folia medica

Folia Medica 64(1):162-8
DOI: 10.3897/folmed.64.e59099

Case Report

Auto-Tooth Bone Graft Material for Reconstruction of Bone Defects in the Oral Region: Case Reports

Nikolay Kanazirski[1], Petya Kanazirska[2]

[1] Department of Oral Surgery, Faculty of Dental Medicine, Medical University of Plovdiv, Plovdiv, Bulgaria

[2] Department of Imaging Diagnostics, Dental Allergy and Physical Therapy, Faculty of Dental Medicine, Medical University of Plovdiv, Plovdiv, Bulgaria

Corresponding author: Nikolay Kanazirski, Department of Oral Surgery, Faculty of Dental Medicine, Medical University of Plovdiv, 3 Hristo Botev Blvd., Plovdiv, Bulgaria; E-mail: nkanazirski@gmail.com; Tel.: +359 888 372 906

Received: 29 Sep 2020 ♦ **Accepted:** 8 Feb 2021 ♦ **Published:** 28 Feb 2022

Citation: Kanazirski N, Kanazirska P. Auto-tooth bone graft material for reconstruction of bone defects in the oral region: case reports. Folia Med (Plovdiv) 2022;64(1):162-8. doi: 10.3897/folmed.64.e59099.

Abstract

We present some clinical cases of autogenous tooth graft –a modern method in which the extracted teeth are processed into a demineralised dentin matrix (DDM) and are then immediately transplanted into the post-extraction sockets or bone defects.

We included patients with jaw lesions due to chronic inflammatory conditions, cystic formations, or peri-implantitis. After removing the pathological processes and tissues, we performed curettage with an Er-YAG laser and treated the bone structures in the borderline area. Then auto-tooth bone (ATB) graft material was applied. The clinical results showed favourable wound healing and good bone integration of implants. Radiological studies showed stimulation and acceleration of bone regeneration with alveolar crest resorption of graft material of no more than 10%. Histological examination found new bone formation which was induced by the osteo-inductive material.

On the basis of the clinical outcomes and the favourable healing process with a very good bone integration of the DDM, we can recommend this method as an option for bone defect reconstruction. The satisfactory quantity (up to 3 grams per molar) and quality of the demineralised dentin matrix determine a relatively low cost of bone grafting.

Keywords

auto-tooth bone graft system, guided tissue regeneration with autogenous bone graft, demineralised dentin matrix

INTRODUCTION

Various graft materials are used for reconstruction of alveolar bone defects in clinical practice. These include allografts (demineralised and lyophilised human bone), xenografts (bovine bone, porcine bone, and coral), and alloplastic materials (biological ceramics, b-tricalcium phosphate [b-TCP] and hydroxyapatite). They are indifferent, osteoconductive and osteoinductive with regard to their absorption by the body and new bone formation.

A good bone graft material should have three properties: 1) osteoconduction, which provides the scaffold for bone regeneration; 2) osteoinduction, which promotes formation of bone from undifferentiated cells and preosteoblasts; 3) osteogenesis, the induction of cells contained in the graft to stimulate bone regeneration.[1]

Bone graft material should stabilise the blood clot and provide a biomechanical scaffold for cell migration, proliferation, and differentiation. It should contain functional proteins and peptides, such as growth factors, and provide resorption and remodelling during the period of new bone formation. Collagen-based materials, especially of type I, have attracted attention because of their ability to improve cellular responses of osteogenic lines, thus ensuring better bone regeneration.[2] The mineral component, which provides biomechanical stability, is an important factor for cell differentiation, a nucleus for calcification and space maintenance during the period of new bone formation.[3] Considering the structure of the bone, the mineralised collagen matrix with functional proteins and appropriate fibril arrays for biomechanics is a suitable natural biomaterial for bone tissue engineering.[4]

The tooth is increasingly attracting attention as a material for alveolar bone regeneration. It is composed of an organic matrix and an inorganic reinforcing phase of hydroxyapatite. Radial arrays of dense type I collagen fibrils, which make up 90% of the organic matrix, and non-cellular acidic proteins play an important role in calcification.[5] The chemical composition of dentin is very similar to that of bone. In adults, the inorganic content is 70%–75%, the organic content is 20% and the water content is 10%. In alveolar bone, these components are present in the following proportions: 65%, 25%, and 10%, respectively.[6] The tooth has a much lower fat content compared to bone and has no bone marrow, which makes it easier to obtain graft material from it.[7]

Raw tooth (non-demineralized) cannot easily induce new bone formation due to its high mineral content, high crystallinity and low porosity, which can impede the migration, attachment and proliferation of vessels and mesenchymal cells.[7,8] In 1967, Yoemans et al. used demineralized teeth for the first time in their studies and proved their osteogenic capacity.[8] In 1977, it was accepted that autogenously and allogenetically demineralized teeth were osteoinductive and osteoconductive graft materials.[9]

Young-Kyun Kim et al. conducted research on the development of biomaterials using human teeth in 1993. After long research based on an analysis of the inorganic and organic components, surface structure and histological evidence of the healing process in the samples collected after clinical application, the authors concluded that the use of bone graft material of autogenous teeth resulted in excellent reconstruction of the bone. Since 2008, Kim et al. developed the auto-tooth bone graft (ATB; Tooth Bank Co; Seoul Korea) methodology. The authors make graft material in the form of powder, chips or a block of extracted teeth and transplant them into the patients from whom the teeth were extracted.[6]

In addition to excellent osteoinductive and osteoconductive properties, the ATB graft material avoids the limiting factors of allografts, xenografts, and alloplastic materials, such as reduced function, potential risk of infection, unsatisfactory resorption, long recovery time, and high costs.[10]

A disadvantage of the ATB graft material is that acids are used for the demineralization process, and prolonged exposure to acid can have a negative effect on non-collagenous proteins involved in the formation of new bones. To overcome these limiting factors, other authors propose a modified ultrasound technology for the process of demineralization of the tooth graft.[11]

Method of preparation of ATB graft material

After the tooth to be used for graft material is extracted, it is mechanically cleaned of soft tissue and pulp **(Fig. 1A-1C)**.

The cleaned tooth is placed in a mechanical mill in which it is crushed. It is then sieved through two sieves, and the larger particles, which are composed mainly of enamel, are discarded. Thus, a powder material with a particle size between 200 and 1000 nm is obtained **(Figs 2A, 2B)**. It is placed in a special container in the Bon Maker device, of the Auto-Tooth Bone Graft System, manufactured by the company Korea Dental Solution (Korea, 2012). In this device, the crushed tooth undergoes three main processes, which require special reactants: 1. removal of contaminated structures and remaining soft tissues through irrigation; 2. processes of dehydration and degreasing; 3. Process of lyophilisation **(Fig. 2C-2E)**.

CASE REPORTS

Case 1: a patient with peri-implantitis

*A 56-year-old female patient with peri-implantitis in the area of tooth 36. Intraoral radiography performed 6 months after implant placement showed bone resorption in the upper third of the implant **(Fig. 3A)**. Tooth 48 was extracted so that it could be used to obtain graft material. Immediately after the extraction, the tooth was cleaned, was crushed mechanically into powder and went through the stages of irrigation,*

Figure 1. Preparation of the extracted tooth: **A**) extracted; **B**) mechanically cleaned tooth of soft tissue; **C**) cleaned tooth of pulp.

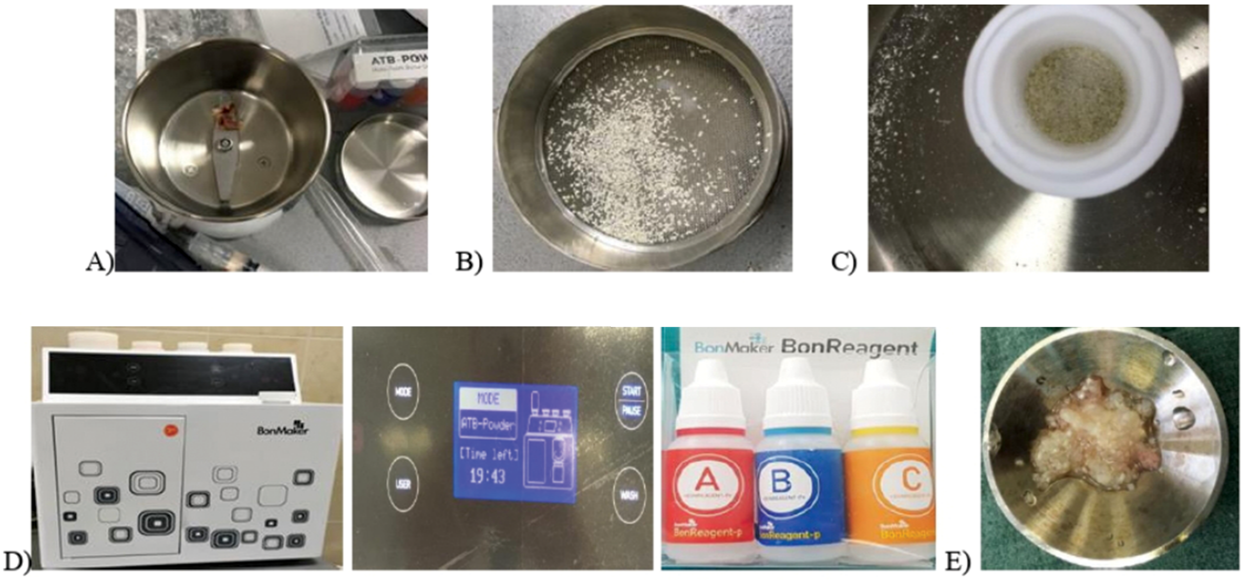


Figure 2. **A**) a mechanical mill for crushing the tooth; **B**) the resulting powder, with a particle size between 200 and 1000 nm; **C**) powder container; **D**) Bon Maker device, operating mode and reactants used for the three main processes; **E**) the ready graft material.

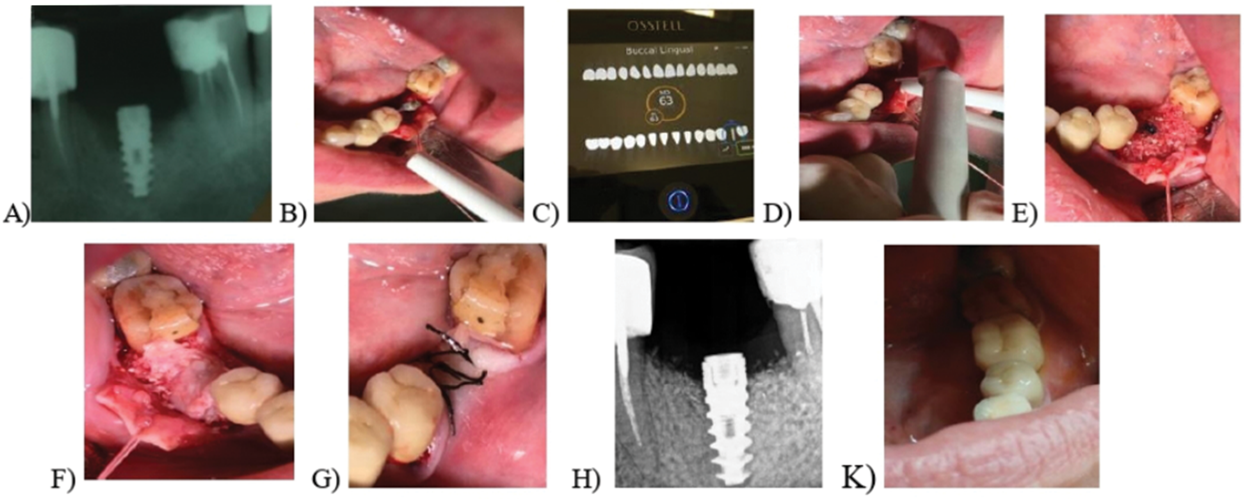


Figure 3. **A**) Intraoral X-ray of the implant in the area of 36; **B**) preparation of the flap; **C**) measured the implant's stability; **D**) Granulation tissue ablation and bone remodeling with Er-YAG laser; **E**) Filling the bone defect with ATB graft material; **F**) Coating the graft material with PRF membrane; **G**) adaptation and suturing of the mucoperiosteal flap; **H**) control radiography after three months; **K**) Prosthetic rehabilitation of the implant.

dehydration, degreasing, and lyophilisation using the method described above.

*After obtaining the graft material, a mucoperiosteal envelope flap was raised in the area of the implant **(Fig. 3 B)**. After exposure of the implant, its stability was measured using the Osstell Implant Stability Quotient module. The stability of the implant in buccolingual and mesiodistal directions was unsatisfactory (63 ISQ) **(Fig. 3C)**. Using an Er:YAG laser, the granulation tissue was removed and the bone was prepared for regeneration **(Fig. 3D)**. The bone defect was filled with graft material and covered with a patient blood-derived PRF membrane **(Figs 3E, 3F)**. The mucoperiosteal flap was adjusted and sutured **(Fig. 3G)**.*

*Three months after the placement of the ATB graft material, a follow-up radiograph was performed – it showed that the newly formed bone around the implant had good density characteristics and height, and no significant alveolar crest resorption was found **(Fig. 3H)**. After exposure of the implant, its stability was measured in buccolingual and mediovestibular directions, and a significant improvement in its stability was found (82 ISQ).*

*No complications were observed six months after prosthetic loading **(Fig. 3K)**.*

Case 2: a patient with a radicular cyst

A 25-year-old male patient with a radicular cyst of tooth 46. Cone-beam computed tomography (CBCT) showed a hy-

*podense oval lesion around the two roots of tooth 46, which had homogeneous structure, with dimensions of 8.88×6.89 mm, distinct borders and a perifocal sclerotic wall **(Fig. 4A)**. Before tooth extraction, a mucoperiosteal flap was raised. At the same visit, ATB graft material was obtained from the extracted tooth according to the described protocol. The socket was cleaned using an Er:YAG laser and filled with bone substitute. Then the flap was adjusted and sutured.*

*Six months later, follow-up computed tomography was performed, which showed excellent bone remodelling of the graft material, with good density and minimal alveolar crest resorption. Measurements were made for the scheduled implantation **(Fig. 4B)**.*

*At the second clinical visit, after raising a flap, biological material was taken from the bone in the graft area for histological analysis. Using a bone trephine bur with a diameter of 2 mm, 5 mm of bone was taken from the boundary zone between the graft and the normal bone. The specimen was fixed with 10% formalin solution and sent for histological analysis. On histological sections, 6 months after placement of the ATB graft material, remodelling in the marginal areas of the graft material and stable osteointegration with the surrounding bone were observed. The newly formed bone has an approximate volume of 33.0% and excellent remodelling of the bone trabeculae. The graft material was incompletely absorbed and the volume of residual graft material was 26.8% **(Fig. 5 A-C)**.*

An implant was placed, without complications during the procedure. The primary stability of the implant in the buccolingual and mesiodistal directions was measured, which featured good levels –73 ISQ.

*Three months after the implant placement, a follow-up radiograph was performed, which showed that the newly formed bone around the implant had good density characteristics, and no significant alveolar crest resorption was found **(Fig. 6)**. After exposure of the implant, its stability was measured in buccolingual and mediovestibular directions. The measured value was 80 ISQ.*

Case 3: a patient with total periodontitis

A 45-year-old male patient with pronounced clinical symptoms of an exacerbated inflammatory process in the area of the attached gingiva of tooth 26. The performed intraoral

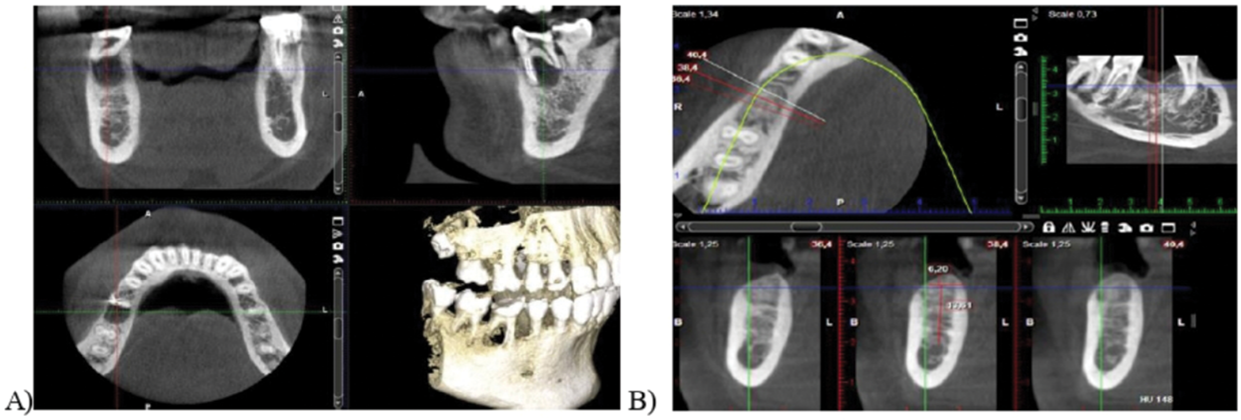


Figure 4. **A**) CBCT imaging of the lesion around the roots of 46; **B**) CBCT imaging after 6 months.

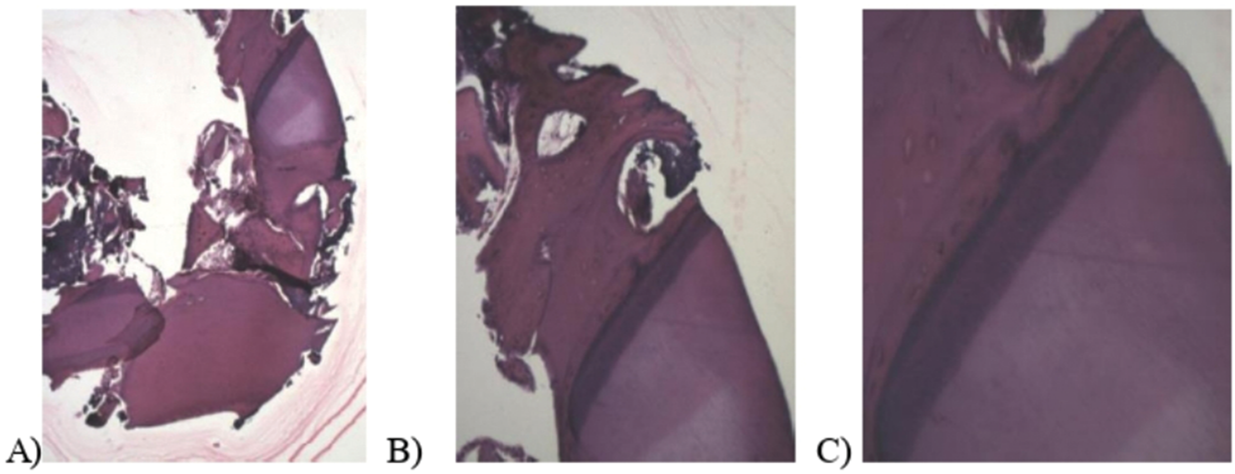


Figure 5. Newly formed bone demonstrating the occurrence of remodeling was identified around the implanted ATB powder. Remodeling of the tooth elements was observed at the bone-implant interfaces (H&E staining): **A**) ×40; **B**) ×100; **C**) ×200.

radiograph showed vertical bone resorption up to the apical third of the mediovestibular root of tooth 26, with involvement of the trifurcation ***(Fig. 7)****.*

With a view to alveolar bone prevention and scheduled implantation, tooth 26 was extracted and ATB graft material was obtained according to the described protocol. No complications occurred in the postoperative period.

Radiography performed six months later showed good remodelling of the graft material, with normal bone structure and density ***(Fig. 8A)****. An implant was placed in that area, which also showed satisfactory levels of the stability measured (74 ISQ)* ***(Fig. 8B)****.*

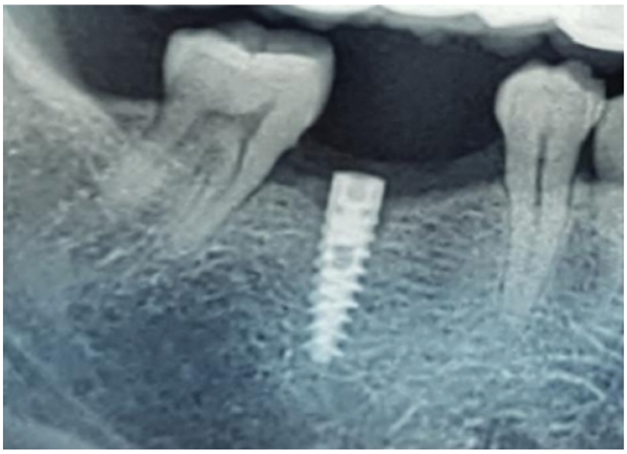


Figure 6. A follow-up radiograph three months after implant placement.

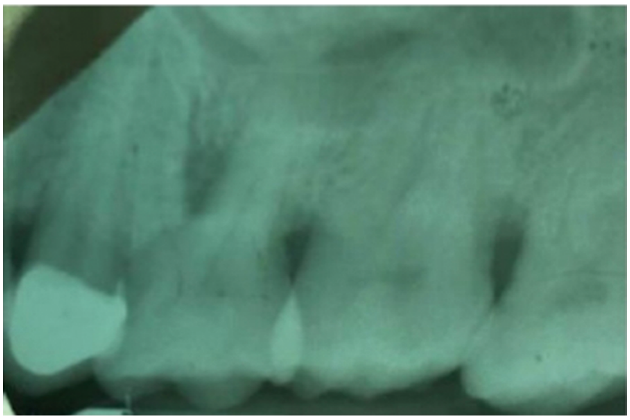


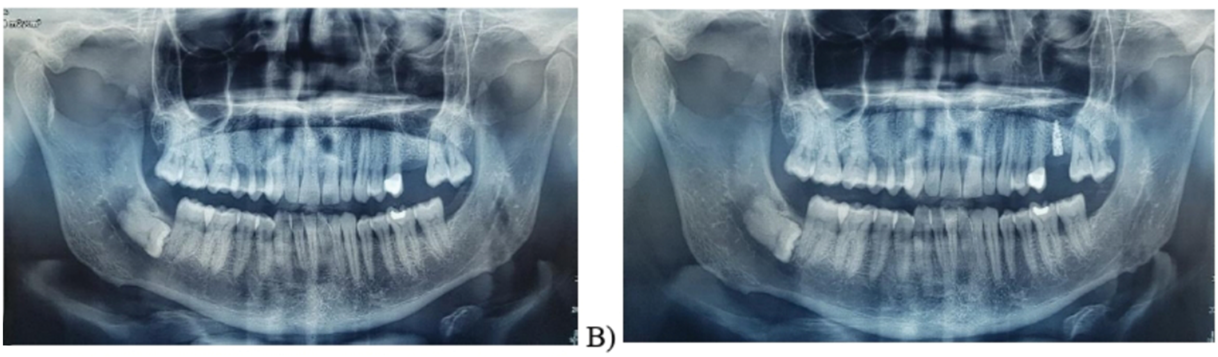
Figure 7. Intraoral X-ray of tooth 26.

DISCUSSION

The outcomes of our clinical cases are identical to those studied by many other authors.[6,7,10,13,14] The stability of the implants was confirmed with a radio frequency device, the Osstell Implant Stability Quotient module, by measuring satisfactory ISQ levels for primary stability. Gharpure et al. have made a systematic review of many scientific publications by other authors who used auto-tooth graft material. After statistical analysis of the results, they found that the average value of the stability of the primary implant was 72.8 ISQ. The authors did not find a statistically significant difference in the measurements of the stability of auto-tooth graft materials and other bone graft materials.[19] The measured values in our study are close to these results. Also, in our study we measured the secondary stability of implants for the final prosthesis to assess the degree of osteointegration.

The results of our histological examination were similar to those of other studies. Appositional bone growth around the ATB graft material was observed, and its resorption implies that the demineralised tooth was osteoconductive with a remodelling characteristic.[6,7,15-18] According to Eun-Seok Kim, the most interesting histological features are the appearance of fusion-like integration between the two matrices of the graft and new bone. This suggests that dentinal tubules provide niches for the cells involved in osteogenesis.[7]

A reasonable explanation of the good results is the high biocompatibility of autogenous tissue and its porous collagen-based structure, which is beneficial for cellular function. Our results confirm those reported in other studies –in particular, that the use of this graft material promotes a rapid healing effect and the newly formed bone has a good radiologically determined density and structure.[10,12,13,15,17]



A) B)

Figure 8. Panoramic X-ray before and after implant placement.

CONCLUSIONS

The good clinical outcomes and the favourable healing process with the desired bone integration give us grounds to recommend this method as an option for bone defect reconstruction. The satisfactory quantity (up to 3 grams per molar) and quality of the demineralised dentin matrix determine a relatively low cost of bone grafting.

REFERENCES

1. Nampo T, Watahiki J, Enomoto A, et al. A new method for alveolar bone repair using extracted teeth for the graft material. J Periodontol 2010; 81:1264–72.
2. Qian JJ, Bhatnagar RS. Enhanced cell attachment to anorganic bone mineral in the presence of a synthetic peptide related to collagen. J Biomed Mater Res 1996; 4:545–54.
3. Liu Y, Luo D, Liu S, et al. Effect of nanostructure of mineralized collagen scaffolds on their physical properties and osteogenic potential. J Biomed Nanotechnol 2014; 6:1049–60.
4. Beniash E. Biominerals –hierarchical nanocomposites: the example of bone. Wiley Interdiscip Rev Nanomed Nanobiotechnol 2011; 1:47–69.
5. Pashley DH. Dentin: a dynamic substrate –a review. Scanning Microsc 1989; 1:161–74.
6. Kim YK, Kim SG, Oh JS, et al. Analysis of the inorganic component of autogenous tooth bone graft material. J Nanoscience and Nanotechnology 2011; 11:7442–5.
7. Kim ES. Autogenous fresh demineralized tooth graft prepared at chairside for dental implant. Plast Reconstr Surg 2015; 37:8.
8. Yoemans D, Urist R. Bone induction by decalcified dentin implanted into oral and muscle tissues. Arch Oral Biol 1967; 12:999–1008.
9. Butler WT, Mikulski A, Urist MR, et al. Noncollagenous proteins of a rat dentin matrix possessing bone morphogenetic activity. J Dent Res 1977; 3:228–32.
10. Kim YK, Lee J, Um IW, et al. Tooth-derived bone graft material. J Korean Assoc Oral Maxillofac Surg 2013; 39:103–11.
11. Xu C, Wang Y. Chemical composition and structure of peritubular and intertubular human dentine revisited. Arch Oral Biol 2012; 4:383–91.
12. Kim ES, Lee IK, Kang JY, et al. Various autogenous fresh demineralized tooth forms for alveolar socket preservation in anterior tooth extraction sites: a series of 4 cases. Maxillofac Plast Reconstr Surg 2015; 37:27.
13. Kim YK, Kim SG, Yun PY, et al. Autogenous teeth used for bone grafting: a comparison with traditional grafting materials. Oral Surg Oral Med Oral Pathol Oral Radiol 2014; 117(1):39–45.
14. Kim YK, Kim SG, Byeon JH, 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.
15. Bhattacharjya C, Gadicherla S, Kamath AT, et al. Tooth derived bone graft material. World J Dent 2016; 7(1):32–5.
16. Pang KM, Um IW, Kim YK, et al. 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 2017; 28(7):809–15.
17. Gharpure A, Bhatavadekar N. Clinical efficacy of tooth-bone graft: a systematic review and risk of bias analysis of randomized control trials and observational studies. Implant Dentistry 2018; 27(1):119–34.
18. Kripal K, Sirajjudin S, Reddy S, et al. Bone engineering using human demineralized dentin matrix (auto-tooth bone graft) in the treatment of human intrabony defects: a case report. EC Dental Science 2017; 8(3):91–100.

Материал из аутотрансплантата кости зуба для реконструкции костных дефектов в области рта: отчёты о клинических случаях

Николай Каназирски[1], Петя Каназирска[2]

[1] *Кафедра оральной хирургии, Факультет дентальной медицины, Медицинский университет – Пловдив, Пловдив, Болгария*

[2] *Кафедра образной диагностики, дентальной аллергологии и физиотерапии, Факультет дентальной медицины, Медицинский университет – Пловдив, Пловдив, Болгария*

Адрес для корреспонденции: Николай Каназирски, Кафедра оральной хирургии, Факультет дентальной медицины, Медицинский университет – Пловдив, бул. „Христо Ботев“ № 3, Пловдив, Болгария; E-mail: nkanazirski@gmail.com; Тел.: +359 888 372 906

Дата получения: 29 сентября. 2020 ♦ **Дата приемки:** 8 февраля 2021 ♦ **Дата публикации:** 28 февраля 2022

Образец цитирования: Kanazirski N, Kanazirska P. Auto-tooth bone graft material for reconstruction of bone defects in the oral region: case reports. Folia Med (Plovdiv) 2022;64(1):162-8. doi: 10.3897/folmed.64.e59099.

Резюме

Мы представляем несколько клинических случаев аутогенной костной пластики – современного метода, при котором удалённые зубы лечат в деминерализованной зубной матрице (ДЗМ) и сразу пересаживают в постэкстракционные зубные гнёзда или костные дефекты.

В исследование были включены пациенты с поражением челюсти вследствие хронических воспалительных состояний, кистозных образований или периимплантита. После удаления патологических процессов и тканей проводили кюретаж Er-YAG-лазером и обрабатывали костные структуры в пограничных зонах. Затем мы применили материал аутогенного костного трансплантата (АГК). Клинические результаты показали благоприятное заживление ран и хорошую интеграцию имплантатов в кость. Рентгенологические исследования показали стимуляцию и ускорение костной регенерации с резорбцией альвеолярного отростка трансплантатного материала не более чем на 10%. Гистологическое исследование выявило новообразование кости, вызванное остеоиндуктивным материалом.

Основываясь на клиническом исходе и благоприятном процессе заживления с очень хорошей интеграцией ДЗМ в кость, мы можем рекомендовать этот метод в качестве варианта реконструкции костных дефектов. Удовлетворительное количество (до 3 г на моляр) и количество деминерализованной дентинной матрицы определяют значительно низкую стоимость костного трансплантата.

Ключевые слова

система аутотрансплантата зубной кости, направленная регенерация ткани аутогенным костным трансплантатом, деминерализованная дентинная матрица