Review Article

Autogenous Tooth Bone Graft: Ingenious Bone Regeneration Material

Chadalavada Sarala, Meghna Chauhan, P. Sathyamurthy Sandhya1, C. H. Dharmendra2, Nirban Mitra
Departments of Prosthodontics, 1Endodontics and 2Orthodontics, Mallareddy Institute of Dental Sciences, Hyderabad, Telangana, India

Abstract

Tooth-derived bone graft material, which is proved to be rich in bone growth factors and bone morphogenic proteins (BMPs), have been becoming a practical substitute to bone grafting. It can also be used as a carrier for growth factors and stem cells as reported in many recent studies. Autogenous-tooth bone grafting technique is significant as this biomaterial has excellent bone regeneratio capacity and also relatively non-existent chances of antigenicity, genetic diseases and disease transmission. In this article, a broad overview of the published findings with regard to the properties and uses of tooth-derived regenerative bone grafting is discussed.

Keywords: Auto-tooth bone graft, biomaterial, osteoconduction, osteoinduction

INTRODUCTION

The postextraction bone loss is a physiological phenomenon which will take place with alveolar resorption and the subsequent formation of bone within the socket follows osteoblastic differentiation of osteoprogenitor cells.1 Bone resorption will cause loss of the socket width that hampers the native alveolar ridge contour.2

Hence, maintaining alveolar bone volume is prerequisite for ideal functional restorations and esthetics.

Bone substitutes are used, frequently to reconstruct bony defects. There are four categories of bone graft materials as follows: autograft, allograft, alloplast, and xenograft. With four available types of graft materials, the use depends on clinical applications, the volume of deficiencies, and evidence-based studies.3 Above all, autografts are known to be the gold standard due to its osteoinductivity, osteoconductivity, and osteogenecity.4

With advancements in tissue engineering and reconstructive dentistry; researchers choose autogenous tooth bone graft which allows both formations of new bone and is steadily observed to be replaced by bone without compromising on the bone–regeneration capacity.5

OSTEOINDUCTION AND OSTEOCONDUCTION PROPERTIES OF AUTOGENOUS TOOTH BONE GRAFT

Human tooth is a rich source of stem cells, matrix, trace metal ions, and growth factors.6

Although the tissue structures of bone and dentin are different, the ratio of the organic and inorganic contents is similar (70% of mineral, 20% collagen, and 10% body fluids by wt). Dentin also contains some growth factors common to bone, namely, insulin-like growth factor–II, bone morphogenetic protein (BMP), and transforming growth factor-beta.7

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.8

Yeomans and Urist first evidenced the regenerative property of autogenous demineralized dentin matrix (DDM). According

Address for correspondence: Dr. Chadalavada Sarala, Department of Prosthodontics, Mallareddy Institute of Dental Sciences, Survey No. 138, Suraram Main Road, GHMC Quthbullapur, Hyderabad - 500 055, Telangana, India. E-mail: babyimprints@gmail.com

How to cite this article: Sarala C, Chauhan M, Sandhya PS, Dharmendra CH, Mitra N. Autogenous tooth bone graft: Ingenious bone regeneration material. Indian J Dent Sci 2018;10:56-9.
to Urist, BMP presents in DDM and bone is a major stimulant to osteoinductive property.

Moreover, it was proven to have BMP promoting cartilage and bone formation, differentiating undifferentiated mesenchymal stem cells into chondrocytes and osteogenic cells.\(^\text{[9,10]}\)

Noncollagenous proteins of dentin such as osteocalcin, osteonectin, phosphoprotein, and sialoprotein are recognized to be involved in bone calcification.\(^\text{[11,12]}\)

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.\(^\text{[13]}\)

Murata et al. concluded that DDM does not inhibit BMP-2 activity and shows better release profile of BMP-2 and thus human recycled DDM is unique, absorbable matrix with osteoinduction ability. Thus, DDM should be considered as an effective graft material which is a carrier of BMP-2 and a scaffold for bone-forming cells.\(^\text{[14]}\)

According to biochemical and histomorphometric analysis of bone and cartilage induced by human DDM and BMP-2, researchers concluded that human DDM of vital teeth origin induced bone and cartilage and that BMP-2 also enhances and accelerates bone formation in DDM carrier system.\(^\text{[15]}\)

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.\(^\text{[16]}\)

**Development of Autogenous Tooth Bone Graft Materials**

Kim et al., in 1993, conducted basic studies such as component analysis, research through electron microscope, and production and autogenous bone graft material after incinerating human teeth at a high temperature of 135°C and then pulverizing to a particle size of 0.149 mm. The main component of tooth ash powder, which formed after incineration and pulverization of teeth, has been identified to be hydroxyapatite and β-Tricalcium phosphate, both of which are osteoconductive bone graft materials with excellent biocompatibility.\(^\text{[17,18]}\)

Tooth ash has been introduced as particulate dentin in various research studies.\(^\text{[19,20]}\)

There are various ethical and biological aspects associated with the production of autogenous tooth graft material as tooth extracted from a person is considered as environmental waste and should be disposed of by an extracted material processor. However, the use of autogenous bone graft is not against the law if the patient agrees the process and uses his/her own teeth. A tooth does not cause problems even when the root rest is in the alveolar bone unless it is contaminated by an infectious lesion.\(^\text{[21]}\) There are also surgeries wherein the root is left on purpose to preserve the alveolar bone.\(^\text{[22]}\)

Autogenous tooth bone graft material has been developed after the autogenous tooth root was reconfirmed to have exceptional compatibility with alveolar bone through these researches. When the DDM of the extracted teeth from a person is used as bone graft material for him/her, it is harmless because there is little immune rejection response. Kim et al. are the pioneers who developed the technology of making bone graft materials with autogenous tooth after partial demineralization and freezing–drying and commercialized it domestically and internationally.\(^\text{[23,24]}\)

Teeth can have a huge amount of organic component even though they have been left for a long time after being extracted because the solid apatite of external teeth can protect the internal organic part for long. Therefore, excellent bone healing effect can be expected if 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.\(^\text{[25]}\)

**Various Forms of Autogenous Tooth Bone Graft Material**

Autogenous tooth bone graft materials are of two types as follows: block and powder types. The block type of graft material demonstrates osteoinduction capacity through blood wettability and also has osteoconduction capacity through space maintenance capability along with 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 for the preservation of the extraction socket, esthetic restoration of the alveolar bone, restoration of perforated sinus membrane, and augmentation of early stabilization of implant. Thus, autogenous tooth bone graft material is very useful in clinical situations due to different available forms which can be availed for different clinical situations. Furthermore, it supports brilliant bone regeneration through osteoinduction and osteoconduction capability and minimizes foreign body reaction due to genetic homogeneity.\(^\text{[26]}\)

**Clinical Application of Autogenous Tooth Bone Graft Material**

Autogenous tooth bone graft material finds 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.\(^\text{[26,27]}\)

Kim et al. used autogenous tooth bone powder and block in a socket immediately after tooth extraction. They concluded good healing of socket when absorbed after 3.5 months which was taken up for implant placement.\(^\text{[28]}\)
Murata et al. appropriate carrier is needed for the BMPs and growth factors to be incorporated as bone grafts, while some other researchers concluded that DDM by itself can play the role of a carrier of exogenous BMP and growth factors as well as have osteoinductive effect.[29]

Lee et al. continued 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 favorable bone formation, but autogenous DDM revealed faster rate and superior quality of bone formation.[30] Similar results were obtained by Jeong et al. in 2011 while carrying out maxillary sinus augmentation using auto-tooth bone graft material.[31]

Chang et al. in 2014 performed a guided bone regeneration (GBR) followed by implant placement and prosthetic restoration and results showed that no significant marginal bone loss difference radiographically immediately after GBR, implant placement, and prosthesis delivery.[32]

**Conclusion**

Autogenous DDM has shown potential applications in bone substitute and scaffold. The advantage is its low morbidity, easy handling, and great radiopacity and enhances bone-remodeling 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 bone growth factors, endodontic, and tooth restorative materials.[33]

Although the selection of graft materials should be dictated by the extent of ridge defects and the surgical procedure, tooth-derived bone graft may be considered as a valuable alternative given its autogenous origin and positive clinical and histological results when teeth extraction is indispensable.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Guglielmotti MB, Cabrini RL. Alveolar wound healing and ridge remodeling after tooth extraction in the rat: A histologic, radiographic, and histometric study. J Oral Maxillofac Surg 1985;43:359-64.
2. Atwood DA, Coy WA. Clinical, cephalometric, and densitometric study of reduction of residual ridges. J Prosthet Dent 1971;26:280-95.
3. Kim YK. Clinical application and classification of bone graft material according to component. J Korean Dent Assoc 2010;48:263-74.
4. Jeong HR, Hwang JH, Lee JK. Effectiveness of autogenous tooth bone used as a graft material for regeneration of bone in miniature pig. J Korean Assoc Oral Maxillofac Surg 2011;37:375-9.
5. Kim YK, Kim SG, Byeon JH. Development of a novel bone grafting material using autogenous teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endo 2010;109:496-504.
6. Murata M, Akazawa T, Mitsuji M, Kabir MA, UM IW. Autograft of dentin materials for bone regeneration. In: Pignatello R, editor. Advances in Biomaterials Sciences and Biomedical Applications. Croatia: InTech; 2013.
7. Smith AJ. Vitality of the dentin-pulp complex in health and disease: Growth factors as key mediators. J Dent Educ 2003;67:678-89.
8. Yeomans JD, Urist MR. Bone induction by decalcified dentine implanted into oral, osseous and muscle tissues. Arch Oral Biol 1967;12:999-1008.
9. Urist MR, Stratou ES. Bone morphogenetic protein. J Dent Res 1971;50:1392-406.
10. Inoue T, Deporter DA, Melcher AH. Induction of cartilage and bone by dentin demineralized in citric acid. J Periodontal Res 1986;21:243-55.
11. Feng QJ, Luan X, Wallace J, Jing D, Ohshima T, Kulkarni AB, et al. Genome organization, chromosomal mapping, and promoter analysis of the mouse dentin sialophosphoprotein (Dsp) gene, which codes for both dentin sialoprotein and dentin phosphoprotein. J Biol Chem 1998;273:9457-64.
12. Ritchie HH, Ritchie DG, Wang LH. Six decades of dentigenesis research. Historical and prospective views on phosphophosphoryl and dentin sialoprotein. Eur J Oral Sci 1998;106 Suppl 1:211-20.
13. Bessho K, Tanaka N, Matsumoto J, Tagawa T, Murata M. Human dentin-matrix-derived bone morphogenetic protein. J Dent Res 1991;70:171-5.
14. Murata M, Akazawa T, Mitsuji M, Um IW, Kim KW, Kim YK. Human dentin as novel biomaterial for bone regeneration. Biomaterials-Physics and Chemistry. In Tech 2011;127-40.
15. Murata M, Akazawa T, Hino J, Tasaki J, Ito K, Arisue M. Bioche-mical and histomorphometrical analyses of bone and cartilage induced by human declassified dentin matrix and BMP-2. Oral Biol Res 2011;33:59-14.
16. Carvalho VA, Tosello Dde O, Salgado MA, Gomes MF. Histomorphometric analysis of homogenous demineralized dentin matrix as osteopromotive material in rabbit mandibles. Int J Oral Maxillofac Implants 2004;19:679-86.
17. Kim YK, Yeo HH, Ryu CH, Lee HB, Byun UR, Cho JO. An experimental study on the tissue reaction of toothshaped implanted in mandible body of the mature dog. J Korean Assoc Maxillofac Plast Reconstr Surg 1993;15:129-36.
18. Kim YK, Yeo HH, Yang IS, Seo HJ, Cho JO. Implantation of toothshaped combined with plaster of Paris: Experimental study. J Korean Assoc Maxillofac Plast Reconstr Surg 1994;16:122-9.
19. Kim SG, Chung CH, Kim YK, Park JC, Lim SC. Use of particulate dentin-plaster of Paris combination with without platelet-rich plasma in the treatment of bone defects around implants. Int J Oral Maxillofac Implants 2002;17:86-94.
20. Kim SY, Kim SG, Lim SC, Bae CS. Effects on bone formation in ovariectomized rats after implantation of tooth ash and plaster of Paris mixture. J Oral Maxillofac Surg 2004;62:852-7.
21. Park SS, Kim SG, Lim SC, Ong JL. Osteogenic activity of the mixture of chitosan and particulate dentin. J Biomed Mater Res A 2008;87:618-23.
22. Gongloff RK. Vital root retention. Int J Oral Maxillofac Surg 1974;3:97-97.
23. Kim YK, Kim SG, Byeon JH, Lee HJ, Um IU, Lim SC, et al. Development of a novel bone grafting material using autogenous teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109:496-503.
24. Kim YK, Lee JY. The evaluation of postoperative safety of autogenous teeth bone graft. J Korean Acad Implant Dent 2009;28:29-35.
25. Schmidt-Schultz TH, Schultz M. Intact growth factors are conserved in the extracellular matrix of ancient human bone and teeth: A storehouse for the study of human evolution in health and disease. Biol Chem 2005;386:767-76.
26. Park SM, Um IW, Kim YK, Kim WK. Clinical application of autogenous bone graft material. J Korean Assoc Maxillofac Surg 2012;38:2-8.
27. Park S, Um IW, Kim YK, Kim WK. Clinical application of autogenous bone graft material. J Korean Assoc Maxillofac Surg 2012;38:2-8.
28. Kim YK, Kim SG, Kim KW, Um IW. Extraction socket preservation and reconstruction using autogenous tooth bone graft. J Korean Assoc Maxillofac Plast Reconstr Surg 2011;33:264-269.
29. Murata M, Sato D, Hino J, Akazawa T, Tasaki J, Ito K, et al.
Acid-insoluble human dentin as carrier material for recombinant human BMP-2. J Biomed Mater Res A 2012;100:571-7.

30. Lee. Histomorphometric study of sinus bone graft using various graft material. J Dent Rehabil Appl Sci 2011;27:141-7.

31. Jeong KI, Kim SG, Kim YK, Oh JS, Jeong MA, Park JJ, et al. Clinical study of graft materials using autogenous teeth in maxillary sinus augmentation. Implant Dent 2011;20:471-5.

32. Chang HY, Kwon TK, Nunn ME, Miyamoto T, Lee KW, Kim YK, et al. Feasibility analysis of autogenous tooth-based bone graft material after guided bone regeneration technique. J Case Rep Stud 2014;1:1-7.

33. Kim YK, Lee J, Um IW, Kim KW, Murata M, Akazawa T, et al. Tooth-derived bone graft material. J Korean Assoc Oral Maxillofac Surg 2013;39:103-11.