The Stability and Survival Rate of Dental Implants After Preparation of the Site by Piezosurgery vs Conventional Drilling: A Systematic Review and Meta-Analysis

Xiaoni Li, MD, PhD1/Xijiang Lin, MD1/Jilai Guo, MD1/Yaozhong Wang, MD1

Purpose: This study aimed to assess the stability and survival rate of dental implants inserted with different site preparation techniques—piezoelectric inserts versus traditional rotary instruments. Materials and Methods: Correlative research was located by searching articles in PubMed, EMBASE, and the Cochrane Library. This was accomplished independently by two different reviewers and supplemented by a manual search. Only prospective studies evaluating piezoelectric vs conventional implant site preparation in dental implantation were included in this review. A meta-analysis was performed on the stability and survival rate of implants. Results: One thousand fifty-five articles were identified following the search strategy, of which five studies were finally included in this meta-analysis. With regard to the survival rate of implants, there was no statistically significant difference between piezoelectric and conventional implant site preparation (RR = 0.98, 95% CI: 0.94, 1.03; \( \chi^2 = 0\%)\) on the other side, the piezoelectric group had better stability in the eighth week (MD = 4.24, 95% CI: 1.36, 7.12; \( \chi^2 = 0\%\); \( P = .80\)) and 12th week (MD = 3.33, 95% CI: 0.59, 6.08; \( \chi^2 = 0\%\); \( P = .87\)) compared with the conventional group. Conclusion: Within the limitations of this study, it suggests that the survival rate of implants may not be influenced by the site preparation techniques (piezoelectric vs conventional), but the piezoelectric group may achieve better stability than the conventional group. Int J Oral Maxillofac Implants 2020;35:e51–e56. doi:10.11607/jomi.5913

Keywords: piezosurgery, site preparation, stability, survival rate

Implant stability is one of the crucial requirements for obtaining desired osseointegration. Fibrous tissue may form around implants if their stability is destroyed during the healing period, which results in micromovements. The method of preparing the implant site is one of several surgical factors that may affect the implant stability and survival rate.

Rotary drills are efficient, but they have several disadvantages, including the generation of debris and chips, the creation of substantial hematoma at the drilling site, the production of heat, and difficulties in attaining geometric accuracy.1–3 Piezosurgery has been introduced as a substitution for conventional drilling to avoid its weakness. Piezosurgery can make accurate and safe cuts, which could achieve better wound healing than rotating instruments.4–8

The purpose of this study was to evaluate the survival rate and stability of dental implants placed in osteotomies made with the piezoelectric method or with conventional drilling.

MATERIALS AND METHODS

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses protocols 2015 (PRISMA-P 2015) statement guidelines.9

Eligibility Criteria

The inclusion criteria were as follows:

- The study compared the survival rate or stability of implants inserted with piezoelectric inserts vs traditional rotary instruments.
- The study must state its design, number of patients, number of implants placed, and failures.
- The study must be conducted in humans.

The exclusion criteria were as follows:

- Case reports or review
- Animal studies
- Studies lack of control groups

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Study Selection
A systematic literature search was conducted in PubMed, Embase, and the Cochrane Library, which was updated to August 9, 2016. The search strategy, described in Table 1, was designed and set up by two investigators (L.X.N. and W.Y.Z.).

The located articles were evaluated for their relevance to the research topic by two investigators (L.X.N. and W.Y.Z.). If there were disagreements, they would be settled by discussion with superior doctors. The final research list was decided by the two researchers before data extraction.

Data Extraction
Data extraction was performed in a standardized protocol and reporting form to withdraw the following information: the first author, the year of publication, the patients’ ages, smoking or not, the area of site preparation, the time interval between implantation and extraction, grafting or not, the height and width of the alveolar ridge, the survival rate of the implant, and the implant stability quotient (ISQ) in different times. Both investigators extracted data independently and made the final form together.

Statistical Analysis
The survival of implants was regarded as the binary variable, and the ISQ of implants was regarded as a continuous variable. The statistical units for “survival” and “ISQ” were related to implants instead of patients. The evaluation of relative effect was indicated as a risk ratio (RR) under the condition of a dichotomous outcome and as a mean difference (MD) under the condition of a continuous outcome, with a 95% confidence interval (CI). Study-specific evaluation used a random effects model if a statistical heterogeneity was detected; otherwise, a fixed effects model was applied. The Q and I^2 statistics were used to evaluate the heterogeneity among studies.

RESULTS

Literature Search
As summarized in Fig 1, the literature search identified a total of 1,055 articles. After 260 articles were excluded for duplicate titles or abstracts, 795 articles were left. After filtering the titles and abstracts, 769 articles were further eliminated on the basis of the inclusion criteria and exclusion criteria. In the end, 26 articles were chosen for full-text screening.

After reading the full texts, 21 articles did not conform to inclusion criteria, of which 16 were conducted in animals, two did not have control groups, and three were reviews. At last, five records were accepted in this analysis.

Description of the Studies
The information of the included articles is shown in Table 2. One hundred twenty patients with 258 implants were included in this meta-analysis. All studies recorded the patients’ ages, and all the patients were

<table>
<thead>
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<th>Table 1 Search Strategy</th>
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<tr>
<td><strong>Database</strong></td>
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</tbody>
</table>
| EMBASE | #1 ‘tooth implant’/exp OR ‘tooth implant’ OR ‘tooth implantation’/exp OR ‘tooth implantation’
#2 ‘dental’ OR ‘oral’/exp OR ‘oral’ OR ‘mouth’/exp OR ‘mouth’ OR ‘tooth’/exp OR ‘tooth’ AND (‘implants’/exp OR ‘implants’ OR ‘implantation’/exp OR ‘implantation’) #3 #1 OR #2
#4 ‘piezosurgery’/exp OR ‘piezosurgery’
#5 ‘piezo electric surgery’ OR (‘piezo’ AND ‘electric’ AND ‘surgery’) OR ‘piezo’ OR ‘ultrasonic’ #6 #4 OR #5
#7 #3 AND #6 |
| Cochrane | #1 MeSH descriptor: [Dental Implantation] explode all trees
#2 MeSH descriptor: [Dental Implants] explode all trees
#3 dental implant*:ti,ab,kw (Word variations have been searched)
#4 (dental or mouth or oral) and (implantation or implant):ti,ab,kw (Word variations have been searched)
#5 #1 or #2 or #3 or #4
#6 MeSH descriptor: [Piezosurgery] explode all trees
#7 piezosurgery or piezo* or ultrasonic:ti,ab,kw (Word variations have been searched)
#8 #6 or #7
#9 #5 and #8 |
Two studies included patients who smoked fewer than 10 cigarettes per day, 14, 15 and one study failed to mention whether patients smoked or not. 16 All implantations were performed more than 6 months after tooth extraction, without grafting (Table 3). All five studies provided the information of implant survival rate, of which three assessed the implant stability.

### Quality Assessment

All trials were evaluated for risk of bias (Fig 2). Each trial was assessed in the following aspects: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, and selective reporting. If the trial met all criteria, it would be classified as low risk of bias. When a study failed to meet one of these criteria, it would be regarded as moderate risk of bias. A study

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**Table 2**  Characteristics of Studies Included in Meta-Analysis

<table>
<thead>
<tr>
<th>Study</th>
<th>Patient ages (y)</th>
<th>Survival rate</th>
<th>ISQ</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Conventional</td>
<td>Piezoelectric</td>
</tr>
<tr>
<td>Peker Tekdal et al, 2016</td>
<td>31–64</td>
<td>19/20 (24 wk)</td>
<td>19/20 (24 wk)</td>
</tr>
<tr>
<td>da Silva Neto et al, 2014</td>
<td>20–60</td>
<td>34/34 (150 d)</td>
<td>34/34 (150 d)</td>
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<tr>
<td>Canullo et al, 2014</td>
<td>32–76</td>
<td>14/15 (15 mo)</td>
<td>15/15 (15 mo)</td>
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<tr>
<td>Stacchi et al, 2013</td>
<td>41–81</td>
<td>19/20 (1 y)</td>
<td>20/20 (1 y)</td>
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<tr>
<td>Di Alberti et al, 2010</td>
<td>38–47</td>
<td>40/40 (90 d)</td>
<td>40/40 (90 d)</td>
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</tbody>
</table>

RFA = Resonance frequency analysis.

**Table 3**  Bone Quality and Intraoral Locations of Studies Included in Meta-Analysis

<table>
<thead>
<tr>
<th>Study</th>
<th>Patient ages (y)</th>
<th>Site preparation area</th>
<th>Time after extractions</th>
<th>Grafting</th>
<th>Height</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peker Tekdal et al, 2016</td>
<td>31–64</td>
<td>Maxillary posterior region</td>
<td>≥ 6 mo</td>
<td>Without</td>
<td>&gt; 8 mm</td>
<td>≥ 7 mm</td>
</tr>
<tr>
<td>da Silva Neto et al, 2014</td>
<td>20–60</td>
<td>Maxillary premolar region</td>
<td>≥ 6 mo</td>
<td>Without</td>
<td>≥ 13 mm</td>
<td>≥ 5 mm</td>
</tr>
<tr>
<td>Canullo et al, 2014</td>
<td>32–76</td>
<td>Mandibular molar region</td>
<td>≥ 6 mo</td>
<td>Without</td>
<td>≥ 12 mm</td>
<td>≥ 6 mm</td>
</tr>
<tr>
<td>Stacchi et al, 2013</td>
<td>41–81</td>
<td>Maxillary premolar region</td>
<td>≥ 6 mo</td>
<td>Without</td>
<td>≥ 10 mm</td>
<td>≥ 6 mm</td>
</tr>
<tr>
<td>Di Alberti et al, 2010</td>
<td>38–47</td>
<td>–</td>
<td>≥ 6 mo</td>
<td>Without</td>
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<td>–</td>
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</table>

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that did not meet two or more criteria would be judged as high risk of bias. In each of the studies, the blinding was not feasible, as the operator cannot be blinded. No other bias was detected. Thus, all trials were considered as having moderate risk of bias.

**Meta-Analysis**

In this analysis, since statistically significant heterogeneity was not found ($P = .86; I^2 = 0\%$), a fixed-effects model was adopted to evaluate the implant survival rate. The test showed that the survival rates of implants inserted with different techniques (piezoelectric vs conventional) had no statistically significant difference ($P = .47$; Fig 3).

For the second outcome, the test showed that there was no statistically significant difference ($P = .55; I^2 = 76\%, P = .02$; Fig 4) in implant stability in the 12th week between the two techniques. A sensitivity analysis was carried out wherein the implant stability was recalculated considering the heterogeneity was statistically significant. After da Silva Neto et al’s study\(^{13}\) was excluded, the test showed that the piezoelectric group had better stability in the 12th week ($P = .02; I^2 = 0\%, P = .87$; Fig 5).

Two studies provided the information of implant stability in the eighth week, and the test showed that the piezoelectric group had better stability in the eighth week ($P = .0004; I^2 = 0\%, P = .80$; Fig 6).

**DISCUSSION**

In this review, three studies assessed the stability of implants. The test showed that there was no statistically significant difference ($P = .55$) in implant stability in the 12th week between two methods. The heterogeneity ($I^2 = 76\%, P = .02$) was so obvious that one study\(^{13}\) was excluded and a sensitivity analysis was conducted. The final test showed that the piezoelectric group had better stability in the 12th week ($P = .02; I^2 = 0\%, P = .87$). This might result from piezosurgery generating less heat compared to conventional drilling with the same drilling parameters,\(^{17}\) which did less harm to osteoblasts and osteocytes and promoted bone regeneration.

Some studies\(^{18,19}\) have illustrated that the drilling processes result in decreasing ISQ values within the first period of healing, and the ISQ values tend to increase with fresh bone forming at the bone-implant interface. In the study by Canullo et al,\(^{14}\) the implant stability decreased during the first 3 weeks in the control group and ISQ values tended to increase just after 8 weeks. On the contrary, in the test group, the implant stability increased continuously throughout the observation period. In the study by Stacchi et al,\(^{15}\) ISQ values decreased in both groups during the first period. However, the lowest ISQ peak was at 21 days in the control group, while ISQ values of the test group began to increase after 14 days. These authors concluded that piezosurgery leads to a limited decrease of ISQ values and in an earlier shifting from a decreasing to an increasing stability pattern, when compared with the traditional drilling technique.\(^{15}\)

Animal studies also showed that the piezosurgery was beneficial to bone healing rates and gave higher implant primary stability in the cancellous bone region, while the drill technique produced better results in the cortical bone.\(^{20,21}\) In this review, three studies performed implantation in the maxillary premolar or posterior region, and one study\(^{14}\) was conducted in the mandibular molar region. It is well known that the maxilla is mainly cancellous and the mandible is mainly cortical. All of these studies achieved favorable results in the piezosurgery group, regardless of maxilla or mandible, which contradicted the animal study. Unfortunately, none of the included studies applied piezosurgery in both cancellous bone and cortical bone, and compared the results.

Within the limit of this review, it hinted that implants inserted by piezoelectric inserts and traditional rotary instruments had the same survival rate. However, piezoelectric implant site preparation may inhibit peri-implant bone tissue inflammation and promote bone tissue healing,\(^{22}\) and larger-sample research is needed to confirm or disprove the above conclusion. Studies suggested that compared with traditional
rotary instruments, the piezoelectric bone surgery technique did better in accuracy and uniformity of the osteotomy cut. On the other hand, compared with conventional drilling instruments, implant site preparation through piezosurgery consumes more time, which may
result from lower drilling speed and feed rate. Ultrasonically assisted drilling with frequency below 20 kHz could generate less heat compared to conventional drilling with the same drilling parameters. However, when vibration frequency exceeded 20 kHz, the temperatures generated were significantly higher than those in traditional drilling.\(^{17}\) Additionally, piezoelectric implant site preparation could preserve bone microarchitecture and increase attrition of metal particles. Thus, vast irrigation is extremely important for piezoelectric implant site preparation.\(^{26}\)

To sum up, piezosurgery may do better in the cancellous bone region, which needs low frequency and generates less heat. Piezosurgery also needs to be studied further to explore its advantages over the conventional drilling instruments.

CONCLUSIONS

Within the limitations of this review, the survival rate of implants may not be influenced by the site preparation techniques (piezoelectric vs conventional), but the piezoelectric group may achieve better stability than the conventional group.

ACKNOWLEDGMENTS

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REFERENCES