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# Piezoelectric versus conventional techniques for orthognathic surgery: Systematic review and meta-analysis

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ABSTRACT

*Purpose:* The purpose of this study was to perform a systematic review and meta-analysis of complications after orthognathic surgery comparing piezo-surgery with conventional osteotomy.
*Methods:* We conducted this study according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. We performed a systematic search of PubMed, Scopus, Science Direct, Lilacs, Cochrane Central Register of Controlled Trials, Google Scholar, and OpenThesis to identify randomized and nonrandomized controlled trials (RCTs and nRCTs, respectively) comparing patient outcomes (operative time, intraoperative blood loss, postoperative swelling, pain, neurosensitivity) after orthognathic surgery by piezoelectric or conventional osteotomy. We pooled individual results of continuous and dichotomous outcome data using the mean difference (MD) and risk difference (RD) with the 95% confidence interval, respectively.
*Results:* Three RCTs and five nRCTs were selected. No difference in operative time was observed between piezo-surgery and conventional osteotomies. We found a decrease of intraoperative blood loss with piezo-surgery (MD −128 mL; $P < 0.001$) and a pooled difference in severe blood loss of 35% ($P = 0.008$) favouring piezo-surgery. Based on pooled individual results of studies evaluating neurosensitivity by clinical neurosensory testing, our meta-analysis showed a pooled difference in severe nerve disturbance of 25% ($P < 0.0001$) favouring piezo-surgery. Test for subgroup differences (I2 = 26.6%) indicated that follow-up time may have an effect on neurosensory disturbance. We found differences between piezo-surgery and conventional osteotomy at 3 months (RD 28%; $P < 0.001$) and 6 months (RD 15%; $P = 0.001$) after surgery. Meta-analyses for pain and swelling were not performed because of a lack of sufficient studies.
*Conclusion:* Currently available evidence suggests that piezo-surgery has favorable effects on complications associated with orthognathic surgery, including reductions in intraoperative blood loss and severe nerve disturbance.


## 1. Introduction

Piezo-surgery was first used in oral and maxillofacial surgery by Vercellotti and colleagues (Vercellotti et al., 2001), who sought to simplify maxillary sinus surgery by avoiding perforation of the schneiderian membrane. Recently, ultrasonic bone cutting has been used in orthognathic procedures (Gruber et al., 2005; Beziat et al., 2007; Robiony et al., 2007; Landes et al., 2008a, 2008b; Chung et al., 2012; Bertossi et al., 2013; Gilles et al., 2013; Spinelli et al., 2014), extraction of impacted third molars (Jiang et al., 2015), corticotomy-facilitated orthodontics (Farid et al., 2014), implant site preparation (Brugnami et al., 2014; Canullo et al., 2014;

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Lamazza et al., 2015), management of temporomandibular disorders (Jose et al., 2014), cyst enucleation (Kocyigit et al., 2012; Pappalardo and Guarnieri, 2014), and head and neck oncological and reconstructive surgeries (Crosetti et al., 2009). Piezo-electric surgery uses low-frequency ultrasonic vibration for osteotomy, which minimizes the risk of damage to soft tissues (nerves, vessels, and mucosa) (Vercellotti, 2004; Landes et al., 2008a, 2008b). Micrometric vibration ensures precise cutting action and permits perioperative control, with a consequent increase in safety, in a difficult-to-access anatomic area (Vercellotti, 2004).

A meta-analysis of randomized controlled trials (RCTs) (Jiang et al., 2015) showed that patients receiving piezo-surgery for impacted third molars experienced longer operative times but less postoperative swelling, pain, and trismus than patients who received conventional rotary techniques. Although piezo-surgery is a promising alternative technique for removal of impacted third molars, there is no evidence that ultrasonic bone cutting decreases operative time, intraoperative blood loss, postoperative swelling, pain, or paresthesia in orthognathic surgery. Therefore, the aim of this study was to perform a systematic review and meta-analysis of complications after orthognathic surgery by piezo-surgery versus conventional osteotomy.

## 2. Materials and methods

We conducted this study according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2010).

### 2.1. Eligibility criteria

We used PICOT elements to define eligibility criteria, as follows: (1) *population:* patients submitted to orthognathic surgery; (2) *intervention:* piezo-electric osteotomy; (3) *comparison:* conventional osteotomy; (4) *predefined outcomes*: operative time, intraoperative blood loss, postoperative swelling, pain, and postoperative neurological analysis; and (4) *study type:* RCTs and non-randomized controlled trials (nRCTs). We excluded animal studies and studies from which we were unable to extract data regarding at least one of the outcomes of interest.

### 2.2. Search strategy

We performed a systematic search to identify relevant studies from PubMed, Scopus, Science Direct, Lilacs, and Cochrane Central Register of Controlled Trials (CENTRAL). A grey-literature search was performed through Google Scholar and OpenThesis. We performed the following consecutive searches in May 2016: ultrasonic surgical procedures, ultrasonic surgery, ultrasonic therapy, ultrasonic cutting, ultrasonic bone cutting, piezo-surgery, piezo-electric surgery, piezo-electric bone surgery, piezo-electric osteotomy, high-energy shock waves, ultrasonic surgery procedure OR high-energy shock waves, orthognathic surgery, orthognathic surgical procedures, jaw surgery, osteotomy, orthognathic surgery OR osteotomy, and ultrasonic surgery procedure OR high-energy shock waves AND orthognathic surgery OR osteotomy. We also conducted a hand search of cross-references from original articles and reviews to identify additional studies that could not be located in the electronic database.

Two reviewers (S.J.A.V. and T.S.S.) independently screened the search results. Considering the titles and abstracts, they identified potentially relevant studies. No restrictions on language or publication year were imposed. Relevant studies were read in full and, if they met the eligibility criteria, were included in the systematic review. Disagreements between the two reviewers were resolved by consensus or by a third reviewer (P.R.S.M.-F.).

### 2.3. Data extraction

Two reviewers (S.J.A.V. and T.S.S.) independently extracted data using a predefined protocol. Disagreements were resolved by consensus or by a third reviewer (P.R.S.M.-F.). Extracted data regarded the study design, study population, indications and methods for orthognathic surgery, characteristics of ultrasonic osteotomy, intraoperative and postoperative parameters, and outcome measures.

### 2.4. Risk of bias

Risk of bias was assessed by considering the Cochrane guidelines for clinical trials. We assessed seven domains: sequence generation (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective outcome reporting (reporting bias), and other potential sources of bias. We rated risk of bias as low, unclear, or high, according to established criteria (Higgins et al., 2011).

### 2.5. Statistical analysis

We used the mean difference (MD) and the risk difference (RD) with the 95% confidence interval (95% CI) to pool individual results of continuous and dichotomous outcome data, respectively. MD was calculated by using the generic inverse variance method, abstracting means and standard deviations (SDs) for each study group and outcome of interest. RD was calculating by comparing rates of severe intraoperative blood loss (>500 mL) and severe nerve injury between piezo-surgery and conventional osteotomy. RD is directly related to the number needed to treat (NNT), a useful measure of clinical effectiveness.

We used forest plots to present graphically the pooled estimates and 95% CIs. In the plot, each study was represented by a square, the size of which was proportional to the study's weight in the meta-analysis. Two-sided p-values less than 0.05 were considered statistically significant. We investigated heterogeneity by the Cochran Q test, using a cut-off of 10% for significance (Cochran, 1954) and the $I^2$ index [100% × (Q−df)/Q] for quantification (Higgins and Thompson, 2002). Although funnel plots may be useful tools in investigating small study effects in meta-analyses, they have limited power to detect such effects when there are few studies (Simmonds, 2015). Therefore, because we had only a small number of included studies, we did not perform funnel plot analysis. All statistical analyses were performed by using Review Manager Version 5.0 (Cochrane Collaboration).

## 3. Results

### 3.1. Selection

In our initial search, we found 999 references to be analyzed by title/abstract. Thirty-five studies were considered to be potentially relevant and were analyzed in full. After a complete reading, we excluded 26 studies because their study design (n = 24) or study population (n = 2) did not match the inclusion criteria. One additional study was excluded because of the potential for overlapping samples. Finally, eight studies (Beziat et al., 2007; Landes et al., 2008b; Bertossi et al., 2013; Rana et al., 2013; Monnazzi et al., 2014; Shirota et al., 2014; Spinelli et al., 2014; Brockmeyer et al.,