ORIGINAL ARTICLE

Assessment of root surfaces of apicected teeth: A scanning electron microscopy evaluation

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Abstract

Objectives: The aim of this study was to determine the apical surface characteristics and presence of dental cracks in single-rooted premolars, resected 3.0 mm from the root apex, using the Er: YAG laser, tungsten carbide bur, and diamond-coated tip, by scanning electron microscopy (SEM).

Experimental design: Thirty single-rooted premolar teeth were collected. The instrumented and obturated teeth were divided into three groups according to the root resection method (2.94 μm, 100 mj, 20-Hz Er: YAG laser, plain tapered fissure tungsten carbide bur at a low speed of 40,000 rpm, or a diamond-coated SG6D tip coupled to the handpiece of a conventional ultrasound device). The specimens were prepared for SEM and analyzed by the Kruskal–Wallis and Mann–Whitney statistical tests.

Results: The SEM images showed that tungsten carbide burs produced significantly smoother resected root surfaces than the diamond-coated tip. There was no statistically significant difference between the Er: YAG and tungsten carbide bur groups. The analysis of scores obtained for the cut quality by the Kruskal–Wallis test revealed no significant differences among the groups. In our study, five teeth had no cracks after the apical resection. The mean number of cracks per tooth was 3.5 ± 1.780 (Er: YAG laser group), 2.5 ± 1.716 (tungsten carbide bur group), and 4.5 ± 2.593 (diamond-coated tip group).

Conclusions: Under the tested conditions smoother surfaces were observed in the groups treated with the tungsten carbide bur and Er: YAG laser when compared with the diamond-coated tips.

Key words: Apicoectomy, dental cracks, Er: YAG Laser, surface roughness

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Introduction

During the last decade, technological improvements have been represented in root canal therapy. However, biological factors can reject these improvements, and therefore, failure may occur.[1,2] If nonsurgical treatment has failed, periradicular surgery must be chosen to keep the treated teeth in the mouth.

Many dental root canal systems have unreachable fields like isthmi, lateral canals, and ramifications in the apical 3 mm. Sometimes these fields may obstruct the essential eradication of infection by the orthograde root canal treatment.[3] Thus, the goal of the apical root resection is to eliminate the infection originating from the root canal and the ramifications of the root canal system, as well as to specify whether the root canal obturation is sufficient in this region.[2]

Apicoectomy is associated with mucoperiosteal flap elevation, followed by osteotomy, to approach the periapical region. Root-end cavity preparation and retrograde

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filling are often performed in the surgical procedure.[1] During resection, an adequate method should be used to provide a more regular and smooth apical surface. At the same time, this method should minimize displacement of the obturation.[2]

Apical anatomy studies indicate that the root apex should be resected 2 to 3 mm during surgical procedures, to remove most of the unprepared and unfilled accessory canals and eliminate the potential reservoir for pathogens.[4,5] Numerous techniques and instruments have been recommended and evaluated in literature, to obtain the ideal method for apical surgery.[2,6,7] Nedderman *et al*.[6] compared different burs at high and low speeds and found that low-speed, plain fissure burs produced more regular and smoother root-end surfaces when compared with the crosscut fissure burs used at high and low speeds.

Laser techniques have also been used for apicoectomy and the preparation of retrograde cavities. This has some advantages over burs, such as, disinfection of the surgical site, absence of vibration (therefore, increased patient comfort), anti-inflammatory effects, and reduction of exposed dentinal tubules, which may prevent the leakage of microorganisms and their products. However, when the laser was used, root-end resection took longer and produced rougher surfaces compared to the burs.[2]

Ultrasonic devices have been used more frequently for root-end cavity preparation than carbide or diamond burs.[8-11] Recent studies have proved the presence of root end cracks after ultrasonic preparations.[12,13] Layton *et al*.[12] have demonstrated a greater number of cracks following root resection and ultrasonic root-end preparation, when compared with root resection alone. These microfractures can affect the healing process around the root, and induce failure due to microleakage.[11,14,15]

Bernardes *et al*.[16] compared the time, factures, and quality of apical cavity preparation, using chemical vapor deposition-coated (CVD-coated) Trinity and Satelec ultrasonic diamond tips. In the CVD tip group, better quality and shorter preparation time were determined. In another study Bernardes *et al*.[1] compared the required time using the ultrasonic CVD-coated tip versus high and low-speed carbide burs, for apicoectomy. The required time was significantly shorter for the high speed bur group than for the CVD tip. Despite this, literature is scarce on studies evaluating the use of ultrasound-activated instruments for apicoectomy; therefore, ultrasonic root-end resection in endodontic surgery should be researched.

The main goal of the present study is to compare the surface characteristics of roots resected with the Er: YAG laser, plain tapered fissure tungsten carbide bur at low speed, and the diamond-coated SG6D tip, used with the conventional ultrasonic device, by scanning electron microscopy.

Materials and Methods

Thirty freshly extracted single-rooted mandibular premolars were selected for the study. After extraction, all teeth were stored in sterile distilled water at 37°C. Teeth with intact roots and mature apexes were selected. Before preparation, the debris and soft tissue remnants were removed from the root surface. The crowns were resected with a diamond fissure bur in a high speed handpiece, below the cementoenamel junction. A size #10 stainless steel K-file (Mani, INC, Tochigi, Japan) was moved down into the canal until the file was just visible. Endodontic working lengths were set by deducting 1 mm from these lengths. The root canals were instrumented by a mechanical–rotary method using a Hero shaper (Micromega, Bestnea, France) instrument. Instrumentation was performed according to the easy canal morphology procedure described by the manufacturer. During instrumentation, ethylenediaminetetraacetic acid (EDTA) gel was used and the root canals were irrigated with 1% NaOCl, between instrument changes. All irrigating procedures were performed by using 31 ga sideport irrigator tips (NaviTip, Ultradent, USA). The specimens were dried with sterile absorbent paper points after receiving a final irrigation with 5 ml of 15% EDTA (Wizard, Rehber Kimya San. ve Tic, A.S., Istanbul, Turkey) for one minute, followed by 1% NaOCl. After preparation, the root canals were filled with laterally condensed gutta-percha and AH Plus root canal sealer. Following obturation, the gutta-percha was removed from the coronal cavity with a warm instrument. The coronal openings were sealed with glass ionomer cement and stored in sterile distilled water at 37°C and 100% humidity for one week, in order to complete the setting time.

The teeth were randomly divided into three groups of 10 teeth each according to the root-resection method. In group 1 the roots were resected perpendicular to the long axis, 3 mm from the apex, using a 2.94 μm, 100 mj, 20-Hz Er: YAG laser (Doctor Smile erbium and diode laser, Lambda Scientifica S.r.l, Vicenza, İtaly) irradiation, under sterile distilled water irrigation, forming a 90° angle with the longitudinal axis of the tooth. In group 2 the roots were resected perpendicular to the long axis, 3 mm from the apex, using a plain tapered fissure tungsten carbide bur (Ela, Thuringia, Germany) at low speed (40,000 rpm). In group 3 a diamond-coated SG6D tip (NSK Variosurg, Japan) coupled to the handpiece of a conventional ultrasound device (NSK Variosurg, Japan) at the S mode and medium power intensity was used for resection. Following the apicoectomies, the resected surfaces were carefully treated with 15% EDTA solution.

The resected teeth were stored at room temperature for drying, and then mounted on metallic stubs, sputter-coated

with gold, and examined with the SEM (EVO LS10, Zeiss, Oberkochen, Germany). SEM photomicrographs were taken at X100 and X350 magnifications for assessment of the quality of the cut and analysis of surface roughness. The scores shown in Figure 1 were used for the analysis of surface roughness.

Two calibrated blinded examiners analyzed and scored them. The presence of cracks was determined by one single observer using photomicrographs.

The following rating system proposed by Beling *et al*.[17] was used:

- Complete cracks extended from the canal space to the external root surface
- Incomplete cracks extended from the canal space into the dentin, for a variable distance, without reaching the external root surface
- Intradentinal cracks appeared to proceed in the vestibular-lingual or mesial–distal region to the root canal.

Results

Table 1 shows the scores attributed to the specimens of each group for the evaluation of surface roughness by the two examiners. The Kendall test showed a high inter-examiner agreement. The analysis of the scores obtained for the surface roughness by the Kruskal–Wallis test determined significant differences among the groups ($P < 0.05$). Tungsten carbide burs produced significantly smoother resected root surfaces than the diamond-coated tip ($P < 0.05$). The Er: YAG laser produced significantly smoother resected root surfaces than the diamond-coated tip ($P < 0.05$). However, there was no statistically significant difference between the Er: YAG and tungsten carbide bur groups. The analysis of scores obtained for the cut quality by the Kruskal–Wallis test revealed no significant differences among the groups ($P > 0.05$). The Er: YAG laser produced a better cut quality than the other groups, but this difference was not statistically significant ($P > 0.05$). Table 2 shows the scores obtained in the assessment of cut quality by the two examiners.

Following resection of the specimens, 105 cracks were observed. Figure 2 shows the cracks on the resected root surface. Table 3 shows that the mean number of cracks per tooth was higher in the diamond-coated tip group compared to the other groups. Intradentinal cracks were observed the most when evaluated as a percentage. A total of five teeth had no cracks, 11 teeth had complete cracks, 23 teeth had incomplete cracks, and 20 teeth had intradentinal cracks. The mean number of cracks per tooth was 3.5 ± 1.780 for the Er: YAG laser group, 2.5 ± 1.716 for the tungsten carbide bur group, and 4.5 ± 2.593 for the diamond-coated tip group. Photomicrographs from groups for observing exposed dentinal tubules after resection are shown in Figure 3.

Discussion

Root-end resection is a common controversial part of endodontic surgery.[18] In literature, there are many specified indications for root-end resection. These indications may be classified as biological or technical.[19]

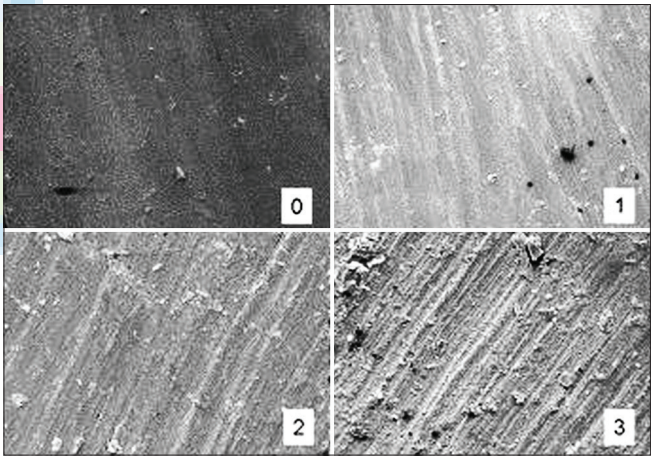

Figure 1: Scores used for the analysis of surface roughness (x400 magnification)

Table 1: Scores attributed to the specimens of each group for the analysis of surface roughness

Specimen	Er: YAG laser		Tungsten carbide bur		Diamond coated tip	
	Examiner 1	Examiner 2	Examiner 1	Examiner 2	Examiner 1	Examiner 2
1	2	2	1	1	3	3
2	1	1	1	0	3	3
3	1	1	0	0	2	2
4	1	2	1	0	2	2
5	1	0	2	1	3	3
6	3	2	2	2	2	3
7	2	2	0	2	2	2
8	1	2	0	0	3	2
9	1	1	1	1	3	2
10	2	2	2	2	2	2

0=smooth surface, 1=Surface with slight roughness, 2=Surface with moderated roughness, 3=Surface with severe roughness

El-Swiah and Walker[20] reported that biological factors constituted 60% of all the factors, whereas, technical factors constituted 40%. The most common biological factors were persistent symptoms and the progressing presence of a periradicular lesion, and the most common technical factors were interradicular posts, crowned teeth without posts, irreparable root canal filling materials, and procedural accidents.

There are three important factors the surgeon has to decide before processing a root-end resection. These are, instrumentation, extent of root-end resection, and angle of resection.[19]

In the present study, the diamond-coated SG6D tip (coupled to the handpiece of a conventional ultrasound device), plain tapered fissure tungsten carbide bur, and Er: YAG laser were used for performing root-end resection.

Table 2: Scores obtained in the assessment of cut quality by two examiners

	Score			
	1	2	3	4
Er: YAG laser	9	6	3	2
T.Carbide bur	3	9	6	2
Diamond coated tip	3	8	8	1

1=Almost complete gutta-percha adaptation, smooth surface, 2= Moderate gutta-percha adaptation, smooth surface, 3=Poor gutta-percha adaptation, smooth surface, 4=No gutta-percha adaptation, smooth surface

Table 3: Cracks in resected root surfaces

Groups	Mean±SD	Comp. (%)	Incomp. (%)	Intraden. (%)	Total
Er: YAG laser	3.5±1.780	7 (20)	14 (40)	14 (40)	35
Tungsten carbide bur	2.5±1.716	6 (24)	10 (40)	9 (36)	25
Diamond coated tip	4.5±2.593	1 (2)	19 (42)	25 (56)	45

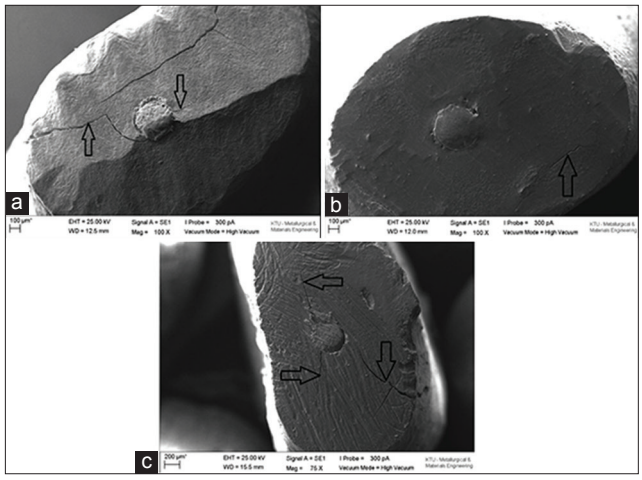

Figure 2: (a) Root apex with incomplete cracks shown with arrows, (b) Root apex with intradentinal crack, (c) Root apex with complete crack shown with upward looking arrow, incomplete crack shown with downward looking arrow

The ultrasound has been used in the preparation of root-end cavities for retrograde filling, because it offers a safer and regular preparation, without causing alterations in the apical root anatomy.[16,21,22] However, there is only one report on the use of ultrasonic tips for root-end resection. In that report they found that carbide burs produced significantly smoother root-end surfaces than the ultrasound-activated CVD coated tips, and the time required for apicoectomy with the low speed bur was significantly shorter than that needed for the CVD tip.[1] In this study, carbide burs produced significantly smoother root-end surfaces than the diamond-coated SG6D tip. The same results, as shown in the previous study, were determined in our study.

Nedderman *et al*.[6] used the SEM for assessment of the resected root surfaces and gutta-percha fillings following root-end resection, with several burs, using low and high speed handpieces. Plain fissure burs produced the smoothest resected surfaces when used with both high and low handpieces. Using the plain fissure bur and low speed handpiece resulted in the least gutta-percha distortion. Komori *et al*.[23] evaluated the use of the Er: YAG laser and Ho: YAG laser for root-end resections. They showed that the Er: YAG laser produced smooth, clean resected root surfaces without thermal damage. In a different study, Komori *et al*.[22] used the Er: YAG laser for root-end resections on eight patients. Although the cutting speed of the laser was slower than with the use of burs, the advantages of the laser subsumed the absence of discomfort and vibrations, less chance for contamination of the surgical region, and a decreased risk of trauma to close tissues.[22] The use of a laser has also been shown to reduce apical dentinal permeability.{Oliveira, 2004 #32}{Oliveira, 2004 #32}{Oliveira, 2004 #32}{Oliveira, 2004 #32}{Oliveira, 2004 #32}[24] According to the results of our study, the Er: YAG laser produced a rougher resected root surface when compared

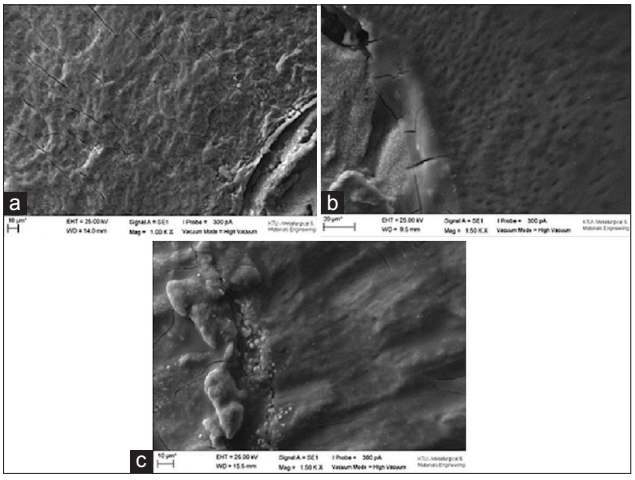

Figure 3: (a) Photomicrographs from the Er: YAG laser group for observing exposed dentinal tubules after resection, (b) Photomicrographs from the Tungsten carbide bur group for observing exposed dentinal tubules after resection, (c) Photomicrographs from Diamond-coated tip group for observing exposed dentinal tubules after resection

with the carbide burs. This finding is probably due to the pulsed cutting mode of the laser, disallowing the uniform cutting of dentin.[2]

In the present study, the apical 3 mm of the roots, with an angle of 90°, were resected. This measure would allow for a better-quality of cut, reduce apical ramifications by 98%, and lateral canals by 93%.[25] Gangliani *et al*.[26] evaluated the apical leakage in extracted teeth with root-end resection at 45° and 90° angles from the long axis of the root. They reported that the exposed dentinal tubules increased by increasing the angle of the root-end resection, therefore, apical leakage increased when the 45° angle was used. In accordance with this study we preferred to use a 90° angle from the long axis of the root for root-end resection.

It was demonstrated that in laser resections, bubbles could occur in the gutta-percha structure, which could result in an irregular adaptation of the filling material to the root walls.[25] In our study, no statistically significant difference was found between the groups.

A total of 105 cracks were identified in 30 roots when evaluated by using the SEM. Intradentinal canal cracks were the most observed cracks (45.7%) among the crack types. As the resection plane (3 mm from the apex) was only used for crack identification, it could be speculated that incomplete canal cracks might be complete canal cracks.[27] At the same time, it has been shown that instrumentation during orthograde root canal preparation could lead to cracks, especially in the apical area.[28] However, the clinical significance of dentinal cracks identified during apical surgery or root canal instrumentation has not yet been clarified, a complete canal crack might contribute to leakage resulting in the recurrence of periapical infection and might explain surgical (and also nonsurgical) failures.[29]

In summary, it can be stated that the tungsten carbide bur and Er: YAG laser groups produce better apical root surfaces than the diamond-coated tip. Within the limitations of this study, we can also conclude that the diamond-coated tip provokes a larger number of cracks when compared to the Er: YAG laser and tungsten carbide bur.

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