Open Access

SCHOLARENA

Journal of Oral Health and Dental Science

REVIEW ARTICLE

ISSN: 2577-1485

The Progress in the Repair of Bone Defect with Demineralized Dentin Matrix

Ding M, Xue L, Zeng Y, Fang C, Cheng W and Li Y*

Department of Oral and Maxillofacial Surgery, the First Affiliated Hospital of Chongqing Medical University, Chongqing, China

***Corresponding author:** Li Y, Department of Oral and Maxillofacial Surgery, the First Affiliated Hospital of Chongqing Medical University, Chongqing 400000, China, Tel: 0086-023-89012907 E-mail: llxxyydd2006@sina.com

Citation: Ding M, Xue L, Zeng Y, Fang C, Cheng W, et al. (2020) The Progress in the Repair of Bone Defect with Demineralized Dentin Matrix. J Oral Health Dent Sci 4: 102

Article history: Received: 07 February 2020, **Accepted:** 02 March 2020, **Published:** 03 March 2020

Abstract

As a new bone graft material, demineralized dentin matrix has good osteogenic, osteoinductive and osteoconductive properties, excellent biocompatibility, no immune response or foreign body reaction, low infection rate, and plays a very important role in the repair of alveolar bone defects. In this paper, the characteristics and clinical application of demineralized dentin matrix were reviewed.

Keywords: Demineralized Dentin Matrix; Bone Defect; Bone Regeneration

Introduction

At present, the bone defect caused by trauma, tumor, inflammation and so on, as well as the increase of bone mass during implantation and maxillary sinus elevation are common in the field of oral and maxillofacial surgery. The treatment is usually to repair bone defect with bone grafts. Ideal material of bone grafts need to have good biocompatibility, osteoinductive, osteoconductive, rapid osteogenic and vascularization properties. It was difficult to find the ideal bone graft material. For a long time, bone graft materials mainly include autogenous bone, allogeneic bone and synthetic bone, but each of them has its own limitations. The volume of autogenous bone is often limited, such as the iliac crest and rib; allogeneic bone has strong immune rejection, which leads to osteonecrosis; synthetic bone is slow in degradation and high price [1-3]. With the innovation of material technology, a new bone graft material has emerged. The demineralized dentin matrix (DDM, also known as autogenous dentin particles) has good biocompatibility, no immune response or foreign body reaction, and does not involve the risk of disease infection. It is gradually used in clinical treatment [4-7]. In this paper, the preparation methods, characteristics and clinical application of demineralized dentin matrix were reviewed, and the basic research of demineralized dentin matrix in repairing bone defect was clarified, which laid a foundation for its extensive application in the field of oral and maxillofacial surgery.

Materials and Methods

Biological characteristics of demineralized dentin matrix

In terms of embryonic development, teeth and jaw tissues come from neural crest cells [8]. Although the tissue structure of teeth and bones is different, the proportion of organic and inorganic content is similar (i.e. 70% minerals, 20% collagen, 10% body fluids). Clinically, most of the demineralized dentin matrix comes from the third molars, orthodontic teeth, residual roots or crowns, loose teeth and deciduous teeth that need to be removed. After demineralization, the demineralized dentin matrix is mainly composed of dentin matrix and part of cementum. It is found that dentin contains many kinds of growth factors, such as insulin growth factor II (IGF-II), bone morphogenetic protein-2 (BMP-2), and transforming growth factor (TGF - β), which are considered as effective graft materials [9]. The cementum also contains transforming growth factor, insulin growth factor (IGF-I), type I and type III collagen, etc. [10]. In view of the multiple proteins and growth factors contained in dentin and cementum, which have osteoinductive, osteoconductive, rapid osteogenic and vascularization properties, and the homology of tooth and jaw tissue in histological development, some scholars have found that inorganic and organic substances in teeth can be used as new bone grafts [11].

Preparation of demineralized dentin matrix

The preparation methods of demineralized dentin matrix include freeze-drying, demineralization, calcination and boiling, which can promote the healing of bone defects in varying degrees. The demineralized dentin matrix can induce osteogenesis in 4 weeks, but common dentin in 8 to 12 weeks [12]. The delayed osteoinductive ability of common dentin may be related to the inhibition of

BMP release by apatite crystal. Because of its high crystalline calcium phosphate and poor bone guidance, it is necessary to remove the enamel from the crown before repairing bone defect with the demineralized dentin matrix. The routine preparation methods are as follows: the teeth are extracted, the enamel, pulp and soft tissues such as periodontal membrane, caries, dental calculus, fillings, restorations, etc., are removed. Then teeth are dealt in the ultrasonic instrument, broken into particles with the self-bone powder preparation system. The particles are dehydrated, demineralised, sterilized at room temperature, washed twice with distilled water or sterile phosphate buffer. According to the needs of the operation, the particles can finally be made into massive or powder, then heated and dried [13,14].

Basic research on demineralized dentin matrix

In 1967, Yeomans and Urist made rabbit dentin as bone graft material to obtain new bone formation [15]. Since then, the research on demineralized dentin matrix has begun [16-18]. There has been a lot of related research about demineralized dentin matrix recently. Some scholars have made the demineralized dentin matrix without enamel and pulp for bone regeneration to repair the bone defects of adult sheep, and found that new bone formation have been observed in the area of demineralized dentin matrix [19]. The demineralized dentin matrix, as a new bone regeneration material, has great value in clinical application. The deproteinized bovine bone grafts (Bio-Oss) and human demineralised dentin particles were respectively implanted into the bottom of the maxillary sinus during the maxillary sinus elevation operation, and the animals were killed at 2 and 8 weeks after the operation. The histomorphology of the two kinds of bone grafts was analyzed by hematoxylin eosin staining and masson trichrome staining. It was found that the new bone was formed in both groups, but the area of new bone formation in the human demineralised dentin particles was significantly higher than that in the Bio-Oss group [20]. The demineralised dentin particles with different particle sizes and densities were used to repair skull defects of rabbits. Rabbits were killed after 2, 4 and 8 weeks respectively. Bone tissue samples were detected by histology, histomorphology and quantitative RT-PCR. It was found that the demineralised dentin particles with a diameter of 200 micrometres had best osteogenic effect. It shows that the material with smaller particle size is more suitable for bone transplantation [21]. Kim et al. implanted implants and demineralized dentin matrix in the extraction fossa of mandible molars with vertical bone defects in small pigs, then calculated the ratio of new bone formation (NBF) to overall bone defect, and the ratio of the length of alveolar bone to implant contact area (BIC) to implant length; The results showed that the ratio of NBF and BIC in the demineralized dentin matrix group was higher than that in control group at the 4^{th}, 8^{th} and 12^{th} week; NBF was (77.13 ± 15.30)%in the demineralized dentin matrix group and (1.33 + 2.31)% in the control group at 12^{th} week; BIC was (75.13 ± 16.55)% in the demineralized dentin matrix group and(1.33 ± 2.31)% in the control group at 12^{th} week. These results indicated that the effect of bone reconstruction in the demineralized dentin matrix group at the 12^{th} week was better than that of the control group. The results of CT showed that the bone density of the demineralized dentin matrix group was significantly higher than that of the control group at the 12^{th} week, and the bone formation of the demineralized dentin matrix group was significantly higher than that of the control group ($P < 0.05$), the immature bone of the demineralized dentin matrix group (25.71%) was less than that of the control group (55.98%) [22].

Some scholars have compared the osteogenic effect of demineralised dentin matrix and recombinant human bone morphogenetic protein-2 (rhBMP-2) with that of inorganic bovine bone (ABB) and rhBMP-2 in the treatment of rabbit skull defect. Circular defects with a diameter of 8mm were formed on each rabbit skull. Each defect was treated by one of the following methods: 1) DDM, 2) ABB / rhBMP-2, or 3) DDM / rhBMP-2. The histology was observed after two weeks. DDM group and ABB / rhBMP-2 group showed conductive bone formation, while DDM / rhBMP-2 group showed conductive and induced bone formation. Compared with DDM group, new bone volume of DDM / rhBMP-2 group increased significantly at 8th week. It should be noted that the new bone volume of ABB / rhBMP-2 group decreased slightly at 8th week. DDM with rhBMP-2 is suitable for autogenous graft material [23].

Clinical application of demineralised dentin matrix

Demineralised dentin matrix have been widely used in clinical practice, such as post extraction alveolar site preservation, implant bone graft, guided bone regeneration, maxillary sinus elevation and bone reconstruction after extraction of impacted mandibular teeth [24].

In the study of maxillary sinus elevation, the demineralised dentin matrix was absorbed gradually and replaced by new bone in histology, and the bone at the bottom of the sinus was reconstructed. So the demineralised dentin matrix can be used as the bone graft material in maxillary sinus elevation, and the effect is satisfied [25,26].

As a new type of bone substitute, demineralised dentin matrix has been used for post extraction site preservation and bone incremental surgery. Some scholars had implanted demineralised dentin matrix in the alveolar fossa after tooth extraction. The cone beam CT and bone density measurement showed that the average alveolar bone absorption height decreased the width of cancellous bone decreased, and the bone density increased in assay group, compared with the blank control group [14] [27-28]. Joshi et al. implanted demineralised dentin matrix and beta-tricalcium phosphate alloplast respectively after tooth extraction. The CBCT was performed immediately after operation, and the height and width of alveolar ridge in both groups were rechecked at 4 months after operation. The results showed that there was more new bone formation in the demineralised dentin matrix site than that in the beta-tricalcium phosphate site [14]. After the average follow-up period of five years, it showed that the formed

cortex and cancellous bone were well maintained after demineralised dentin matrix was implanted, which was consistent with other short-term follow-up studies [4]. Demineralised dentin matrix can be used as a good material for bone transplantation, even in patients with severe periodontitis [6,29-32]. Demineralised dentin matrix can promote early osteogenesis to achieve good osseointegration with implant surface [33,34].

The autologous bone is considered by some authors the gold standard for bone regeneration. Autologous bone can be gotten from different regions, for example the iliac crest, rib or fibula. Nevertheless, they provide limited quantities of bone, and are associated with morbidity [35]. Allogeneic bone blocks offer a viable alternative to autologous bone, as they can be obtained in almost unlimited quantities. But they are antigenic, and present a risk of disease transmission thanks to a complex process of delipidization, oxidation, dehydration, and gamma irradiation [36].The synthetic bone is difficult to shape, does not permit fibro-osseous ingrowth, and has a much higher modulus of elasticity than bone [37]. Teeth and bones have a very similar chemical composition. Research on graft materials that can overcome the limitations of autogenous bone and other substitutes has led to the development of demineralised dentin matrix, which is an ideal substitute and has many sources. The demineralised dentin matrix has excellent osteoinductive and osteoconductive abilities, and the recovery process induced by demineralised dentin matrix histologically resembles that induced by autogenous bone [38].

Conclusion

As a new bone graft material, demineralised dentin matrix not only has the function of osteoconduction and osteoinduction, but also has the advantages of good biocompatibility, no rejection, simple process and convenient operation. Basic and clinical research showed that it had a good osteogenic effect, and had been initially used in periodontal and implant fields. However, the research on the physical and chemical stability of autogenous teeth after long-term storage is also in progress and the long-term clinical cases of demineralised dentin matrix is less. However, we believe that the extracted teeth of patients should be kept properly. When patients need bone transplantation, they can be used. Demineralised dentin matrix will be a better choice in bone transplantation in the future. It has a good development prospect and is expected to be widely used and promoted in the world.

Compliance with Ethical Standards

Conflict of Interest: Ming Ding declares that he has no conflict of interest. Lingli Xue declares that she has no conflict of interest. Yan Zeng declares that she has no conflict of interest. Chuan Fang declares that he has no conflict of interest. Wei Cheng declares that she has no conflict of interest. Yadong Li declares that he has no conflict of interest.

Funding: This study was supported by Natural Science Foundation Project of CQ CSTC (cstc2018jcyjAX0763), Medical High-end Reserve Talent Training Program Chongqing Municipal Health Bureau (2017HBRC004)

References

1. Oryan A, Alidadi S, Moshiri A, Maffulli N (2014) Bone regenerative medicine: classic options, novel strategies, and future directions. J Orthop Surg Res 9: 18.

2. Santos PL, Gulinelli JL, Telles Cda S, Betoni Junior W, Okamoto R, et al. (2013) Bone substitutes for peri-implant defects of post extraction implants. Int J Biomater 2013: 307136.

3. Bohner M, Tadier s, Garderen NV, de Gasparo A, Dobelin N, et al. (2013) Synthesis of spherical calcium phosphate particles for dental and orthopedic applications. Biomater 3: e25103.

4. Kim YK, Lee JH, Um IW, Cho WJ (2016) Guided Bone Regeneration Using Demineralized Dentin Matrix: Long-Term Follow-Up. J Oral Maxillofac Surg 74: 515.e1-9.

5. Um IW, Kim YK, Park JC, Lee JH (2019) Clinical application of autogenous demineralized dentin matrix loaded with recombinant human bone morphogenetic-2 for socket preservation: A case series. Clin Implant Dent Relat Res 21: 4-10.

6. Minamizato T, Koga T, I T, Nakatani Y, Umebayashi M, et al. (2018) Clinical application of autogenous partially demineralized dentin matrix prepared immediately after extraction for alveolar bone regeneration in implant dentistry: a pilot study. Int J Oral Maxillofac Surg 47:125-32.

7. Schwarz F, Hazar D, Becker K, Sader R, Becker J (2018) Efficacy of autogenous tooth roots for lateral alveolar ridge augmentation and staged implant placement. A prospective controlled clinical study. J Clin Periodontol 45: 996-1004.

8. Yuan Y, Chai Y (2019) Regulatory mechanisms of jaw bone and tooth development. Curr Top Dev Biol 133: 91-118.

9. Duncan HF, Smith AJ, Fleming GJ, Reid C, Smith G, et al. (2017) Release of bio-active dentine extracellular matrix components by histone deacetylase inhibitors (HDACi). Int Endod J 50: 24-38.

10. Wang J, Tian ZL, Liu YP, Liu ZH, Sun HC, et al. (2019) Application of biological factor in cementum regeneration]. Zhonghua Kou Qiang Yi Xue Za Zhi 54: 568-72.

11. Rijal G, Shin HI (2017) Human tooth-derived biomaterial as a graft substitute for hard tissue regeneration. Regen Med 12: 263-73.

12. Henriksen K, Andreassen KV, Thudium CS, Gudmann KN, Moscatelli I, et al. A specific subtype of osteoclasts secretes factors inducing nodule formation by osteoblasts. Bone 51: 353-61.

13. Jin SY, Kim SG, Oh JS, You JS, Lim SC, et al. (2016) Histomorphometric Analysis of Contaminated Autogenous Tooth Graft Materials after Various Sterilization. Implant Dent 25: 83-9.

14. Joshi CP, Dani NH, Khedkar SU (2016) Alveolar ridge preservation using autogenous tooth graft versus beta-tricalcium phosphate alloplast: A randomized, controlled, prospective, clinical pilot study. J Indian Soc Periodontol 20: 429-34.

15. Yeomans JD, Urist MR (1967) Bone induction by decalcified dentine implanted into oral, osseous and muscle tissues. Arch Oral Biol 12: 999-1008.

16. Nam JW, Kim MY, Han SJ (2016) Cranial bone regeneration according to different particle sizes and densities of demineralized dentin matrix in the rabbit model. Maxillofac Plast Reconstr Surg 38: 27.

17. Kim SK, Huh CK, Lee JH, Kim KW, Kim MY (2016) Histologic study of bone-forming capacity on polydeoxyribonucleotide combined with demineralized dentin matrix. Maxillofac Plast Reconstr Surg 38: 7.

18. Calvo-Guirado JL, Mate-Sanchez de Val JE, Ramos-Oltra ML, Perez-Albacete Martinez C, Ramirez-Fernandez MP, et al. The Use of Tooth Particles as a Biomaterial in Post-Extraction Sockets. Experimental Study in Dogs. Dent J (Basel) 6: E12.

19. Kabir MA, Murata M, Akazawa T, Kusano K, Yamada K, et al. (2017) Evaluation of perforated demineralized dentin scaffold on bone regeneration in critical-size sheep iliac defects, Clin Oral Implants Res 28: e227-35.

20. Xu X, Sohn DS, Kim HG, Lee SJ, Moon YS (2018) Comparative Histomorphometric Analysis of Maxillary Sinus Augmentation With Deproteinized Bovine Bone and Demineralized Particulate Human Tooth Graft: An Experimental Study in Rabbits. Implant Dent 27: 324-31.

21. Koga T, Minamizato T, Kawai Y, Miura K, T I, et al. (2016) Bone Regeneration Using Dentin Matrix Depends on the Degree of Demineralization and Particle Size. PLoS One 11: e0147235.

22. Kim SK, Kim SW, Kim KW (2015) Effect on bone formation of the autogenous tooth graft in the treatment of peri-implant vertical bone defects in the minipigs. Maxillofac Plast Reconstr Surg 37: 2.

23. Um IW, Hwang SH, Kim YK, Kim MY, Jun SH, et al. (2016) Demineralized dentin matrix combined with recombinant human bone morphogenetic protein-2 in rabbit calvarial defects. J Korean Assoc Oral Maxillofac Surg 42: 90-8.

24. Li B, Wu D, Yan J, Liu W, Zhou S, et al. (2015) Research and development of the autogenous tooth bone graft material. Zhonghua Kou Qiang Yi Xue Za Zhi 50: 765-7.

25. Esposito M, Felice P, Worthington HV (2014) Interventions for replacing missing teeth: augmentation procedures of the maxillary sinus. Cochrane Database Syst Rev 13: CD008397.

26. Pohl V, Schuh C, Fischer MB, Haas R (2016) A New Method Using Autogenous Impacted Third Molars for Sinus Augmentation to Enhance Implant Treatment: Case Series with Preliminary Results of an Open, Prospective Longitudinal Study. Int J Oral Maxillofac Implants 31: 622-30.

27. Kim ES, Lee IK, Kang JY, Lee EY (2015) Various autogenous fresh demineralized tooth forms for alveolar socket preservation in anterior tooth extraction sites: a series of 4 cases. Maxillofac Plast Reconstr Surg 37: 27.

28. Del Canto-Diaz A, de Elio-Oliveros J, Del Canto-Diaz M, Alobera-Gracia MA, Del Canto-Pingarron M, et al. (2019) Use of autologous tooth-derived graft material in the post-extraction dental socket. Pilot study. Med Oral Patol Oral Cir Bucal 24: e53-60.

29. Li P, Zhu H, Huang D (2018) Autogenous DDM versus Bio-Oss granules in GBR for immediate implantation in periodontal postextraction sites: A prospective clinical study, Clin Implant Dent Relat Res 20: 923-8.

30. Pang KM, Um IW, Kim YK, Woo JM, Kim SM, et al. (2017) Autogenous demineralized dentin matrix from extracted tooth for the augmentation of alveolar bone defect: a prospective randomized clinical trial in comparison with anorganic bovine bone. Clin Oral Implants Res 28: 809-15.

31. Ge J, Yang C, Wang Y, Zheng J, Hua H, et al. (2018) Comparison of different grafting materials for treatment of bone defect distal to the molar in canine. Clin Implant Dent Relat Res 20: 444-54.

32. Testori T, Scaini R, Weinstein T, Deflorian M, Taschieri S, et al. (2018) Autogenous transplant of two impacted mandibular canines: a case report with 2-year follow-up. Eur J Oral Implantol 11: 227-32.

33. Kim YK, Pang KM, Yun PY, Leem DH, Um IW (2017) Long-term follow-up of autogenous tooth bone graft blocks with dental implants, Clin Case Rep 5: 108-18.

34. Gual-Vaques P, Polis-Yanes C, Estrugo-Devesa A, Ayuso-Montero R, Mari-Roig A (2018) . Med Oral Patol Oral Cir Bucal 23: e112-9.

35. Cabbad NC, Stalder MW, Arroyave A, Wolfe EM, Wolfe SA (2019) Autogenous Bone Cranioplasty: Review of a 42-Year Experience by a Single Surgeon. Plast Reconstr Surg 143: 1713-23.

36. Pérez-González F, Molinero-Mourelle P, Sánchez-Labrador L, Sáez-Alcaide LM, Limones A, et al. (2020) Assessment of clinical outcomes and histomorphometric findings in alveolar ridge augmentation procedures with allogeneic bone block grafts: A systematic review and meta-analysis. Med Oral Patol Oral Cir Bucal 25: e291-8.

37. Mohamed KR, Beherei HH, El Bassyouni GT, El Mahallawy N (2013) Fabrication and mechanical evaluation of hydroxyapatite/oxide nano-composite materials. Mater Sci Eng C Mater Biol Appl 33: 4126-32.

38. Kuperschlag A, Keršytė G, Kurtzman GM, Horowitz RA (2020) Autogenous Dentin Grafting of Osseous Defects Distal to Mandibular Second Molars After Extraction of Impacted Third Molars. Compend Contin Educ Dent 41: 76-82.