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Review article

Piezosurgery vs conventional rotary instrument in the third molar surgery: A systematic review and meta-analysis of randomized controlled trials

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Abstract *Background/purpose:* The surgical removal of mandibular third molars is frequently accompanied by significant postsurgical sequelae. Different instruments such as piezosurgery and conventional rotary handpiece have been used to decrease such adverse events. There are controversial results from randomized controlled trials evaluating the effects of Piezosurgery in the mandibular third molar extraction, compared with conventional rotary instrument. This study was performed to determine the impact of piezosurgery versus conventional rotary instrument on postoperative reactions after extraction.
Materials and methods: A systematic review and meta-analysis was performed to combine relevant RCTs results.
Results: Five RCTs were eligible for this study, enrolling a total of 402 patients. Compared with conventional rotary instrument, pain score at 6 or 7 days and mouth opening at 1 day after surgery was significantly lower in Piezosurgery group (SMD -0.33, 95% CI: −0.56 to −0.10, $P = 0.005$), as well as swelling score at 7 days after surgery (SMD -1.95, 95% CI: −3.22 to −0.67, $P = 0.003$). Furthermore, mouth opening at 1 day after surgery was significantly better in patients treated with Piezosurgery (SMD 0.84, 95% CI: 0.19 to 1.49, $P = 0.01$). However, more operation time will be required for Piezosurgery (MD 6.23, 95% CI: 3.32 to 9.14, $P < 0.0001$). With regard to analgesic dosage, pooled results from two RCTs suggested there were no significant differences between Piezosurgery and conventional rotary instrument (SMD -1.45, 95% CI: −4.39 to 1.49, $P = 0.33$).
Conclusion: There might be some advantages on third mandibular molar extraction with piezosurgery compared to conventional rotary instrument. More multi-centre trials are required to get more conclusive results.

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Introduction

It is believed that as human being evolved, a refined diet may lead to less migration of teeth, causing higher incidence of impacted third teeth.[1] Ninety percent of the general population have mandibular third molars, with 33% of them have at least one impacted molar.[2,3] Many reasons are suggested to removed the third molar such as caries, periodontal problems of adjacent molar, germination disorders, orthodontic problems.[2,4] So surgical procedures of impacted mandibular third molars are the most commonly operation undertaken of oral and maxillary surgeries.[5] There are many common complications such as pain, swelling, trismus even parethesia of lower lip or tongue caused by the trauma of the surgery.[6] Protocols evaluated to reduce postoperative complications have included different flap designs,[2,7] different medications,[8,9] and different instruments for osteotomy in extraction procedure of lower impacted mandibular third teeth.[10]

Conventional rotary instrument is widely used in extraction procedure, considered to be a moderate, high-efficiency, minimal invasive method for osteotomy compared to traditional instrument, such as bone hammer and osteotome. But it has disadvantages, the excessive high temperatures produced during osteotomy may lead to marginal osteonecrosis and impair regeneration and healing.[11] Newer instruments are needed to reduce the trauma and difficulty of third molar surgery.

Piezosurgery is a new method for osteotomy, which was first proposed in oral surgery in the late 1970s by Horton et al.[12,13] It is utilizing the microvibrations of scalpels at ultrasonic frequency to perform effusive and safe osteotomies, which promotes the healing of the cuts. This device is widely used in cases which the bone is close to the important structures where both thermal and mechanical injury must be avoid.[14,15] The reason is that this technical only works on mineralized structures.[16] Reports has been published that piezosurgical instruments is used in periodontal surgery, cranial osteoplasty, implantology, orthognathic surgery, to remove cysts and tumor, and extraction of tooth.[17–22]

Researchers have conducted a great many of randomized controlled trials to evaluate which technical carries the less postoperative reaction. The purpose of the study was to summarize the evidence of rotary instrument versus piezosurgery used for osteotomy in mandibular third molar extraction on operation procedure and postoperative reaction, such as operation time, pain, facial swelling, trismus, analgesic doses, and periodontal situation of adjacent molar.

Materials and methods

This study was reported according to the preferred reporting items for Systematic Reviews and Meta-analyses (PRISMA) statement.

Eligibility criteria

Types of studies: Randomised controlled trials. No publication date, and language restriction were imposed.

Types of participants: Patients with third molar extraction were eligible for inclusion in this study.

Types of intervention: Piezosurgery; conventional rotary instruments.

Types of outcome measures: The primary outcome was pain score after surgery. Secondary outcomes included operation time, swelling after, mouths open, and analgesic dosage after surgery.

Literature searching and assessment of risk of bias

A search of the medical literature was performed using Medline (1946 to December 2014), Embase (1974 to December 2014), Science Citation Index (1980 to September 2014), and the Cochrane central register of controlled trials (September 2014). The literature search is presented as the supplementary data. The records retrieved from each database were imported into EndNote 6 and merged into one database to remove duplicate records. To enhance objectivity and avoid mistakes in the process of study selection, eligibility assessment and data extraction was performed independently by 2 reviewers. Disagreements between reviewers were resolved by consensus. Risk of bias assessment was performed independently by two investigators, with disagreements resolved by discussion. Risk of bias was assessed as described in the Cochrane handbook.

Statistics

The meta-analyses were performed by computing standardized mean differences with 95% confidence intervals using random-effects model to incorporate the heterogeneity into analysis. Heterogeneity between studies was assessed using both the I^2 statistic with a cut off of $\geq$50%, and the X^2 test with a P value < 0.10 used to define a significant degree of heterogeneity. Data not suitable for pooled analysis were reported in a descriptive way. All analyses were performed using Review Manager Version 5.3.

Results

The searching flow chart was shown in Fig. 1. Eight studies were found to be potentially eligible. However, one study was excluded because it is not RCT. And another two RCTs were excluded due to no information of interest reported. Finally, a total of 5 RCTs were eligible for inclusion in this study. The characteristics of included studies were shown in Table 1. As we saw in Table 1, all trials were conducted in

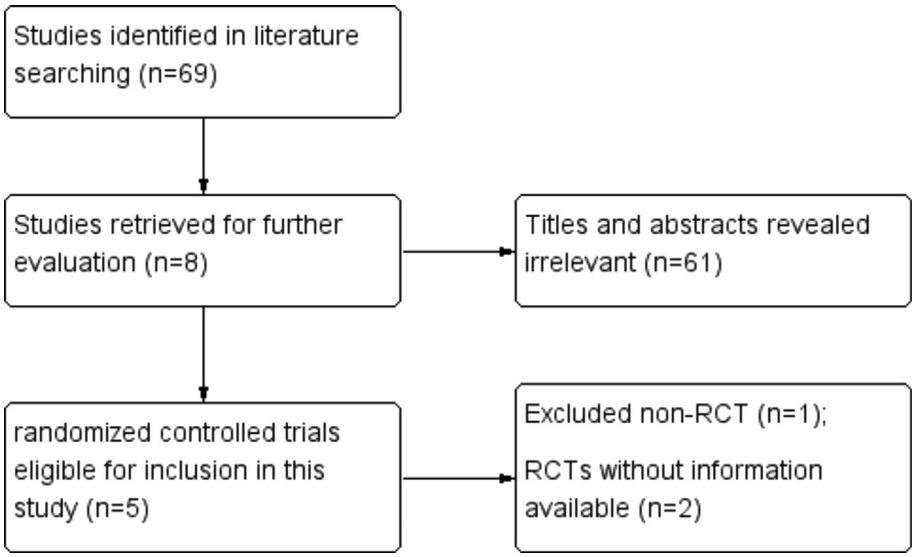

Figure 1 Flow diagram of article selection process.

Italy, and two trials enrolled less than 50 patients. All patients were healthy. However, there were some differences regarding the impacted type.

Assessment of risk of bias

The summary of risk of bias was shown in Fig. 2. Blinding design is very difficult or even impossible for operator in surgical procedure, so we decided not to assess the risk of bias in the domain of double blinding according to the recommendation of Cochrane handbook. Allocation concealment and sequence generation are the most unreported methodological issue. Three trials included in our study were ultimately classified as having a low risk of bias,[22–24] and the other two trials as having a high risk of bias for their unclear or pseudo randomized design.[16,25] All trials achieved full or nearly full follow-up.

Meta-analysis

Pain score

Pain score were reported in four RCTs. Pain score at 6 or 7 days after surgery was significantly lower in Piezosurgery group (SMD -0.33, 95% CI: −0.56 to −0.10, P = 0.005, Fig. 3A), compared with conventional rotary instrument. No heterogeneity were detected between studies (P = 0.47; I^2 = 0%). However, there were no significant differences between Piezosurgery and conventional rotary instrument as to pain score at 4 or 5 days after surgery (SMD -0.21, 95% CI: −0.63 to 0.20, P = 0.31, Fig. 3B) and pain score at1 or 2 days after surgery (SMD -0.21, 95% CI: −0.54 to 0.12, P = 0.22, Fig. 3C).

Mouth opening

Mouth opening data were available in three RCTs. Mouth opening at 1 day after surgery was significantly better in Piezosurgery group (SMD 0.84, 95% CI: 0.19 to 1.49, P = 0.01, Fig. 4A), compared with conventional rotary instrument. No heterogeneity were detected between studies (P = 0.29; I^2 = 0%). However, there were no significant differences between Piezosurgery and conventional rotary instrument regarding mouth opening at 5 days after surgery (SMD 0.44, 95% CI: −0.14 to 1.03, P = 0.14, Fig. 4B) and pain score at 6 or 7 days after surgery (SMD 0.25, 95% CI: −0.21 to 0.70, P = 0.29, Fig. 4C).

Swelling, operation time, and analgesic dosage

Swelling data were available in two RCTs. Pooled results suggested that swelling score at 7 days after surgery was significantly lower in Piezosurgery group (SMD -1.95, 95% CI: −3.22 to −0.67, P = 0.003, Fig. 5A), compared with conventional rotary instrument, and significant heterogeneity were detected between studies (P = 0.01; I^2 = 84%). Data of operation time were reported in three RCTs, with pooled results suggesting more operation time will be required for Piezosurgery, compared with conventional rotary instrument (SMD 6.23, 95% CI: 3.32 to 9.14, P < 0.0001, Fig. 5B). Data of analgesic dosage were reported in two RCTs, and pooled results suggested there were no significant differences between Piezosurgery and conventional rotary instrument (SMD -1.45, 95% CI: −4.39 to 1.49, P = 0.33, Fig. 5C).

Discussion

Third molar extraction is one of the most common therapies in oral surgery. Extraction of the lower impacted mandibular third molar need the osteotomy, which might produce a severe trauma to the adjacent hard and soft tissue, potentially resulting in some postoperative complications, such as pain, bleeding, trismus, swelling and so on. Piezosurgery and high speed rotary handpiece are both widely used for osteotomy in recent years, instead of bone chisel,

Table 1 Main characteristics of included studies.

Reference	Location	Study Design	Sample size	Age (year)	Male (%)	Surgical technical	Related outcomes	Impaction type
Barone 2010	Italy	Parallel	13/13	$30.3 \pm 5.8/32.2 \pm 6.7$	53.6/53.6	Traditional rotary instruments vs Ultrasound bone surgery	Pain Trismus Swelling Number of analgesics	Mixed
Mantovani 2014	Italy	Split mouth	100/100	24.02 ± 4.21	41/41	Traditional rotary instrument vs Piezosurgery	Surgery duration Pain Swelling	Mixed
Piersanti 2014	Italy	Split mouth	10/10	22.4 ± 2.3	40/40	Conventional handpiece vs Piezosurgery	PoSSe Pain Swelling	Symmetric
Rullo 2013	Italy	Split mouth	52/52	26.2 (18—54)	38.5	Conventional rotative instruments vs Piezoelectric device	Surgery duration Pain	bilaterallysymmetrical impacted lower thirdmolars
Sivolella 2011	Italy	Crossover	26/26	15.4 ± 1.29	38.5/38.5	piezoelectric surgical device vs burs fitted on astraighthandpiece	Operating time Suitability Bleeding Mouth opening Clinical appearance of soft tissue Postoperative complications	Germ

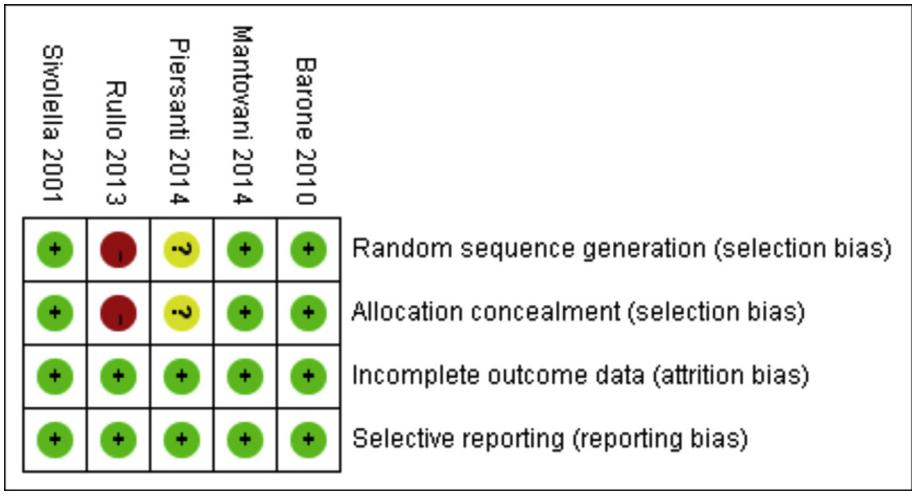

Figure 2 Risk of bias summary: reviewer's judgment on each risk of bias item for the included trials.

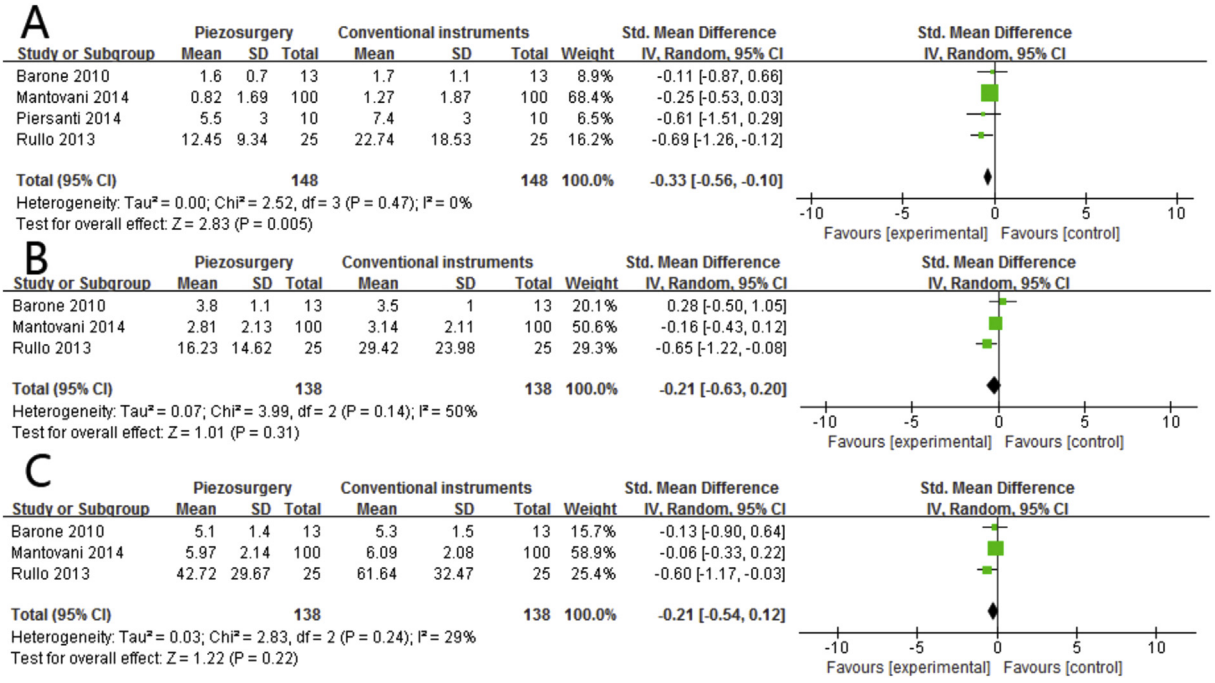

Figure 3 Piezosurgery versus conventional rotary instrument for the outcome pain at days A 6-7, B 4-5 and C 1-2.

in order to reduce surgery trauma. Some previous studies have reported that piezosurgery requires a longer operation duration compared with high speed handpiece use, might cause more discomfort.[15] Other researches revealed that piezosurgery works selectively to bone, protects soft tissues, such as blood vessels and nerves.[16] There is a controversial which instrument is better for osteotomy in third molar extraction.

Four of the included RCTs have evaluated the pain in one week after surgery, while Sivolella's trial had followed up for one month. The results suggested that pain score at 6 or 7 days after surgery was significantly lower in piezosurgery group compared with conventional rotary handpiece, but no significant differences between the two groups at day 1—2 or day 4—5 with no heterogeneity. However, two of the included trials were at high risk of bias for their inadequate randomized design. Thus, they warrented not very strong confidence in this pooled estimates, and more RCTs with high quality are required to make a more conclusive result. The evaluating scales of pain were somewhat different, so the pooled estimates only revealed a trend in favor of piezosurgery. One trial reported by Bartuli et al. suggested postoperative pain is almost equal either in those extractions performed by means of highspeed rotary handpiece or in those by means of piezosurgery at fifth and tenth days after surgery.[26] However, the data in this trial were not able to be combined with other trials. Another clinical study published by Goyal et al. suggested patients in the piezotome group had significantly less pain than those in the conventional group, which was consistent with our

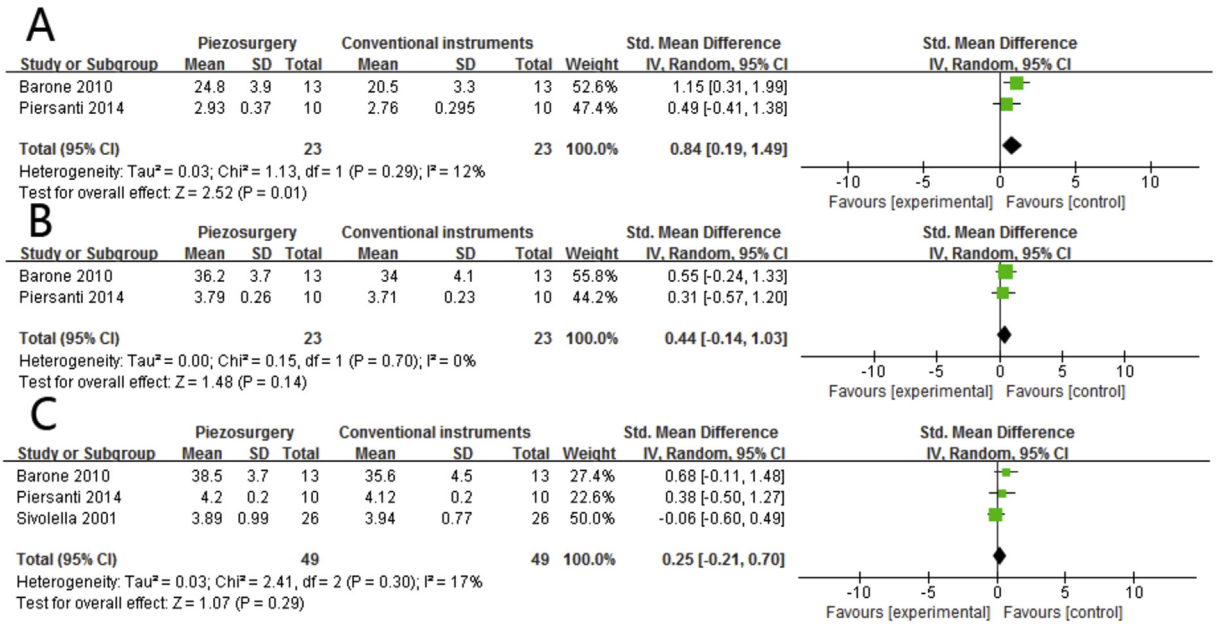

Figure 4 Piezosurgery versus conventional rotary instrument for the outcome trismus at days A 1, B 5 and C 7.

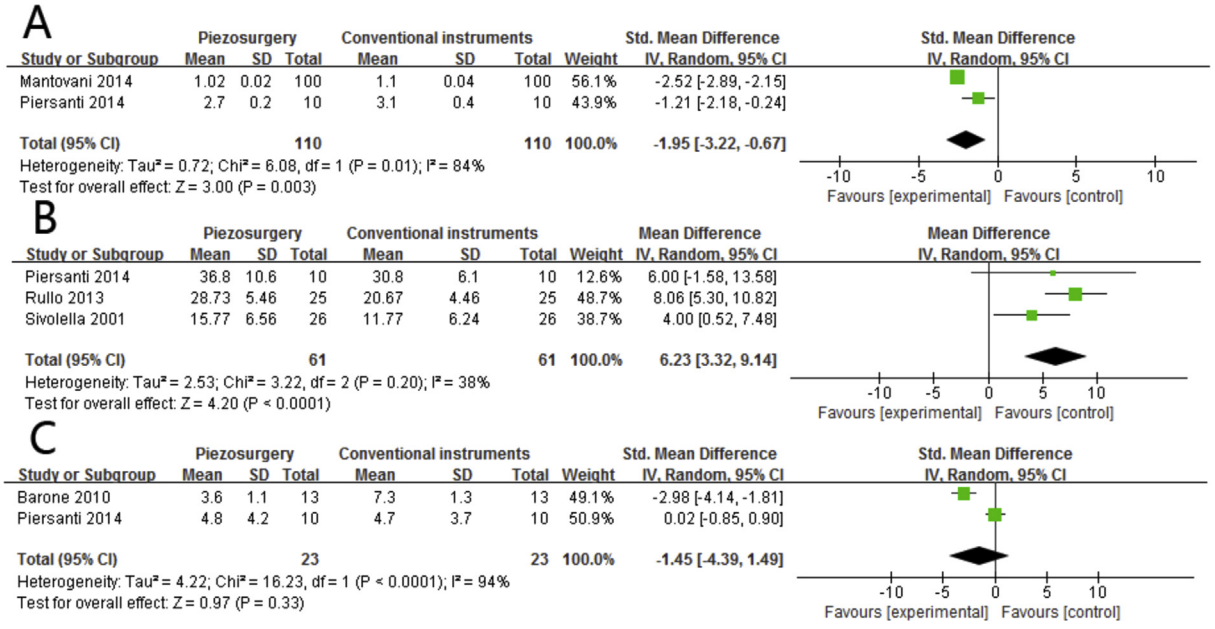

Figure 5 Piezosurgery versus conventional rotary instrument for the outcome A swelling, B operation time and C analgesic dosage.

results.[27] The main reason of operative pain in the early stage after surgery is the stress response and inflammatory reaction caused by trauma during surgery. However, osteitis, inflammation of soft tissue and lymphadenitis play important roles in postoperative pain at late stage after surgery.[28] Compared to conventional rotary instrument, the piezosurgery provided less injury of bone tissues, which insured a better blood supply resulting in lower incidence of postoperative inflammation. This hypothesis above could explain our results in some extent.

The included three RCTs had evaluated mouth opening in both conventional rotary instrument group and piezosurgery group during one week after surgery, suggesting mouth opening was significantly better in piezosurgery group at day 1 after surgery without heterogeneity and no significant differences between two group at 5 and 7 days after surgery.[22,24,25] Two of these trails with high quality were at low risk of bias,[22,25] however, Piersanti's study without a clear description of sequence randomization was at unclear risk of selection bias. Overall, we have moderate confidence on this pooled estimate. A non-RCT published by Goyal et al. reported that mouth opening was greater in the piezosurgery group at day 1,3,5,7 after procedure and similar in the 2 groups on day 15,[28] which is

accordance to our results. But moth opening after surgery is also related to other factors, such as flap design, position of impacted tooth, etc. Therefore, piezosugery is of valuable clinical application in reducing the risk of surgical trauma to the adjacent tissues. In fact, the ultrasonic dissection has been classified as a tissue-selective technique that might reduce the morbidity rate resulting from collateral iatrogenic injures, which may be one reason for better mouth opening after surgery.[22]

Facial swelling is an important index to evaluate the postoperative effects of surgery. Two trials included has reported facial swelling at one week after surgery, both suggesting patients in piezosurgery group suffered from less facial swelling compared to conventional rotary instrument group.[23,25] And the pooled results also supported that swelling score was significantly lower in piezosurgery group with significant heterogeneity. Barone et al. reported that postoperative swelling was more obvious in conventional rotary instrument group for the entire observation period,[22] and the mean difference in facial swelling between two groups showed a significantly higher value in the control group at day 5 after surgery. Unfortunately, the type of the data in this trial is unable to be combined with other studies. Another non-RCT reported by Goyal suggested swelling was worse in patients treated by conventional rotary instrument.[28] One study suggested that piezotome delivered a micrometric cut in the minimum surface area, contributing to the good results.[28] But other factors such as age, flap design and drainage might also affect the result of facial swelling, and more RCTs with high qualities were required to get more conclusive outcomes.

Three trials compared the operation time between the two grous.[16,24,25] The pooled results suggesting more operation time will be required for Piezosurgery, compared with conventional rotary instrument. And another RCT published by Bartuli also reported that surgery with conventional rotary instrument needed less time, but the data was unable to be combined with other three trials.[26] This result suggested that the protection of bone tissue by piezotome was at the cost of lower cutting efficiency. Therefore, we have strong confidence on the conclusion that piezosurgery requires more operation time.

Data of analgesic dosage were reported in two RCTs, and pooled results suggested there were no significant differences between piezosurgery and conventional rotary instrument. We have little confidence on this outcomes due to relatively small sample size, and more large RCTs are required.

There are some limitations in this study. All of the included RCTs were performed in Italy. More RCTs in other countries are required in order to get more conclusive results. Most outcomes suggested that piezosurgery was a better way in third molar extraction, but piezosurgery is much more expensive than conventional rotary handpiece. Meanwhile, there might be some limits of spreading in some developing area.

Only one trial reported by Tsai et al. evaluated the periodontal condition after removal of third molar,[14] suggested that there was no significant difference of average pocket depth after extraction between piezosurgery group and rotary handpiece group, as well as the attachment level at the distal side of the mandibular second molar was better where extraction was done with piezoelectric instruments. It is important to preserve the periodontal tissue of adjacent molar when removing the mandibular third molar, therefore, it is essential to selected a proper instrument such as piezotome. More much larger trials are required to get a consensus on piezosurgery among various instruments.

Sivolella et al. had reported that the amount of bleeding was lesser in pizosurgery group, but no statistically differences exited. Larger data are needed to get more conclusive results.

Patients suffered from minor postoperative complication by using piezosurgery, including pain, trismus, swelling. The most likely reason might be that the piezosurgery is a selective osteotomy tool. When used appropriately, piezosurgery causes less damage to adjacent soft tissue, including blood vessel and nerve which might cause less bleeding during and after operation. And there is less hematoma formed around extraction sockets, which might reducing facial swelling and trismus. Less bleeding ensures clear vision during operation, which might contribute to protect the inferior alveolar nerve. Not like conventional rotary instrument, the piezosurgery do not produce heat during surgery, causing less damage at the structural and cellular levels. Consequently, new bone formation is more rapid than with handpiece. In summary, there might be some advantages on third mandibular molar extraction with piezosurgery compared to conventional rotary instrument. However, due to the limitation of this study, such as risk of bias, the heterogeneity among trials and relatively small number of included studies, produced not very high confidence in the estimates. More multi-centre trials are required to get more conclusive results. The results of this review provide an inclination to use piezosurgery on third molar extraction when economically permit.

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