Journal of Dentistry & Oral Disorders

Open Access

Austin Publishing Group

Research Article

Efficacy of Piezosurgery versus Conventional Techniques in the Surgical Extraction of Third Molars: A Systematic Review

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Received: March 31, 2016; **Accepted:** April 29, 2016; **Published:** May 02, 2016

Abstract

A limited number of studies have compared piezosurgery with conventional methods in extraction of impacted third molars. To date, no systematic review of the literature analyzing the efficacy of chisels, rotary instruments, and piezosurgery in the extraction of impacted third molars has been reported. The aim of the present study was to systematically review the efficacy of chisels, rotary instruments, and piezosurgery in the extraction of impacted third molars. To address the focused question, "Is there a difference in efficacy between piezosurgery and conventional techniques in extraction of impacted third molars?", we searched indexed databases through February 2016 using various key words "piezosurgery"; "piezoelectric"; "impaction"; "third molars" and "extraction". Letters to the editor, commentaries, historic reviews, and experimental studies were excluded. The pattern of the present systematic review was customized to primarily summarize the pertinent data. Thirteen studies were included with 1251 subjects. A discrepancy in the reported results and conclusions was observed in the included studies. From the literature reviewed, there seems to be no difference between using chisels, rotary instruments, or piezosurgery in efficiently extracting impacted third molars; however, further well-designed controlled clinical trials are needed in this regard. We conclude that selection of technique depends on operator preference.

Keywords: Piezosurgery; Third molar; Rotary instrument; Chisel; Extraction

Introduction

Surgical extraction of impacted third molars is commonly performed in dental practice [1]. A variety of complications might be encountered during or after surgical extraction of impacted third molars such as pain, swelling and trismus, dry socket, dysthesia due to trauma to either the Inferior Alveolar Nerve (IAN) or lingual nerve, infection, or even jaw fracture [2,3]. Many factors can contribute to the incidence or severity of post-operative complications such as flap design [4-6], osteotomy techniques [7,8] and operator experience [9]. It has been shown that the severity of postoperative pain and swelling is related to surgical difficulty or the degree of intraoperative tissue damage [10]. According to Strietzel et al. [11] age, duration of operation, primary or secondary wound closure, impaction type, and pathology associated with the third molar are predictors for the postoperative course.

Osteotomy is inevitable for the extraction of third molars that are partially and/or fully impacted in bone. Although surgical hand pieces with a carbide bur are commonly used to perform osteotomies during the removal of impacted third molars, a recent morphological analysis of bone samples has shown that a bur produces irregular surfaces and marginal osteonecrosis due to the high temperature generated during osteotomy [12]. A review by Sarikov et al. [2] mentioned that IAN trauma is a complication of surgery which uses conventional techniques with chisels and hand pieces. Nearly three decades ago Horton et al. [13] introduced the clinical use of ultrasonic inserts in the surgical removal of alveolar bone, where they histologically studied the effect of the ultrasonic cutting inserts on alveolar bone and concluded that ultrasonic inserts remove bone with ease and preciseness, resulting in minimal hemorrhage from surgical sites and improved healing with less postoperative complications. Furthermore, patients reported minimal discomfort during and following the surgical application of this instrumentation. Vercelloti et al. [14] reported that the piezoelectric device (piezosurgery) is effective for performing osteotomy for maxillary sinus graft. Since then piezosurgery has been widely used as an alternative to rotary instruments or chisels for osteotomy. Piezoelectric device has also been used in a variety of procedures: root canal treatments, smoothening and shaping bony edges, oral and cranio-maxillofacial surgeries. A technologic advantage of piezosurgery that it has a built-in alarm that will sound to warn the surgeon of excessive pressure or heat [15]. Moreover, Schaeren et al. [16]. reported that the chances of mutilation of the IAN are minimal even in the case of direct exposure of the nerve to the piezosurgery tip. Piezosurgery provides better visibility at the surgical site because it increases irrigation and distribution of the cooling system, which allows for blood to be washed away via a cavitation effect [17]. From the literature reviewed [9,18-29], we speculate that extraction of impacted third molars using piezosurgery is an efficient technique that reduces the incidence of postoperative complications, as compared to the use of rotary instruments.

To date, no systematic review of the literature analyzing the efficacy of chisels, rotary instruments, and piezosurgery in the

Citation: Farag AS, Kellesarian SV, Javed F, Arany S and Malmstrom H. Efficacy of Piezosurgery *versus* Conventional Techniques in the Surgical Extraction of Third Molars: A Systematic Review. J Dent & Oral Disord. 2016; 2(3): 1015.

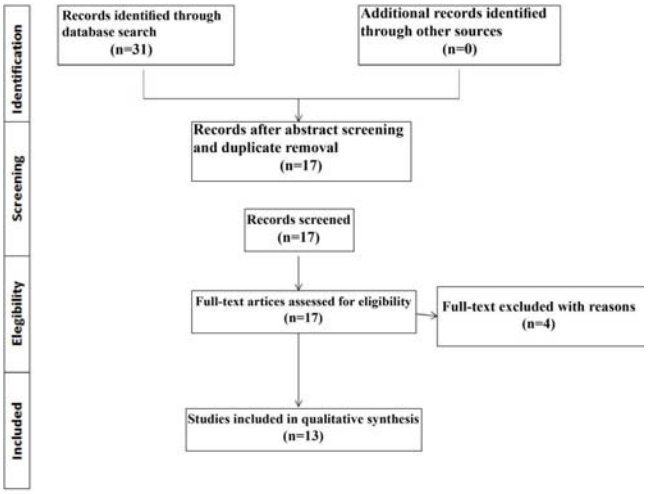

Figure 1: Article selection flow chart for the systematic review according to PRISMA guidelines.

extraction of impacted third molars has been yet reported. The aim of the present study was to systematically review the efficacy of chisels, rotary instruments, and piezosurgery in the extraction of impacted third molars.

Material and Methods

Focused question

Based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a specific question was constructed according to the Participants, Interventions, Control, Outcomes (PICO) principle (Figure 1). The focused question, "Is there a difference between the efficacy of Piezosurgery and conventional techniques in the extraction of impacted third molars?" was addressed in this systematic review.

(P) Participants: It was essential for subjects to have undergone impacted third molars surgical extraction

(I) Types of interventions: The intervention of interest was surgical extraction of impacted third molars using a piezoelectric device.

(C) Control Intervention: Surgical extraction of impacted third molars was done using conventional techniques (rotary instruments or chisels).

(O) Outcome Measures: Procedure duration and postoperative complications (such as pain, swelling, trismus, infection, numbness… etc.) were recorded.

Eligibility criteria

The eligibility criteria were as follows: (a) Original studies (clinical studies); (b) inclusion of a control group (patients who had undergone impacted third molar surgical extractions by means of rotary instruments or chisels); and (c) intervention: patients who had undergone impacted third molar surgical extractions by piezosurgery. Letters to the editor, historic reviews, commentaries, case-series, and case-reports were excluded.

Literature search protocol

PubMed/Medline (National Library of Medicine, Washington, DC), EMBASE, Scopus, Web of Knowledge, and Google-Scholar databases were searched through February 2016 using different combinations of the following key words: "piezosurgery"; "piezoelectric"; "ultrasonic"; "ultrasound"; "third molars" and "extraction". Titles and abstracts of studies identified using the above-described protocol were screened by two authors (ASF and SVK) and checked for agreement. Full-texts of studies judged by title and abstract to be relevant were read and independently evaluated for the stated eligibility criteria. Reference lists of potentially relevant original and review articles were hand-searched to identify any studies that could have remained unidentified in the previous step. Once again, the articles were checked for disagreement via discussion among the authors (Figure 1). The pattern of the present systematic review was customized to mainly summarize the relevant data.

The initial search yielded 31 studies. Eighteen studies, which did not fulfill the eligibility criteria, were excluded (see Appendix A). In total, 13 clinical studies [9,18-29] were included and processed for data extraction.

Quality assessment

Quality assessment was performed in an attempt to increase the strength of the present systematic review. The 13 studies [9,18-29] that were included underwent a quality assessment with the Critical Appraisal Skills Program (CASP) Cohort Study Checklist [30]. The CASP tool uses a systematic approach based on 12 specific criteria, which are: 1) Study issue is clearly focused; 2) Cohort is recruited in an acceptable way; 3) Exposure (surgical procedure) is accurately measured; 4) Outcome (duration of the procedure and postoperative complications) is accurately measured; 5) Confounding factors are addressed; 6) Follow-up is long and complete; 7) Results are clear; 8) Results are precise; 9) Results are credible; 10) Results can be applied to the local population; 11) Results fit with available evidence; and 12) There are important clinical implications. Each criterion was given a response of either "Yes", "No", or "Cannot tell". Each study could have a maximum score of 12. CASP scores were used to grade the methodological quality of each study assessed in the present systematic review.

Results

General characteristics of the studies included

One case control study [25] and 12 clinical trials [9,18-24,26-29], of which three studies [18,19,22] were randomized clinical trials, 3 studies [9,26,27] were split mouth randomized clinical trials, and two studies [20,28] were crossover randomized clinical trials, included a total of 1251 study subjects. In all studies [9,18-29], both genders were included with an age range from 14 to 54 years. In all studies [9,18-29] the number of subjects ranged from 10 to 300 patients (Table 1).

Characteristics of the surgical procedure

In all studies [9,18-29] impacted third molar extractions were done under local anesthesia with the use of a full thickness mucoperiosteal flap. In 12 studies [9,18-23,25-29] the duration of procedure was reported, which ranged from: 15.77±6.56 to 45±16 minutes for the piezosuregery group; 11.77±6.24 to 35±11 minutes for the rotary group; and 7.22±0.15 to 30±8.7 minutes for the chisel group.

Table 1: Characteristics of the study.

Author	Study Design	Age range (Mean) years	Study subjects N= Number	Gender M/F	Study groups
Barone et al. [18]	Randomized Clinical Trial	24-45 (31.2)	N= 26	14/12	Piezo = 13 Rotary = 13
Bartuli et al. [19]	Randomized Clinical Trial	25-35 (31.4)	N= 194	102/90	Piezo = 96 Rotary = 96
Chang et al. [20]	Randomized Crossover Clinical Trial	17- 29	N=20	18-Feb	Piezo =10 Rotary =10
Gao,Y et al. [21]	Clinical Trial	18-40 (29) years	N=228	130/98	Piezo = 114 Chisels =114
Goyal et al. [22]	Randomized Clinical Trial	22-36 (29)	N= 40	24/16	Piezo = 20 Rotary = 20
Guo Z et al. [23]	Clinical Trial	20-30	N=300	189/111	Chisels = 100 Rotary =100 Piezo =100
Itro et al. [24]	Clinical Trial	NA	N= 140	NA	Piezo = 70 (35 Max- 35 Mand) Rotary =70 (35 Max- 35 Mand)
Mantovani et al. [9]	Split-mouth Randomized Clinical Trial	NA (24±4.21)	N=100	41/59	Piezo = 100 Rotary =100
Mozzati et al. [25]	Case Control	18-34 (22.5)	N=15	8-Jul	Piezo = 15 Rotary = 15
Piersanti et al. [26]	Split-mouth Randomized Clinical Trial	NA (22.4±2.3)	N=10	6-Apr	Piezo = 10 Rotary = 10
Rullo et al. [27]	Prospective split-mouth Randomized Clinical Trial	18-54 (26.2)	N= 52	20/32	Piezo = 52 Rotary = 52
Sivolella et al. [28]	Prospective Crossover Randomized Clinical Trial	14-18 (15.4±1.29)	N=26	16-Oct	Piezo = 26 Rotary =26
Sortino et al. [29]	Clinical Trial	(P)14-39 (23.26±6.62) (R)14-45 (24.36±6.23)	N= 100	46/54	Piezo = 50 Rotary = 50

*Max: Maxillary; Mand: Mandibular

Eight studies [9,18,19,22,25-28] reported use of pre-operative medications; six studies [9,18,19,22,26,27] used pre-operative antibiotics either 1 hour before the procedure or the day before the procedure and doses varied from 500mg amoxicillin to 2g of amoxicillin and clavulanic acid. In two studies [25,28] patients were instructed to use antiseptic mouth rinse (0.2% Chlorhexidine) 1 minute before the surgery.

Post-operative antibiotics were reported in 10 studies [9,18,19,21,25-29], in which five studies [9,18,19,22,26] amoxicillin and clavulanic acid were prescribed, and in two studies [27,28] amoxicillin was prescribed alone. Sortino et al. [29] prescribed intramuscular injections of 2g piperacillin, Yongbo et al. [21] prescribed a combination of acetylspiramycin and Metronidazole and Mozzati et al. [25] used an unspecified antibiotic.

Ten studies [9,18,19,22,25-29] reported the use of post-operative pain analgesics. Naproxen sodium was prescribed in two studies [9,18], Ibuprofen was prescribed in two studies [26,27], Paracetamol was prescribed in one study [19], Nimesulide was prescribed in one study [28], Diclofenac was injected intramuscularly in one study [29], and the type of analgesic was not reported in two studies [22,25].

In six studies [9,18,19,25,27,28] oral rinses were used post operatively, in which five studies [9,18,25,27,28] used Chlorohexidine 0.12% or 0.2% , and one study19 used a 50%-50% Peroxide mouthwash.

In all studies [9,18-29] the patients were followed from day 0 to post-operative day 90 (Table 2).

Post-operative outcomes and complications

Post-operative pain scores in the first days after surgery ranged from 3.55±1.43 to 5.97±2.14 in the piezosurgery group and 4.1±2.5 to 7.4±3.0 in the rotary group. Guo Z et al. [23] reported that mild pain was reported more frequently in the piezosurgery group compared to the chisel group, but moderate and severe pain were greater in the chisel group compared to the piezosurgery group.

In nine studies [9,18,20-22,25,26,28,29] there was no significant difference between piezosurgery and conventional techniques; in the study by Itro et al. [24] manifestation of post-operative swelling was greater in the conventional technique groups compared to the piezosurgry group.

On post-operative day 1, nine studies [18,20-22,24-26,28,29] reported trismus, which ranged from 11.15 to 38.2mm in the piezosurgery group and 14.76 to25.4mm in the rotary group. Yongbo et al. [21] reported that trismus was 17.86±10.11mm in the chisel group.

Post-operative infection or dry socket was only reported in five studies [9,19,23,25,28] ;post-operative infection or dry socket was greatest in the chisel group, followed by the rotary group, and was least in the piezosurgery group (Table 3).

Quality assessment of included studies

Quality assessment identified that all the studies were conducted on humans and the total quality score ranged from 8 to 11. On average, the quality of included studies on efficacy of piezosurgery compared to conventional techniques was good. The most common shortcomings among all studies were the short term, incomplete follow up of the groups and omission of confounding variables like smoking, which could limit the application of the study outcomes. Quality assessment of the individual studies is summarized in Table 4.

Table 2: Characteristics of the surgical procedure.

Author	Anesthesia	Duration of Procedure (min)	Follow up time (days)	Medication preoperative	Medication post-operative
Barone et al. [18]	NA	(P) 34.3±7.4 (R) 30.5±4.4	1,3,5,7	2g of (Amoxicillin+Clavulanic Acid)1 hour before the surgical procedure	1gm (Amoxicillin+Clavulanic acid) 2/day for 5 days 550 mg of naproxen sodium, when needed; and chlorhexidine mouthwash for 14 days.
Bartuli et al. [19]	3%Mepivacaine Without Epinephrine	(P) 54.50 (R) 32.73	5,10,20,90	-1gm (Amoxicillin+Clavulanic Acid)	-1gm (Amoxicillin+Clavulanic acid) 2/day for 5 days -Paracetamol 1000mg -50%-50% H2O2+H2O
Chang et al. [20]	NA	NA	1,2,3,4,5,6,7	NA	NA
Gao,Y et al. [21]	Primacaine	(P) 16±5.2 (C) 30±8.7	2-Jan	NA	Acetylspiramycin, metronidazole
Goyal et al. [22]	2%Lignocaine	(P) 45±16 (R) 35±11	0,1,3,5,7,15	-625 mg (Amoxicillin+Clavulanic Acid)	-625 mg (Amoxicillin+Clavulanic Acid) 3/day -Analgesic
Guo Z et al. [23]	Primacaine	(C) 7.22±0.15 (P) 25.23±0.32 (R)14.12±0.12	1	NA	NA
Itro et al. [24]	NA	(P) 20 (R) 15	1,2,3,7	NA	NA
Mantovani et al. [9]	Mepivacaine with epinephrine	(P)*21.50±8.64 *19.33±6.45 *20.16±7.11 (R)*18.75±5.87 *16.52±5.22 *18.74±5.96	2,7,14,28	-2gm (Amoxicillin+Clavulanic Acid) 1 h before operation	-2gm (Amoxicillin+Clavulanic Acid)/day -Naproxen 550mg -0.12% Chlorhexidine
Mozzati et al. [25]	4%Articaine with epinephrine	(P) 33±5 (R) 25±5	7,14,30,90	-No antimicrobial - Rinse with Chlorhexidine 1 min before operation	Antibiotic Anti-inflamatory Chlorhexidine 0.12%
Piersanti et al. [26]	Mepivacaine with Epinephrine	(P) 36.8±10.6 (R) 30.8±6.1	1,2,3,4,5,6,7	-2gm (Amoxicillin+Clavulanic Acid) 1 h before operation	-2gm (Amoxicillin+Clavulanic Acid)/day -Ibuprofen 600mg
Rullo et al. [27]	4%Articaine with Epinephrine	(P) *16.47±3.38 *20.67±4.46 (R) *18.34±4.42 *28.73±5.46	0,1,2,3,4,5,6	500mg Amoxicillin 3/day 1 day before surgery	500 mg Amoxicillin for 6 days starting the day of surgery -Ibuprofen 600mg 3/day for 4 days - Chlorhexidine 0.12% for 7 days from day after surgery
Sivolella et al. [28]	Mepivacaine	(P) 15.77±6.56 (R) 11.77±6.24	30-Jul	-Rinse with 0.2% Chlorhexidine 1min before operation	-Amoxicillin 50mg/kg 2/day for 6 days - Nimesulide 50mg 3/day as necessary -0.2% Chlorhexidine 3/day for 6 days
Sortino et al. [29]	NA	(P) 22.92 (R) 17	1	NA	Injection of 2 g piperacillin and 75 mg diclofenac, twice daily by IM administration, for 4 days.

*(P) Piezosurgery; (R) Rotary instruments; (C) Chisels

Discussion

To our knowledge, this is the first study to systematically review the efficacy of piezosurgery compared to available conventional techniques in extraction of impacted third molars. Our review generally indicates that all techniques are effective for extraction of impacted third molars. Thus, by no means is this systematic review intended to convince the reader to select a particular technique over others.

Our review analyzed results from 13 included studies [9,18-29]. We showed how time efficient the rotary instrument technique is compared topiezourgery and chisels, as these techniques usually have longer procedure duration. This is critical since procedure duration plays a role in predicting post-operative complications.

Nearly 70% of the studies did not show any significant difference in post-operative swelling regardless of the technique used, peizosurgery trended to have the best results. Swelling can usually be reduced by post-operative measures, such as application of cold packs for a period of time after the procedure or by the use of a short-term, small dose of steroid [31,32].

Our analysis found that trismus was usually higher in the piezosurgery group and that trismus could be influenced by longer procedure duration. Mantovani et al. [9] was the only study to compare procedure duration. Procedure duration was decreased with the operator's experience was between 3 and 5 years.

We observed a discrepancy in several parameters, such as medications and means of their administration. In approximately 62% of the studies the operators favored using pre-operative antibiotics, which agree with the results from a meta-analysis studying the effectiveness of prophylactic antibiotic in third molar surgery [33]. In 77% of the studies, post-operative antibiotics were used and the combination of Amoxicillin and clavulanic acid was the most reported. Interestingly, in 12 studies [9,18-27,34] medications were administered orally, while in only one study by Sortino et al. [29] intramuscular injections of antibiotics were preferred, possibly to maximize the effect of the medication [35]. Subjective measure for the assessment of post-operative pain was approached by several methods (internally valid for each study), therefore comparison between all studies was not possible.

It is well known that the severity of impaction and anatomical

Table 3: Post-operative outcomes and complications.

Author	Pain	Duration of pain (days)	Severity of Pain	Swelling	Duration /severity of swelling	Trismus	Numbness of lips and tongue	Infection/ Dry socket
Barone et al. [18]	Y	7	(P) 5.1±1.4 @ 1st day (R) 5.3±1.5 @ 1st day	Y	R>P @ 5th day	(P) 7th day 38.5±3.7 (R) 7th day 35.6±	NA	NA
Bartuli et al. [19]	Y	10	(P) 5.97@ 5 days (R) 6.89@ 5 days	NA	NA	NA	NA	-Exudates 3cases after 10 days -Infection 1 case after 30 days
Chang et al. [20]		(P) 2.2±1.2 (R) 2.2±1.2	(P) 4.1±2.3 (R) 4.1±2.5	Y	(P) 3.6±1.9 days (R) 3.7±1.9 days	P>R 2nd day	NA	NA
Gao,Y et al. [21]	Y	2	Mild pain P>C Moderate and severe pan C>P	Y	(P) 42.20±10.12% (C) 66.36±11.65%	(P) 12.72±8.23 mm (C) 7.86±10.11 mm	NA	NA
Goyal et al. [22]	Y	15	(P) 1st day 3.55(1.43) (R) 1st day 6.45(1.19)	Y	(P) 3rd day 11.44(0.49) cm (R)3rd day 12.36(0.96) cm	(P) 7th day 4.48(0.81) (R) 15th day 4.34(0.75)	(P) 0 (R) 1	NA
Guo Z et al. [23]	Y	(C) 62.15±1.51 hours (R) 48.23±1.23 hours (P) 14.34±0.80 hours	NA	NA	NA	NA	(C) 6 (R) 2 (P)0	(C) 9 (R) 2 (P) 1
Itro et al. [24]	NA	NA	NA	Y	(P) 1st day 2.86mm (R) 1st day 6.23mm	(P) 1st day 11.15mm (R) 1st day 14.76mm	NA	NA
Mantovani et al. [9]	Y	7	(P) 2nd day 5.97±2.14 (R) 2nd day 6.09±2.08	Y	7th day (P) 1.02 (R) 1.10	NA	(P) 0 (R) 1 temporary numbness resolved after 4 weeks	(P) 0 (R) 2 Dry socket
Mozzati et al. [25]	Y	7	R>P from day 1 to day 7	Y	R>P	7th day (P) 0 (R) 1	NA	(P) 0 (R) 1 Dry socket
Piersanti et al. [26]	Y	7	(P) 5.5±3.0 (R) 7.4±3.0	Y	7th day (P) 2.75±0.23cm (R) 3.1±0.39cm	2nd day highest values R>P	NA	NA
Rullo et al. [27]	Y	6	R>P day 0 simple extractions P>R day 0 to day 6 for complex extractions	NA	NA	NA	NA	NA
Sivolella et al. [28]	Y	30-Jul	7th day (P) 14 patients (R) 24 patients 30th day (P) 5 patients (R) 4 patients	Y	7th day (P) 7 patients (R) 8 patients 30th day (P) 1 patient (R) 1 patient	7th day (P) 3.89(0.99) (R) 3.94(0.77) 30th day (P) 4.71(0.68) (R) 4.52(0.48)	NA	7th day (P) 0 (R) 1 30th day (P) 0 (R) 2
Sortino et al. [29]	Y	NA	NA	Y	(P) 4.22±3.21 cm (R) 7.04±3.45 cm	(P) 12.52±7.99 mm (R) 16.76±9.11 mm	NA	NA

*(P) Piezosurgery; (R) Rotary instruments; (C) Chisels

position and morphology for impacted third molars greatly influence the procedure duration, surgical approach and post-operative complications [36,37]. These parameters were not recorded in most of the studies, thus posing a limitation to interpretation of the analysis.

A recent meta-analysis by Jiang et al. [38] comparing piezosurgery to rotary instruments showed statistically significant differences in operating time, post-operative pain, swelling and trismus in favor of piezosurgery. However, they only included studies that had relevant data for their analysis. In this review, we included all available techniques in the field as long as chisels were known to be used in oral surgery and third molar extractions.

Although minimally reported, numbness of the tongue or lips was reported in nine cases [9,22,23], none of which was in the piezosurgery group but were mostly reported in the chisel group. This might imply the use of piezoelectric devices when the osteotomy may endanger major anatomical structure as the IAN or lingual nerve. It

Table 4: CASP quality assessment of the reviewed papers.

Authors	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Total quality score (0 to 12)
Barone et al. [18]	Yes	Yes	Yes	Yes	Cannot tell	Yes	Yes	Yes	Yes	No	Yes	Yes	10
Bartuli et al. [19]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Cannot tell	Yes	Yes	Yes	10
Chang et al. [20]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	11
Gao,Y et al. [21]	Yes	Yes	Yes	Yes	Cannot tell	No	Yes	Cannot tell	Cannot tell	Yes	Yes	Yes	8
Goyal et al. [22]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Cannot tell	Yes	Yes	10
Guo Z et al. [23]	Yes	Yes	Yes	Cannot tell	No	No	Yes	Yes	Yes	Yes	Yes	Yes	10
Itro et al. [24]	Yes	Yes	No	Yes	Cannot tell	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Mantovani et al. [9]	Yes	Yes	Yes	Yes	Cannot tell	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11
Mozzati et al. [25]	Yes	Yes	Yes	Yes	Cannot tell	Yes	Yes	Cannot tell	Cannot tell	No	Yes	Yes	8
Piersanti et al. [26]	Yes	Yes	Yes	Yes	Cannot tell	Yes	Yes	Yes	Yes	No	Yes	Yes	10
Rullo et al. [27]	Yes	Yes	Yes	Yes	Cannot tell	Yes	Yes	Cannot tell	Cannot tell	Yes	Yes	Yes	9
Sivolella et al. [28]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Cannot tell	Yes	Yes	11
Sortino et al. [29]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	11

is also pertinent to mention that the use of chisels was related to the majority of post-operative infection cases [23].

In all the included studies patients were relatively young and healthy, with an average age 27.8 years. Patients with diabetes, smoking, and who were immunosuppressed were excluded. It would be of interest to see how the results would change if medically compromised subjects were included.

A relatively new effective technique for atraumatic extractions by a sonic hand piece "sonosurgery" [39] using specially designed inserts for teeth extraction has been reported in the literature. Future randomized clinical trials with strict inclusion and exclusion criteria and standardized operation methods are needed to compare all available techniques for surgical extractions of impacted third molars.

Conclusion

From our current systematic review we conclude that there are several variables that influence the efficacy of piezosurgery, rotary instruments and chisels during the extraction of impacted third molars. In this regard, all techniques are effective in extraction of impacted third molars and selection of technique depends on operator preference.

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J Dent & Oral Disord - Volume 2 Issue 3 - 2016
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Citation: Farag AS, Kellesarian SV, Javed F, Arany S and Malmstrom H. Efficacy of Piezosurgery *versus* Conventional Techniques in the Surgical Extraction of Third Molars: A Systematic Review. J Dent & Oral Disord. 2016; 2(3): 1015.