]

Guided Bone Regeneration

Implant placement and severe periodontitis develops bone dehiscence and bone fenestrations over time. In order to avoid this, guided bone regeneration using bone graft in the peri-implant areas are becoming popular these days. A study conducted by Kim et al,[14] evaluated the use of autogenous DDM in growing bone by guided bone regeneration. They achieved 46 to 74% new bone formation in 3 to 6 months when compared to Babbush.[23]

Another study conducted by Kim et al said that histologically, autogenous DDM shows resorption initially and eventually shows new bone formation by osteoinduction and osteoconduction when subjected to guided bone regeneration.[24]

Collateral Uses

Autogenous bone can be used as a potent bone graft material after tumor resections, traumatic injuries, large cyst enucleations, etc. hence, this prevents pathological fractures of the remaining bone.

DISCUSSION

A tooth is the simplest thing one could think of to be used as a bone substitution material. The easy availability makes the job even easier. The dentinal matrix obtained from a tooth has to be demineralized before using as a bone graft material. The demineralized dentinal matrix is highly biocompatible and can support cell growth and proliferation. It is osteoconductive with the host cells and has a long shelf life. There are no reports of allergies or inflammations till date. Only shortcoming is, sacrifice of a healthy tooth to obtain the bone graft, however, this problem is solved by using a third molar, which are indicated for extraction in most of the cases. Further studies on the risks of disease transmission and antigenicity of the material are yet to be done. Otherwise, autogenous DDM can be used as a bone graft material.

Kim et al have conducted large number of studies and was successful in finding out that autogenous demineralized dentin matrix can be used for alveolar ridge augmentation, tooth socket preservation and sinus lifts. Pioneer studies performed by Yeoman and Urist in the year as early as 1967 proved that autogenous DDM possessed regenerative property.[5] Gomes et al had pointed out that autogenous DDM had osteoconductive properties, and produce radiopaque bone.[16,25] Lastly, an amazing work by Jiang et al have showed that autogenous DDM may prosper in the future endodontic world as an apexification material and as a permanent root canal filling material as well.[26]

Furthermore, being autogenous leads to the absence of antigenicity, hence, enhances the bone-remodeling capabilities. This makes it a safe and effective bone graft material. Autogenous DDM was further suggested to be an ideal scaffold for stem cells and bone growth factors, and endodontic and tooth restorative material.[27] Therefore, autogenous tooth could be recycled as the innovative biomaterial.[28] Quick in forming bone (6–8 weeks)[13] as compared to the conventional bone graft, this material is a boon to the dental world in this era.

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