

# The Application of ultrasonic bone knife combined with turbodrill cross incision in extraction of mandibular impacted third molar

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## Abstract

The extraction of mandibular impacted third molars is a common yet complex surgical procedure in oral and maxillofacial surgery due to the close association with mandibular nerves and deep impaction. Traditional bone-chisel extraction methods, though effective, are associated with high trauma and extended recovery periods, leading to increased patient discomfort. This study aims to: (1) Explore individualized approaches for impacted tooth extraction to provide safer and faster options for the removal of mandibular impacted third molars; (2) Provide an alternative sectional extraction approach for impacted teeth in clinical oral surgery; (3) Offer new ideas and a theoretical basis for the extraction of mandibular impacted third molars in clinical practice. This study adopts a case-control research design, including 120 patients with mesioangular impacted mandibular third molars, divided into three groups: traditional bone-chisel extraction (control group) and two experimental groups using an ultrasonic bone scalpel combined with a turbine drill, with either linear or cross-shaped incision. The outcomes were analyzed for surgery time, postoperative pain, swelling, mouth-opening limitation, and complication rates.

The results showed significant differences in surgical time, postoperative pain, and swelling among the groups. The ultrasonic bone scalpel with a cross-shaped incision provided the best outcomes, with shorter surgical times, reduced pain, and minimized swelling compared to the traditional method. The combined use of an ultrasonic bone scalpel and a turbine drill significantly reduced surgical trauma, enhanced recovery, and minimized postoperative complications. The cross-shaped incision method demonstrated particular efficacy, suggesting its potential as the preferred choice for similar extractions.

**Keywords:** Ultrasonic Bone Knife; Turbodrill Cross Incision; Mandibular Impacted Third Molar

## Introduction

The extraction of mandibular impacted third molars is one of the most common surgical procedures in oral and maxillofacial surgery, with its complexity mainly attributed to the deep impaction of the teeth and their close association with the mandibular nerve canal (Smith, 2011). Due to its anatomical location, the surgical procedure is particularly challenging, especially in mesioangular or horizontal impaction cases, which often lead to prolonged surgery times and increased risk of postoperative complications (Liu & Zhang, 2020).

Although the traditional bone-chisel extraction method has a long history and can effectively resolve impacted teeth issues, it has significant drawbacks, including high surgical trauma, extensive bone removal, severe postoperative pain and swelling, and a prolonged recovery period (Chen, 2019). Additionally, insufficient protection of surrounding nerve tissues can easily lead to postoperative nerve injuries, increasing patient discomfort and the incidence of complications (Wang, 2020).

In recent years, medical technology has advanced continuously, and the concept of minimally invasive surgery has gained widespread attention and application. Its goal is to ensure surgical effectiveness while minimizing patient trauma and accelerating postoperative recovery (Zhang, et al., 2021). As minimally invasive surgical technology continues to develop, reducing surgical trauma and improving patients' postoperative quality of life have become important considerations for oral and maxillofacial surgeons when choosing surgical methods (Huang, et al., 2019). The combined use of ultrasonic bone scalpel and turbine drill has gradually become a new approach for the extraction of mandibular impacted third molars. The ultrasonic bone scalpel, as a cutting tool based on high-frequency vibrations, has been increasingly used in oral and maxillofacial surgery. It uses ultrasonic waves to drive the surgical instrument to vibrate at high frequency, allowing precise cutting of hard tissue with minimal force, resulting in less damage to surrounding soft tissue and nerves (Kim, et al., 2021). Compared with traditional burs and bone chisels, the ultrasonic bone scalpel provides better control over cutting depth, reduces the risk of nerve damage, and decreases the incidence of postoperative complications such as lower lip numbness and sensory abnormalities. Additionally, the vibration helps close small blood vessels during bone cutting, reducing intraoperative bleeding and improving the surgical field, although the cutting speed is relatively slower. The turbine drill, with its high-speed rotation, quickly segments the tooth structure, enhancing surgical efficiency and shortening operation time (Xu, et al., 2019). The combination of both instruments reduces surgical trauma and lowers the rate of postoperative complications, offering significant advantages in protecting nerves and soft tissues (Liu, et al., 2023). In clinical practice, the ultrasonic bone scalpel and turbine drill can be used to divide the tooth body as needed. Theoretically, the amount of tooth division is proportional to the division time—the more division performed, the less bone removal needed, but prolonged time increases surgical trauma (Tan, et al., 2021).

As the technology of the ultrasonic bone scalpel and turbine drill matures, optimizing the incision method to further reduce surgical trauma and improve surgical efficiency has become a research focus. Under the concept of minimally invasive surgery, postoperative pain, swelling, and patient recovery time have become key indicators for evaluating surgical outcomes. Therefore, this study compares the traditional bone-chisel extraction method with two different incision methods (linear and cross-shaped) using ultrasonic bone scalpel combined with turbine drill, aiming to evaluate the impact of different surgical methods on operation time, postoperative pain, swelling, mouth-opening limitation, and complication rates, thereby providing a theoretical basis for clinical practice and further validating the application value of different tooth extraction methods in mandibular impacted third molar extraction.

## Research Objectives

1. Explore individualized approaches for impacted tooth extraction to provide safer and faster options for the removal of mandibular impacted third molars;
2. Provide an alternative sectional extraction approach for impacted teeth in clinical oral surgery;
3. Offer new ideas and a theoretical basis for the extraction of mandibular impacted third molars in clinical practice.

## Literature Review

The extraction of mandibular impacted third molars is a common yet complex procedure in oral surgery, often accompanied by postoperative adverse reactions such as pain, swelling, and limited mouth opening. Although traditional turbine drills are efficient for tooth extraction, they generate high temperatures, vibrations, and significant tissue trauma. In recent years, piezoelectric surgery has emerged as an alternative minimally invasive technique due to its precise cutting capability and reduced damage to both hard and soft tissues. The combined use of an ultrasonic bone scalpel and a turbine drill aims to balance the efficiency of traditional methods with the advantages of minimal invasiveness, optimizing patient recovery. Current research focuses mainly on comparing the outcomes of ultrasonic bone scalpels and traditional turbine drills in the removal of mandibular impacted third molars.

A randomized controlled trial by Siddiqi et al. (2021) showed that the ultrasonic bone scalpel significantly reduced postoperative pain and facial swelling compared to the traditional turbine drill, thus enhancing patient comfort. Chiriac et al. (2020) confirmed the advantages of ultrasonic bone scalpel in reducing intraoperative bleeding and minimizing soft tissue damage. Additionally, the low thermal effect of the ultrasonic bone scalpel helps reduce the risk of bone tissue necrosis, as validated by Beck-Mannagetta et al. (2021). Del Fabbro et al. (2019) explored the practical application of the combined ultrasonic bone scalpel and turbine drill technique, demonstrating improved surgical precision and shorter operation times. Furthermore, clinical studies by Ion et al. (2020) indicated that the combined technique can significantly enhance the quality of postoperative recovery while maintaining high efficiency.

The application of the combined ultrasonic bone scalpel and turbine drill in the extraction of mandibular impacted third molars has demonstrated significant advantages, including reduced intraoperative trauma, fewer postoperative complications, and accelerated recovery. However, further clinical trials and studies are needed to evaluate its long-term outcomes, determine optimal indications for various cases, and establish the best extraction practices.

## Research Methodology

### 1. Population and research sample

This study employed a case-control design, selecting patients who visited the Department of Stomatology at Guangxi International Zhuang Medicine Hospital for the extraction of mandibular impacted third molars between March 2022 and March 2024. A total of 120 patients were screened based on strict inclusion and exclusion criteria, and were randomly divided into three groups: control group (Group A, n=40), using the traditional bone chisel extraction method; and two experimental groups using ultrasonic bone scalpel combined with a turbine drill—linear incision (Group B, n=40) and cross-shaped incision (Group C,

n=40), as shown in Figure 1. All patients had mesioangular impactions. X-ray imaging was used to confirm the diagnosis before surgery, and the surgical procedure was thoroughly explained to all patients, who provided informed consent for the procedure. There were no significant differences in age, gender, or other characteristics among the groups ( $P>0.05$ ). The experimental design and ethical procedures of this study were approved by the Clinical Trials Ethics Committee of Guangxi International Zhuang Medicine Hospital, in compliance with medical ethical standards.



**Figure 1** Control Group Diagram  
(Source: Photographed by researcher, 2024)

Selection criteria: (1) Age: Patients aged between 18 and 40 years, suitable for extraction without any contraindications for tooth extraction. (2) Type of Tooth Impaction: All included patients were diagnosed using X-ray films with impacted mandibular third molars, with the roots closely associated with the mandibular nerve canal. Additionally, the crowns of the teeth were partially exposed, and the impaction type was high-level mesioangular, ensuring control during extraction. (3) Condition of Adjacent Teeth: Adjacent teeth were intact without severe caries, avoiding potential interference in postoperative pain evaluation caused by pulpitis. (4) Crown Soft Tissue: Before surgery, the soft tissue surrounding the impacted tooth's crown had no acute inflammatory response, and the tooth was not loose, minimizing potential intraoperative and postoperative complications. mandibular impacted third molar.

Exclusion Criteria: (1) Contraindications for Extraction: Patients with clear contraindications for tooth extraction, such as severe coagulation disorders, hypertension, heart disease, diabetes, or other systemic conditions unsuitable for surgery. (2) Inability to Attend Follow-Up Visits: Patients unable to attend follow-up appointments or with incomplete follow-up records, which may affect outcome evaluation, were excluded. (3) Heavy Smoking or Drinking Habits: Patients with long-term smoking or alcohol abuse, as their recovery might be adversely affected, were also excluded from the study.

## 2. Research tools

### 2.1 Imaging Tools

Used to diagnose the condition of the patient's mandibular impacted third molars and the relationship between the tooth root and the mandibular nerve canal. Also used after tooth extraction to examine the condition of the extraction socket, ensuring there are no remnants or abnormalities that may lead to complications.

### 2.2 Anesthesia Tools and Drugs

5% compound lidocaine surface anesthetic: Applied to the oral mucosa in the surgical area to reduce the stinging sensation during anesthetic injection.

2% lidocaine with 1:100,000 epinephrine: Used for inferior alveolar nerve block anesthesia to block pain conduction in the mandibular region.

Articaine: Used for local infiltration anesthesia to ensure more thorough anesthesia of the surgical area.

### 2.3 Surgical Instruments

No. 15 surgical scalpel: Used to incise the gingiva in the control group surgery.

Periosteal elevator: Used in the control group surgery to lift the mucoperiosteum and fully expose the tooth.

Bone chisel: Used in the control group surgery to remove the alveolar bone covering the impacted tooth.

Surgical forceps, luxators, dental extraction forceps: Used in the control group surgery to separate and extract the impacted tooth.

Turbine drill: Used in the experimental group surgery for linear or cross-shaped incisions of the crown, with high-speed rotation to quickly create precise cutting lines.

Ultrasonic bone scalpel: Used in the experimental group surgery to further separate uncut portions, especially bone around the tooth root. The high-frequency vibration effectively reduces damage to surrounding soft tissues and nerves, and the vibration helps close small blood vessels, reducing intraoperative bleeding.

Tweezers: Used to remove cut portions of the tooth.

Minimally invasive luxator, extraction forceps: Used to gradually extract the remaining tooth portions.

### 2.4 Measurement Tools

Graduated steel ruler: Used to measure the distance from the lingual midpoint of the mandibular first molar crown to the corresponding buccal skin to assess postoperative swelling. Also used to measure the linear distance between the upper and lower central incisor cutting edges to assess preoperative and postoperative mouth-opening limitation.

Standard stopwatch: Used to record the time from incision to the end of suturing for each surgery as an evaluation of surgical duration.

### 2.5 Data Processing Tools

Excel: Used for inputting experimental data.

SPSS 26.0 statistical software: Used for analyzing experimental results, including t-tests, variance analysis, and multiple comparisons between groups.

## 3. Data collection

All surgeries were performed by an experienced oral surgeon to ensure the standardization and reliability of the results. The surgical procedure included anesthesia, incision, tooth segmentation and extraction, and postoperative management, with specific steps as follows:

### 3.1 Anesthesia

Before the surgery, local anesthesia was administered to the injection area to ensure that the patient would not feel pain throughout the procedure. The specific steps were as follows: a 5% compound lidocaine topical anesthetic was applied to the oral mucosa of the surgical area and allowed to act for about 4 minutes to ensure effective surface anesthesia. This step helped reduce the stinging sensation during the injection of anesthetics. Next, a 2% lidocaine solution with 1:100,000 epinephrine was used for inferior alveolar nerve block anesthesia to effectively block pain transmission in the mandibular region. This local anesthesia method is a standard procedure for extracting impacted mandibular third molars and provides

sufficient anesthesia for the surgery. Additionally, articaine was used for local infiltration anesthesia to further ensure complete anesthesia of the surgical area, preventing discomfort caused by incomplete anesthesia. Due to its rapid onset and wide anesthetic range, articaine is commonly used in complex tooth extraction procedures.

### 3.2 Control Group Surgical Procedure

For the control group patients (Group A, n=40), the traditional bone-chisel extraction method was used. The surgical steps were as follows: after sufficient local anesthesia, a No. 15 scalpel was used to incise the gingiva, and a periosteal elevator was used to reflect the mucoperiosteal flap to fully expose the tooth. A bone chisel was then used to remove the alveolar bone covering the impacted tooth. The bone chisel method involves using mechanical force to remove bone, which can easily lead to bleeding and soft tissue injury. Afterward, dental forceps were used to separate and remove the impacted tooth, with a surgical elevator or forceps being used as needed to assist with tooth extraction. Due to the significant amount of bone removal required by the traditional method, the surgery duration was relatively long, and patients experienced more noticeable postoperative pain and swelling.

### 3.3 Experimental Group Surgical Procedure

The experimental group patients (Groups B and C, n=40+40) underwent impacted tooth extraction using the ultrasonic bone scalpel combined with a turbine drill with either a linear or cross-shaped incision. The specific steps were as follows:

**Linear Incision (Group B):** After anesthesia, a turbine drill was used to create a linear incision on the tooth crown, making an oscillating motion from the buccal to the lingual direction. Due to the high-speed rotation of the turbine drill, a precise cut line was quickly made on the tooth crown, extending to the bifurcation area. During this process, the surgeon had to carefully control the cutting depth to avoid completely cutting through the enamel, thereby preventing damage to adjacent soft tissue and tooth roots.

**Cross-Shaped Incision (Group C):** For the cross-shaped incision, the surgeon made an oscillating motion from buccal to lingual to incise the tooth, and then made an additional cut along the mesiodistal direction, creating a cross-shaped cut line. This incision allowed better exposure of all parts of the tooth, facilitating more efficient segmentation and extraction. Particularly for deeply impacted teeth, the cross-shaped incision reduced the difficulty of extraction and shortened the surgery duration.

**Use of Ultrasonic Bone Scalpel:** After the initial cut with the turbine drill, the surgeon used the ultrasonic bone scalpel to further segment the parts not fully cut through, especially the bone around the tooth roots. The ultrasonic bone scalpel uses high-frequency vibrations to cut, effectively minimizing damage to surrounding soft tissue and nerves, and the vibrations also help close small blood vessels, reducing intraoperative bleeding. During the procedure, a pendulum motion was used to ensure a smooth, even cut and to avoid excessive damage. Once the tooth was adequately segmented, the gingiva was separated, and the divided parts of the tooth were removed using tweezers. A minimally invasive elevator or forceps was used to gradually remove the remaining tooth parts. The entire operation aimed for precision, minimizing flap reflection to reduce soft tissue damage. In complex cases requiring flap reflection, only a small flap was reflected to minimize trauma.

### 3.4 Postoperative Management

After tooth extraction, the surgeon thoroughly cleaned the extraction socket to prevent postoperative infection. The specific steps were as follows: the extraction socket was irrigated with sterile saline to ensure cleanliness and to remove any residual tooth fragments or bone

debris. A panoramic radiograph was then taken to further assess the condition of the extraction socket, ensuring no remnants or abnormalities that could cause complications. Gelatin sponge was placed in the extraction socket to help with hemostasis and promote healing. Finally, 4-0 non-absorbable sutures were used to close the wound, ensuring the sutures were tight without excessive tension on the soft tissue.

### 3.5 Postoperative Care and Follow-Up

All patients received standardized postoperative care:

Patients were instructed to use antibiotics for three days to prevent postoperative infection. Broad-spectrum antibiotics were commonly used, with specific medications and dosages adjusted based on individual patient conditions. Patients were advised to use mouthwash of the same brand daily to maintain oral hygiene and protect the wound from bacterial infection. Additionally, patients were advised to avoid strenuous exercise and spicy foods to minimize irritation to the extraction area. All patients were scheduled for a follow-up visit one week after the surgery. At the follow-up, sutures were removed, and wound healing was assessed and recorded. Patients showing signs of postoperative complications, such as infection or nerve injury, received further treatment.

### 3.6 Data Recording

During postoperative follow-up, the surgeon meticulously recorded indicators such as postoperative pain, swelling, mouth-opening limitation, and complications to objectively and scientifically evaluate the effectiveness of different surgical methods.

## 4. Efficacy Evaluation

**4.1 Surgery Time:** A standard stopwatch was used to record the time for each surgery from the start of incision to the end of suturing, serving as the basis for evaluating surgery time. The specific recording steps were as follows:

**Start of Incision:** When the surgeon first used surgical instruments (such as a turbine drill, ultrasonic bone scalpel, or bone chisel) to make the initial cut on the tooth and alveolar bone, the stopwatch was started. **End of Suturing:** The stopwatch was stopped when the surgeon completed the extraction and used non-absorbable sutures to close the wound. Surgery time was accurately recorded in minutes.

**4.2 Postoperative Pain (VAS Score):** Postoperative pain is an important indicator of patient comfort after surgery (Li et al., 2023). The Visual Analog Scale (VAS) was used in this study to quantify pain levels at 1 day, 3 days, and 7 days postoperatively. The VAS is a subjective self-assessment method for measuring pain, with the following steps: A visual analog scale ranging from 0 to 10 was used, where 0 represents no pain and 10 represents unbearable pain. Patients freely selected their pain level on the scale. **Evaluation Time Points:** Pain was evaluated on the 1st day (1d), 3rd day (3d), and 7th day (7d) postoperatively to record changes in pain levels. Data at each time point were recorded by patients under the guidance of the doctor.

**4.3 Postoperative Swelling:** Postoperative swelling is a common reaction after tooth extraction and reflects the extent of soft tissue injury during surgery. To objectively assess the degree of swelling, this study used a calibrated steel ruler for quantitative measurements. The specific steps were as follows:

On the 7th day before and after surgery, the distance from the lingual midpoint of the crown of the mandibular first molar to the corresponding buccal skin was measured using a calibrated steel ruler. The difference between the preoperative and postoperative data reflected the soft tissue response after surgery, and swelling was evaluated at 7 days postoperatively.

**4.4 Postoperative Mouth-Opening Limitation:** Postoperative mouth-opening limitation is an important indicator for assessing the impact of tooth extraction on the function of the mandibular joint. Changes in mouth opening primarily reflect trauma to the mandibular muscles, nerves, and soft tissue during surgery. The specific measurement steps were as follows:

A calibrated steel ruler was used before surgery to measure the linear distance between the incisal edges of the upper and lower central incisors, serving as the baseline value for preoperative mouth opening. The patient was asked to open their mouth as wide as possible, and the maximum mouth-opening distance was measured. On the 7th day after surgery, the same measurement method was used again to evaluate the impact of surgery on mouth opening. A steel ruler was used to measure the linear distance between the incisal edges of the upper and lower central incisors at 7 days postoperatively to assess mouth-opening limitation.

**4.5 Incidence of Severe Complications:** To comprehensively assess the safety of the surgery, this study recorded severe complications that occurred postoperatively, including:

**Nerve Injury:** If symptoms such as lower lip numbness or sensory abnormalities occurred after surgery, nerve injury was recorded, and the severity of the injury and the recovery situation were assessed. **Infection:** The occurrence of local infection after tooth extraction was recorded, including the frequency of symptoms such as wound redness and pus. If an infection occurred, appropriate anti-infection treatment was administered. **Dry Socket:** Dry socket is a common postoperative complication that usually manifests as increased pain after surgery and failure to form a blood clot in the extraction socket, which was closely monitored and recorded during follow-up. **Mandibular Fracture:** Any mandibular fractures that occurred during or after surgery were recorded in detail, and the causes and treatment plans were analyzed. The occurrence of nerve injury, infection, dry socket, and mandibular fracture was recorded to assess the incidence of severe complications.

## 5. Data analysis

The experimental data were entered into Excel, and SPSS 26.0 statistical software was used to analyze the results. Data analysis included t-tests, variance analysis, and multiple comparisons among groups for surgery time, postoperative pain, swelling, and differences in mouth opening. The results were expressed as mean  $\pm$  standard deviation ( $\bar{x} \pm s$ ). The chi-square test was used to analyze the incidence of severe complications. A significance level of  $\alpha = 0.05$  was used, and  $P < 0.05$  indicated statistically significant differences.

## Research Scope

The study selected patients who visited the Stomatology Department of Guangxi International Zhuang Medicine Hospital between March 2022 and March 2024 for the extraction of mandibular impacted third molars.

### Content Scope:

**Independent Variables:** Patients requiring extraction of mandibular third molars, age, gender.

**Dependent Variables:** Data on various indicators, including surgery time for each group, postoperative pain, postoperative swelling, postoperative mouth-opening limitation, and severe complications.

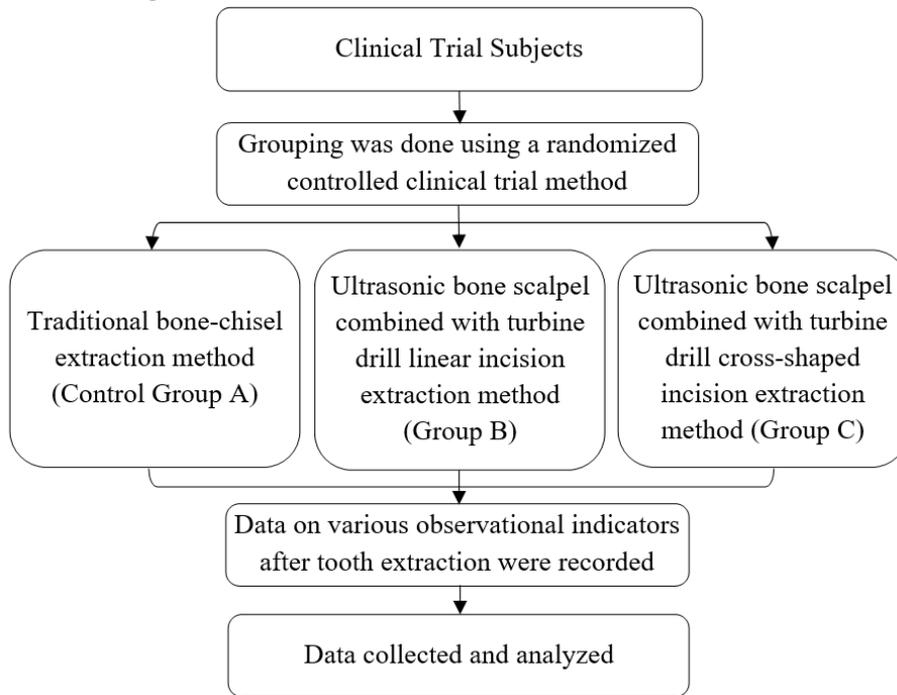
**Regional Scope:**

The study area is the Stomatology Department of Guangxi International Zhuang Medicine Hospital, Nanning, Guangxi Zhuang Autonomous Region, China.

**Time Scope:** From March 2022 to March 2024.

**Research Conceptual framework**

As shown in Figure 2.



**Figure 2** Research Conceptual Framework  
(Source: Constructed by researcher, 2024)

**Research Results**

**1. Surgery Time Comparison**

The extraction time for Group A was (25.3 ± 1.9) minutes, Group B was (15.7 ± 2.0) minutes, and Group C was (16.2 ± 2.1) minutes. Analysis of variance (ANOVA) and inter-group difference analysis showed F=290.01, P<0.001, indicating significant differences in surgery time among the three groups. Group A had the longest surgery time among all groups, with significant differences compared to Groups B and C (P<0.001). Although the average time for Group B was shorter than Group C, the difference was not statistically significant (P=0.538). Surgery time comparison among the three groups: Group A > Group B = Group C (Table 1).

**Table 1** Comparison of Surgery Time for Different Surgical Methods ( $\bar{x} \pm s$ , min)

Group	Surgery Time (minutes)
Group A	25.3 ± 1.9
Group B	15.7 ± 2.0
Group C	16.2 ± 2.1

## 2. Postoperative Pain Evaluation

Analysis of variance and multiple comparisons were performed.

Postoperative Day 1 Swelling Results:  $F=87.9$ ,  $P<0.05$ . The pain level in Group A was the highest on postoperative day 1, significantly higher than in Groups B and C ( $P<0.001$ ). There was a statistically significant difference in pain levels between Groups B and C ( $P=0.02$ ). There were significant differences in pain scores among different groups on day 1 postoperatively, with Group A having significantly higher pain levels than Groups B and C. Group B also had higher pain levels than Group C, but the difference was relatively small.

Postoperative Day 3 Swelling Results:  $F=97.3$ ,  $P<0.05$ . The pain level in Group A was the highest on postoperative day 3, significantly higher than in Groups B and C. There was a statistically significant difference in pain levels between Groups B and C ( $P<0.05$ ). There were significant differences in pain scores among the groups on day 3 postoperatively, with Group A having the highest pain level, followed by Group B, and finally Group C.

Postoperative Day 7 Swelling Results:  $F=97.34$ ,  $P<0.001$ . The pain level in Group A on postoperative day 7 was significantly higher than in Groups B and C. Group B also had higher pain levels than Group C ( $P=0.011$ ), but the difference was relatively small (Table 2).

**Table 2** Postoperative Pain Evaluation for Different Surgical Methods ( $\bar{x} \pm s$ )

Group	Postoperative Day 1	Postoperative Day 3	Postoperative Day 7
Group A	5.7 ± 1.1	4.1 ± 0.7	3.1 ± 0.6
Group B	3.6 ± 0.5	2.5 ± 0.5	2.0 ± 0.2
Group C	3.0 ± 1.0	1.6 ± 0.5	1.6 ± 0.5

## 3. Postoperative Swelling Comparison

Analysis of variance and multiple comparisons were performed, with  $F=290.9$ ,  $P<0.05$ . The degree of swelling in Group A on postoperative day 7 was significantly higher than in Groups B and C ( $P<0.001$ ). There was no significant difference in the degree of swelling between Groups B and C on postoperative day 7 ( $P=0.538 > 0.05$ ) (Table 3).

**Table 3** Postoperative Swelling Evaluation for Different Surgical Methods ( $\bar{x} \pm s$ , mm)

Group	Postoperative Swelling (mm)
Group A	25.3 ± 1.9
Group B	15.7 ± 2.0
Group C	16.2 ± 2.1

## 4. Comparison of Preoperative and Postoperative Mouth-Opening Limitation

Paired t-tests showed statistically significant differences in mouth opening before and after tooth extraction for Group A ( $t=9.70$ ,  $P<0.05$ ), Group B ( $t=9.90$ ,  $P<0.05$ ), and Group C ( $t=5.08$ ,  $P<0.05$ ). The preoperative mouth-opening degree in Groups A, B, and C was significantly higher than the postoperative mouth-opening degree at day 7.

In the analysis of variance for preoperative mouth opening among the groups, there was no significant difference between Groups A, B, and C ( $F=2.019$ ,  $P=0.137 > 0.05$ ). On day 7 postoperatively, the mouth-opening degree ( $F=26.05$ ,  $P<0.001$ ) showed significant differences between Groups A and C, and between Groups B and C ( $P<0.05$ ). However, there was no significant difference between Groups A and B ( $P>0.05$ ). Group A's mouth-opening degree was significantly lower than that of Group C, and Group B was also significantly lower than Group C. Group C had the highest average mouth-opening degree (Table 4).

**Table 4** Comparison of Preoperative and Postoperative Mouth-Opening Degree Changes for Different Surgical Methods ( $\bar{x} \pm s$ , mm)

Time	Group A	Group B	Group C
Preoperative	40.0 ± 3.5	38.3 ± 3.5	39.1 ± 4.1
Postoperative Day 7	30.1 ± 3.9	31.6 ± 3.6	36.2 ± 4.3

#### 5. Comparison of Complication Incidence

In Group A, there were 2 cases of nerve injury and 1 case of infection. In Group B, there was 1 case of infection, and in Group C, no complications occurred. For nerve injuries, neurotrophic drugs were administered, and for infections, irrigation and oral anti-infection treatment were provided, resulting in improvement. No cases of dry socket or mandibular fractures were recorded in any group. The comparison of complication incidence among the three groups showed no statistically significant differences ( $P>0.05$ ).

## Discussion

The extraction of mandibular impacted third molars is a routine procedure in oral and maxillofacial surgery. Traditional extraction techniques have a long history and have developed relatively complete surgical procedures and technical standards, but they also have obvious limitations. Traditional bone-chisel extraction often requires longer surgery time and causes significant trauma to the surrounding tissues, resulting in severe postoperative reactions such as pain, swelling, and functional limitations (Bouloux & Steed, 2007). As patients' demands for medical technology continue to increase, minimally invasive techniques have become a focal point in the medical field. Minimally invasive techniques aim to optimize surgical outcomes by reducing damage to surrounding tissues and accelerating patient recovery (O'Connor & Thangavel, 2018). During the extraction of mandibular impacted third molars, the combined use of an ultrasonic bone scalpel and a turbine drill has demonstrated the advantages of minimally invasive surgery. Previous studies have shown that the ultrasonic bone scalpel can efficiently and precisely cut tooth and bone tissue, effectively shortening surgery time, reducing postoperative pain and swelling, and mitigating mouth-opening limitations (Duran & Kwan, 2015; Wu & Zhang, 2021). However, there is relatively little research comparing different incision methods, especially regarding which method can achieve the greatest efficiency and minimal trauma during the procedure.

This study comprehensively compared the clinical outcomes of the traditional bone-chisel method and the ultrasonic bone scalpel combined with a turbine drill under different incision methods. The results showed that the surgery time for the traditional bone-chisel extraction method (Group A) was longer, mainly because this method requires flap reflection and the use of a chisel or mallet to cut bone. The process is relatively rough and time-

consuming. In the experimental groups (Groups B and C), the ultrasonic bone scalpel combined with the turbine drill was able to cut the tooth and bone tissue more quickly and precisely, significantly reducing surgery time. Particularly in the cross-shaped incision method (Group C), although the surgery time was slightly longer than in the linear incision method (Group B), the tooth segmentation was more thorough, the exposed area was larger, and the overall operation was smoother. The slightly longer time for Group C may be related to the larger amount of cutting needed, as adjacent teeth must be protected before the cross-shaped cut to prevent damage. Nonetheless, the time difference between the two groups was not statistically significant ( $P>0.05$ ).

Overall, the combination of an ultrasonic bone scalpel and a turbine drill made the surgical process more efficient, enabling safe and precise tooth extraction in a shorter time. The severity of postoperative pain is directly related to the extent of damage to oral soft tissues and nerves during the surgery. The traditional bone-chisel method typically causes significant damage to the surrounding soft tissues and nerves, leading to more pronounced postoperative pain. In the experimental groups, especially the cross-shaped incision method (Group C), the postoperative pain scores were significantly lower than those of the other groups ( $P<0.05$ ). This may be because this incision method allows for better separation of the tooth, reducing tension and damage to the surrounding soft tissues. Additionally, the precision of the cross-shaped incision reduces the need for flap reflection, resulting in less trauma and, therefore, reduced postoperative pain. In contrast, although the linear incision method also had good postoperative outcomes, its smaller incision area may make it difficult to completely avoid soft tissue damage in some complex cases, leading to higher postoperative pain compared to Group C.

Postoperative swelling is a common response after tooth extraction, usually closely related to the extent of surgical trauma. The study showed that the degree of postoperative swelling in the experimental groups was significantly lower than in the control group, especially in the cross-shaped incision group (Group C), which had the least swelling. This could be because the ultrasonic bone scalpel combined with the turbine drill allows for more precise cutting of bone tissue, reducing damage and edema in the surrounding soft tissues. The high-frequency vibrations of the ultrasonic bone scalpel help close small blood vessels, reducing intraoperative bleeding, thus alleviating postoperative inflammation. Furthermore, the larger range of separation of the tooth in the cross-shaped incision method helps minimize excessive soft tissue tension, further reducing tissue bruising and swelling.

Mouth-opening limitation is an important indicator of postoperative recovery. The experimental group patients showed significantly better mouth-opening recovery compared to the control group, especially in the cross-shaped incision group (Group C), where the degree of mouth-opening limitation was the lowest. This may be due to the more thorough separation of the tooth in the cross-shaped incision, reducing tearing and tension of the gingiva during extraction, leading to faster recovery of the soft tissue postoperatively. In contrast, Groups A and B showed more significant mouth-opening limitations postoperatively, particularly in the traditional bone-chisel extraction group, which required extensive gingival incision, disrupting gingival integrity and causing a significant decline in postoperative mouth opening.

This study demonstrated that the combination of an ultrasonic bone scalpel and turbine drill also had significant advantages in reducing the incidence of severe postoperative complications. The traditional bone-chisel method caused more trauma, and postoperative complications such as nerve injury and infection were more common. The precise cutting ability of the ultrasonic bone scalpel and the high-speed segmentation capability of the turbine

drill effectively reduced the risk of nerve injury and the possibility of intraoperative bleeding and postoperative infection. In this study, the cross-shaped incision method performed best in avoiding damage to adjacent teeth and reducing soft tissue damage, making it the preferred choice in the experimental groups.

Despite the comprehensive comparison of the ultrasonic bone scalpel combined with the turbine drill regarding surgery time, postoperative pain, swelling, and mouth-opening limitations, there are still some limitations to this study. Firstly, the sample size of the study was relatively small, and future studies could expand the sample size to verify the generalizability of the results. Secondly, the skills of different surgeons may have had an impact on the surgical outcomes, so future studies could consider comparing different operators. Additionally, the specific cutting parameters of the ultrasonic bone scalpel and turbine drill (e.g., vibration frequency, drill type) and their effects on surgical outcomes have not been thoroughly investigated, providing direction for future research.

## **Recommendations**

### **1. Theoretical Recommendations**

Future research should focus on refining the use of ultrasonic bone scalpel technology to further improve precision and reduce trauma in oral surgery. Additional studies could explore the biomechanics of different incision methods to optimize outcomes for impacted tooth extraction. A theoretical framework incorporating patient-specific factors, such as bone density and anatomical variations, should be developed to customize surgical approaches.

### **2. Policy Recommendations**

Hospitals and healthcare institutions should adopt updated clinical guidelines that prioritize minimally invasive techniques, such as the combined use of ultrasonic bone scalpel and turbine drill for mandibular third molar extraction. Training programs for oral and maxillofacial surgeons should include comprehensive instruction on the use of these advanced technologies to ensure better patient outcomes. Policymakers should consider subsidizing the acquisition of ultrasonic bone scalpel equipment to make these techniques accessible to more healthcare facilities.

### **3. Further Research Recommendations**

Further studies with larger sample sizes are needed to validate the findings of this research and establish more robust clinical guidelines. Comparative studies between different minimally invasive techniques should be conducted to determine the most effective methods for various types of impaction. Long-term follow-up studies are also recommended to assess the impact of these surgical techniques on patients' quality of life and to monitor for any delayed complications.

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