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Piezosurgery for the Lingual Split Technique in Lingual Positioned Impacted Mandibular Third Molar Removal

A Retrospective Study

Jing Ge, PhD, Chi Yang, MD, PhD, Jiawei Zheng, MD, PhD, and Wentao Qian, MM

Abstract: The aim of this study was to evaluate the effect and safety of lingual split technique using piezosurgery for the extraction of lingual positioned impacted mandibular 3rd molars with the goal of proposing a more minimally invasive choice for this common surgery.

Eighty-nine consecutive patients with 110 lingual positioned impacted mandibular 3rd molars requiring extraction were performed the lingual split technique using piezosurgery. One sagittal osteotomy line and 2 transverse osteotomy line were designed for lingual and occlusal bone removal. The success rate, operative time, postoperative outcome, and major complications (including nerve injury, mandible fracture, severe hematoma or edema, and severe pyogenic infection) were documented and analyzed.

All impacted mandibular 3rd molars were successfully removed (110/110). The average time of operation was 14.6 minutes (ranged from 7 to 28 minutes). One hundred and seven extraction sites (97.3%) were primary healing. Pain, mouth opening, swelling, and PoSSe scores on postoperative 7-day were 0.34 ± 0.63, 3.88 ± 0.66(cm), 2.4 ± 0.2(cm), and 23.7 ± 5.9, respectively. There were 6 cases (5.5%) had lingual nerve disturbance and 3 cases (2.7%) developed inferior alveolar nerve impairment, and achieved full recovery within 2 months by neurotrophic drug treatment.

Our study suggested piezosurgery for lingual split technique provided an effective way for the extraction of lingual positioned and deeply impacted mandibular 3rd molar.

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Abbreviations: CBCT = cone-beam computed tomography, IAN = inferior alveolar nerve, MC = mandibular canal, PoSSe = postoperative symptom severity.

INTRODUCTION

The lingual split technique for mandibular 3rd molar extraction was 1st proposed by Kelsey Fry in 1933, then described in print by Ward in 1956[1] and modified by Lewis in 1980.[2] The indication of lingual split technique was distal and lingual positioned mandibular 3rd molar. Easier and faster tooth luxation and extraction in lingual direction can be achieved by the technique. However, the technique has not gained much acceptance apparently, and fallen out of favor over the decades. Opponents of the technique are concerned about potential damage to the lingual nerve,[3] excessive hemorrhage from the lingual tenacious soft tissue, introducing infection into the sublingual or parapharyngeal spaces, and edema in the proximity to the airway. Over the years, a lot of efforts have been made to improve the technique. Simplified split-bone technique was proposed by Yeh in 1995,[4] that is, tapping the chisel into the tooth's lingual periodontal space and proceeding lingually and distally to separate the lingual plate from the tooth. This technique can reduce the operating time and incidence of morbidity, but requires very good tactile sense and experience of the operator. A case of lingual positioned fully impacted mandibular 3rd molar extraction through lingual split technique with piezosurgery was reported by Pippi in 2013.[5] Although the surgery was successful, the operating time was 2 or 3 times longer than the buccal approach with the surgical bur technique.

The purpose of this study was to describe lingual split technique with piezosurgery for the extraction of lingual positioned deeply impacted mandibular 3rd molar. The investigators hypothesize that the unique extraction technique can remove lingual positioned impacted mandibular 3rd molar successfully. The specific aim of the study was to evaluate its success rate, operating time, postoperative outcome, and incidence of major complication.

MATERIAL AND METHODS

Study Design and Sample

To address the research purpose, a retrospective study was designed and implemented. The study population was composed of all patients who required extraction of impacted mandibular 3rd molars from September 2013 to September

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From the Department of Oral Surgery (JG, CY, WQ); and Department of Oral-Maxillofacial Head and Neck Surgery (JZ), Shanghai Ninth People's Hospital, College of Stomatology, Shanghai Jiao Tong University School of Medicine, Shanghai Key Laboratory of Stomatology, Shanghai, China.
Correspondence: Chi Yang, Department of Oral Surgery, Shanghai Ninth People's Hospital, College of Stomatology, Shanghai Jiao Tong University School of Medicine, Shanghai Key Laboratory of Stomatology, Shanghai, China (e-mail: yangchi63@hotmail.com).
Jiawei Zheng, Department of Oral-Maxillofacial Head and Neck Surgery, Shanghai Ninth People's Hospital, College of Stomatology, Shanghai Jiao Tong University School of Medicine, Shanghai Key Laboratory of Stomatology, Shanghai, China (e-mail: davidzhengjw@sjtu.edu.cn).
JG assisted the surgeries primarily, participated in the study design, acquisition of data, analysis and interpretation of data, drafting, and revising the manuscript for important intellectual content; CY conceptualized and designed the study, performed the surgeries, and critically reviewed revising the manuscript for important intellectual content; JZ participated in the study design and the data collection instruments, reviewed and revised the manuscript, and approved the final manuscript as submitted; and WQ participated in the study design and the data collection instruments, critically reviewed revising the manuscript for important intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.
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2015. To be included in the study sample, patients must have at least 1 mandibular 3rd molar which is classified as lingual position[6] (the impacted tooth is located at the lingual side of the mandible body, according to buccal-lingual classification) and level C impaction pattern[7] (the impacted tooth is below the cervical line of the adjacent 2nd molar, according to Pell-Gregory classification) (Figure 1)

Patients were excluded as study subjects if they had a history of uncontrolled diabetes, blood dyscrasias, alcoholism, drug abuse and heavy smoking, or if they had acute infections such as pericoronitis, acute alveolar abscess, or oral submucous fibrosis at the time of operation.

Study Variables

The predictor variable was the extraction technique.

All patients were informed about the procedure, the post-operative recovery time, possible complications, and signed a detailed consent form. After a detailed medical and dental history was obtained, orthopantomogram and cone-beam computed tomography (CBCT) of the site were taken, and treatment started. The retrospective study followed the tenets of the Declaration of Helsinki for research involving human subjects, informed consent was obtained from all participants, and the study was critically reviewed and approved by the institutional review board of the Ninth People's Hospital (Shanghai, China). The methods were carried out in accordance with the approved guidelines of MEDICINE.

Surgical Procedure

All patients were operated by the same surgeon under local anesthesia with 2% lidocaine. A mouth prop was put into the patient's mouth on the other side to ensure the mandible was adequately supported. The flap involved a sulcular incision from the mesial aspect of the 2nd mandibular molar and a distal relieving incision along the external oblique ridge to the anterior border of the ramus.[8] For fully impacted teeth, the incision was extended to the 1st molar for greater access. After a full thickness flap was elevated, a piezosurgical device (Silfradent, Italy) was used to cut a precisely defined bony window. Cutting of bone and tooth was continuously accompanied by copious irrigation with chilled saline solution. When cutting and loosening of the alveolar bone, a curved periosteal elevator was placed on the lingual bone to improve exposure of the surgical field, to protect the lingual nerve, and to prevent the 3rd molar slipping accidentally into the lingual soft tissue[4] (Figure 2). After the alveolar bone was removed by a periosteal detacher, the tooth was exposed and delivered in distolingual direction by inserting a straight elevator (Figure 3). No drainage was adopted in any cases. The extraction socket was debrided and filled with colloidal silver (Gelatamp, Germany). All extraction sockets

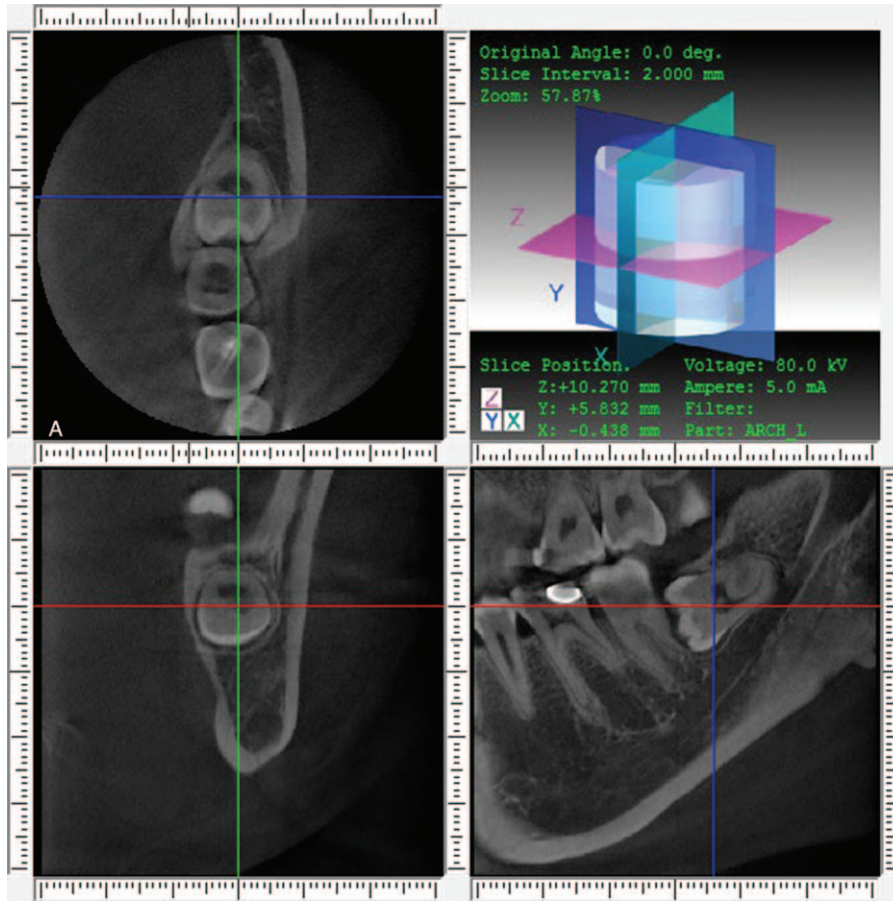

FIGURE 1. Cone-beam computed tomography (CBCT) image of axial view, paraxial view, and sagittal view of a lingual positioned fully impacted mandibular 3rd molar.

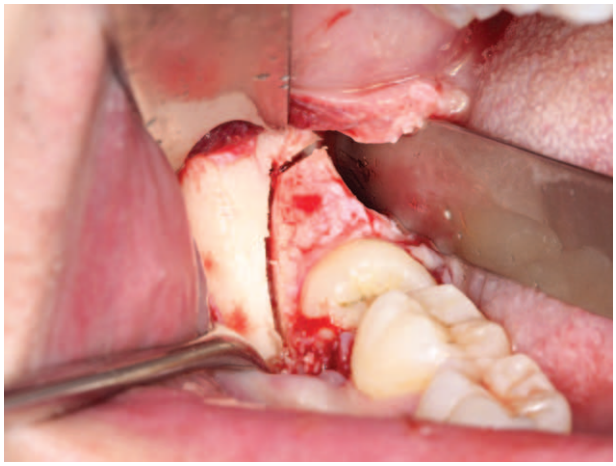

FIGURE 2. A curved periosteal elevator is placed on the lingual side of the alveolar ridge to provide exposure of the surgical area and to protect the lingual nerve.

were closed by interrupted 4/0 absorbable silk (Covidien, US) sutures.

The osteotomy line was designed in the following pattern: 1 oblique sagittal line was made just parallel with the lateral side of the 3rd molar, stretching from the molar's mesial point to distal point (Figure 4); 2 transverse lines, including the mesial one and the distal one, were made from the oblique sagittal line to the lingual plate (Figure 5). There is no sagittal osteotomy line on the lingual plate in this technique, the lingual plate would break at its weakest point where the 3rd molar is nearest to the lingual cortex bone. During the procedure, gentle irrigation within the osteotomy permitted visualization of the lingual nerve (Figure 6).

Outcome Variables and Their Assessment

The primary outcome variables were success rate, operating time (from the 1st incision to the last suture), and the incidence of major complications. The secondary outcome variables were pain, swelling, restricted mouth opening, and the postoperative symptom severity (PoSSe) score at the postoperative 7-day. Major complications include mandibular 2nd molar injury, permanent sensory impairment of lingual and inferior alveolar nerve (IAN), tooth pieces slipping into pterygomandibular space, mandibular fracture, temporomandibular joint injury, excessive hemorrhage, severe pharyngeal space swelling, and severe pyogenic infection. Sensory deficit lasting longer than 6 months is deemed to be permanent.[9]

FIGURE 3. Tooth was delivered in lingual direction after bone removal.

Patients were recalled on postoperative 7-day and examined for wound healing, nerve function, postoperative assessment, and major postoperative complications. Potential neurosensory disturbances of the lip, chin, and tongue were assessed before surgery and the postoperative 1 week recall, additional examinations were made at 1, 3, and 6 months postoperatively if any alteration of the sensation was noted. The postoperative outcome assessment included evaluation of pain, trismus, swelling, and the PoSSe score at recall 7-day. Pain was assessed with a visual analog scale of 10 units in combination with a graphic rating scale.[10] On the visual analog scale, the leftmost end represented absence of pain (score of 0) and the rightmost end indicated the most severe pain (score of 10). Trismus was evaluated by measuring the interincisal distance at maximum mouth opening (cm) with a ruler.[11] The preoperative measurement was the baseline value. Swelling was measured using standard calipers from the lingual aspect of the crown of the mandibular 1st molar to the tangent of the skin of the cheek, according to previous studies.[12–14] Patient also completes the PoSSe scale at postoperative 7-day.[15] This questionnaire was designed to assess the patient's perception of adverse effects in 7 subscales: eating, speech, sensation, appearance, pain, sickness, and interference with daily activities. A score was assigned to the possible responses to each forced question. The scores of the responses to each question were summed.[16] The outcome variables would be compared with data from previously published studies to evaluate the effect and safety of the lingual split technique using piezosurgery.

The demographic data included age, gender, and anatomic position of wisdom tooth. Anatomic position of wisdom tooth was assessed regarding to the following items: the status of eruption, the relationship with ramus, and the relationship with mandibular canal (MC).

Data Analysis

Data were entered into a spreadsheet (Excel; Microsoft Inc, Redmond, WA) over the course of the study and analyzed using a statistical software package (SPSS, version17.0, Chicago). Quantitative data were presented as mean ± SD. Paired *t*-test was used to compare patients' mouth opening scores at baseline and 7-day postoperatively, and a value of $P \leq 0.05$ was considered statistically significant. Demographic data and parametric data (such as success rate, operative time, and major complication rate) were analyzed using descriptive statistics.

RESULTS

In total, 89 patients fulfilled the eligibility criteria and 110 surgeries were performed. There were 46 males and 43 females, aged from 22 to 56 years (mean age of 33.2 years). Sixty-two of the 3rd molars were on the right side and 48 of the 3rd molars on the left. Forty-seven molars (42.7%) were deeply impacted while 63 molars (57.3%) were fully impacted. According to Pell–Gregory classification, 50 molars (45.4%) were class 1, 41 molars (37.3%) were class 2, and 19 molars (17.3%) were class 3. With regard to the radiographical relationship between dental apices and MC, 25 molars (22.7%) were not contacting the MC,

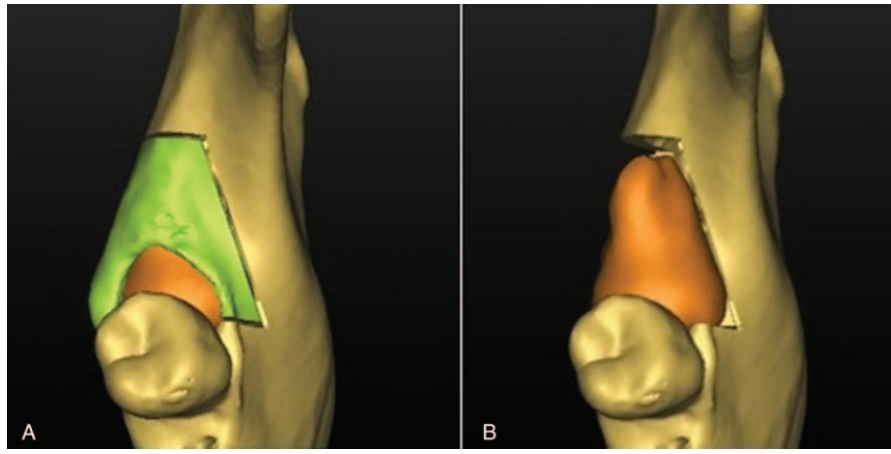

FIGURE 4. 3D reconstruction occlusal view showed the osteotomy line for lingual split technique. (A) There was 1 sagittal osteotomy line and 2 transverse osteotomy line. (B) Full exposure of the third molar after removal of the alveolar bone.

47 molars (42.7%) were contacting the MC, and 38 molars (34.6%) were constricting or penetrating the MC.

All impacted mandibular 3rd molars were successfully removed, the success rate was 100%. The average time of operation was 14.6 minutes (ranged from 7 to 28 minutes). No major intraoperative complication occurred during the operation. There were 6 cases (5.5%) had lingual nerve disturbance and 3 cases (2.7%) developed IAN impairment on the

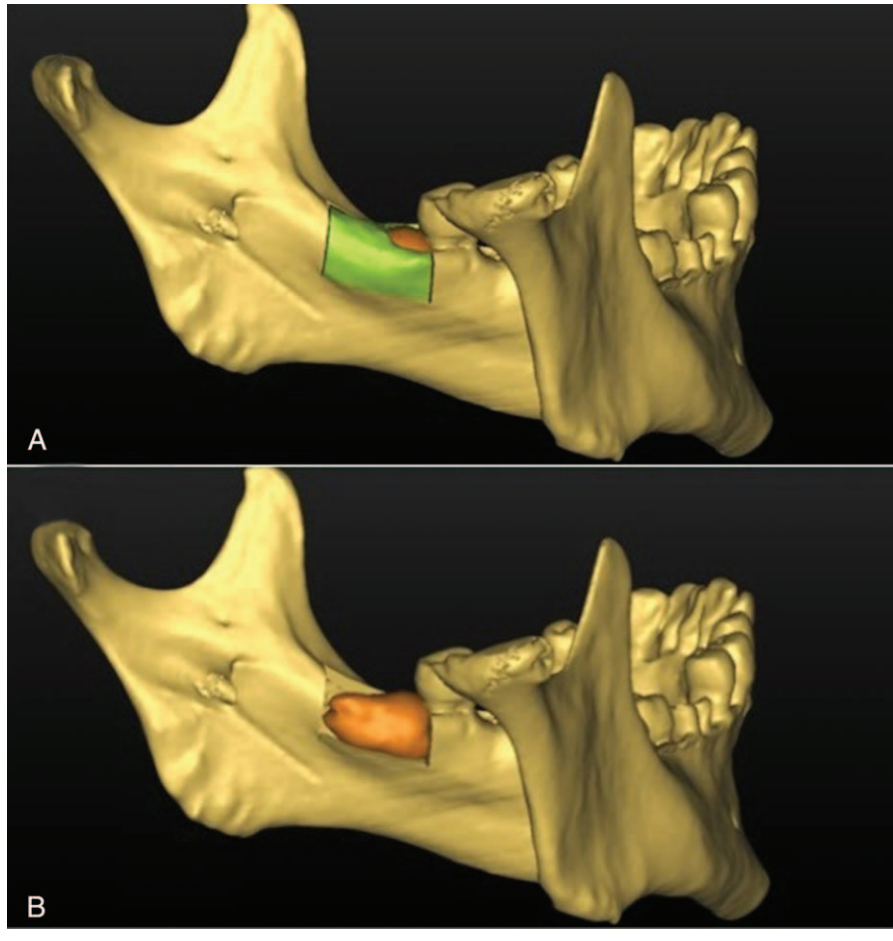

FIGURE 5. 3D reconstruction lingual view showed the osteotomy line for lingual split technique. (A) There was 2 transverse osteotomy line on the lingual plate. (B) The tooth was delivered in lingual direction after removal of the alveolar bone.

FIGURE 6. 3D reconstruction showed the relationship among inferior alveolar nerve, lingual nerve, and osteotomy line. (A) Lingual view: deep osteotomy should be avoided in case of inferior alveolar nerve injury. (B) Overlook: lingual nerve contacted the lingual plate of the third molar.

recall 7 days. Further reassessment showed that the 9 cases achieved full recovery within the 1st postoperative 2 months by neurotrophic drug treatment. A total of 107 sites (97.3%) were primary healing. Three cases (2.7%) developed the postoperative infection, and recovered by draining and antibiotic administration within 1 week.

The demographic data, operation time, parameters evaluated preoperatively, and postoperatively are summarized and shown in the Table 1. The interincisal distance in this study was significantly reduced at postoperative 7-day. Table 1 also showed the relevant data of previous studies on bony impacted mandibular 3rd molar extraction performed by piezosurgery. The patients' scores on the full PoSSe scale and subscales as well as the data published on previous studies are presented in Table 2.

DISCUSSION

The purpose of this study was to describe lingual split technique using piezosurgery for the extraction of lingual positioned impacted mandibular 3rd molar. The authors hypothesized that the unique extraction technique can remove lingual positioned impacted mandibular 3rd molar successfully. The specific aim of the study was to evaluate its success rate, operative time, postoperative outcome, and incidence of major complication. The hypothesis that the lingual split technique using piezosurgery could be used to remove lingual positioned impacted mandibular 3rd molars was accepted.

In this study, the authors proposed lingual split technique using piezosurgery after reviewing their 2-year experience of clinical applications. The indications for this technique were lingual positioned and level C impacted mandibular 3rd molars. The results indicated that the lingual split technique using piezosurgery has high efficiency for lingual positioned mandibular 3rd molar's extraction. Generally, the piezosurgery device was deemed less efficient than conventional saw.[20,21] However, the mean time taken to complete the whole operation procedures was shorter than that of previous studies using piezoelectric osteotomy technique (Table 1), and even slightly shorter than that of previous studies using the conventional rotatory instruments.[9,22–24] The occlusal and lingual resistant alveolar bone was removed adequately by this osteotomy method, thus allowed easier and faster tooth luxation and extraction in lingual direction, reduced the surgical difficulty (coronal sectioning or root sectioning) and saved operation time, and avoided adjacent second molar injury. As the buccal plate is much more thicker than lingual plate in the lingual positioned impacted mandibular 3rd molar,[6] applying conventional buccal technique would cause larger surgical trauma and longer operation time than lingual osteotomy. Furthermore, buccal access could have put the lingual cortex at risk of fracture during tooth luxation, with higher risk of lingual nerve injury and tooth displacement. Finally, because less bone was removed compared with the buccal approach, a better healing process could be expected.

Our results revealed that lingual split technique using piezosurgery could minimize the drawbacks of conventional lingual split technique. Although lingual split technique has prominent advantages over conventional buccal approach, it was not wildly accepted because of the high incidence of

TABLE 1. Comparison Between Present Study and Previous Reports of 3rd Molar Extraction Performed by Piezosurgery on Postoperative Outcome Assessment

Investigator	Present Study	Sortino et al[17] 2008	Barone et al[14] 2010	Goyal et al[18] 2012	Piersanti et al[12] 2014	Rullo et al[19] 2013
Patients	89	50	13	20	10	52
Male, %	46(51.7%)	23 (46.0%)	7 (53.8%)	12 (60.0%)	4 (40.0%)	20 (38.5%)
Female, %	43 (48.3%)	27 (54.0%)	6 (46.2%)	8 (40.0%)	6 (40.0%)	32 (61.5%)
Age, year	33.2 ± 5.8	23.26 ± 6.62	32.2 ± 6.7	29	22.4 ± 2.3	26.2
Operation time, minutes	14.6 ± 6.4	22.92 ± 8.88	34.3 ± 7.4	45 ± 16	36.8 ± 10.6	28.73 ± 5.46
Pain post-7 day	0.34 ± 0.63	–	1.6 ± 0.7	0.20 ± 0.41	–	–
Mouth opening preoperation	4.24 ± 0.47	–	44.5 ± 3.9	4.75 ± 0.76	–	–
Post-7 day	3.88 ± 0.66*	–	38.5 ± 3.7	4.48 ± 0.81	–	–
Swelling	2.4 ± 0.2	–	–	–	2.7 ± 0.2	–

TABLE 2. Comparison Between Present Study and Previous Reports on Postoperative Symptom Severity (PoSSe) Scale

	Present Study	Goyal et al[18] 2012	Piersanti et al[12] 2014		Grossi et al[16] 2007
PoSSe Score	Using Piezosurgery	Using Piezosurgery	Using Piezosurgery	Using Rotatory Instruments	Using Rotatory Instruments
Eating	9.1 ± 3.2	9.58	9.4 ± 4.2	11.0 ± 2.3	12.5
Speech	1.2 ± 1.4	0.44	1.4 ± 1.6	2.7 ± 1.6	2.6
Sensation	1.4 ± 2.4	0	1.6 ± 1.8	1.2 ± 2.1	1.3
Appearance	3.2 ± 2.3	3.08	3.4 ± 2.1	7.0 ± 4.9	5.3
Pain	4.7 ± 2.2	4.27	5.5 ± 3.0	7.4 ± 3.0	6.8
Sickness	0.9 ± 1.7	0.13	0.6 ± 1.1	0.4 ± 1.2	0.7
Interference with daily life	3.1 ± 1.9	7.22	3.1 ± 2.0	6.3 ± 3.0	4.3
Total score	23.7 ± 5.9	24.72	24.7 ± 10.3	36.0 ± 7.6	33.7

hemorrhage and lingual nerve injury. The incidence of hemorrhage and temporary lingual nerve disturbance in this study were 0% and 5.5%, respectively, and no permanent lingual nerve injury was observed. A systematic review reported that temporary lingual nerve disturbance due to the lingual split technique was ranging between 6.64% and 19.80%, and for permanent disturbance between 0% and 1.02%.[3] Unintended iatrogenic injury to the lingual nerve is due to its anatomical proximity, the nerve was found at the level of the alveolar crest or higher, horizontally contacted the lingual plate of the 3rd molar, separated from the cortex of the 3rd molar region only by the periosteum.[22] The reasons of the lingual nerve damage during 3rd molar surgery include raising and retracting a lingual mucoperiosteal flap,[25] lingual flap trauma during osteotomy or tooth sectioning, and lingual plate perforation and supra-crestal incision. Association of depth of impaction with lingual nerve paresthesia also observed and found that 3rd molar present below the cervical line of adjacent second molar (deeply or fully impacted) is more often to develop paraesthesia.[23,26] Although this study recruited deeply or fully impacted mandibular 3rd molars as study sample, the incidence rate of hemorrhage and lingual nerve damage were much lower compared with that of the previously published literatures. The underlying reasons for this outcome might be as follows:

(1) Piezosurgery is a minimally invasive and selectively cutting instrument that inert to surrounding soft tissues and important structures such as nerves, vessels, and mucosa[20,27]
(2) The incision was made from the buccal side of the anterior border of the ramus to the mesial aspect of the 2nd molar, which reduced the chance of accidental injury to the lingual nerve
(3) Using a curved periosteal elevator to retract lingual flap could also provide protection to the lingual nerve during osteotomy, which is supported by many researchers[28,29]

The elevation of the lingual flap may be the most important surgical factor contributing to temporary lingual nerve disturbance in this study. The lingual nerve injured by retraction has a considerable potential for spontaneous recovery, so permanent nerve damage was rare. To prevent postoperative hemorrhage, it is also very important to infiltrate lidocaine with 1:10,000 epinephrine into the lingual soft tissue for the veso-constrictive effect before making the incision and osteotomy.

The results of this study also demonstrated that lingual split technique might reduce the incidence of IAN injury. IAN injury can cause paresthesia to complete numbness and/or pain in the region of the skin of the mental area, the lower lip, mucous membranes, and the gingiva as far posteriorly as the 2nd premolar.[30,31] Furthermore, IAN injury commonly interferes with speech, eating, kissing, make-up application, shaving, and drinking.[32] The incidence of IAN damage has been reported as 1.2% to 5.5% of the lingual split technique,[4] no statistically significant difference compare to the conventional buccal approach.[33] IAN injury occurs in approximately 11% to 30% of the cases where a contact relationship is observed between the MC and the 3rd molar.[34,35] Eighty-five (77.3%) molars had intimate relationship with MC in this study, while the relatively low rate of temporary nerve injury (2.7%) indicated that this technique might impose less trauma than conventional technique. The 3 cases in this study that developed temporary IAN injury might be due to their roots were penetrating into the MC. When performing the distal transverse line osteotomy, the depth of the cutting tip should always be within the distance from the alveolar crest to the MC, which is estimated from the CBCT images. CBCT is indispensable for optimal risk assessment and adequate surgical planning as it provides a 3-dimensional view of the 3rd molar and the adjacent anatomical structures.

Our results concerning postoperation outcome (pain, trismus, swelling, and the PoSSe score) were comparable to those from other reports of mandibular 3rd molar extraction completed with piezosurgery (Tables 1 and 2). The short-term outcomes of 3rd molar operations differ depending on preoperative index of difficulty.[36] According to the Parant scale,[19] surgical difficulty of extraction need osteotomy is level II or higher. This study was homogeneous with other such studies in terms of surgical difficulty indicated that the lingual split technique would not increase patients' discomfort. Furthermore, 5 subscales (eating, speech, appearance, pain, and interference with daily life) and total PoSSe score in this study were lower than those of previous studies using rotatory instruments (Table 2). This finding is consistent with a meta-analysis,[21] which revealed patients undergoing piezosurgery have less swelling, less pain, and trismus. Noticeably, the score of sickness in this study was slightly higher than that of other studies (Table 2), which suggests lingual flap retraction and lingual plate osteotomy increase the trauma to the lingual soft tissue. All in all, the benefits of the lingual split technique using

piezosurgery overwhelmed its disadvantages as long as the indication was carefully selected.

The piezoelectric device was indispensable for the application of lingual split technique in this study. The conventional lingual split technique requires the operator have a very good tactile sense and take precautions to control the chisel and hammer, thus prevent the chisel from penetrating soft tissue. Piezosurgery, as a part of minimal invasive surgery, has prominent advantages over conventional osteotomy instruments, including precise cutting, soft tissue protection, and flexibility in complex anatomic areas. The lingual split technique in this study could not be executed effectively and safely without the piezosurgical device. Also, a great difference was observed in the recovery of bone tissues treated by bur and piezoelectric device, as bur induces degeneration of cellular elements along the edges with reduced vitality of osteoblasts and osteoclasts. This side effect was minor in the ones treated with scalpel or ultrasonic instrument techniques. This is due to the osteotomies were done with a relative low temperature, and marginal osteonecrosis was occurred as a result of thermal injury. In addition, the oscillating tip drives the irrigation solution and evacuates debris in the operating field, which allows the lingual split technique can be executed with better visibility and safety.[37]

As a retrospective study, the limitation of potential referral bias cannot be overlooked: the conclusion drawn from its data compared with those in previously published articles is not adequate. A further research, designed as a prospective randomized controlled trial to compare the lingual split technique using piezosurgery and conventional buccal technique, may be a worthwhile exercise. In addition, the choice of the lingual route for surgical access should always be reached through a careful clinical and radiographic diagnosis in which all parameters are evaluated in relation to the morphology of the tooth, its location, and relationship with adjacent anatomical structures.

CONCLUSIONS

From the results of the study, it can be concluded that the lingual split technique using piezosurgery is an effective and minimally invasive approach for lingual positioned bony impacted mandibular 3rd molars' extraction. As lingual position type occupies the largest proportion in deeply or fully impacted mandibular third molars,[6] this technique can be widely applied.

REFERENCES

1. Ward TG. The split bone technique for removal of lower third molars. *Br Dent J.* 1956;101:297–304.
2. Lewis JE. Modified lingual split technique for extraction of impacted mandibular third molars. *J Oral Surg.* 1980;38:578–583.
3. Pichler JW, Beirne OR. Lingual flap retraction and prevention of lingual nerve damage associated with third molar surgery: a systematic review of the literature. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2001;91:395–401.
4. Yeh CJ. Simplified split-bone technique for removal of impacted mandibular third molars. *Int J Oral Maxillofac Surg.* 1995;24:348–350.
5. Pippi R, Alvaro R. Piezosurgery for the lingual split technique in mandibular third molar removal: a suggestion. *J Craniofac Surg.* 2013;24:531–533.
6. Ge J, Zheng JW, Yang C, et al. Variations in the buccal-lingual alveolar bone thickness of impacted mandibular third molar: our classification and treatment perspectives. *Sci Rep.* 2016;6:16375.
7. Juodzbalys G, Daugela P. Mandibular third molar impaction: review of literature and a proposal of a classification. *J Oral Maxillofac Res.* 2013;4:e1.
8. Briguglio F, Zenobio EG, Isola G, et al. Complications in surgical removal of impacted mandibular third molars in relation to flap design: clinical and statistical evaluations. *Quintessence Int.* 2011;42:445–453.
9. Coulthard P, Kushnerev E, Yates JM, et al. Interventions for iatrogenic inferior alveolar and lingual nerve injury. *Cochrane Database Syst Rev.* 2014;4:Cd005293.
10. Scott J, Huskisson EC. Graphic representation of pain. *Pain.* 1976;2:175–184.
11. UStün Y, Erdogan O, Esen E, et al. Comparison of the effects of 2 doses of methylprednisolone on pain, swelling, and trismus after third molar surgery. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2003;96:535–539.
12. Piersanti L, Dilorenzo M, Monaco G, et al. Piezosurgery or conventional rotatory instruments for inferior third molar extractions? *J Oral Maxillofac Surg.* 2014;72:1647–1652.
13. Al-Khateeb TH, Nusair Y. Effect of the proteolytic enzyme serrapeptase on swelling, pain and trismus after surgical extraction of mandibular third molars. *Int J Oral Maxillofac Surg.* 2008;37:264–268.
14. Barone A, Marconcini S, Giacomelli L, et al. A randomized clinical evaluation of ultrasound bone surgery versus traditional rotary instruments in lower third molar extraction. *J Oral Maxillofac Surg.* 2010;68:330–336.
15. Ruta DA, Bissias E, Ogston S, et al. Assessing health outcomes after extraction of third molars: the postoperative symptom severity (PoSSe) scale. *Br J Oral Maxillofac Surg.* 2000;38:480–487.
16. Grossi GB, Maiorana C, Garramone RA, et al. Effect of submucosal injection of dexamethasone on postoperative discomfort after third molar surgery: a prospective study. *J Oral Maxillofac Surg.* 2007;65:2218–2226.
17. Sortino F, Pedulla E, Masoli V. The piezoelectric and rotatory osteotomy technique in impacted third molar surgery: comparison of postoperative recovery. *J Oral Maxillofac Surg.* 2008;66:2444–2448.
18. Goyal M, Marya K, Jhamb A, et al. Comparative evaluation of surgical outcome after removal of impacted mandibular third molars using a Piezotome or a conventional handpiece: a prospective study. *Br J Oral Maxillofac Surg.* 2012;50:556–561.
19. Rullo R, Addabbo F, Papaccio G, et al. Piezoelectric device vs. conventional rotative instruments in impacted third molar surgery: relationships between surgical difficulty and postoperative pain with histological evaluations. *J Craniomaxillofac Surg.* 2013;41:e33–e38.
20. Labanca M, Azzola F, Vinci R, et al. Piezoelectric surgery: twenty years of use. *Br J Oral Maxillofac Surg.* 2008;46:265–269.
21. Jiang Q, Qiu Y, Yang C, et al. Piezoelectric versus conventional rotary techniques for impacted third molar extraction: a meta-analysis of randomized controlled trials. *Medicine.* 2015;94:e1685.
22. Miloro M, Halkias LE, Slone HW, et al. Assessment of the lingual nerve in the third molar region using magnetic resonance imaging. *J Oral Maxillofac Surg.* 1997;55:134–137.
23. Cheung LK, Leung YY, Chow LK, et al. Incidence of neurosensory deficits and recovery after lower third molar surgery: a prospective clinical study of 4338 cases. *Int J Oral Maxillofac Surg.* 2010;39:320–326.
24. Aalam AA, Nowzari H. Mandibular cortical bone grafts part 1: anatomy, healing process, and influencing factors. *Compend Contin Educ Dent.* 2007;28:206–212 quiz 213.

25. Leung YY, Cheung LK. Risk factors of neurosensory deficits in lower third molar surgery: an literature review of prospective studies. *Int J Oral Maxillofac Surg.* 2011;40:1–10.

26. Chossegros C, Guyot L, Cheynet F, et al. Is lingual nerve protection necessary for lower third molar germectomy? A prospective study of 300 procedures. *Int J Oral Maxillofac Surg.* 2002;31:620–624.

27. Robiony M, Polini F, Costa F, et al. Piezoelectric bone cutting in multipiece maxillary osteotomies. *J Oral Maxillofac Surg.* 2004;62:759–761.

28. Pogrel MA, Goldman KE. Lingual flap retraction for third molar removal. *J Oral Maxillofac Surg.* 2004;62:1125–1130.

29. Gomes AC, Vasconcelos BC, de Oliveira e Silva ED, et al. Lingual nerve damage after mandibular third molar surgery: a randomized clinical trial. *J Oral Maxillofac Surg.* 2005;63:1443–1446.

30. Alhassani AA, AlGhamdi AS. Inferior alveolar nerve injury in implant dentistry: diagnosis, causes, prevention, and management. *J Oral Implantol.* 2010;36:401–407.

31. Roy TS, Sarkar AK, Panicker HK. Variation in the origin of the inferior alveolar nerve. *Clin Anat.* 2002;15:143–147.

32. Ziccardi VB, Assael LA. Mechanisms of trigeminal nerve injuries. *Atlas Oral Maxillofac Surg Clin North Am.* 2001;9:1–11.

33. Steel B. Lingual split versus surgical bur technique in the extraction of impacted mandibular third molars: a systematic review. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2012;114:294–302.

34. Smith WP. The relative risk of neurosensory deficit following removal of mandibular third molar teeth: the influence of radiography and surgical technique. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2013;115:18–24.

35. Monaco G, Montevecchi M, Bonetti GA, et al. Reliability of panoramic radiography in evaluating the topographic relationship between the mandibular canal and impacted third molars. *J Am Dent Assoc.* 2004;135:312–318.

36. Yuasa H, Sugiura M. Clinical postoperative findings after removal of impacted mandibular third molars: prediction of postoperative facial swelling and pain based on preoperative variables. *Br J Oral Maxillofac Surg.* 2004;42:209–214.

37. Leclercq P, Zenati C, Amr S, et al. Ultrasonic bone cut part 1: state-of-the-art technologies and common applications. *J Oral Maxillofac Surg.* 2008;66:177–182.