DOI: http://doi.org/10.54617/adoklinikbilimler.1471621

Original Research Article

Comparative Evaluation of Postoperative Edema Following Mandibular Third Molar Extraction Using Zirconia versus Carbide Burs

Mandibular Üçüncü Molar Çekiminde Zirkonyum ve Karbid Frezlerin Kullanımının Postoperatif Ödem Üzerine Karşılaştırmalı Değerlendirmesi

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ABSTRACT

Aim: The use of zirconia burs with low thermal conductivity in the extraction of impacted mandibular third molars may improve postoperative patient outcomes. The aim of this study was to evaluate the effect of using zirconia burs on postoperative edema, trismus, and pain in impacted mandibular third molars.

Material and Method: This prospective randomized controlled study was conducted between January and July 2023 with participants who underwent impacted mandibular third molar extraction surgery at the Marmara University Faculty of Dentistry, Department of Oral and Maxillofacial Surgery. The primary outcome measures were facial volume and surface area change measured by a mobile 3D scanning device. Postoperative maximum interincisal opening (MIO) and pain (measured by the VAS) were secondary outcome measures for this study. Age, sex, classification and position of the mandibular third molar were the demographic variables. Facial volume changes, MIO, and pain were compared within and between groups using a general linear model.

Results: A total of 40 patients aged between 18 and 45 years were included in the final analysis. Postoperative facial volume, surface area, MIO, and pain did not significantly differ between the zirconia group and the carbide bur group on days 3 and 7 ($P > 0.05$).

Conclusion: The use of zirconia burs for bone removal in mandibular wisdom tooth extraction did not result in a statistically significant difference with regard to postoperative facial edema, MIOs or pain.

Keywords (MeSH): Impacted Tooth; Mandible; Morbidity; Zirconia

ÖZET

Amaç: Gömülü mandibular üçüncü molar dişlerin çekiminde düşük termal iletkenliğe sahip zirkonya frezlerin kullanılması postoperatif hasta sonuçlarını iyileştirebilir. Bu çalışmanın amacı, gömülü mandibular üçüncü molar dişlerde zirkonya frez kullanımının postoperatif ödem, trismus ve ağrı üzerindeki etkisini değerlendirmektir.

Gereç ve Yöntem: Bu prospektif randomize kontrollü çalışma, Ocak-Temmuz 2023 tarihleri arasında Marmara Üniversitesi Diş Hekimliği Fakültesi Ağız Diş ve Çene Cerrahisi Anabilim Dalı'nda gömülü mandibular üçüncü molar diş çekimi ameliyatı için başvuran katılımcılarla yürütülmüştür. Birincil sonuç ölçütleri, mobil bir 3D tarama uygulaması ile ölçülen yüz hacmi ve yüzey alanı değişimidir. Ameliyat sonrası maksimum interinsizal açıklık (MIA) ve ağrı (VAS skoru ile ölçülen) bu çalışma için ikincil sonuç ölçütleridir. Yaş, cinsiyet, sınıflandırma ve mandibular üçüncü molar dişin pozisyonu demografik özellikleri oluşturmuştur. Yüz hacmi değişiklikleri, MIO ve ağrı, genel lineer model kullanılarak grup içinde ve gruplar arasında karşılaştırılmıştır.

Bulgular: Yaşları 18 ila 45 arasında değişen toplam 40 hasta son analize dahil edilmiştir. Zirkonya grubunda, ameliyat sonrası yüz hacmi, yüzey alanı, MIA ve 3. ve 7. günlerdeki ağrı ölçümleri, karbür frez grubundakilere kıyasla istatistiksel olarak anlamlı farklılıklar göstermemiştir ($P > 0.05$).

Sonuç: Mandibular yirmi yaş dişi çekiminde kemik çıkarılması için zirkonya frezlerin kullanılması, ameliyat sonrası yüz ödemi, MIA'lar ve ağrı açısından istatistiksel olarak anlamlı bir farka yol açmamıştır.

Anahtar Kelimeler: Gömülü diş; Mandibula; Morbidite; Zirkonyum

Makale gönderiliş tarihi: 21.04.2024; Yayına kabul tarihi: 14.08.2024
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INTRODUCTION

Impacted teeth are more commonly observed in the mandible,[1] and the incidence of mandibular third molars is greater in females than in males.[2,3] The extraction of these teeth depends on the position of the tooth and often necessitates various osteotomies in the tooth itself or the surrounding bone. Various intraoperative or postoperative complications are observed depending on the extraction of the tooth and the osteotomy performed around it. Common complications following the extraction of these teeth include swelling, trismus, and pain,[4] while rare complications include nerve damage.[5] Osteotomies in bone cause an increase in temperature,[6,7] which can harm living cells if the pressure or temperature becomes excessive,[8] and elevated temperatures can increase postoperative morbidity in individuals. Therefore, it is crucial to prevent excessive temperature increases in the bone during surgery on impacted mandibular third molars.

During the surgery of impacted third molars, various methods, such as conventional burs, piezosurgery,[9,10] and lasers,[11] are utilized in clinical settings. Among these methods, carbide burs are often preferred due to their cost-effectiveness and ease of use. However, the disadvantage of this method is the thermal changes it causes in the bone.[12] Due to this drawback of carbide burs, zirconia burs have been proposed as an alternative.[13] Zirconia is useful for osteotomy in bone due to its mechanical properties, biocompatibility, reliability, strength, and resistance to corrosion.[14] Despite the increasing advancements in the production of zirconia burs, only a limited number of studies have assessed the impact of heat increase in bone, and these studies are confined to *in vitro* conditions or dental implant osteotomies.[15,16] To the authors' knowledge, the effect of using zirconia burs on postoperative morbidity in osteotomies for the extraction of impacted mandibular teeth has not been previously investigated.

The aim of this study was to compare the postoperative morbidity following the extraction of impacted third molars using zirconia and carbide burs. To the authors' knowledge, this is the first study to undertake such a comparison. Our hypothesis is that the use of zirconia in the extraction of impacted mandibular teeth does not have a positive effect on early postoperative morbidity.

MATERIAL AND METHOD

Study Setting

This prospective randomized controlled study was conducted at the Marmara University Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, between January and July of 2023. Ethical approval for this study was granted by the Ethics Committee of Marmara University School of Medicine, with approval number 09.2022.1029 dated November 29, 2022.

Inclusion criteria

Eligible participants were individuals aged between 18 and 45 years with an ASA physical status of I or II. Participants required the extraction of impacted mandibular third molars for prophylactic or orthodontic reasons and were classified as Class II according to Pell and Gregory and mesioangular according to Winter's classification. The exclusion criteria included individuals with systemic diseases or medication use affecting bone or soft tissue metabolism, pregnant or lactating women, individuals who smoked more than 10 cigarettes per day or who were alcohol dependent, and those with a history of malignancy, chemotherapy, or radiotherapy. Additionally, individuals unwilling to give informed consent were excluded from the study.

Participants and Groups

Participants were divided into two treatment groups: the zirconia group and the carbide group. Preoperative radiographic assessments were conducted using panoramic radiographs to document the type of impaction, which included mesioangular, distoangular, and horizontal classifications.

Randomization

A total of 40 patients were randomized into two groups of 20 each using a computer-generated random number sequence. The randomization process was overseen by an independent statistician and the random numbers were kept in sealed, opaque envelopes, which were opened only by the surgical team prior to each procedure.

Surgical Procedure

All surgical procedures were conducted under local anesthesia. Preoperative antisepsis was achieved using a 10% povidone-iodine solution for extraoral sites and 0.12% chlorhexidine gluconate for intraoral sites. Inferior alveolar nerve blocks and vestibular infiltration were performed using articaine hydrochloride with epinephrine for local anesthesia. An envelope flap was created to access the surgical site. The buccal and distal surfaces of the teeth were osteotomized using a bur according to the group assignment—either zirconia or carbide (Figure 1). If necessary, the impacted tooth was sectioned and then elevated for extraction. After hemostasis was achieved, the wounds were closed primarily with 3/0 silk sutures using simple interrupted sutures.

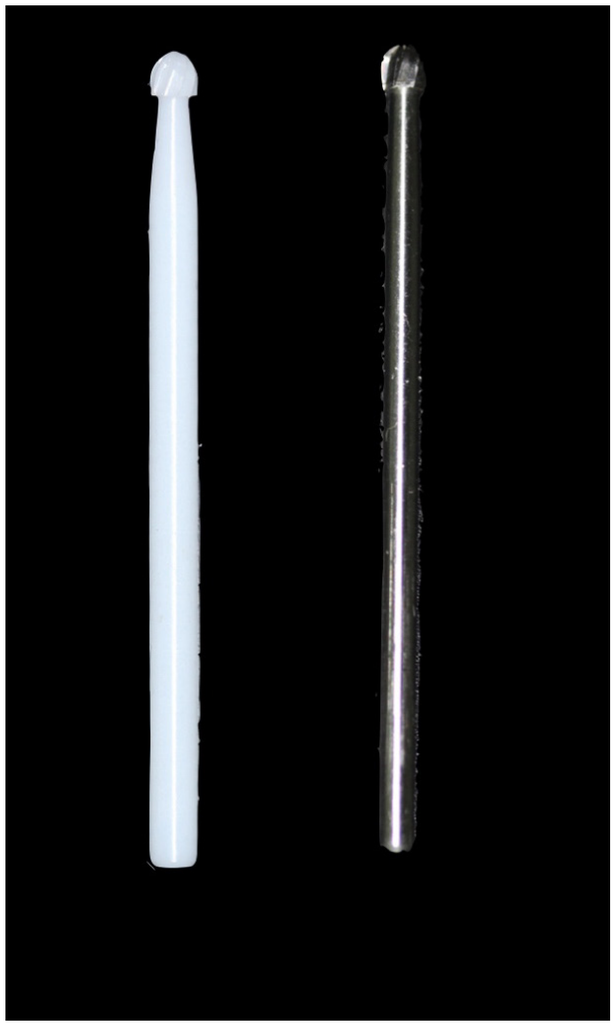

Figure 1. Zirconia bur (left) vs. Carbide bur (right) used in third molar extractions.

Outcome Measures

Changes in facial volume and surface area were measured using a mobile 3D scanning device. For this purpose, the Heges® mobile app (Marek Simonik, North Moravia, Czech Republic) on an iPhone 14 (Apple Inc., California, USA) was used at all time points (T0: preoperative, T1: postoperative 3rd day, T2: postoperative 7th day). Preoperative and postoperative data obtained were overlaid with Meshmixer (Autodesk, California, USA) software. The superimposed STL data were split in the mid-sagittal plane, leaving the side of tooth extraction, and the remaining part was discarded. Then, a line was drawn from the tragus to the lateral canthus, and the remaining part was discarded. In the remaining data, in profile view, a line parallel to the ground was drawn from the cervicomental junction, and a perpendicular line descended from the tragus to this line. The final STL data obtained at 3 different times were used for the evaluation of edema. The surface area of the remaining part in the STL data was measured in mm^2, and the facial volume was measured in mm^3 with the help of Meshmixer software (Figure 2).

To assess the restriction in mouth opening (trismus), the distance between the mesioincisal edge of the right maxillary first incisor and the mesioincisal edge of the right mandibular first incisor was measured during the patient's unassisted maximum interincisal opening. These measurements, recorded in millimeters, were documented at all time points.

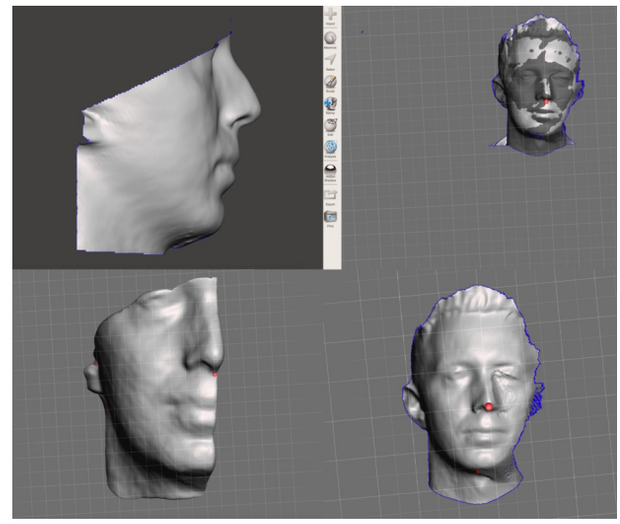

Figure 2. Preoperative and postoperative facial changes were analyzed using a mobile 3D scanner application and Meshmixer software.

To measure pain, the visual analog scale (VAS) was utilized. The VAS is a scale that ranges from 0 to 10, with endpoints defined as 'no pain at all' and 'worst possible pain'. Participants were asked to indicate their level of pain on the scale between these two endpoints. The distance from 'no pain' to the point marked by the participants represents their perceived pain level. In our study, this scale was used to assess the postoperative pain conditions of the participants.

Statistical analysis

Continuous variables were summarized using means and standard deviations, while categorical variables were described using frequencies and percentages. The fit of the distribution of the data to normal distribution was analyzed using the Shapiro–Wilk test. A general linear model (GLM) was applied to compare outcomes between groups across three time points (preoperative, third-day postoperative, and seventh-day postoperative) using SPSS version 29.0. This analysis aimed to identify significant differences in edema, mouth opening, and pain between the groups over time, with a significance level set at $p < 0.05$.

RESULTS

Demographics

This study included 40 participants. The mean age was 27.5 years, with a standard deviation of 7.2 years, indicating a young adult population. In terms of gender distribution, the sample consisted of 24 women and 16 men. The majority of the participants, 32 out of 40, were nonsmokers. The reasons for the extraction of impacted third molars were primarily prophylactic (70% of patients), while the remaining 30% were extracted for orthodontic purposes (Table 1).

Table 1. Descriptive statistics of the sample used

Variable	Mean	SD	n	%
Age	27.5	7.2	40	
Gender				
Female			24	60
Male			16	40
Smoking status				
Absent			32	80
Present			8	20
Indication for extraction				
Prophylactic			28	70
Orthodontic			12	30

SD: Standard deviation

Postoperative Edema

The analysis of volume changes across three specific time points—preoperative, third postoperative day, and seventh postoperative day—revealed significant temporal variations ($F = 12.24$, $p < 0.001$), suggesting substantial changes in volume over time. However, the interaction between time and the type of bur used (zirconia vs. Carbide) did not reach statistical significance ($p = 0.265$), indicating that the volume change pattern was consistent across different burs. In the surface area analysis, there were notable changes over time ($F = 8.8$, $p < 0.002$), with no significant interaction between time and material type ($p = 0.309$), suggesting consistent surface area changed regardless of the material used (Table 2).

Table 2. Comparison of volume changes, surface area changes, maximum interincisal opening, and pain between zirconia and tungsten groups at different time points

Parameter	Time Point	Zirconia	Tungsten	F	p
		Mean (SD)	Mean (SD)		
Volume Changes (mm³)				12.2	< 0.001
	Preoperative	0.031 (0.006)	0.034 (0.006)		
	3rd day	0.048 (0.118)	0.040 (0.006)		
	7th day	0.031 (0.005)	0.035 (0.005)		
Interaction (Time * Group)					0.265
Surface Area Changes (mm²)				8.8	< 0.002
	Preoperative	0.038 (0.006)	0.036 (0.006)		
	3rd day	0.040 (0.005)	0.040 (0.008)		
	7th day	0.039 (0.006)	0.037 (0.009)		
Interaction (Time * Group)					0.309
Maximum Interincisal Opening				36.2	< 0.001
	Preoperative	39.6 (1.4)	40.5 (1.3)		
	3rd day	35.5 (1.0)	35.5 (2.7)		
	7th day	39.0 (1.3)	38.1 (2.2)		
Interaction (Time * Group)					0.204
Pain (VAS)				300.1	< 0.001
	3rd day	7.5 (0.8)	7.3 (0.4)		
	7th day	1.7 (0.3)	1.5 (0.3)		
Interaction (Time * Group)					0.713

SD: Standard deviation

Maximum Interincisal Opening

Significant fluctuations were also observed in Maximum interincisal opening (MIO) across the measured time points ($F = 36.2$, $p < 0.001$). The lack of a significant interaction effect between time and group ($p = 0.204$) indicates that MIO changes were uniform across both groups throughout the study period (Table 2).

Pain

Visual Analog Scale (VAS) assessments for pain revealed dramatic changes over time ($F = 300.08$, $p < 0.001$), with no significant difference in pain reduction between the groups over time ($p = 0.713$), highlighting a uniform decrease in pain levels across all participants (Table 2).

DISCUSSION

Third molar surgery is one of the most common outpatient procedures performed by dentists,[17] and efforts to minimize associated complications are highly important. The literature suggests various recommendations for reducing complications, including the use of advanced techniques such as piezosurgery and PRF[9,18] however, many of these techniques are costly and not easily applicable to every patient in routine practice. Therefore, alternative approaches to decrease postoperative morbidity are necessary. According to our results, there were no statistically significant differences in postoperative morbidity assessed through edema, MIO, or pain parameters between the zirconia and carbide bur groups, thus supporting our hypothesis

that the type of bur used does not significantly influence early postoperative outcomes. This finding suggests that both materials are equally effective in managing postoperative morbidity within the parameters of our study.

The thermodynamic effects induced by surgical burs in bone are widely described in the literature,[19-21] with most of these studies being conducted *in vitro*.[8] However, the actual magnitude of temperature increase in the oral mucosa and jawbone under clinical conditions remains unclear.[22] Furthermore, the literature does not provide definitive conclusions about the impact of the material from which the bur is made on heat production during osteotomy.[23] Zirconia burs are considered a suitable alternative to tungsten carbide burs for superficial bone drilling with cooling fluids due to their lower wear and temperatures.[16] A meta-analysis including recent *in vitro* studies by Bento *et al*.[24] showed that zirconia burs result in significantly less temperature change than stainless steel burs. However, these *in vitro* studies lack extensive clinical support. In our study, no differences were found in postoperative morbidity between zirconia and carbide burs. These findings, combined with those of *in vitro* studies, suggest that zirconia burs may produce less heat increase, but this difference may not be clinically significant.

Accurately measuring postextraction edema is challenging due to its three-dimensional distribution. Various techniques have been employed, including Neupert *et al*.[25] five-point measurement technique. With the widespread adoption of 3D scanning technologies, assessing superficial and volumetric changes in tissues has become more straightforward and precise. 3D digital analysis, such as that of Heges®, is an objective, repeatable, and reliable method for evaluating facial swelling. In our study, we employed a unique application of this method, providing a clinically feasible alternative for routine edema measurement.[26]

This study has several strengths that support its scientific validity and relevance. The use of a randomized controlled design minimizes bias and ensures broad applicability of the results, which is crucial in the evaluation of clinical interventions. The inclusion of a homogeneous aged cohort, specifically participants aged 18 to 45 years, reduces variability due to age-related factors and focuses the findings on a demographic commonly seen in clinical settings. Furthermore, the use of three-dimensional imaging for edema assessment provides precise measurements of postsurgical swelling, providing detailed and quantifiable data. However, this study also has several limitations that should be considered. First, the design does not include the long-term effects of the materials used. The follow-up period was limited to only seven days postoperatively, which provides a snapshot rather than a comprehensive view of the healing process or late-onset complications or successes associated with the burs tested. A longer follow-up will be necessary to fully understand the effects of using zirconia versus carbide in surgical procedures. Second, while the sample size was sufficient to detect large differences, it may have been too small to detect smaller but clinically meaningful effects. This may particularly affect the ability to generalize findings to a wider population or to identify subtle differences between groups. Future studies would benefit from a larger sample pool to increase the robustness and applicability of the findings.

CONCLUSION

In conclusion, this study found that both zirconia and the more economical and widely used carbide were similar in terms of postoperative morbidity in the extraction of impacted mandibular third molars seven days after surgery, regardless of the bur used. Supported by a randomized controlled design and three-dimensional imaging, these findings highlight the applicability of both materials in clinical settings. Nonetheless, the short follow-up period and limited sample size call for further research to assess long-term outcomes and validate these results across a broader population. Extending the follow-up duration beyond seven days may provide a more comprehensive understanding of potential delayed complications or benefits. Moreover, future studies should also consider directly measuring intraoperative temperature to better analyze its impact on postoperative morbidity.

ACKNOWLEDGEMENT

None

CONFLICT OF INTEREST

None

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