Detection of dentinal cracks after use of piezoelectric device and surgical bur during root-end resection: An ex vivo comparative study

Yaser Dalaan Abdulraheem, Raif Rashad Marqoshi, Mohsen Hasan Daghestani, Hussain Nasser Almashhadi, Mohamed AhmedRefky Ibrahim, Majed Abdullah Almalki

Jeddah Specialty Dental Center, Ministry of Health, Dental Department, King Abdullah University for Science and Technology Health, Fakeeh Care, Dental Department, Ministry of Health, Al Thagher Hospital, Jeddah, Ministry of Health, Primary Health Care Dental, Tabuk Health Affairs, Department of Restorative Dentistry, Faculty of Dentistry, Umm Al-Qura University, Makkah, Saudi Arabia

Abstract

Introduction: The piezoelectric device was implemented successfully in many oral and maxillofacial surgeries. However, in endodontic surgery, it is not widely used due to lack of scientific support. Thus, the aim of the conducted study was to compare the formation of the cracks of roots resected with piezoelectric surgery versus high-speed surgical bur using scanning electron microscopy.

Materials and Methods: Sixty single-rooted human teeth were accessed followed by canal preparation with rotary files and filled with gutta-percha. The teeth were mounted on plastic cylindrical test tubes and emerged within the impression material to simulate periodontal ligament. Consequently, the teeth were divided into three groups: the control group (n = 10), piezoelectric group (n = 25), and the surgical bur group (n = 25). The surface of the resected root was examined under scanning electron microscopy for cracks detection. The one-way analysis of variance test was used to investigate the number and types of cracks at a significance level of 95%.

Results: Dentinal cracks were detected in all groups. However, there was no statistically significant difference in the number of cracks between the three groups, but they differed in terms of crack type.

Conclusions: All tested groups produce cracks on resected root surface, whereas the piezoelectric presented with satisfactory result.

Keywords: Apical surgery, cracks, piezosurgery, root-end resection, root-end surface

INTRODUCTION

Apical surgery is an essential treatment option for apical periodontitis if nonsurgical retreatment or certain primary root canal treatments have failed. Such cases include extraradicular factors such as cysts, colonization of apical root surface by microorganisms, bacteria within the lesion itself, or foreign body reaction, or in some cases of persistent intraradicular infection, following iatrogenic errors. The purpose of the endodontic surgery procedure...
is to expose the affected root tip and the periapical tissue with the treatment aim to restrain and remove a potential intraradicular infection. This procedure is accomplished by resecting a 3 mm of the apical root tip to remove most of the unfilled and unprepared accessory canals and then to seal it by suitable and biocompatible root-end filling material.

The root-end resection as a procedure should be nearly at a perpendicular angle to the root long axis that resulted in a shallow bevel angle (0°–10°), which reduces the exposure of the dentinal tubules and consequently decreases the apical leakage. Many attempts have been made to find the ideal techniques, instruments, and devices for root-end resection. Numerous studies examined whether there were cracks after root-ended resected on the surface with different tools such as a diamond bur, Lindemann bur, multipurpose bur, erbium-doped yttrium aluminum garnet (Er: YAG) laser, fissure tungsten carbide bur, and diamond-coated ultrasonic tips. Saunders et al. reported that cracking of the root-end surface was observed more often after ultrasonic root-end preparation than after preparation with a round bur in a slow-speed hand-piece. Further, Rainwater et al. found that cracks occurred in 85% of the teeth after the root-end resection and 68% of the teeth after using a high-speed hand-piece diamond bur and ultrasound to prepare the cavity. Ayranci et al. concluded that the Er: YAG and tungsten carbide bur produce fewer cracks on the resected root surface than the diamond-coated ultrasonic tip. However, these dentinal cracks and defects may be of concern when there are bacterial residues present.

Piezoelectric instruments have been used safely in oral surgery. The selective cutting effect is one of the most innovative features of piezoelectric surgery. As the Piezoelectric technology’s precision and soft tissue-sparing system for bone cutting is based on microvibrations ultrasound energy, it reduces the soft tissue injuries. Therefore, not only in the field of oral surgery, as in other specialties, but also in the field of modern endodontic surgery, the implication for piezoelectric has increased recently. Del Fabbro et al. studied the piezoelectric device on the cadaver’s teeth, with various operating modes provided by the device and different power settings to perform retrograde cavity preparation. They found that the oscillating piezoelectric tip during constant vibration mode causes a fewer number of cracks than the vibration + pulsation mode. In contrast, there was no difference when the piezoelectric tip operated in a constant vibration mode with different power settings, regarding dentinal crack formation on the resected root surface. Piezotome® 2 (Satelec Acteon, Mérignac, France) is one of the devices that motorized instruments with ultrasonic vibrations employing a piezoelectric transducer. However, there is a lack of studies investigating the formation of the cracks on the resected root-end by piezoelectric (Piezotome® 2). Therefore, the present study aims to compare the formation of the cracks of roots resected with piezoelectric surgery versus high-speed surgical bur by analyzing the root-end surface with scanning electron microscopy (SEM).

MATERIALS AND METHODS

Approval for this project was obtained from the local institutional review board (IRB) in Jeddah Health Affairs according to the KACST (GCP) regulations (IRB registration number: KSA: H-02-J-002 and the research number is: 1322).

Teeth preparation

Seventy extracted maxillary and mandibular anterior and bicuspide teeth were collected from oral surgery clinic. The extracted teeth were stored in a 10% formalin solution until used. The reasons for the extraction were periodontal disease and orthodontic treatments. The teeth were assessed with radiographs and under a dental operating microscope (OPMI Pico Dental Microscope; Zeiss, Oberkochen, Germany). Teeth were selected based on the followings: no restoration, root filling, cracks, root fracture, or immature apex. Finally, 60 teeth were selected.

Root canal preparation

Access cavity was performed for all teeth using #2 and #4 high-speed round carbide bur (Meisinger, Hager and Meisinger GmbH, Germany). Under the dental operating microscope, a hand file #10 (Mani, Tochigi, Japan) was inserted into the canals until its tip was just visible at the apical foramina and then 1 mm subtracted to determine the working length. All specimens were radiographed in a buccolingual direction using a periapical digital oral sensor (Gendex™ GXS-700; Gendex Dental Systems, Hatfield, PA, USA) to confirm the working length. Following the manufacturers’ instruction, canals were cleaned and shaped with a ProTaper Next rotary system (Dentsply Tulsa Dental Specialties/Dentsply Maillefer) to the determined working length to size X2 (25/0.06 v). Throughout the instrumentation, all root canals were copiously irrigated with 1% sodium hypochlorite (Master-X Bleach, Portland, OR). All canals were filled with ProTaper Next Conform Fit Gutta-Percha Points (Dentsply Tulsa Dental Specialties/Dentsply Maillefer) along with ADSEAL® Resin-Based Sealer (Meta-Biomed, Cheongwon, Korea) using vertical compaction technique. Thereafter, final

Abdulrahim, et al.: Root-end resection with piezoelectric device

[Downloaded free from http://www.saudiendodj.com on Sunday, September 12, 2021, IP: 84.235.85.233]
radiographs were taken and another assessment by the dental operating microscope for root fracture and cracks was carried out to exclude any teeth with defects.

**Periodontal ligaments simulation and supporting structure**

Sixty plastic cylindrical test tubes were prepared as follows to simulate the periodontal ligament of each tooth samples. The (Express 3M-ESPE, Germany) was mixed and placed into the plastic tubes. Afterward, teeth crowns were immersed within the impression material leaving nearly 5 mm of root tips exposed. Before root-end resection, a fixation device with two ends was used with each sample. This device intends to hold the tube from one side and to firmly grasp a stable object from another side [Figure 1].

**Root-end resection**

Teeth were randomly divided into three groups according to the methods of resection:

- **Group 1 (control):** root end was resected with a water-cooled high-speed diamond saw. The resected site was irrigated with saline solution during the cutting procedure \( n = 10 \)
- **Group 2 (Piezoelectric):** root end was resected with a Piezotome® 2 device with the Ninja™ tip (Satelec Acteon, Merignac, France). The recommended power mode by manufacture was set at D1 and fine setting #3 with a controlled irrigation flow rate of 80 ml/m by saline. The cuts were made horizontally with the lowest pressure possible, in back and forth movement \( n = 25 \)
- **Group 3 (surgical bur):** root end was resected horizontally with multi-purpose bur made of tungsten carbide (Dentsply, Maillefer), which was 23 mm long and had 11 mm of cutting flutes. A high-speed hand-pieace was used with a profuse amount of water spray \( n = 25 \).

All the root tips were resected about 3 mm perpendicular to the long axis of each root.

**Scanning electron microscopy**

The resected teeth were kept at room temperature for drying. Then, the teeth were mounted using silver paint (Agar G302, Stansted, UK) on an aluminum stub and coated with platinum (Q150T ES, West Sussex, UK). The specimens were analyzed, and digital images were taken in an Ultra 55 field emission SEM at 5 kV using the SE2 detector (Zeiss, Oberkochen, Germany).

**Data collection and scanning electron microscopy micrographic analysis**

Two independent, calibrated, and blinded evaluators interpreted and scored the cracks from the photomicrograph images. When there is a disagreement between them, a third evaluator made the final decision. Each evaluator interpreted every photomicrographic image twice with 2 weeks’ interval.

The following evaluation criteria were proposed and used to determine the location, number, and type of cracks [Figure 2]:

- **Type I:** External complete – Starting from the external surface and ending on the other side without passing the root canal
- **Type II:** External incomplete – Starting from the external surface and ending in dentin
- **Type III:** Intradaental – Starting from dentin and ending in dentin
- **Type IV:** Canal complete – Starting from the canal and ending on the external root surface
- **Type V:** Canal incomplete – Starting from the canal and ending in dentin.

**Statistical analysis**

The data were analyzed using the Kolmogorov–Smirnov test to evaluate the normality assumption. The one-way analysis of variance test was used to investigate the number and types of cracks at a significance level of 95% managed by SPSS software (v22.0) (IBM Corp, Armonk, NY, USA).
Abdulraheem, et al.: Root-end resection with piezoelectric device

RESULTS

One sample from the bur group was excluded due to a fracture that occurred during preparations for the SEM analysis. The two calibrated observers had high degrees of intraexaminer agreement (Kappa scores: 0.83% and 0.91%) and substantial interobserver agreement (Kappa scores: 0.76%).

Table 1 summarizes the results for the total number of cracks of each tested group. Cracks were observed in all groups. The ANOVA test showed no significant difference between the three tested groups ($P > 0.05$). Nevertheless, in the surgical bur group, the number of cracks was slightly higher than other tested groups, followed by the piezoelectric group.

Five distinct crack types are presented in Figure 3. The distribution of crack types among tested groups is demonstrated in Figure 4. The ANOVA test showed no significant difference between tested groups concerning the type of crack formation ($P > 0.05$) [Table 2]. However, the most common type of crack observed was Type IV.

In the piezoelectric group, the most common crack type was Type IV, followed by Type II, and the least amount was Type I. However, in the surgical bur group, Type II was the most common type of crack found, followed by Type V, and the Type I is the least.

DISCUSSION

Apicoectomy is considered one of the last options to save teeth with a relatively high success rate. Through the years, clinicians have adopted modern technologies and instruments, such as the use of the dental microscope and ultrasonic tips in endodontic microsurgery; this has considerably improved the success rate to approximately 90%. Recently, a piezoelectric device has been used in oral surgery such as in the sinus lift procedure, since it plays an important role in reducing the risk of Schneiderian membrane perforation. This technology is used in apicoectomy procedures involving bone removal and resecting the root.

Table 1: Total number, mean, and standard deviation values of cracks among the three tested groups in resected root surface

<table>
<thead>
<tr>
<th>Groups</th>
<th>Total number of cracks</th>
<th>Mean±SD</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>12</td>
<td>1.2±0.79</td>
<td>0.39</td>
</tr>
<tr>
<td>Piezo</td>
<td>39</td>
<td>1.63±1.56</td>
<td></td>
</tr>
<tr>
<td>Bur</td>
<td>50</td>
<td>2±1.85</td>
<td></td>
</tr>
</tbody>
</table>

SD: Standard deviation

Table 2: Frequency of crack types within each tested group on the resected root surface

<table>
<thead>
<tr>
<th>Groups</th>
<th>Crack types</th>
<th>Control</th>
<th>Mean±SD</th>
<th>Group A</th>
<th>Mean±SD</th>
<th>Group B</th>
<th>Mean±SD</th>
<th>One-way ANOVA test $(F, P)$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type I</td>
<td>0.20±0.42</td>
<td>0.08±0.41</td>
<td>0.20±0.50</td>
<td>0.475, 0.625</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type II</td>
<td>0.30±0.67</td>
<td>0.38±0.82</td>
<td>0.60±0.87</td>
<td>0.682, 0.510</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type III</td>
<td>0.20±0.63</td>
<td>0.33±0.64</td>
<td>0.36±0.70</td>
<td>0.213, 0.809</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type IV</td>
<td>0.50±0.85</td>
<td>0.54±0.72</td>
<td>0.52±0.82</td>
<td>0.011, 0.989</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type V</td>
<td>0.00±0.00</td>
<td>0.29±0.81</td>
<td>0.32±0.90</td>
<td>0.642, 0.530</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1.20±0.79</td>
<td>1.63±1.56</td>
<td>2.00±1.85</td>
<td>0.953, 0.392</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SD: Standard deviation, ANOVA: Analysis of variance
The SEM analysis showed that all groups contained cracks. However, the results showed no statistically significant difference between the groups in terms of the number of cracks. Only one study investigated the root‑end surface after retrograde cavity preparation performed with a piezoelectric device. The results showed fewer cracks significantly in constant vibration mode than vibration + pulsating mode of the piezoelectric device. Nevertheless, in the current study, the root‑end surfaces were investigated after root‑end resection without retropreparation.

Ayranci et al. used SEM after root‑end resection to detect the cracks on the resected surface after using the Er: YAG laser, tungsten carbide bur, and diamond‑coated tip (connected to the hand‑piece of a conventional ultrasound device). They concluded that the diamond‑coated tip produces a higher number of cracks when compared to the Er: YAG laser and tungsten carbide bur. However, in the present investigation, the total number of cracks identified by SEM in the Piezotome® 2 group was fewer than the surgical bur group. Hence, it is possible to hypothesize from the present and Ayranci et al.’s study that piezoelectric technology produces better surface cutting after root resection when compared to conventional ultrasonic devices. Further investigation is needed to test the hypothesis.

The present study compared the frequency of cracks using two parameters; the number and type of crack formation. The results shows that all five types of cracks were noticed in all tested groups have. Few studies examined the different types of cracks produced after root‑end resection. Ayranci et al. found that the majority of crack type was intradentinal, which represents Type III in the present classification. That contradicts with the present result, as the Type IV was the most common type of crack observed. This could be due to different methodologies and the crack types definitions.

This study has some limitations. First, the dentinal cracks formed during orthograde root canal instrumentation cannot be avoided. Karataş et al. showed that the ProTaper Next and TF Adaptive rotary systems produced significantly fewer cracks than the ProTaper Universal and WaveOne systems in the apical one third. Accordingly, teeth were shaped using the ProTaper Next X2 in the present study. Furthermore, De Bruyne and De Moor reported that one of the limitations of the in vitro approach is the loss of periodontal support, which absorbs forces generated by the ultrasonic device. In the present ex vivo investigation, the conducted methodology tried to mimic a clinical situation by impeding the tooth in an impression material to simulate the periodontal ligament. Moreover, the tooth was stable with the fixation device to avoid any possible vibration movement during root‑end resection. Finally, improper teeth storage or handled may cause alternations of the dentin structure.

CONCLUSIONS

Within the limitation of the current study, all tested methods of root‑end resection resulted in visible cracks on the resected surface. However, fewer cracks formation was produced by piezoelectric when compared with a surgical bur. Moreover, there is no difference in cracks. Piezoelectric may be a suitable alternative to the conventional surgical bur in root‑end resection.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

Abdulraheem, et al.: Root-end resection with piezoelectric device


