

Piezo-osteotomy in orthognathic surgery: A comparative clinical study

ABSTRACT

Background: After the clinical introduction of ultrasound scalpel in recent years, piezosurgery has become competitive with conventional instruments in orthognathic procedures to reduce the operative and postoperative complications reported to occur in association with these surgeries.

Aims: The aim of this prospective clinical study was to compare intraoperative and postoperative outcomes of both piezoelectric device and the traditional bur technique in orthognathic surgery. Intraoperative bleeding time, operative time, postoperative swelling, and neurological impairment were evaluated.

Materials and Methods: In this study, a split-mouth technique was applied on ten patients requiring orthognathic surgery. To make the osteotomy cuts, on the one side, piezo-osteotome was used, and on the other side, conventional osteotomy bur was used.

Results: Duration of osteotomy was found to be greater with piezo osteotomy compared to bur osteotomy. Mild bleeding was observed with piezosurgery. Postoperative swelling was greater on the side of piezosurgery compared to the bur side. Altered neurosensory activity was found to be equal on the 1st day postoperatively, but the piezo side recovered faster compared to the bur side in the 1st month after surgery.

Conclusion: Piezoelectric device offers better advantages over the conventional bur in orthognathic surgery and hence can be considered an alternative to the bur in some orthognathic procedures.

Keywords: Bilateral sagittal split osteotomy, jaw osteotomies, nerve impairment, orthognathic surgery, piezosurgery, ultrasonic device

INTRODUCTION

In orthognathic surgeries, osteotomies are performed in close relationship with delicate anatomic structures. Saws, burs, and chisels are traditionally used for cutting bones. Although these instruments are highly effective, they can cause damage to the adjacent soft tissues and nerves. These rotating instruments can be potentially injurious as the production of excessively high temperatures can impair bone regeneration and result in bone necrosis.^[1,2]

The need for less invasive surgery and greater precision compared to standard bur and saw encouraged the development of piezosurgery. Invented by Tomasso Vercelloti, piezosurgery works on the principle of “pressure electrification.” When electric tension is applied to certain

materials like quartz and Rochelle salts, it causes the materials to expand and contract producing ultrasonic vibrations. This device uses ultrasonic vibration at 60–210 $\mu\text{m/s}$ at 24–29 kHz to selectively remove the bone with minimum damage to the soft tissues such as blood vessels and nerves. In addition, it provides excellent visibility due to its cavitation effect.^[3-6]

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Due to these benefits, piezosurgery has become an alternative tool and is increasingly used in orthognathic surgeries.

This prospective study aims to evaluate the effects of piezoelectric surgery compared to conventional burs in orthognathic surgery. The objective of this study is to assess intraoperative bleeding, compare the operative time taken for piezotome and bur, and evaluate postoperative swelling and neurological impairment.

MATERIALS AND METHODS

The clinical study was conducted on a total of ten patients who required orthognathic surgery. In this study, a standard split-mouth model was used. On the one side, piezo-osteotome was used, and on the contralateral side, conventional bur was used to make the osteotomy cuts. Each was randomly assigned to the left or right side. All the surgeries were carried out by the same surgeon. Ethical clearance was obtained by the ethical committee before the commencement of the study. The patients were selected based on specific inclusion and exclusion criteria. Ethical Clearance was obtained from Ethical Committee of Rajarajeshwari Dental College and Hospital dated 27/11/2018 with Ref No: RRDCET/02OS/2018.

Patients between 16 and 40 years with skeletal dysmorphia requiring orthognathic surgery were included in the study. Skeletally immature patients, pregnant patients, and medically compromised patients were excluded from the study. Prior to surgery, necessary consent was taken from the patients, which explained the procedure and any complications arising due to surgery. A detailed case history was recorded. General physical examination, routine hematological investigations, and preoperative radiographs such as lateral cephalograms, computed tomography (CT) facial skeleton, and cone-beam computed tomography were done. Preoperative orthodontic treatment, if needed, was performed for the correction of dental decompensation, which enabled occlusion coordination of both dental arches. Following this, patients were operated under general anesthesia with nasal intubation. For both maxillary and mandibular osteotomies, following surgical exposure, conventional osteotomy bur [Figure 1] was used to give the osteotomy cut on the one side and piezo unit [Figure 2] was used to give osteotomy cut on the other side.

Postoperatively as a standard protocol, antimicrobials such as cefotaxime, metronidazole, and paracetamol as analgesics were administered to the patients. Injection dexamethasone 8 mg was administered in tapering doses only during the postoperative period for a maximum of 4 days.

The following parameters were used to evaluate the subjects in the study:

Intraoperative assessment

- Bleeding during surgery was evaluated based on a visual guide by Ali Algadiem *et al.*^[7] which was created to aid the estimation of blood absorbed by gauze at different percentages of calculation. The amount of blood loss in milliliter was correlated as mild (<500 ml), moderate (500–1000 ml), and severe (>1000 ml)
- Surgical duration time was calculated in minutes from the start of each osteotomy cut until the end of the osteotomy with either piezo-osteotome or conventional bur on the respective sides, and the mean was calculated.

Postoperative assessment

- Postoperatively patients were evaluated on day 1, 1 week, and 1 month
- Postoperative facial swelling was assessed on day 1 and week 1 after surgery and using a modification of the tape measure method by Gabka and Matsumura. In this method, linear distances were taken from the corner of the eye to the angle of the mandible (S1), from the tragus of the ear to the corner of the mouth (S2), and the tragus of the ear to the soft-tissue pogonion (S3). The sum of these sizes was calculated as the facial dimension and used to measure the swelling level on the side of the bur and piezo
- Nerve impairment was checked with pin pressure, brush directional discrimination, and static light touch. The patients were explained about the tests before performing them. The patients were told to relax, close their eyelids, and sit in a semi-reclining position. The right and left sides were examined separately on the lips, chin, upper lip, and cheeks. The patients were asked to evaluate sensory recovery, and the grade of response is shown as Grade 1 – absent sensation and anesthesia, Grade 2 – severely altered sensation and paresthesia, Grade 3 – moderately altered or slightly reduced



Figure 1: Conventional osteotome device (NSK)

sensation, Grade 4 – mildly reduced or subnormal sensation, and Grade 5 – normal sensation.

Statistical analysis

Statistical Package for Social Sciences (SPSS) for Windows, Version 22.0 Released 2013 (Armonk, NY: IBM Corp.) was used to perform statistical analyses. Independent Student's *t* test was used to compare the mean scores for blood loss and operative time between the piezo osteotomy and bur osteotomy. Chi-square/Fisher's exact test was used to compare the postoperative swelling and nerve impairment between the two groups at different time intervals. The results were analysed by descriptive and analytic statistics. A value of $P < 0.05$ was considered to be significant.

RESULTS

A total of ten patients between the age groups of 16 and 40 years who required orthognathic surgery were included in the study [Table 1]. Out of the ten study participants, four were female and six were male. The mean age of the participants was 20.40. Intraoperative clinical parameters included in the study were the duration of osteotomy and blood loss on each side. The postoperative parameters were nerve impairment and swelling.

The mean duration of osteotomy with bur was 8.62 min, whereas the mean duration with piezo-osteotome is



Figure 2: Piezotome device, handpiece, and burs (Acteon)

13.28 min (<0.001) [Figure 3]. Out of ten patients, three patients had mild bleeding on the bur side and seven patients had moderate bleeding. On the piezo side, eight patients had mild bleeding and only two patients had moderate bleeding ($P = 0.07$) [Figure 4].

Postoperative paresthesia was assessed on day 1, week 1, and 1 month after surgery. On day 1, on the bur side, three patients were evaluated as Grade 2 and seven patients as Grade 3, whereas on the piezo side, four patients were assessed with Grade 3 and six patients with Grade 4 ($P = 0.007$). After 1 week postoperatively, on the bur side, five patients were evaluated as Grade 3 and five patients as Grade 4. On the piezo side, four patients were assessed with Grade 4 and six patients with Grade 5 ($P = 0.004$). After 1 month, it was observed that on the bur side, five patients were evaluated as Grade 5, three patients as Grade 4, and two patients as Grade 3. On the piezo side, all ten (100%) patients were evaluated as Grade 5 normal sensation ($P = 0.04$) [Figure 5]. Two patients who underwent bimaxillary procedure and intraoral

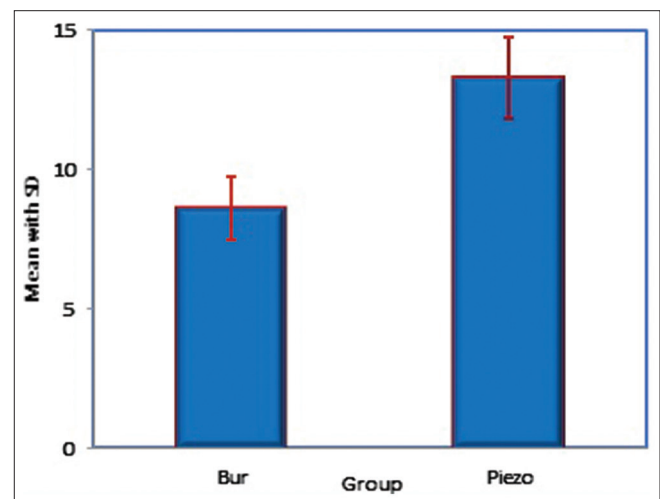


Figure 3: Intraoperative duration of osteotomy comparing with bur and piezotome

Table 1: Clinical features and procedures performed

Case	Age	Gender	Facial skeletal deformity	Procedure	Jaw	Bur	Piezo
1	19	Female	Skeletal class II	LeFort I with 5-mm advancement and genioplasty	Maxilla	Right	Left
2	18	Female	Skeletal class II	LeFort I with 5 mm with advancement genioplasty	Maxilla	Right	Left
3	17	Male	Maxillary hypoplasia	LeFort I with 3-mm posterior impaction	Maxilla	Left	Right
4	17	Male	Mandibular prognathism	BSSO with 10-mm setback	Mandible	Left	Right
5	20	Male	Mandibular prognathism	IVRO with 10-mm setback	Mandible	Left	Right
6	29	Female	Skeletal class III with maxillary hypoplasia	BSSO with 8-mm setback and genioplasty	Mandible	Right	Left
7	20	Male	Skeletal class III	BSSO with 9-mm setback	Mandible	Right	Left
8	20	Male	Maxillary hypoplasia	LeFort 1 with 5-mm advancement	Maxilla	Right	Left
9	25	Female	Skeletal class III	BSSO with 6-mm setback	Mandible	Left	Right
10	19	Male	Mandibular retrognathism	BSSO with 7-mm advancement	Mandible	Right	Left

BSSO: Bilateral sagittal split osteotomy, IVRO: Intraoral vertical split osteotomy

vertical split osteotomy, respectively [Figures 6 and 7], had continued paresthesia up to 1 month after surgery on the bur side.

Postoperative swelling was measured on day 1 and 1 week postoperatively. On postoperative day 1, the mean measurement of swelling on the bur side was 12.78 cm, whereas on the piezo side, it was 12.55 cm ($P = 0.36$). On the 1st week after surgery, the mean measurement of swelling was 11.87 cm, and on the piezo side, it was 11.83 cm ($P = 0.93$) [Figure 8]. In most cases, mild swelling was observed on the bur side for 1 week postoperatively [Figure 9].

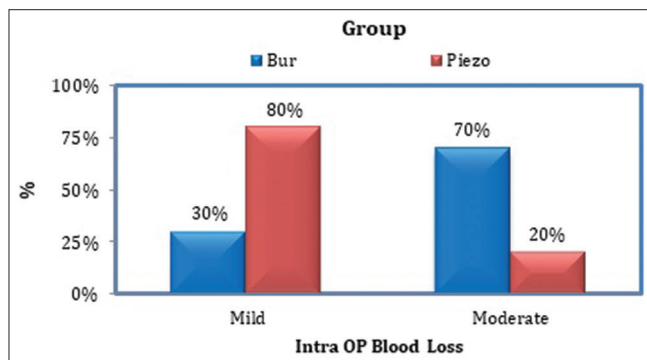


Figure 4: Intraoperative blood loss between bur and piezo side

During piezo-osteotomy, the cut design was assessed, which showed precise and neat cut edges compared to the ragged and uneven edges with bur osteotomy [Figure 6]. The accurate cuts can be appreciated when piezotome was used for genioplasty along with bilateral sagittal split osteotomy (BSSO) in a case of skeletal class III [Figure 10].

DISCUSSION

The increasing trend for minimally invasive surgery with more precision encouraged the development of piezoelectric

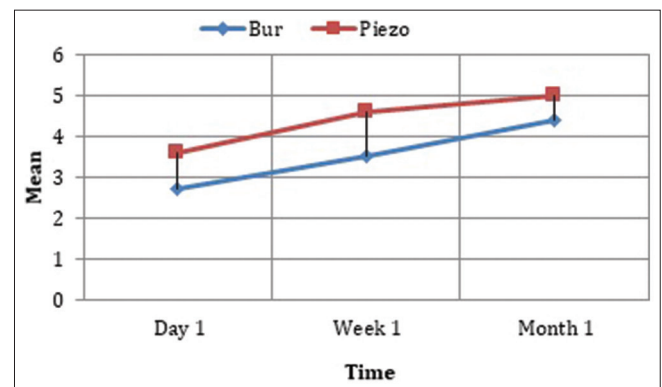


Figure 5: Mean of paresthesia grading and recovery observed over the follow-up period



Figure 6: Case of maxillary hypoplasia with mandibular prognathism. (a) Preoperative picture. (b) Procedure planned – 3-mm maxillary advancement with LeFort 1 and 10-mm setback with bilateral sagittal split osteotomy. (c) Piezo-osteotomy on the right side. (d) Bur osteotomy on the left side. (e) LeFort 1 osteotomy with piezo on the right and with bur on the left. (f) 3D printed orthognathic splint. (g and h) Persistent paresthesia present on the left side at 1 week and 1 month



Figure 7: Case of skeletal class III. (a) Preoperative profile. (b) Intraoral vertical split osteotomy with 10-mm setback. (c) 3D printed orthognathic splint. (d) One month postoperatively

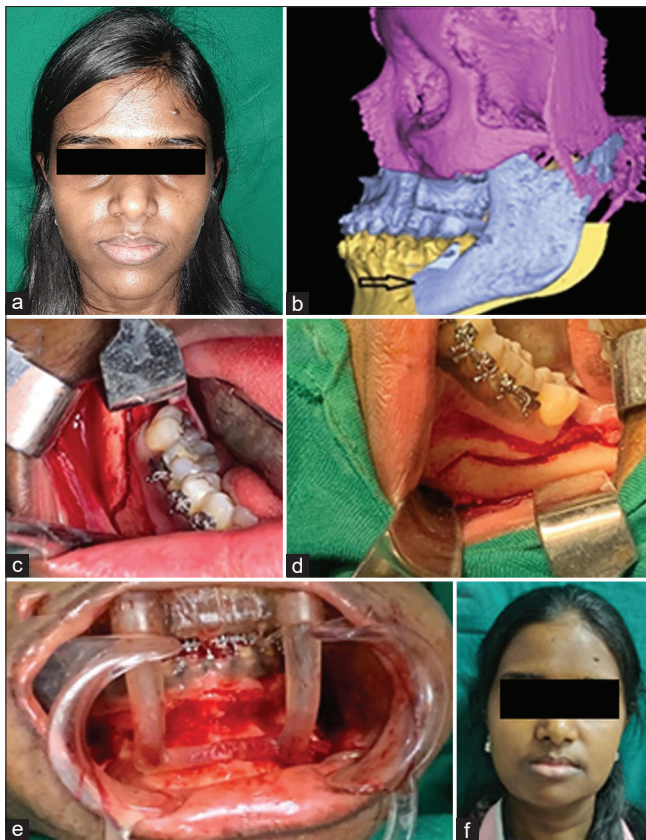


Figure 9: Case of skeletal class III deformity with maxillary hypoplasia. (a) Preoperative. (b) Procedure planned – 8-mm mandibular setback with bilateral sagittal split osteotomy. (c) Bur osteotomy on the right side. (d) Piezo-osteotomy on the left side. (e) 3D printed orthognathic splint. (f) Follow-up after 1 week – swelling present only on the right side

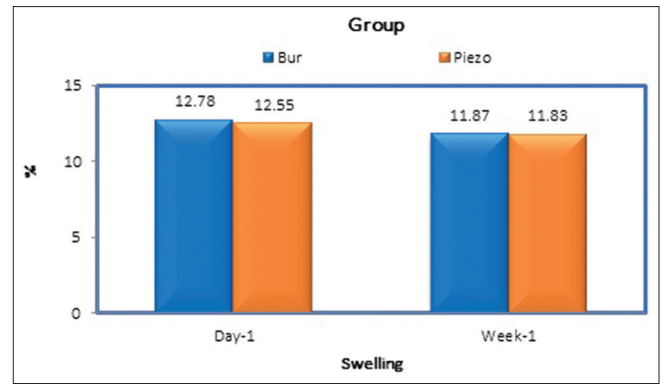


Figure 8: Comparison of mean values of swelling between bur side and piezo side at different times of follow-up

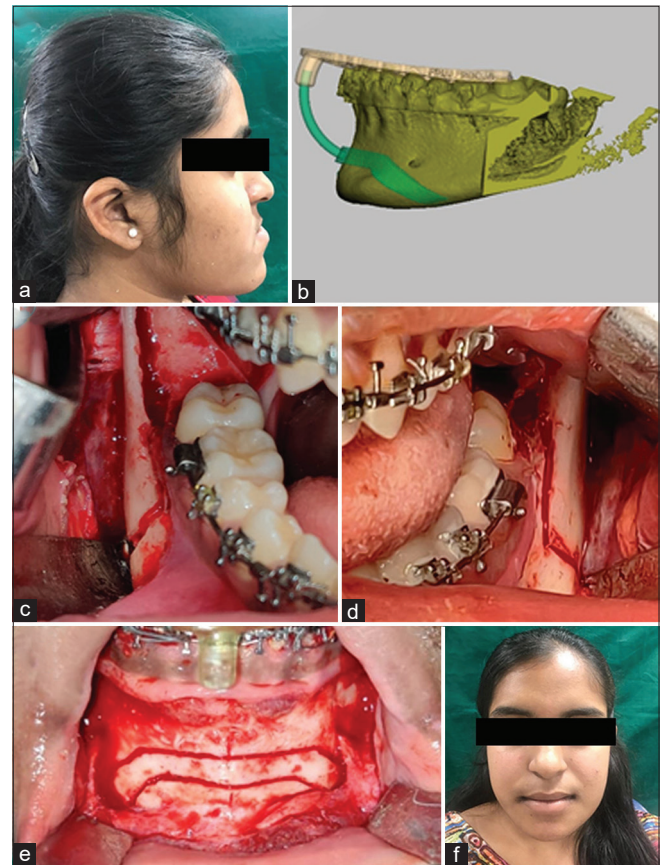


Figure 10: Case of skeletal class III. (a) Preoperative. (b) Final procedure – 6-mm setback with bilateral sagittal split osteotomy with 4-mm reduction genioplasty. (c) Bur osteotomy on the right side. (d) Piezo-osteotomy on the left side. (e) Genioplasty with piezo-osteotomy. (f) One month postoperative

surgery in orthognathic procedures, such as the BSSO, surgically assisted rapid maxillary expansion, and LeFort I osteotomy. This is a comparative study done on ten patients where a split-mouth technique is applied to compare the outcomes of piezo-osteotome and conventional bur in orthognathic surgery.

In the present study, based on the parameters evaluated, the advantages of piezo were as follows:

1. Reduced intraoperative bleeding with piezo-osteotomy compared to the osteotomy with the bur. Blood-free surgical field enabled better visualization
2. Better clinical outcomes in terms of neurosensory disturbances – most patients attained complete recovery on the piezo side within a shorter duration than the bur side
3. The difference in postoperative swelling was not significant on both sides but faster resolution with piezo usage compared to the bur. This could be due to the administration of dexamethasone postoperatively in our study
4. During piezo-osteotomy, the cut design was precise, and neat cut edges were observed compared to the ragged and uneven edges with bur osteotomy
5. Bone loss during piezo-osteotomy cuts was less compared to the bur osteotomy, which enabled proper interdigitation of the segments with piezo-osteotomy cuts.

The main drawbacks observed were as follows:

1. Piezo-osteotomy takes a longer duration compared to the bur osteotomy increasing the overall operative time
2. There is a slight reduction in cutting efficiency in the presence of dense cortical bone.

Similar observations were made in various studies in the literature. Spinelli *et al.*^[3] reported a significant reduction in mean blood loss of 25% in piezosurgery compared to a traditional saw procedure. According to Bertossi *et al.*,^[8] piezosurgery provides more controlled bleeding than conventional osteotomy. Due to the piezoelectric effect, the distribution of cooling fluid and microvibrations provides a blood-free surgical field.

The results in our study regarding neurosensory disturbances were in consensus with the literature. According to Beziat *et al.*,^[9] faster recovery was observed on both sides by the first postoperative week, but the percentage of sensation recovery was higher following ultrasound osteotomy. Likewise, other studies have reported significant differences after 3 months and 6 months postoperatively, but piezo surgery showed a lesser amount of neurosensory disturbance compared to the conventional bur side.^[10-12] This is due to preserving the soft tissues, including the perineurium of the nerve.

Postoperative swelling is a common occurrence after orthognathic surgery, and it is resolved after 2–3 weeks.^[11] Spinelli *et al.*^[3] reported a majority of the patients recovered within a week and the rest in the first postoperative month and a decreased incidence of postoperative swelling with piezoelectric surgery. Rossi *et al.*^[13] reported less swelling in the piezo side compared to the traditional saw, and the

difference was significant 30 days after follow-up. Many studies have also reported a higher accuracy and cutting precision with the piezoelectric device when compared to conventional burs or saws.^[3,6] The cavitation effect seen in piezosurgery causes the evacuation of the detritus to provide a clear surgical field.^[6,8] Studies by Semper-Hogg *et al.*^[14] and Weber and Griffin^[15] showed that administration of dexamethasone either intraoperatively or postoperatively also has a significant effect on reduction on postoperative swelling.

Studies by Spinelli *et al.*^[3] and Rossi *et al.*^[13] have reported a longer duration of the procedure with the piezo when compared with the bur. It is reported that the duration of surgery with piezo-osteotomy takes 30%–50% longer than the conventional bur, especially when cutting through dense cortical bone.^[12]

Overall, despite these shortcomings, the piezoelectric device offers better advantages over the conventional bur in orthognathic surgery and hence can be considered an alternative to the bur in some procedures.

CONCLUSION

It was observed that piezosurgery offers several benefits over conventional bur in orthognathic surgery: precise cutting, sparing of vital structures, and better visualization of the surgical field. It reduces blood loss and promotes better clinical outcomes with regard to neurosensory disturbance when compared to the use of conventional bur. However, it has several limitations like prolonged duration of osteotomy, thus increasing the surgical time. As our sample size is small, further studies are recommended to evaluate the outcomes of orthognathic procedures with piezo-osteotomy. To conclude, piezoelectric devices provide an innovative, safe, and effective osteotomy compared to rotating instruments in orthognathic surgery.

Declaration of patient consent

The authors declare that they have obtained consent from patients. Patients have given their consent for their images and other clinical information to be reported in the journal. Patients understand that their names will not be published and due efforts will be made to conceal their identity but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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