ORIGINAL ARTICLE

UDC: 616.314-089
DOI: https://doi.org/10.2298/VSP250506069Z

Postoperative customary outcomes and complications after extraction of impacted mandibular third molars and influence of surgery on the adjacent second molar

Postoperativni ishodi i komplikacije posle hirurškog vađenja impaktiranih donjih trećih molara i uticaj hirurškog pristupa na susedni drugi molar

Tian Zhang*, Chen Liu†

***Zhejiang University School of Medicine, Second Affiliated Hospital, Department of Oral and Maxillofacial Surgery, Hangzhou, China; †Capital Medical University, Beijing Stomatological Hospital, Department of Wangfujing General Dentistry, Beijing, China**

Abstract

Background/Aim. Extraction of impacted mandibular third molars (IMTMs) may be difficult due to a hidden position, anatomical structure, and limited operating space. Therefore, searching for an effective and safe extraction method has always been the focus of research. The aim of this study was to examine postoperative customary outcomes and complications after the extraction of IMTMs and the possible influence of surgery on the adjacent second molar. **Methods.** A total of 86 patients with IMTMs, admitted from March 2022 to March 2024, were randomized into two equal groups: the control group (CG) and the study group (SG), each consisting of 43 patients. Traditional IMTM extraction was performed for CG, while piezosurgery was conducted for SG. Clinical indicators, customary outcomes (pain degree, swelling degree, and degree of mouth opening limitation), and complications were compared between the two groups. **Results.** The pain factor levels and periodontal status of the adjacent second molar were observed pre- and postoperatively. In SG, the operation time was shorter and intraoperative blood loss was less than in CG ($p < 0.05$). After surgery, the Visual Analogue Scale scores were higher in both groups than preoperatively, but they were lower in SG than in CG ($p < 0.05$). The degrees of swelling and mouth opening limitation were lower in SG than in CG ($p < 0.05$). SG had a lower percentage of complications than CG on the 30th day postoperatively ($p < 0.05$). **Conclusion.** For IMTM extraction, patients receiving piezosurgery have satisfactory short-term healing outcomes, accompanied by good long-term outcomes of the adjacent second molar.

Key words:
molar; oral surgical procedures; piezosurgery; tooth extraction; tooth, impacted; treatment outcome.

Apstrakt

Uvod/Cilj. Vađenje impaktiranih donjih (mandibularnih) trećih molara (IMTM) može biti teško zbog skrivenog položaja, anatomske strukture i ograničenog operativnog prostora. Stoga je potraga za efikasnom i bezbednom metodom ekstrakcije uvek bila u fokusu istraživanja. Cilj ovog rada bio je da se ispitaju uobičajeni postoperativni ishodi i komplikacije nakon vađenja IMTM i mogući uticaj operacije na susedni drugi molar. **Metode.** Ukupno 86 pacijenata kojima je izvršena IMTM, primljenih od marta 2022. do marta 2024. godine, randomizovano je u dve jednake grupe: kontrolnu grupu (KG) i ispitivanu grupu (IG), u svakoj po 43 pacijenata. Tradicionalna ekstrakcija IMTM izvršena je u KG, dok je u IG sprovedena piezohirurgija. Između dve grupe upoređeni su klinički indikatori, uobičajeni ishodi (stepen bola, stepen otoka i stepen ograničenja otvaranja usta) i komplikacije. **Rezultati.** Nivoi faktora bola i parodontalni status susednog drugog molara praćeni su pre i posle operacije. U IG, vreme operacije bilo je kraće i intraoperativni gubitak krvi manji nego u KG ($p < 0,05$). Nakon operacije, skorovi na vizuelnoj analognoj skali bili su viši u obe grupe nego pre operacije, ali su bili niži u IG nego u KG ($p < 0,05$). Stepen otoka i stepen ograničenja otvaranja usta bili su niži u IG u poređenju sa KG ($p < 0,05$). IG je imala manji procenat komplikacija nego KG 30. dana nakon operacije ($p < 0,05$). **Zaključak.** Kod vađenja IMTM, pacijenti podvrgnuti piezohirurgiji imaju zadovoljavajuće kratkoročne ishode zarastanja, praćene dobrim dugoročnim ishodima za susedni drugi molar.

Ključne reči:
molari; hirurgija, oralna, procedure; piezohirurgija; zub, ekstrakcija; zub, impakcija; lečenje, ishod.

Correspondence to: Tian Zhang, Zhejiang University School of Medicine, Second Affiliated Hospital, Department of Oral and Maxillofacial Surgery, Hangzhou 310009, Zhejiang Province, China. E-mail: zhangtzju@163.com

Introduction

Impacted teeth are a common finding. Because of their hidden position, impacted and especially semi-impacted mandibular third molars are difficult to clean properly. This allows food residues to accumulate, which can lead to pericoronitis, caries, and periodontal problems [1, 2]. Plaque index (PI), probing depth (PD), and bleeding on probing (BOP) are commonly used indicators for detecting periodontal diseases. PI is mainly based on the thickness of dental plaque, which is directly proportional to plaque thickness [3]. PD is measured as the distance from the upper gingival margin to the bottom of the gingival sulcus, normally ≤ 3 mm [4]. Swelling occurs during gingival inflammation, and in its active stage, this is manifested by sulcus bleeding. Hence, BOP can reflect the degree of gingival inflammation [5]. Impacted mandibular third molar (IMTM) significantly affects the health status of the adjacent second molar, resulting in abnormal increases in PI, PD, and BOP [6]. Therefore, the timely extraction of the IMTM is of great significance.

Extraction of IMTM is a common surgical procedure in stomatology, which aims to remove impacted teeth and restore oral health. Due to the limitations of medical technology, IMTMs were previously often extracted by chisel osteotomy. Despite a high success rate of surgery, this traditional method caused great trauma and obvious postoperative pain, as well as periodontal defects of adjacent second molars. Some patients were unable to tolerate this method [7, 8]. With the continuous development of minimally invasive technology in recent years, the concept of minimal invasion has been gradually applied to stomatology. As a result, various tooth extraction tools, such as air turbine handpieces (ATHs) and ultrasonic bone knives (UBKs), have emerged, gradually replacing traditional extraction techniques [9]. The ATH is characterized by high rotational speed, which helps avoid hammering and chiseling. However, the turbine temperature increases due to high rotational speed, thus damaging the soft tissue [10]. The UBK has the advantages of precise cutting, low heat, and clear surgical fields, but it produces a poor bone cutting effect [11]. For this reason, an ATH and UBK are often combined to further improve the effect of the minimally invasive technique.

The aim of this study was to examine the clinical effects of traditional extraction and piezosurgery of IMTM in patients undergoing extraction. In addition, postoperative customary outcomes, complications, and influence on the adjacent second molar were observed, aiming to provide valuable evidence for better future treatment.

Methods

The study included 86 patients with IMTM admitted to the Beijing Stomatological Hospital, Department of Wangfujing General Dentistry, Beijing, China, from March 2022 to March 2024. The patients were randomized into a control group (CG) and a study group (SG), each comprising 43 patients. This study was approved by the Ethics Committee of the Beijing Stomatological Hospital (approval No. BSH202203006).

Inclusion and exclusion criteria

Inclusion criteria were as follows: patients meeting the diagnostic criteria for IMTMs by imaging examination [12]; lower third molars with total soft tissue retention; lower third molars lack of distal space (Pell-Gregory classification); lower third molars with mesio-angular tilt (Winter's classification) [13]; those with surgical indications, normal coagulation function and good compliance; those who voluntarily signed the informed consent form.

Exclusion criteria included: patients with a history of adjacent tooth extraction; menstruating, lactating, or pregnant women; those complicated with severe infectious diseases; those with recent immune deficiency; chronic smokers and alcoholics; those complicated with hypertension or heart disease; those with loosening of adjacent second molars preoperatively; those with psychosis.

Type of extraction

Extraction of IMTMs was performed in both groups. Coagulation function test, electrocardiogram, and oral examinations were carried out preoperatively. Patients with contraindications to tooth extraction, such as acute inflammatory period, menstrual period, hypertension, and heart disease, and women three months before and after pregnancy were excluded. An X-ray image was taken to identify the position and morphology of the third molar.

Traditional extraction was performed in CG. After anesthesia with local injection of 5 mL of 0.2% lidocaine and 1.7 mL of articaine/epinephrine and disinfection with anerdian, the upper and surrounding soft tissue covering the third molar was incised to expose the third molar fully. Using conventional rotary instruments, the bone tissue was removed to expand the space, and the dental crown and root were separated. Then the tooth tissue was gradually elevated using a dental elevator, and the root was extracted with dental forceps, followed by washing with normal saline. Finally, the wound surface was sutured, and hemostasis by compression was performed with a sterilized cotton sheet.

Piezosurgery was performed in SG [14]. After anesthesia and disinfection in the same way as in CG, a straight-line incision was made on the third molar and flapped with a separator, and the bone tissue was removed using a USI1004 UBK (Shanghai Langyi Medical Equipment Co., Ltd., Shanghai, China) to expose the crown fully. After the resistance of the crown was eliminated, an ATH was used to separate the crown and the root. When approaching the alveolar bone, the tooth tissue was removed using the UBK, the crown was extracted, and the periodontal ligament was separated with a minimally invasive knife. After the root became loose, it was elevated using a minimally invasive dental elevator, and the residual dental sac tissue

was scraped off. Then the UBK was switched to a flush mode to flush the alveolar fossa with hypothermic normal saline. Finally, the wound surface was sutured, and hemostasis by compression was performed with a sterilized cotton sheet.

The patients in both groups were followed up for one week postoperatively. An ice compress was applied intermittently during the first three days. No food was allowed within two hours after surgery, and tooth brushing was prohibited within the first 24 hrs. Meanwhile, prophylactic prescription of antibiotics was given to both groups.

Evaluation of outcomes

To assess clinical indicators, the operation time and intraoperative blood loss were compared between the two groups. In detail, blood from the operative field was suctioned into a calibrated container, and the volume was recorded. Additionally, gauze pads were weighed before and after surgery using a high-precision electronic scale, and the weight difference (1 g approximating 1 mL of blood) was calculated. Total intraoperative blood loss was determined by summing these two measurements.

Customary outcomes include the following: 1) pain degree was evaluated using the Visual Analogue Scale (VAS) preoperatively and 2 and 7 days postoperatively [15], with a maximum score of 10 points. The score was directly proportional to the pain degree. 2) Swelling degree: cheek circumference was measured preoperatively and 2 and 7 days postoperatively. The difference in measurements was used to grade swelling – grade I: ≤ 2 mm; grade II: 2–10 mm; grade III: > 10 mm. 3) To evaluate the degree of mouth opening limitation, the distance between the upper and lower middle teeth was measured with calipers 2 and 7 days postoperatively. Limitation was graded as follows: grade I (> 20 mm), grade II (10–20 mm), grade III (< 10 mm).

For assessing complication, the percentages of dry socket, periodontal defects of adjacent second molars, numbness of lower lip and nerve injury, and delayed infection of the surgery operated area were recorded on the 14th and 30th day postoperatively.

For assessing periodontal status, both groups, both groups were given comprehensive oral examinations preoperatively and 7, 14, and 30 days postoperatively, and the periodontal status of the adjacent second molar was compared from PI, PD, and BOP between the two groups [16].

Statistical analysis

SPSS 23.0 software (IBM, New York, USA) was used for statistical analysis. Measurement data were described by mean ± standard deviation and underwent the independent-samples *t*-test. The count data were described by numbers and percentages. The Chi-square ($\chi 2$) test was used. The rank sum test was performed for ranked data. The value of $p < 0.05$ was considered statistically significant.

Results

In CG, there were 21 males and 22 females aged 22–35 years, with a mean of 26.44 ± 3.33 years. The IMTM was located on the left side in 17 cases and on the right side in 26 cases. The body mass index (BMI) was 20–24 kg/m^2, with a mean of 21.55 ± 1.32 kg/m^2. In SG, there were 24 males and 19 females aged 20–36 years, with a mean of 26.84 ± 3.19 years. The IMTM was located on the left side in 21 cases and on the right side in 22 cases. The BMI was 20–24 kg/m^2, with a mean of 21.89 ± 1.18 kg/m^2. The general data were well balanced between the two groups ($p > 0.05$).

Operation time and intraoperative blood loss

In SG, the operation time was shorter and intraoperative blood loss was less than in CG ($p < 0.05$) (Table 1).

Pain degree

No significant differences were found in the VAS score between the two groups preoperatively ($p > 0.05$). On the first postoperative day, the VAS scores were higher in both groups than preoperatively. However, scores were lower in SG than in CG ($p < 0.05$) (Table 2).

Degrees of swelling and mouth opening limitation

The degrees of swelling and mouth opening limitation were lower in SG than in CG ($p < 0.05$) (Table 3).

Complications in both groups

On the 14th day postoperatively, the two groups had similar percentages of complications. SG had a lower percentage of complications than CG on the 30th day postoperatively ($p < 0.05$) (Table 4).

Table 1

Operation time and intraoperative blood loss

Group	Operation time (min)	Intraoperative blood loss (mL)
Control group (n = 43)	29.76 ± 5.10	6.07 ± 1.14
Study group (n = 43)	26.53 ± 3.47	4.80 ± 1.37
t	3.434	4.673
p	0.001	< 0.001

n – number.
All values are presented as mean ± standard deviation.
Independent-samples *t*-test was used.

Table 2

Pain degree assessed by VAS score

Group	VAS	
	preoperatively	one day postoperatively
Control group (n = 43)	1.35 ± 0.74	4.35 ± 0.54*
Study group (n = 43)	1.36 ± 0.72	2.86 ± 0.64*
t	0.064	11.668
p	0.950	< 0.001

VAS – Visual Analogue Scale; n – number.
All values are presented as mean ± standard deviation.
Independent-samples t-test was used. *$p < 0.05$ vs. the same group preoperatively.

Table 3

Degrees of swelling and mouth opening limitation

Group	Degree of swelling			Degree of mouth opening limitation		
	I	II	III	I	II	III
Control group (n = 43)	9 (20.93)	11 (25.58)	23 (53.49)	3 (6.98)	11 (25.58)	29 (67.44)
Study group (n = 43)	19 (44.19)	17 (39.53)	7 (16.28)	12 (27.91)	21 (48.84)	10 (23.26)
Z		3.408			4.150	
p		0.001			< 0.001	

n – number.
All values are presented as numbers (percentages). The χ^2 test was used.

Table 4

Complications in two groups

Group	Dry socket		Periodontal defects of adjacent second molars		Numbness of the lower lip		Nerve injury		Total	
	days postoperatively									
	14th	30th	14th	30th	14th	30th	14th	30th	14th	30th
Control group (n = 43)	1 (2.33)	1 (2.33)	1 (2.33)	2 (4.65)	2 (4.65)	3 (6.98)	1 (2.33)	2 (4.65)	5 (11.63)	8 (18.60)
Study group (n = 43)	0 (0)	0 (0)	1 (2.33)	1 (2.33)	0 (0)	0 (0)	0 (0)	1 (2.33)	1 (2.33)	2 (4.65)
χ^2									1.613	4.074
p									0.204	0.044

n – number.
All values are presented as numbers (percentages). The χ^2 test was used.

Table 5

Periodontal health

Group	PI, mean ± SD		PD, mean ± SD (mm)		BOP, n (%)	
	days postoperatively					
	14th	30th	14th	30th	14th	30th
Control group (n = 43)	1.15 ± 0.15	0.89 ± 0.08	2.12 ± 0.25	2.03 ± 0.20	11 (25.6)	6 (14.0)
Study group (n = 43)	1.12 ± 0.16	0.91 ± 0.06	2.14 ± 0.22	2.01 ± 0.23	13 (30.2)	9 (20.9)
t/χ^2	0.897	1.312	0.394	0.430	0.839	0.711
p	0.372	0.193	0.695	0.668	0.404	0.479

PI – plaque index; PD – probing depth; BOP – bleeding on probing; n – number; SD – standard deviation.

Periodontal health

On the 14th and 30th day postoperatively, there were no significant differences between PI, PD, and BOP of the two groups ($p > 0.05$) (Table 5).

Discussion

Third molars are the last set of teeth to develop in the mouth and usually emerge at the age of 18–25. As humans evolve, the jaw gradually shrinks, resulting in the dislocation of the third molars, which is clinically known as impacted teeth. Impacted teeth not only fail to achieve normal masticatory function but also cause inflammation of the periodontal tissue. IMTM causes difficulty in eating and mouth opening, gingival swelling and pain, and fever as major clinical symptoms. If left untreated for a long time, this can lead to interdental space infection, which seriously affects patients' daily life [17]. In addition, IMTM can also lead to pathological changes in the adjacent second molars. Therefore, early detection and early treatment are of great significance. Due to a hidden position, complex anatomical structure, and limited

operating space, the extraction of IMTM may be difficult. Therefore, searching for an effective and safe extraction method has always been the focus of research.

Influenced by the available medical devices and prevailing surgical concepts, dental root extraction was previously performed mainly with chisel osteotomy. In this technique, bone tissue was removed and space was expanded through hammering and crown splitting [18]. However, these maneuvers generate strong impact forces that can damage normal periodontal tissues, increase intraoperative blood loss and postoperative complications, and even cause serious injuries such as joint dislocation or fracture. Such outcomes may also heighten the patient's psychological burden and reduce cooperation during surgery [19]. With the advent of minimally invasive surgery, chisel osteotomy has been gradually replaced by piezosurgery. Currently, ATHs and UBKs are commonly used in minimally invasive extraction, and their clinical advantages have been reported [20]. In this study, the results showed that the operation time was shorter and intraoperative blood loss was less in SG than in CG, indicating that the ATH combined with UBK can effectively shorten the operation time and reduce intraoperative blood loss during the extraction of IMTM. The ATH consists of a compressor and a turbine. During surgery, compressed air drives the tur-bine at high speed, enabling efficient separation of the crown and root [21]. By converting electrical energy into mechanical, the UBK gradually removes bone tissue of specific hardness under high-frequency vibration, exhibiting high efficiency and safety when applied to cutting deep alveolar bone tissues [22]. In addition, the cavitation effect produced during the use of the UBK helps prevent blood exudate from the wound surface, eliminates tissue debris, and maintains clear surgical fields [23]. Therefore, the combination of the ATH and the UBK offers the advantages of reduced trauma and minimized mechanical impact compared with chisel osteotomy. This approach can significantly shorten operative time and decrease intraoperative blood loss.

Following the extraction of IMTM, obvious pain, swelling, and mouth opening limitation are often caused, which are closely related to the postoperative natural outcomes. In this study, it was also found that the VAS score was higher in both groups on the first postoperative day than preoperatively, but it was lower in SG compared to CG. The degrees of swelling and mouth opening limitation were also lower in SG than in CG. The ATH can quickly and accurately cut bone tissues, but it is difficult to accurately control the range of cutting deep alveolar bone tissues, and the heat generated may damage soft tissues, causing postoperative pain and swelling [24]. The UBK can automatically distinguish between hard tissues and soft tissues, and selectively cut hard tissues, thereby effectively avoiding damage to soft tissues during bone removal and space expansion. Cooperative use of ATH and UBK can complement each other to further relieve postoperative pain, and reduce the degrees of swelling and mouth opening limitation, achieving good postoperative natural outcomes [25].

In this study, SG had a lower percentage of complications than CG, suggesting that piezosurgery of IMTM can effectively reduce postoperative complications, exhibiting a good safety profile. The reason is mainly related to the less violent operation. In addition, the vibration frequency of the UBK head is 24–30 kHz, which can only damage mineralized tissues. Soft tissues, such as periodontal mucosa and blood vessels, cannot be damaged until the vibration frequency reaches 50 kHz. As a result, the risk of lower lip numbness and nerve injury can be effectively reduced [26]. Moreover, the UBK generates less heat, and the water mist flushing function can reduce thermal damage and prevent dry socket [27]. According to related studies, IMTM can trap dental plaque and food residues in the space between it and the adjacent second molar. This may trigger inflammatory responses and even lead to defects in the second molar, ultimately affecting periodontal health [28]. In this study, there were no significant differences between PI, PD, and BOP of the two groups on the 14th and 30th postoperative days, suggesting that both traditional extraction and piezosurgery can improve periodontal health of adjacent second molars, because oral cleaning becomes simple after the extraction of the third molar. Although the inclusion and exclusion criteria were set up in this prospective randomized controlled study, the influence of individual differences on the study results cannot be completely avoided. In the future, confounding factors should be further reduced, and in-depth analyses are required to provide reliable reference data for clinical practice.

Conclusion

For impacted mandibular third molar extraction, patients receiving piezosurgery have satisfactory short-term healing outcomes, accompanied by good long-term outcomes of the adjacent second molar.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. *Sifuentes-Cervantes JS, Carrillo-Morales F, Castro-Núñez J, Cunningham LL, Van Sickels JE.* Third molar surgery: Past, present, and the future. Oral Surg Oral Med Oral Pathol Oral Radiol 2021; 132(5): 523–31.
2. *Gulnahar Y, Alpan AL.* Comparison of postoperative morbidity between piezoelectric surgery and conventional rotary instruments in mandibular third molar surgery: a split-mouth clinical study. Med Oral Patol Oral Cir Bucal 2021; 26(3): e269–75.
3. *Del Rey YC, Rikvold PD, Johnsen KK, Schlafer S.* A fast and reliable method for semi-automated planimetric quantification of dental plaque in clinical trials. J Clin Periodontol 2023; 50(3): 331–8.
4. *Suryavanshi VG, Tale RK, Aasole AG, Barge AK, Sanikop S, Gopashetti P.* Assessment of IL-8 Levels in Saliva of Healthy and Chronic Periodontitis Individuals. J Pharm Bioallied Sci 2024; 16(Suppl 1): S825–7.

5. *P SM, S S.* Effectiveness of Microneedling Technique Using Olive Oil on the Severity of Gingival Inflammation and Plaque Accumulation: A Randomised Controlled Trial. Cureus 2024; 16(4): e59415.
6. *Canullo L, Rakic M, Corvino E, Burton M, Krumbeck JA, Chittoor Prem A,* et al. Effect of argon plasma pre-treatment of healing abutments on peri-implant microbiome and soft tissue integration: a proof-of-concept randomized study. BMC Oral Health 2023; 23(1): 27.
7. *Chen YW, Chi LY, Lee OK.* Associations between aging and second molar diseases in patients having adjacent impacted third molar extraction. J Formos Med Assoc 2021; 120(1 Pt 2): 380–7.
8. *Patel PS, Shah JS, Dudhia BB, Butala PB, Jani YV, Macwan RS.* Comparison of panoramic radiograph and cone beam computed tomography findings for impacted mandibular third molar root and inferior alveolar nerve canal relation. Indian J Dent Res 2020; 31(1): 91–102.
9. *Mann A, Scott JF.* Coronectomy of mandibular third molars: a systematic literature review and case studies. Aust Dent J 2021; 66(2): 136–49.
10. *Jiang S, Zhou B, Li Z, Gao J, Wang P.* Comparison of the effects of two extraction methods on the alveolar ridge preservation of Maxillary Anterior Teeth. Pak J Med Sci 2023; 39(2): 549–52.
11. *Wang L, Liu Y, Wang S, Li J, Sun Y, Wang J,* et al. Research on ultrasonic bone cutting mechanism based on extended finite element method. Biomech Model Mechan 2024; 23(3): 861–77.
12. *Yang Y, Bao DY, Ni C, Li Z.* Three-dimensional positional relationship between impacted mandibular third molars and the mandibular canal. BMC Oral Health 2023; 23(1): 831.
13. *Kaposvári I, Körmöczi K, Csurgay K, Horváth F, Ashourioun AH, Buglyó A,* et al. Delayed-onset infections after lower third molar surgery: A Hungarian case-control study. Oral Surg Oral Med Oral Pathol Oral Radiol 2021; 132(6): 641–7.
14. *Cicciù M, Stacchi C, Fiorillo L, Cervino G, Troiano G, Vercellotti T,* et al. Piezoelectric bone surgery for impacted lower third molar extraction compared with conventional rotary instruments: a systematic review, meta-analysis, and trial sequential analysis. Int J Oral Maxillofac Surg 2021; 50(1): 121–31.
15. *Hamad SA.* Outcomes of coronectomy and total odontectomy of impacted mandibular third molars. Int Dent J 2024; 74(2): 195–8.
16. *Zhang Y, Chen X, Zhou Z, Hao Y, Li H, Cheng Y,* et al. Effects of impacted lower third molar extraction on periodontal tissue of the adjacent second molar. Ther Clin Risk Manag 2021; 17: 235–47.
17. *Miguel DCN, Oliveira RDS, Panzarella FK.* Postoperative Complications After Extraction of impacted mandibular third molars: A clinical observational study on dental position and risks. J Int Soc Prev Community Dent 2025; 15(2): 155–72.
18. *Genç BGÇ, Orhan K, Or S.* A clinical comparison of Er: YAG Laser, piezosurgery, and conventional bur methods in the impacted third molar surgery. Photobiomodul Photomed Laser Surg 2023; 41(6): 283–90.
19. *Caputo A, Rubino E, Marcianò A, Peditto M, Bellocchio AM, Nucera R,* et al. Three-dimensional facial swelling evaluation of piezoelectric vs conventional drilling bur surgery of impacted lower third molar: a randomized clinical trial. BMC Oral Health 2023; 23(1): 233.
20. *Steel BJ, Surendran KSB, Braithwaite C, Mehta D, Keith DJW.* Current thinking in lower third molar surgery. Br J Oral Maxillofac Surg 2022; 60(3): 257–65.
21. *Civak T, Ustun T, Yilmaz HN, Gursoy B.* Postoperative evaluation of Er: YAG laser, piezosurgery, and rotary systems used for osteotomy in mandibular third-molar extractions. J Craniomaxillofac Surg 2021; 49(1): 64–9.
22. *Nogueira DGM, Leão JC, Sales PHDH, Silva PGB, Gomes ACA.* Piezoelectric surgery is effective in reducing pain, swelling, and trismus after removal of impacted lower third molars: A meta-analysis. J Oral Maxillofac Surg 2023; 81(4): 483–98.
23. *Nehme W, Fares Y, Abou-Abbas L.* Piezo-surgery technique and intramuscular dexamethasone injection to reduce postoperative pain after impacted mandibular third molar surgery: A randomized clinical trial. BMC Oral Health 2021; 21(1): 393.
24. *Alraqibah MA, Rao JKD, Alharbi BM.* Periotome versus piezotome as an aid for atraumatic extraction: A randomized controlled trial. J Korean Assoc Oral Maxillofac Surg 2022; 48(6): 356–62.
25. *Costa SM, Ribeiro BC, Gonçalves AS, Araújo LM, Toledo GL, Amaral MB.* Double blind randomized clinical trial comparing minimally-invasive envelope flap and conventional envelope flap on impacted lower third molar surgery. Med Oral Patol Oral Cir Bucal 2022; 27(6): e518–24.
26. *Wu L, Wang S.* Effect of Ultrasonic Osteotome on therapeutic efficacy and safety of spinal surgery: A system review and meta-analysis. Comput Math Methods Med 2022; 2022: 9548142.
27. *Blagova B, Krastev D, Malinova L.* Conventional drilling versus ultrasound and laser osteotomy in mandibular third molar surgery: A comparative study. Lasers Surg Med 2023; 55(10): 862–70.
28. *Bernabeu-Mira JC, Peñarrocha-Oltra D, Peñarrocha-Diago M.* Coronectomy of impacted mandibular third molars: A clinical and radiological retrospective case series study with 2-9 years of follow-up. Med Oral Patol Oral Cir Bucal 2024; 29(2): e180–6.

Received on May 6, 2025
Revised on July 11, 2025
Accepted on July 23, 2025
Online First September 2025