Journal of Dental Sciences 20 (2025) 553–559

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-jds.com

Original Article

# The effect of autologous demineralized dentin matrix on postoperative complications and wound healing following lower third molar surgery: A split-mouth randomized clinical trial

**Nhan Thanh Nguyen, Son Hoang Le*, Bich-Ly Thi Nguyen**

*Department of Oral Surgery, Faculty of Odonto-Stomatology, University of Medicine and Pharmacy at Ho Chi Minh City, Ho Chi Minh City, Viet Nam*

Received 11 April 2024; Final revision received 26 April 2024
Available online 4 May 2024

**KEYWORDS**
Demineralized dentin;
Graft;
Inflammatory proliferative remodeling scale scores;
Postoperative complications;
Third molar surgery

**Abstract** *Background/purpose:* Autologous dentin materials are among the most promising bone substitutes for preventing osseous defects on the distal side of the lower second molar. This study aimed to investigate the effects of autologous demineralized dentin matrix on postoperative complications and wound healing after lower third molar surgery.
*Materials and methods:* Thirteen patients with bilateral symmetrical lower third molars participated in this split-mouth randomized clinical trial. After removal surgery, one socket of the lower third molar was grafted with dentin material (demineralized dentin matrix side), and a piece of collagen sponge was used for the tooth socket of the remaining side (control side). The upper third molar on the same lateral side was extracted immediately before lower third molar surgery and used to create a demineralized dentin matrix according to the manufacturer's protocol (KometaBio). After lower third molar surgery, pain, swelling, trismus, and Inflammatory Proliferative Remodeling Scale scores were used to evaluate postoperative complications and wound healing.
*Results:* Pain, swelling, and trismus of the demineralized dentin matrix and control sides were not significantly different at any assessment time ($P > 0.05$). The wound-healing scores of the demineralized dentin matrix side were better than those of the control side; however, the differences were only significant at 7th and 30th days ($P < 0.05$).
*Conclusion:* Grafting autologous demineralized dentin matrix into the tooth socket did not increase the postoperative complications after lower third molar surgery. However, wound healing on the graft side was comparatively better than that on the control side.

* Corresponding author. Department of Oral Surgery, Faculty of Odonto-Stomatology, University of Medicine and Pharmacy at Ho Chi Minh City, 652 Nguyen Trai Street, Ho Chi Minh City, 72714, Viet Nam.
*E-mail address:* lehoangson@ump.edu.vn (S.H. Le).

https://doi.org/10.1016/j.jds.2024.04.026

*Clinicaltrials.gov identifier:* NCT06073639, date 10 October, 2023. This is a retrospectively registered trial.


## Introduction

Patient expectations of dental treatment have become more stringent. In case of lower third molar (L3Ms) surgery, one of the most frequent complications following mesioangular and horizontal tooth extraction is an osseous defect on the distal side of the lower second molars (L2Ms).[1] This type of defect can cause late infection on the extracted side, the distal pocket of the L2Ms, or chronic periopathology, leading to a high demand for grafted biomaterials to prevent this complication.[2]

Numerous biomaterials have been studied for their ability to prevent osseous defects on the distal sides of L2Ms. Generally, grafting materials are bone substitutes such as autologous bone, autologous dentin, deproteinized animal bone, bioactive ceramics, and collagen materials.[3–7] Autologous dentin material (ADM) is among the most promising options, owing to its efficacy, affordability, and availability. The clinical efficacy of ADM has been reported in systematic reviews and case reports with longitudinal observations of up to 4 years.[8,9] The ADM, prepared from the extracted teeth of the hosts with simple chairside preparations within 20 min, is typically affordable.[10] Few limitations of other biomaterials, such as a second surgical site to harvest bone and immunity reaction, can be overcome by utilizing extracted teeth, which are discharged as medical waste in normal conditions.[11]

Despite numerous benefits in dental applications, grafting a material can increase post-operative complications like pain and swelling.[9] Further, patients can become reluctant to comply with the treatment plan in case of severe postoperative complications that compromise their daily activities and quality of life.[12,13] Although several studies reported efficacy of ADM on bone regeneration, there are no previous studies examining its effect on postoperative complications. Therefore, this study aimed to investigate the effects of an autologous demineralized dentin matrix (DDM) on postoperative complications and wound healing after L3M extraction.

## Materials and methods

### Study design

This split-mouth randomized clinical trial was conducted at the Department of Oral Surgery, Faculty of Odonto-Stomatology, University of Medicine and Pharmacy at Ho Chi Minh City, between December 2021 and February 2022. The study protocol was approved by the Biomedical Research Ethics Council (IRB-VN01002/IORG00086/FWA0002448) under number 21470. Written informed consent for publication of their details was obtained from all participants.

### Participants

We recruited patients who visited the Department of Oral Surgery for bilateral M3Ms extractions. The participants were required to satisfy the following inclusion criteria: (1) being at least 18 years old; (2) having symmetrical bilateral L3Ms; (3) having upper third molars (U3Ms) in sound condition (for collecting DDM); and (4) being classified as ASA I or II according to the Physical Status classification of the American Society of Anesthesiologists. The exclusion criteria for participants were as follows: (1) pregnancy or breastfeeding; (2) allergy to any drugs that were used in this study; (3) presence of abnormal signs of clinical symptoms or orthopantomogram (OPG), which suggested a serious condition; (4) operation time of more than 10 min between the two sides; (5) ceased provision of essential information for data collection; and (6) absence of post-operative assessment appointments.

The bilateral M3Ms of a participant were defined as symmetrical if they satisfied these requirements on the OPG: (1) same Winter classification; (2) difference of less than 15° between the angle of L3M and the adjacent tooth between two sides; and (3) same Pell-Gregory classification both in vertical and horizontal impacted level.

### Outcomes

All outcomes were self-evaluated by the participants or assessed by a single researcher (N.T.N.). Postoperative complications were assessed using the following three variables: pain, swelling, and trismus. Pain was self-evaluated on 1st, 3rd, and 7th days after L3Ms surgery using a modified visual analog scale (VAS).[14] Swelling was measured using both subjective and objective methods. In the subjective method, swelling was self-evaluated using a modified VAS at 1st, 3rd, and 7th days post-operatively.[14] In the objective method, swelling was defined as the increase in facial dimensions (segments AB and CD) at 3rd and 7th days of postoperative periods to baseline (Fig. 1). Segment AB was the distance from the lateral orbital to the gonial angle. Segment CD represented the distance from the tragus to the anguli oris. Measurements were conducted using a tape measure. Trismus was defined as a reduction in maximal mouth opening (MMO) at 3rd and 7th days after surgery. MMO is the distance between the incisal edges of the maxillary and mandibular central incisors. Measurements were performed using calipers and rounded to the nearest millimeter (Fig. 1). Wound healing was evaluated using the inflammatory proliferative remodeling (IPR)

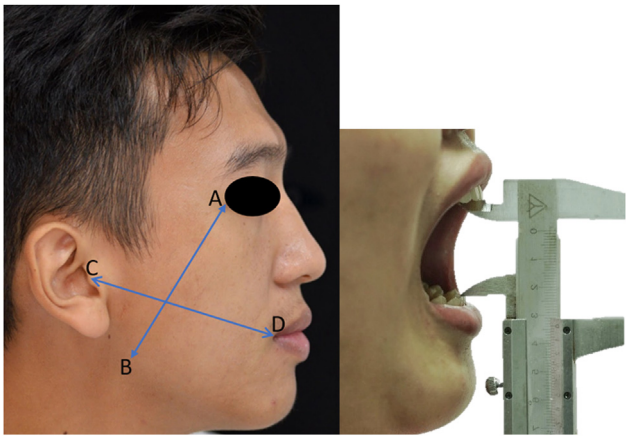


**Figure 1** Measurement of facial dimensions (left) and maximal mouth opening (right). A, the labial orbital; B, the gonial angle; C, the tragus; D, the anguli oris.

Scale.[15] The scores were recorded on the 3rd, 7th, and 30th days after the M3M surgery.

### Dentin graft preparation

U3Ms on the same side (left/right) were used to prepare dentin grafts. The extracted teeth contained curretted debris, calculus, and soft tissue. Subsequently, a researcher (S.H.L.) removed the enamel using a high-speed handpiece and a diamond bur. The remaining part of the tooth was dried by spraying air and ground with a Smart Dentin Grinder™ (KometaBio, Fort Lee, NJ, USA). The machine was set up with a processing cycle consisting of a grinding time of 3 s and a sorting time of 20 s. This processing cycle was repeated until the entire tooth was completely ground into a powder–like material. This material was, then, processed with a kit of chemicals (KometaBio, Fort Lee, NJ, USA). Specifically, the collected dentin material was soaked in 0.5M sodium hydroxide and 20% ethanol for 10 min to decontaminate microorganisms. Sterile gauze was used to remove any residual medium. The dentin graft was demineralized using 17% ethylenediaminetetraacetic acid for 2 min. Finally, the DDM was washed with phosphate buffered saline 1X twice to remove the remaining chemicals and prepare it for grafting into the L3M socket.

### Study procedure

Each participant underwent two operations a minimum of 30 days apart, one on the control side and the other on the DDM side. First, a researcher (N.T.N.) collected demographic data and radiographic characteristics, and measured the participants' facial dimensions (segment AB and CD, and MMO) at baseline. The participants then picked a lottery ticket to choose the surgical side (left/right first) and dentin graft side under the guidance of a single researcher (S.H.L.).

All participants underwent the same surgical protocol, which was performed by an experienced oral surgeon (B.T.N.) on both the control and DDM sides. Initially, U3M was extracted for grafting if the surgery was performed on the DDM side; otherwise, it was disposed off as medical waste. Simultaneously, the surgeon performed the L3M surgery. After removing the L3M, the tooth socket was filled with either dentin graft and collagen sponge (Lyostypt®, B. Braun, Melsungen, Germany) on the DDM side or only collagen sponge on the control side (Fig. 2). The collagen sponge that used for both sides were prepared with the same size of 10x15 mm. The participants were prescribed the same medications, including amoxicillin (500 mg pill, three times per day for 5 days), ibuprofen (400 mg pill, three times per day for 3 days), and acetaminophen (500 mg pill, three times per day for 3 days).

### Statistical analysis

The collected data were analyzed using SPSS (version 24.0; IBM, Armonk, NY, USA). Data are presented as mean ± standard deviation (SD). The Mann–Whitney U test was used to compare pain, swelling, MMO, trismus, and wound healing IPR scores between the experimental and control groups. The Kruskal–Wallis H test was used to compare pain, swelling, MMO, and trismus in each group at different time points. If the null hypothesis of the Kruskal–Wallis H test was rejected, the Dunn–Bonferroni test was used to compare the differences between the two assessment times. $P < 0.050$ indicated significant difference.

## Results

### Participant characteristics

Fourteen participants agreed to participate in the study between December 2021 and February 2022. One participant did not return for postoperative assessment. Finally, 13 participants with 26 L3Ms surgical sides were eligible for the statistical analysis. Participant characteristics are presented in Table 1. According to the Pell–Gregory classification, most of the extracted M3Ms belonged to classes II and B in the horizontal and vertical planes, respectively. No significant difference was found in the extraction time of U3M between the control and DDM sides (Mann–Whitney U test, U = 84.5, $P = 1.000$). The L3M extraction time on the DDM side was significantly longer than that on the control side (Mann–Whitney U test, U = 22.5, $P = 0.001$).

### Postoperative complications

Table 2 shows that pain, self-evaluating swelling, facial dimension, and MMO of the control and DDM sides were not significantly different at all assessment times (Mann–Whitney U test, $P > 0.05$). During the first week after surgery, the pain, swelling, and MMO on both the control and DDM sides showed the same trend.

### Wound healing

The wound healing IPR scores of both groups at the three assessment times are shown in Fig. 3. The Mann–Whitney U test revealed that the wound healing IPR score on the 3rd

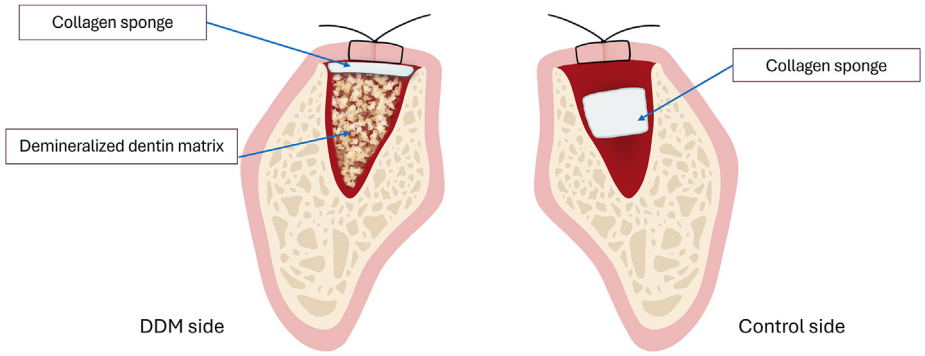


**Figure 2** Lower third molars socket after surgery. Left (DDM side): Demineralized dentin matrix was placed into the tooth socket, covered with collagen sponge, and finally sutured. Right (control side): Only collagen sponge was placed into the tooth socket.

**Table 1** Characteristics of the 13 patients.

| Characteristics | |
|---|---|
| Sex, n (%) | |
| Female | 4 (30.77) |
| Male | 9 (69.23) |
| Age, mean (SD), year | 23.00 (1.83) |
| Winter classification, n (%) | |
| Mesioangular | 6 (46.15) |
| Horizontal | 7 (53.85) |
| Horizontal impacted level, n (%) | |
| I | 0 (0.00) |
| II | 24 (92.31) |
| III | 2 (7.69) |
| Vertical impacted level, n (%) | |
| A | 2 (7.69) |
| B | 24 (92.31) |
| C | 0 (0.00) |
| Extraction time, mean (SD), minute | |
| U3M, control side | 1.69 (1.33) |
| U3M, DDM side | 1.69 (1.33) |
| L3M, control side | 12.69 (1.49) |
| L3M, DDM side | 15.00 (1.63) |

Note. SD, standard deviation; DDM, demineralized dentin matrix; L3M, lower third molar; U3M, upper third molar.

day on both sides was not significantly different (control side 7.54 ± 0.88; DDM side 7.62 ± 0.87; U = 78.5; $P = 0.692$). On 7th day, wound healing IPR score of the DDM side (4.85 ± 0.38) was significantly higher than that of the control side (4.46 ± 0.52) with U = 52.0, $P = 0.043$. Similarly, the wound healing IPR score on the 30th day of the DDM side (2.85 ± 0.38) was continuously higher than that on the control side (2.38 ± 0.51) (U = 45.5, $P = 0.018$).

## Discussion

The outstanding point of this study protocol is that the U3M was extracted prior to L3M removal and used to prepare autologous DDM for L3M sockets. This protocol significantly reduced the surgical time because the DDM and L3M extractions could be performed simultaneously. In previous studies, the extracted L3Ms were used to create dentin grafts with a reported surgical time of approximately 12 min longer than the control group; however, the difference between the two sides was only 2 min in this study.[16]

Pain, swelling, and trismus are commonly accepted critical clinical indicators of inflammatory conditions following oral surgery, where prostaglandins are crucial.[17] Inflammatory conditions after L3M extraction induce the secretion of wound exudates. The release of extracellular fluid together with chemical mediators compresses the surrounding tissue and stimulates pain. Although the mechanism of trismus has not been understood completely, it significantly correlated with surgical difficulty.[18,19] Consequently, pain, swelling, and trismus frequently synchronize with each other and correlate with level of salivary $\alpha$ − amylase, a typical inflammatory biomarker.[19–21]

The clinical effects of the ADM on bone regeneration have been investigated in numerous studies. However, no previous studies have reported its effects on local inflammatory reactions at the molecular level. Histological images of the autologous mineralized dentin matrix indicated similar inflammatory conditions to xenografts or a combination of dentin grafts and xenograft materials.[22] Additionally, grafting bone substitute materials were claimed to induce an increase in the total number of monocytes and fibroblasts and increase the interleukin−1 expression.[23] Therefore, we assumed that, although DDM is autologous, it may provoke an inflammatory reaction in the L3M socket.

All postoperative complications like pain, swelling, and trismus were higher in the DDM group than in the control group; however, these differences were not significant. Similarly, Sánchez-Labrador et al. revealed that dentin grafts did not increase pain perception in patients with L3M extraction.[16] Studies utilizing other grafting materials like autologous bone and collagen membrane to preserve the tooth socket also showed comparable results regarding pain.[24,25] Prior studies utilizing dentin materials for grafting have not evaluated swelling consequences. A previous study in which collagen membranes were placed in tooth sockets also revealed a higher swelling level on the grafting side. However, the difference from the control group was not significant.[24] Sánchez-Labrador et al. also reported an insignificant increase in trismus following L3M extraction with dentin grafts compared to L3M extraction only.[16]

**Table 2** Pain, swelling, and trismus complications after L3Ms surgery.

| Parameter | Control side (n = 13) | DDM side (n = 13) | U | *P* |
|---|---|---|---|---|
| Pain | | | | |
| 1st day | 2.38 ± 0.65 | 2.38 ± 0.77 | 83.0 | 0.929 |
| 3rd day | 1.69 ± 0.63$^{\$\$}$ | 1.77 ± 0.60$^{\$\$}$ | 78.5 | 0.725 |
| 7th day | 0.85 ± 0.56$^{\$\$\&\&}$ | 1.00 ± 0.58$^{\$\$\&\&}$ | 73.5 | 0.488 |
| Self-evaluated swelling | | | | |
| 1st day | 2.08 ± 0.64 | 2.23 ± 0.73 | 78.0 | 0.693 |
| 3rd day | 1.92 ± 0.64 | 2.15 ± 0.56 | 68.5 | 0.330 |
| 7th day | 0.92 ± 0.64$^{\$\$\&\&}$ | 1.15 ± 0.56$^{\$\$\&\&}$ | 68.5 | 0.330 |
| AB (millimeter) | | | | |
| Baseline | 110.85 ± 9.73 | 111.15 ± 8.57 | 80.5 | 0.837 |
| 3rd day | 115.77 ± 8.65$^{\#\#}$ | 116.38 ± 7.48$^{\#\#}$ | 75.0 | 0.625 |
| 7th day | 112.38 ± 9.47$^{\#\#\&\&}$ | 112.77 ± 8.30$^{\#\#\&\&}$ | 77.0 | 0.700 |
| Increase to AB (millimeter) | | | | |
| 3rd day to baseline | 4.92 ± 2.75 | 5.23 ± 2.32 | 82.5 | 0.917 |
| 7th day to baseline | 1.54 ± 1.66 | 1.62 ± 1.33 | 76.5 | 0.673 |
| CD (millimeter) | | | | |
| Baseline | 117.54 ± 5.27 | 119.08 ± 5.98 | 69.5 | 0.487 |
| 3rd day | 121.31 ± 5.31$^{\#\#}$ | 122.92 ± 6.36$^{\#\#}$ | 71.0 | 0.472 |
| 7th day | 119.08 ± 5.74$^{\#\#\&\&}$ | 120.62 ± 6.23$^{\#\#\&\&}$ | 78.5 | 0.692 |
| Increase to CD (millimeter) | | | | |
| 3rd day to baseline | 3.77 ± 1.48 | 3.85 ± 1.57 | 82.0 | 0.895 |
| 7th day to baseline | 1.54 ± 1.66 | 1.54 ± 1.13 | 79.0 | 0.757 |
| Maximal mouth opening (millimeter) | | | | |
| Baseline | 52.08 ± 5.33 | | | |
| 3rd day | 44.31 ± 5.65$^{\#\#}$ | 43.77 ± 5.78$^{\#\#}$ | 79.0 | 0.776 |
| 7th day | 48.62 ± 5.12$^{\#\#\&\&}$ | 47.77 ± 4.69$^{\#\#\&\&}$ | 75.5 | 0.643 |
| Trismus (millimeter) | | | | |
| 3rd day to baseline | 7.77 ± 3.86 | 8.31 ± 3.38 | 80.0 | 0.815 |
| 7th day to baseline | 3.46 ± 2.90 | 4.31 ± 2.56 | 65.0 | 0.302 |

*Note*. Data are presented as means ± standard deviations; DDM, demineralized dentin matrix.
$^{\#}$Comparison between baseline and 3rd, 7th day. $^{\#\#}$ indicates P < 0.01, Dunn–Bonferroni test.
$^{\$}$Comparison between 1st day and 3rd, 7th day. $^{\$\$}$ indicates P < 0.01, Dunn–Bonferroni test.
$^{\&}$Comparison between 3rd day and 7th day. $^{\&\&}$ indicates P < 0.01, Dunn–Bonferroni test.

Interestingly, other trials with collagen membranes or autologous bone depicted a significant increase in trismus in the experimental groups.[24,25] Paricularly, the slight increase in pain, swelling, and trismus on the DDM side compared with the control side in this study may be because of an inflammatory reaction against the dentin material in the L3M socket. Moreover, we proposed a different mechanism in which the placement of the grafting material occupied some space inside the tooth socket and may further increase compression of the surrounding structure. Thus, grafting autologous dentin into the L3M socket may not significantly worsen postoperative complications.

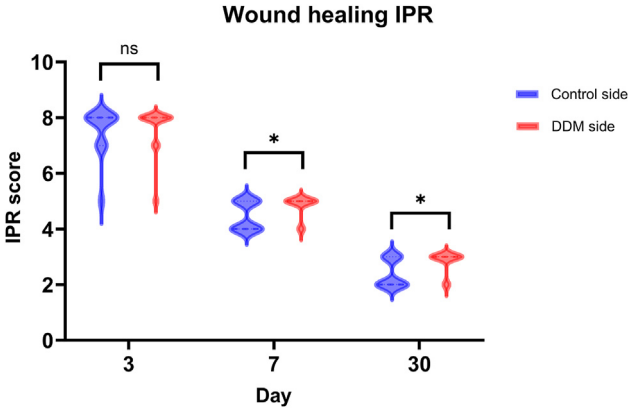


**Figure 3** Wound healing inflammatory proliferative remodeling scores of the control and DDM side on 3rd, 7th, and 30th days after L3M surgery. n = 13 for each group. DDM, demineralized dentin matrix; ns, not significant; *$P < 0.05$.

During the first 30 days after L3M surgery, wound healing was primarily assessed by observing soft tissue. In this study, the soft tissue healing index proposed by Hamzani and Chaushu was used because of its comprehensive approach and detailed guidance.[15] The findings showed that, during the proliferative and remodeling phases—but not the inflammatory phase—wound healing on the DDM side was superior to that of the control side. To the best of our knowledge, no previous studies have longitudinally assessed surgical wound healing during the first 30 days after dentin grafting. Kuperschlag et al. reported that nearly half the control side was affected by food debris during the early healing phase, which was not observed on the experimental side.[26] Food impaction on the surgical side during wound healing is a sign of flap dehiscence and

does not favor proper wound healing. Similarly, xenograft placement in the L3M socket significantly reduces the risk of flap dehiscence.[27] Therefore, grafting dentin into the L3M socket may support clinical wound healing.

This split-mouth randomized clinical trial was designed to eliminate confounding factors such as patient sex, age, L3M surgical difficulty, and surgeon experience. Postoperative complications and wound healing were assessed by a single researcher to limit variations. However, this study has some limitations. First, the number of participants was limited and the proportion of the Winter and Pell—Gregory classification of L3Ms was not representative of the community. Therefore, these results should be considered carefully when grafting dentin materials under different conditions. Second, postoperative complications could be confounded by the surgical time. A longer procedure on the experimental side may also worsen postoperative complications.[19] Third, postoperative complications and wound healing were assessed using self-evaluation methods and clinical observations, which lacked objectivity. Use of wound-healing biomarkers, such as matrix metalloproteinase-1 and bone morphogenetic protein-7, is warranted to make the study results more convincing.[28]

Within the limitations of this study, the results revealed that DDM grafting may not exacerbate pain, swelling, and trismus after L3Ms surgery. Additionally, it promoted wound healing for up to 30 days after surgery. Future studies should examine inflammatory condition on graft side at the molecular level and investigate grafting effect in a more diverse population to generalize the study results.

## Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

## Acknowledgements

The authors sincerely thank the participants who volunteered to participate in this study.

## References

1. Leung YY, Yeung AWK, Ismail IN, Wong NSM. Bone regeneration at the distal aspect of the adjacent second molar after lower third molar coronectomy: a long-term analysis. *Int J Oral Maxillofac Surg* 2020;49:1360—6.
2. Low SH, Lu SL, Lu HK. Evidence-based clinical decision making for the management of patients with periodontal osseous defect after impacted third molar extraction: a systematic review and meta-analysis. *J Dent Sci* 2021;16:71—84.
3. Leventis M, Tsetsenekou E, Kalyvas D. Treatment of osseous defects after mandibular third molar removal with a resorbable alloplastic grafting material: a case series with 1- to 2-year follow-up. *Materials (Basel)* 2020;13:4688.
4. Wushou A, Zheng Y, Han Y, Yang ZC, Han FK. The use of autogenous tooth bone graft powder in the treatment of osseous defects after impacted mandibular third molar extraction: a prospective split-mouth clinical pilot study. *BMC Oral Health* 2022;22:433.
5. Ge J, Yang C, Wang Y, Zheng J, Hua H, Zhu J. Comparison of different grafting materials for treatment of bone defect distal to the molar in canine. *Clin Implant Dent Relat Res* 2018;20:444—54.
6. Kilinc A, Ataol M. Effects of collagen membrane on bone level and periodontal status of adjacent tooth after third molar surgery: a randomized controlled trial. *Head Face Med* 2023;19:13.
7. Kim JW, Seong TW, Cho S, Kim SJ. Randomized controlled trial on the effectiveness of absorbable collagen sponge after extraction of impacted mandibular third molar: split-mouth design. *BMC Oral Health* 2020;20:77.
8. Kim YK, Pang KM, Yun PY, Leem DH, Um IW. Long-term follow-up of autogenous tooth bone graft blocks with dental implants. *Clin Case Rep* 2017;5:108—18.
9. Mahardawi B, Rochanavibhata S, Jiaranuchart S, Arunjaroensuk S, Mattheos N, Pimkhaokham A. Autogenous tooth bone graft material prepared chairside and its clinical applications: a systematic review. *Int J Oral Maxillofac Surg* 2023;52:132—41.
10. Dhuvad JM, Mehta D. Does an autogenous demineralized dentin (ADDM) graft has the ability to form a new bone? *Natl J Maxillofac Surg* 2021;12:181—7.
11. Zhao R, Yang R, Cooper PR, Khurshid Z, Shavandi A, Ratnayake J. Bone grafts and substitutes in dentistry: a review of current trends and developments. *Molecules* 2021;26:3007.
12. Starch-Jensen T, Bruun NH. Patient's perception of recovery after osteotome-mediated sinus floor elevation with Bio-Oss collagen compared with no grafting material: a randomized single-blinded controlled trial. *Int. J. Implant Dent*. 2021;7:20.
13. Hallab L, Azzouzi A, Chami B. Quality of life after extraction of mandibular wisdom teeth: a systematic review. *Ann Med Surg (Lond)* 2022;81:104387.
14. Khande K, Saluja H, Mahindra U. Primary and secondary closure of the surgical wound after removal of impacted mandibular third molars. *J Maxillofac Oral Surg* 2011;10:112—7.
15. Hamzani Y, Chaushu G. Evaluation of early wound healing scales/indexes in oral surgery: a literature review. *Clin Implant Dent Relat Res* 2018;20:1030—5.
16. Sánchez-Labrador L, Martín-Ares M, Ortega-Aranegui R, López-Quiles J, Martínez-González JM. Autogenous dentin graft in bone defects after lower third molar extraction: a split-mouth clinical trial. *Materials (Basel)* 2020;13:3090.
17. Ricciotti E, FitzGerald GA. Prostaglandins and inflammation. *Arterioscler Thromb Vasc Biol* 2011;31:986—1000.
18. de Santana-Santos T, de Souza-Santos a A, Martins-Filho PR, da Silva LC, de Oliveira ESED, Gomes AC. Prediction of postoperative facial swelling, pain and trismus following third molar surgery based on preoperative variables. *Med Oral Patol Oral Cir Bucal* 2013;18:e65—70.
19. Le SH, Tonami K, Umemori S, et al. Relationship between preoperative dental anxiety and short-term inflammatory response following oral surgery. *Aust Dent J* 2021;66:13—9.
20. Gutiérrez-Corrales A, Campano-Cuevas E, Castillo-Dalí G, Serrera-Figallo M, Torres-Lagares D, Gutiérrez-Pérez JL. Relationship between salivary biomarkers and postoperative swelling after the extraction of impacted lower third molars. *Int J Oral Maxillofac Surg* 2017;46:243—9.
21. Surin W, Chatiketu P, Hutachok N, Srichairatanakool S, Chatupos V. Pain intensity and salivary $\alpha$-amylase activity in patients following mandibular third molar surgery. *Clin Exp Dent Res* 2022;8:1082—91.
22. Özkahraman N, Balcıoğlu NB, Soluk Tekkesin M, Altundağ Y, Yalçın S. Evaluation of the efficacy of mineralized dentin graft in the treatment of intraosseous defects: an experimental in vivo study. *Medicina (Kaunas)* 2022;58:103.
23. Markel DC, Guthrie ST, Wu B, Song Z, Wooley PH. Characterization of the inflammatory response to four commercial bone

graft substitutes using a murine biocompatibility model. *J Inflamm Res* 2012;5:13—8.
24. Kilinc A, Ataol M. How effective is collagen resorbable membrane placement after partially impacted mandibular third molar surgery on postoperative morbidity? A prospective randomized comparative study. *BMC Oral Health* 2017;17:126.
25. Ge J, Yang C, Zheng J, Hu Y. Autogenous bone grafting for treatment of osseous defect after impacted mandibular third molar extraction: a randomized controlled trial. *Clin Implant Dent Relat Res* 2017;19:572—80.
26. Kuperschlag A, Keršytė G, Kurtzman GM, Horowitz RA. Autogenous dentin grafting of osseous defects distal to mandibular second molars after extraction of impacted third molars. *Compend Contin Educ Dent* 2020;41:76—82. quiz 3.
27. Ranganathan M, Balaji M, Krishnaraj R, Narayanan V, Thangavelu A. Assessment of regeneration of bone in the extracted third molar sockets augmented using xenograft (CollaPlug(TN) Zimmer) in comparison with the normal healing on the contralateral side. *J Pharm BioAllied Sci* 2017;9: S180—6.
28. Pellegrini G, Rasperini G, Pagni G, et al. Local wound healing biomarkers for real-time assessment of periodontal regeneration: pilot study. *J Periodontal Res* 2017;52:388—96.