

Scientific Paper

Radiological evaluation of mandibular alveolar reconstruction after retained third molar removal procedures using autogenous dentin matrix (ADM)

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Abstract

Introduction: Bone regeneration materials are often used in dental surgery procedures. At present, we have the possibility to use materials from different groups due to the way they are obtained. The gold standard still remains the use of autogenous bone substitute material due to its osteogenic, osteoinductive and osteoconductive properties. The surgical removal of the third retained tooth is one of the most common procedures performed in dental surgery. As a result of such a procedure, bone tissue atrophy occurs. In order to avoid the formation of a bone defect on the distal surface of the second molar, an augmentation method using an autogenous dentin matrix can be used in such procedures.

Material and methods: Procedures for bilateral removal of retained third molars were performed in 15 patients. On one side, augmentation was performed with an autogenous dentin matrix obtained by grinding and preparing the extracted retained tooth (study group). On the opposite side, the bone defect was left to heal spontaneously (control group). After 6 months, the degree of bone regeneration was compared on the basis of bone density testing and the size of the resulting bone defect on the distal side was compared on the basis of radiographic examination.

Results: Analysis of the obtained material showed significant differences in healing after treatments with autogenous dentin matrix. Thus, the use of an autogenous dentin matrix made it possible to obtain a completely regenerated bone defect.

Conclusions: This procedure seems to be useful for bone regeneration after the removal of the third molar.

Keywords: biomedical engineering; augmentation; third molar extraction; autogenous dentin graft.

Introduction

Retained third molars are commonly present in most of the adult population.¹ A study of 693 patients shows that 77% of the study population showed the presence of a retained third molar. Very importantly, in as many as 68.5% of cases, the retained third molar was in significant proximity to an adjacent second molar.² Many studies have shown that second molars in close proximity to the retained third molar have a significantly higher incidence of periodontal disease.^{3,4} Maintaining proper hygiene in the distal part of the arch is relatively difficult. Extraction of a third molar can lead to gingival changes, bone loss, periodontal pocket formation, and exposure of cementum on the distal root

of the second molar.⁵ Removal of retained third molars for prophylactic reasons or as a result of local or general indications is one of the more common procedures performed in oral surgery. This type of procedure for asymptomatic teeth is controversial and a source of debate.⁶ Critical voices that have emerged stem from the assumption that one of the consequences of this procedure is the formation of pathological periodontal pockets on the distal surface of second molars adjacent to the surgical site.⁷

Many authors take the position that the use of bone substitute materials in the removal of retained third molars is an effective method of treating post-extraction defects compared to not using bone restoration.^{8,9} In such a case, autogenous bone is still

considered the gold standard and the material of choice for bone regeneration due to its osteogenic, osteoconductive and osteoinductive properties.¹⁰ However, the use of autogenous materials has several disadvantages. One is the need to create a donor site and thus create another wound.¹¹ In order to eliminate an additional treatment site on the donor side, other augmentation materials such as allografts and xenografts have been introduced. However, these materials are not able to replace autogenous materials in all types of procedures. Allografts are characterized by high cost and xenografts lack osteoinductivity.^{12,13} One method of obtaining material for the augmentation procedure is to create an autogenous dentin matrix (ADM) from the patient's own tooth. Many researchers are leaning towards the possibility of using autogenous dentin matrix in regenerative procedures. Reports the results of the study were satisfactory and the use of this type of transplant showed acceptable clinical results.¹⁴ A major advantage is that the tooth-derived mineralized dentin matrix shows a similar composition to bone.¹⁵ Autogenous dentin matrix is gaining popularity among clinicians and researchers due to the fact that the structure of the tooth is very similar to bone, no risk of disease transmission is observed, and obtaining this material is relatively inexpensive.^{16,17}

The purpose of this study was to evaluate the validity of using an autogenous dentin matrix in mandibular alveolar bone augmentation procedures after third molar retained tooth extraction procedures in order to reduce the bone defect created after the procedure by increasing the degree of bone regeneration. This study is also expected to answer the question of whether the use of this method is valid for bone regeneration procedures.

Material and Methods

The study enrolled 15 patients who had the need to remove retained third molars in both the 3rd and 4th quadrants. Informed written consent was obtained from each patient to include the patient in the control and study groups. Indications for the removal procedures were obstructed eruption of the retained tooth with the presence of inflammation, complete retention not promising eruption observed on prophylactic OPG X-ray or orthodontic indications. The procedures were performed at the Outpatient Dental Surgery and Implantology Clinic in Bytom. At the stage of qualification for the procedure, each patient underwent a follow-up OPG X-ray (**Figure 1**).

Two procedures were performed on each patient. During the first procedure, the retained third molar tooth was removed without using the method of augmentation with an autogenous dentin matrix. In the second stage, after 2 weeks, the removal of the retained tooth on the other side was carried out using the augmentation method with an autogenous dentin matrix obtained from grinding the patient's own tooth.



Figure 1. Review X-ray (OPG X-ray) of a patient qualified for the study.

For the production of an autogenous dentin matrix, depending on the clinical qualification, the extracted retained tooth was used, thus the donor and recipient sites were in the same area. This method required a prolonged procedure due to the time required to prepare and process the autogenous dentin matrix during the procedure. In patients who also qualified for removal, retained third molars in the maxilla were the donor site. In conclusion, if the patient had an indication for removal of retained teeth 18, 28, 38, 48 to the donor site in the procedures were teeth 18 or 28 but if the patient did not have teeth 18 and 28 or they were erupted and had the correct position then the donor and recipient site were teeth 38 and 48.

Inclusion criteria were the presence of at least both retained third molars in the 3rd and 4th quadrant or, in addition, the presence of an upper third retained tooth which allowed the method using an autogenous dentin matrix (study group) and the creation of a control group. An additional inclusion criterion was the patient's age above 18 years.

The exclusion criteria were as follows: smokers, immunosuppression, head-and-neck-irradiated patients in the past 5 years, regular intake of bisphosphonates, chronic drug abuse or alcoholic habits, patients with poor oral hygiene (full-mouth plaque score and full-mouth bleeding score >15%), lack of motivation, uncontrolled diabetes (reported levels of glycated hemoglobin exceeding 7%), and uncontrolled and/or untreated periodontal disease.

Two procedures were scheduled for each patient. During the first procedure, a full-thickness mucoperiosteal flap was debulked under infiltration and regional anesthesia using Septanest 1:100-Articaini hydrochloridum (Septodont, Saint-Maur-des-Fosses Cedex, France) from an angled incision in projections 38-37 or 48-47. After osteotomy and odontotomy, the retained tooth was removed in parts. The wound was then sutured with Atramat Nylon 4/0 non-resorbable sutures (Atramat, Mexico City, Mexico). A pressure dressing was applied. Postoperative recommendations were given to the patient. Patients were treated with empirical antibiotic therapy for 7 days. After one week, sutures were removed from the surgical site during a follow-up examination.

After 14 days, the second procedure was performed. Again as above, the extraction of the retained third molar on the opposite side to the first procedure was performed (**Figures 2 and 3**).

Depending on the clinical case at this stage, the material for producing the autogenous dentin matrix was an extracted tooth in the mandible, or a surgically extracted retained third molar in the maxilla if it was previously qualified for removal based on clinical and radiographic examination.

The second phase of the procedure proceeded to produce an autogenous dentin matrix.

To obtain the AutoBT from the impacted teeth, the Smart Dentin Grinder produced by KometaBio, (KometaBio, New Jersey, United States) was used. The extracted tooth was processed according to the procedure's protocol. The tooth was mechanically cleaned of soft tissue using a drill and sickle probes. These were some debris of tooth follicles or periodontal fiber. After drying, the tooth was put in the chamber of the KometaBio, where it was ground for 3 s, and then the material was chopped through the sieve system for 20 s to obtain a homogeneous grafting material with a particle size of 200-1000 μm (**Figures 4 and 5**).



Figure 2. The condition before tooth extraction surgery 48.

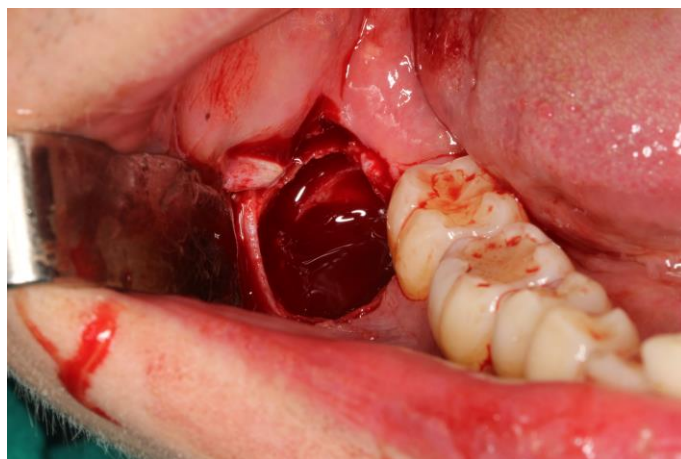


Figure 3. Status after atraumatic tooth extraction procedure 48.



Figure 4. A cleaned tooth prepared for the grinding procedure.



Figure 5. Preparation obtained from grinding the patient's own tooth.



Figure 6. Preparations for performing decontamination of the obtained bone graft material.



Figure 7. Finished material obtained after decontamination using a procedure developed by the manufacturer.

The graft material prepared this way was immersed in cleanser (sodium hydroxide solution with 20% ethanol, (KometaBio, Fort Lee, NJ, USA), supplied by the manufacturer, for 10 min, and then after draining the cleanser for 3 min, the particulate was treated with saline (Dulbecco's phosphate-buffered saline DPBS, without calcium, magnesium), (KometaBio, Fort Lee, NJ, USA), also provided by the manufacturer. Thus, prepared and drained particulate dentin was ready for grafting (**Figures 6 and 7**).

In the next phase of the procedure, augmentation of the post-extraction alveolus was performed using the obtained material (**Figure 8**). In each clinical case, we used all of the material obtained from grinding. This amount was always sufficient and adequate to completely fill the locus of the extracted retained tooth.

Then, as in the first procedure, the wound was sutured with Atramat Nylon 4/0 non-resorbable sutures (Atramat, Mexico City, Mexico) (**Figure 9**).



Figure 8. Status after post-extraction alveolar augmentation.

A pressure dressing was applied. Postoperative recommendations were given to the patient. Patients were given empirical antibiotic therapy for 7 days. After one week, sutures were removed from the surgical site during a follow-up examination (**Figure 10**). No signs of inflammation were found during the follow-up examination.



Figure 9. Condition after suturing the wound with non-resorbable sutures.

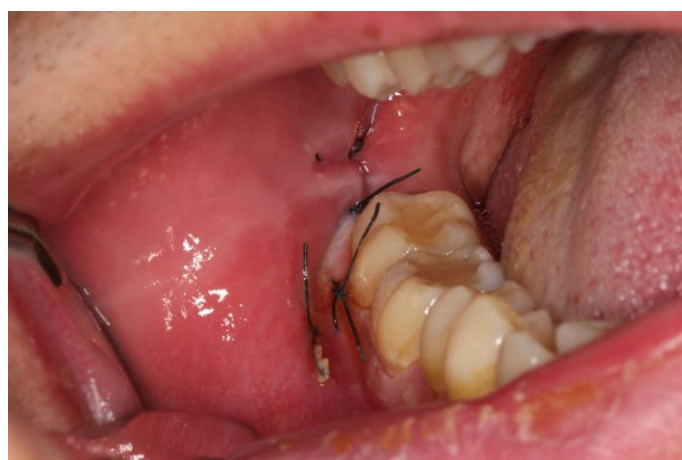


Figure 10. Clinical status 7 days after surgery.

A follow-up CBCT scan of the mandible using a GENDEX iCAT cone beam computed tomography (CBCT, Gendex Corp, Hatfield, PA, USA) was performed in each patient included in the study after 6 months. It would be ideal to have a CBCT check-up after 3 months as well. However, the limitation of our study influenced the CBCT check-up regimen to stop only after 6 months.

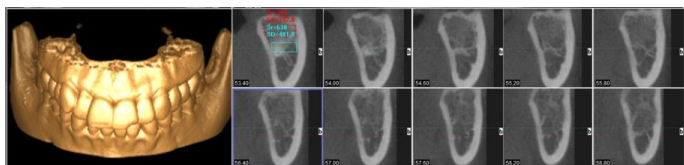


Figure 11. Treated side sagittal sections. Visible fully healed bone. Visually significantly thickened bone tissue („śr” in the photos mean average).

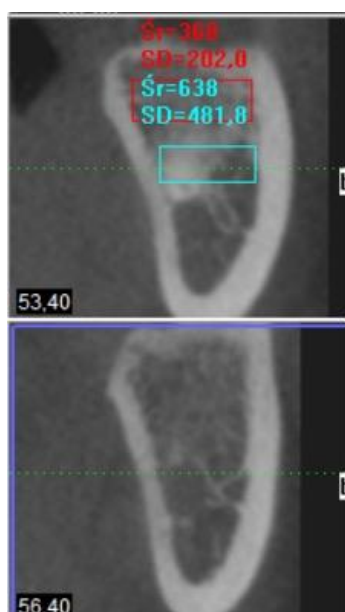


Figure 12. Treated side sagittal cross-section magnification. Visible fully healed bone. Visually significantly thickened bone tissue („śr” in the photos mean average).

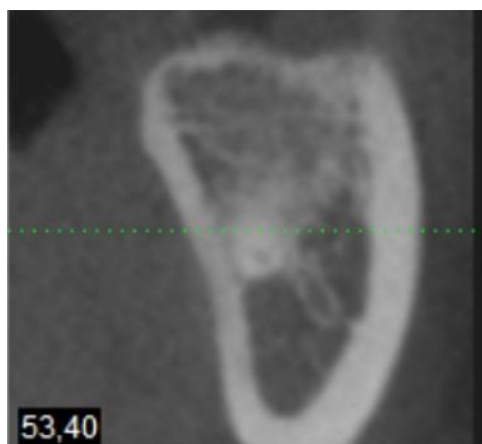


Figure 13. Treated side sagittal cross-section-visual evaluation. Visible fully healed bone along with significant bone density on visual assessment.

Based on the obtained CBCT scan, radiological data analysis was performed. Measurement points were determined in the obtained scans to compare the Hounsfield bone density on both treatment sides (Figures 11-16).

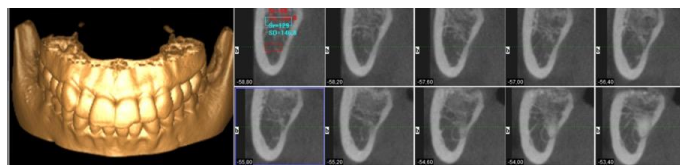


Figure 14. Control page sagittal cross sections. The bone is healed but visually the bone density is lower compared to the study group („śr” in the photos mean average).

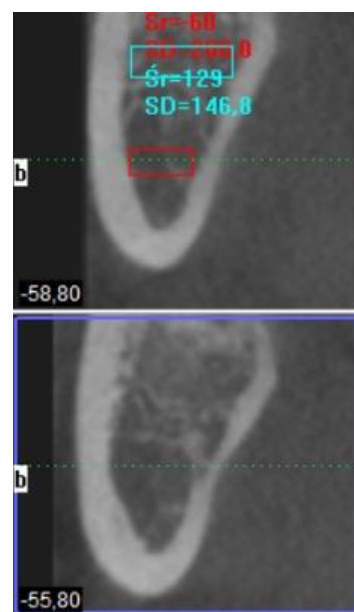


Figure 15. Control side of arrow cross-section - magnification. The bone is healed but visually the bone density is lower compared to the study group („śr” in the photos mean average).

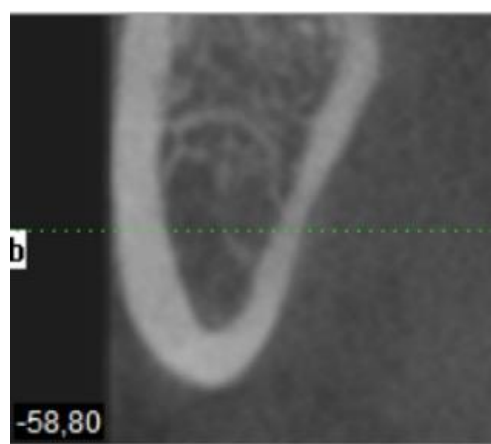


Figure 16. Inspection page sagittal cross-section-visual evaluation. The bone is healed but visually the bone density is lower compared to the study group.

Three measurement areas were established at 3 different heights of the analyzed cross sections on each side. Bone density analysis was performed on the side using an autogenous dentin matrix and on the control side. There were two types of parameters taken into consideration – density (HU) of chosen tooth cross-section and the range of density (maximum – minimum) from each cross-section.

The parameters were derived from both studied groups at a similar time after treatment – it was 6 months after surgery. Statistical analysis was performed by using Statistica 13.1 (StatSoft Polska, Kraków, Poland). Data were expressed as mean and median values $\pm$ standard deviation (SD) and standard error (SE). In the case of normal distribution and homogeneity of variances, Student T-tests have been used. Opposite, the Wilcoxon signed-rank test was processed. The significance level was set as $p < 0.05$.

Results

Evaluation of bone regeneration based on Hounsfield bone density analysis using ImageJ software (ImageJ1.53k, Wayne Rasband and contributors National Institutes of Health, Kensington, MD, USA) on the study and control sides showed significant differences. In the case of CBCT, the nominal voxel size was 0.125 mm and the slice thickness was set as 0.5 mm. The mean density was measured by using Hounsfield Units. It was calculated as the mean as well as the maximum and minimum intensity of chosen regions of interest for patients treated by using an autogenous dentin matrix and a control group treated in the standard method. The density parameters characterizing ossification were derived at three heights of the dental pit. Representative digital photos with marked regions of interest are presented in **Figure 17**.

The presented box graph shows the differences between density counted from chosen teeth areas in Hounsfield Units values obtained for a group of patients treated by augmentation (T) and without (C) (**Figure 18**).

It is obvious, that it is not possible to precisely convert the Hounsfield Unit values into the density of the examined tissue. However, changes in bone density are indicated by changing HU values. Therefore, changes in bone density were estimated based on the analysis of tomographic images using the conventional Hounsfield scale. As you can see in **Figure 18**, for patients treated with autogenous dentin matrix, the Hounsfield unit values doubled (median was 532 HU) compared to the control group (median 245 HU).

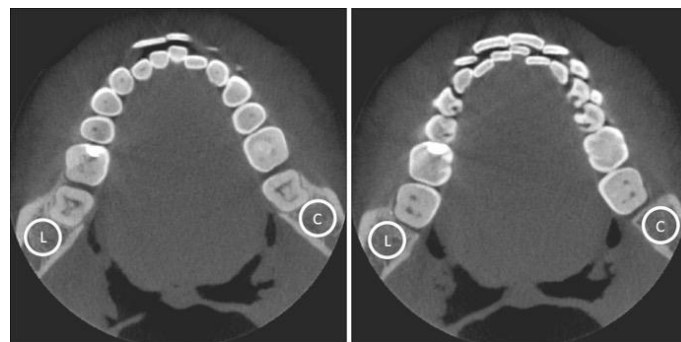


Figure 17. Digital photos with marked regions of interest (L-lesion, C-control).

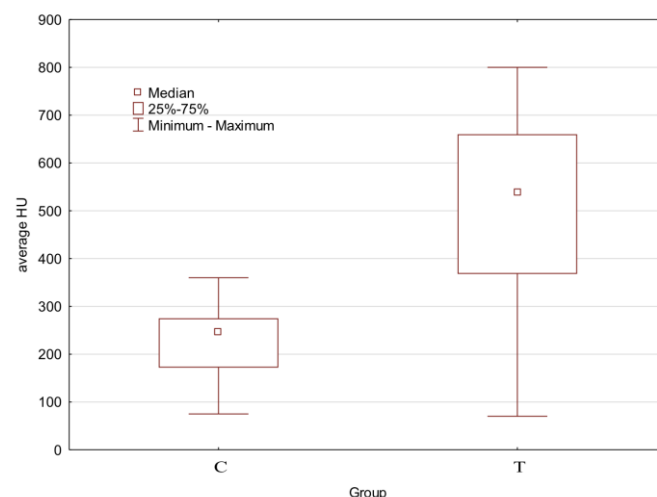


Figure 18. Box plot showing the differences in bone density between the test (T) and control (C) groups.

It was obtained that the median density obtained for patients treated by using the augmentation method is significantly higher ($p=0,001$) than in the case of the control group of patients treated with the standard method. Such results explain the shorter time of bone tissue rebuilding in the tooth. For deeper insight into the problem, additional analyses were done and the density range from three different cross-sections of every tooth was taken into consideration.

The sample size has been stated taking into account the whole group of implant procedures in Poland yearly as 100 000. The augmentation is a quite new procedure in Poland so it was assumed 5000 augmentation procedures yearly. It was assumed that the trust level was 95% and the power of the test was 80% (it usually should be taken). Moreover in the case when the occurring characteristic is not known in the study population the characteristic size should be set as 0.5. For all those assumptions the sample size should be 15 as it was in performed studies.

Discussion

According to our analysis of the data we collected, it seems reasonable to use an autogenous dentin matrix for bone regeneration after surgery to remove a third molar retained tooth. Of course, the research we conducted has a limitation, which we will also mention in the discussion.

PD (pocket depth) is the distance between the gingiva margin and the pocket bottom (the surface of the attachment). Referring to the study by Luis Sanchez-Labrador¹⁸ this clinical trial found a notable reduction in mean PD in the test group compared with the control group, at both three and six months after surgery, with a statistically significant difference between the groups.

In our study, we demonstrated in radiographic measurements a reduced risk of bone loss on the distal surface of second molars in patients who received autogenous dentin matrix due to a higher level of bone regeneration. One of the limitations of our study was the inability to measure PD in clinical trials in our patients. Presenting such data would have allowed us to more reliably prove the validity of using an autogenous dentin matrix to reduce postoperative PD measurement.

According to authors including Leung et al¹⁹, the presence of a mesial-angular third molar favors the formation of periodontal pockets and bacterial colonization on the distal surface of second molars. Also, surgery to remove a third molar is associated with the risk of periodontal cavity formation on the distal surface of the second molar.

Numerous authors in their studies report that the use of regenerative techniques with bone substitutes is an effective method of reducing the resulting bone defects compared to the extraction of a retained third molar without the addition of bone substitute material.^{20,21} Similarly, our research allowed us to present results confirming this thesis.

As reported by DeOliveira in his study, dentin shares many similarities in terms of inorganic, organic and water content, exhibiting osteoconductive²² and osteoinductive properties.

Autogenous dentin matrix does not exhibit osteogenic abilities. Nevertheless, its use as an augmentation material avoids the complications associated with autogenous bone harvesting.²²

Clinically, autogenous dentin matrix has shown favorable results compared to other bone graft materials for guided bone regeneration.²³ Such conclusions in their paper were presented by Kim and another co-author. Our work cannot address such a conclusion because we did not make comparisons with other bone substitute materials. However, our work confirms the thesis, that autogenous dentin matrix can be successfully used in bone regeneration procedures.

In our study, a third molar retained without enamel removal was used to obtain an autogenous dentin matrix, which was performed according to the methodology reported by Minetti et al.²⁴ or Kabir et al.²⁵ The use of such a method seems to be the

most reasonable from the point of view of the duration of the procedure and the ease of application of such a method.

Similar to our study, Sanchez-Labrador et al.¹⁸ observed a similar appearance of native and newly formed bone after 6 months, and higher bone density confirmed by higher values in Hounsfield units in the study group than in the control group. Of course, this does not prove that the newly formed bone at the site where the autogenous dentin matrix was applied has a better quality composition. However, such an analysis allows to prove that the use of such material allows to achieve proper bone regeneration in quantitative terms.

It was concluded from our study that dentin grafts achieved higher HU values compared to the control group.

The use of autogenous dentin matrix can help achieve normal vertical and transverse bone dimensions. Despite this, it may be necessary to use additional techniques to carry out proper implant treatment. As reported by Wachol et al.²⁶ the analysis and correlation between error values show that accurate planning and precise execution of the implantation procedure at the initial or entry stage will contribute to obtaining the desired or planned total effect. Therefore, the use of autogenous dentin matrix as one of the methods of bone regeneration has a positive impact on further treatment including implantoprosthesis treatment.

According to the authors, the bone height decreases progressively by 25% during the first year after tooth loss, with a total of 4 mm height loss during this first year post-extraction.²⁷ This demonstrates the importance of using augmentation techniques after tooth extraction procedures.

Post-treatment care of the surgical and prosthetic patient is equally important. Clinical studies have demonstrated satisfactory efficacy in eliminating pathological oral flora using therapeutic preparations of natural origin, such as tea tree oil and the ethanolic extract of propolis.^{28,29}

The use of autogenous dentin matrix has many advantages but also has disadvantages. One of the main advantages is the ability to obtain a large amount of bone substitute material sufficient for most surgical procedures performed. According to Kim, the material obtained by this method exhibits physical characteristics similar to human cortical bone.³⁰ As Haugen states in his article, this material exhibits features of osteogenesis, osteoconduction and osteoinduction.³¹ Therefore, this material exhibits all the characteristics necessary to be considered a suitable material in bone tissue reconstruction procedures. The biggest disadvantage associated with the use of this method is the need to create an additional wound at the donor site during the procedure.

Conclusions

According to the analysis of the data we collected, it seems reasonable to use an autogenous dentin matrix for bone regeneration after the third molar retained tooth removal surgery.

Autogenous dentin matrix can be successfully used in alveolar bone augmentation procedures after retained teeth removal procedures.

The use of an autogenous dentin matrix made it possible to obtain a completely regenerated bone defect.

The described method is one of the possibilities that can be used to accelerate the healing of bone defects.

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