

EFFECT OF SPUTTER-COATING ON CRACKING OF ROOT-END SURFACES AFTER ULTRASONIC RETROGRADE PREPARATION - A SEM STUDY OF RESECTED ROOT APICES AND THEIR RESPECTIVE IMPRESSIONS

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ABSTRACT

The aim of this study was to evaluate *in vitro* the effect of sputter-coating for SEM analysis on the formation of cracks on root-end surfaces after retrograde cavity preparation with ultrasonic tips. Root-end cavities were prepared with either Satelec S12/90°D diamond-coated or S12/90° non-coated stainless steel retreatips.

Impressions were taken before and after retrograde cavity preparation. The resected root apices and their respective impressions were examined using a scanning electron microscope, and the presence, extension and numbers of cracks were recorded after each procedure.

The number of cracks observed directly on the ultrasonically prepared root-end surfaces was larger than that observed in their respective impressions taken after root-end cavity preparation, which suggests that cracking was mostly produced by the sputter-coating process required for SEM analysis. Impressions of the root-end cavities prepared with non-coated ultrasonic stainless steel retreatips showed a greater incidence of cracks (3/10 impressions) than those that replicated cavities prepared with diamond-coated retreatips (1/10 impressions). No statistical difference was found between the diamond and stainless steel retreatips.

Key words: ultrasonic, root canal therapy, tooth apex, microscopy.

EFFECTO DEL METALIZADO SOBRE LA FORMACIÓN DE FRACTURAS EN RETROPREPARACIONES APICALES REALIZADAS CON ULTRASONIDO. ESTUDIO CON MICROSCOPIA ELECTRÓNICA DE BARRIDO SOBRE ÁPICES Y SUS IMPRESIONES

RESUMEN

El objetivo del presente estudio fue evaluar *in vitro* el efecto del proceso de metalización de la dentina, necesaria para la observación al microscopio electrónico de barrido, sobre la formación de fracturas dentinarias en retropreparaciones apicales realizadas con ultrasonido.

Se realizaron retropreparaciones apicales en 20 piezas dentarias utilizando puntas ultrasónicas diamantadas Satelec S12/90° D (N=10) o puntas no diamantadas Satelec S12/90°. Se tomaron impresiones con silicona antes y después de que fueran realizadas las retropreparaciones. Los ápices radiculares y sus respectivas impresiones fueron metalizados y examinados utilizando un microscopio electrónico de barrido. La presencia, extensión y número de fracturas en la dentina fue registrada después de cada procedimiento.

El número de fracturas observados en la dentina en las retropreparaciones fue mayor que el observado en las impresiones tomadas después de realizado el procedimiento ultrasónico, lo cual indica que gran cantidad de fracturas en la dentina fueron producidas por el proceso de metalización requerido para el análisis al microscopio electrónico de barrido y no por el procedimiento ultrasónico. El análisis de las impresiones mostró una mayor incidencia de fracturas cuando se utilizaron las puntas ultrasónicas no diamantadas (3/10) que cuando se utilizaron las puntas ultrasónicas diamantadas (1/10). Sin embargo, la diferencia no fue estadísticamente significativa ($p > 0.05$).

Palabras clave: ultrasonido, tratamiento de los conductos radiculares, cirugía apical, microscopía.

INTRODUCTION

Endodontic surgery can be defined as the surgical procedure that aims to treat complications unsolved by conventional root canal treatment^{1,2}. Apicoectomy combined with retrograde filling is one of the most widely performed endodontic surgical procedures. The ideal root-end cavity preparation can be

described as at least 3-5 mm deep class-I cavity, with walls parallel to the long axis of the root. This regularly shaped cavity should incorporate the root canal anatomy and should retain the retrograde filling material¹. The use of ultrasound-activated tips for root-end cavity preparation improves this procedure since less removal of bone tissue is required to

gain proper access to the apical region. Also, the resected apical segment can be smaller and less angulated³⁻⁵. In addition, ultrasonically prepared root-end cavities can be more conservative than bur-prepared cavities, involving both the canal and the isthmus, allowing better adaptation of the retro-filling material and consequently improving the apical seal. Both non-coated stainless steel and diamond-coated retrotips can be used for root-end cavity preparation^{6,7,8,10}.

Several studies have mentioned the potential of cracking the root-end surface during preparation of retrograde cavities with ultrasound-activated tips¹²⁻¹⁵. Other studies have not found any evidence of dentin and radicular damage^{9,16-20}. In a clinical study, Sumi et al.¹¹ showed high clinical success rates after the use of ultrasonic root-end preparation for periradicular surgery.

Root cracks are classified as complete, incomplete or intradentinal^{10,14,15,18}. A complete crack extends from the root canal to the external root surface; an incomplete crack extends from the root canal to the center of one of the dentinal surfaces; an intradentinal crack is limited to the root dentin, without compromising the canal walls or the external root surface. Root cracks after the use of ultrasound-activated tips have been detected using stereomicroscopy and scanning electron microscopy (SEM), and are the consequence of several reasons, such as the use of dehydrated extracted teeth^{15,18,21}, absence of periodontal ligament^{13,18,21}, power settings of the ultrasound unit^{5,8,17,21} and sputter-coating of specimens for SEM examination^{10,18,22}.

The aim of this study was to evaluate *in vitro* the effect of sputter-coating on the formation of cracks on the root-end surfaces after retrograde cavity preparation with two ultrasonic tips by SEM examination of the resected root apices and their impressions.

MATERIALS AND METHODS

Twenty fresh extracted human maxillary molars were obtained and stored in 10% formalin buffer solution until use. The palatal root of each tooth was sectioned at the cemento-enamel junction with a water-cooled diamond disk and separated from the crown. Apicoectomy was performed at 3 mm from the apex using a water-cooled low-speed #700 carbide bur positioned perpendicular to the root.

The resected apical root segments were replicated with a polyvinylsiloxane impression material (Addflow, SSWhite, Rio de Janeiro, Brazil), obtain-

ing a total of 20 impressions. In half of the teeth (n=10) the root-end cavities were prepared with diamond-coated retrotips S12/90°D (Satelec, Merignac, France). The other teeth were prepared using the S12/90° non-coated stainless steel retrotips (Satelec). Both types of tips were attached to the handpiece of an ultrasonic unit (Jet-Sonic Four Plus; Gnatus, Ribeirão Preto, SP, Brazil) set to the *Endo* mode with the level of intensity adjusted to 5 (1 to 10 range) under continuous water flow. The depth of the cavities was the same as the cutting end of the ultrasonic retrotips (3 mm). After preparation of the root-end cavities, the resected apical segments were replicated again with the same polyvinylsiloxane impression material (Addflow, SS White, Brazil).

The 20 teeth with the root-end cavities and their respective 40 impressions (20 after apicoectomy and 20 after preparation of the root-end cavities) were mounted on stubs, sputter-coated with gold (Denton Vacuum Inc., Morrestown, NJ, USA) and examined with a scanning electron microscope (JSM, 220A, JEOL Tokyo, Japan) at 15X magnification. The images were analyzed and the presence and number of cracks formed after each procedure were recorded. Cracks extending from the root canal wall that did not include the root surface were considered as incomplete and those that reached the extension of the resected root surface were considered as complete. After the evaluation of the impressions, non-parametric Fisher's exact test was used to compare the number of roots with the presence of cracks in the coated and non-diamond coated retrotips groups. The level of significance was set at 5%.

RESULTS

Data concerning the presence, extension and number of cracks observed on the specimens ultrasonically prepared and on the impressions taken after apicoectomy and after cavity preparation are shown in Table 1 (diamond-coated ultrasonic tips) and Table 2 (stainless steel ultrasonic tips). In the impressions taken immediately after apicoectomy, only 3 cracks were observed: two in the group prepared with diamond-coated ultrasonic tips and one in the group prepared with stainless steel tips (Tables 1 and 2).

Analyses of the impressions gave different results. After root-end cavity preparation with the diamond-

Table 1: Number and extension of cracks on root end surface observed on SEM images of impressions taken after apicoectomy and after ultrasonic root-end cavity preparation with diamond-coated ultrasonic tips, and direct SEM images of the root-end surface after cavity preparation and sputter-coating.

Roots	Impressions after apicoectomy	Impressions after ultrasonic root-end cavity preparation	Resected root apices after cavity preparation and sputter-coating	Type of cracks
1	1	1	3	Complete
2	0	2	4	Complete
3	0	0	5	Complete
4	1	1	2	Complete
5	0	0	2	Incomplete
6	0	0	6	Complete
7	0	0	4	Complete
8	0	0	2	Complete
9	0	0	3	Complete
10	0	0	3	Complete
Total	2	4	34	

Table 2: Number and extension of cracks on root end surface observed on SEM images of impressions taken after apicoectomy and after ultrasonic root-end cavity preparation with non-coated stainless steel ultrasonic tips, and direct SEM images of the root-end surface after cavity preparation and sputter-coating.

Roots	Impressions after apicoectomy	Impressions after ultrasonic root-end cavity preparation	Resected root apices after cavity preparation and sputter-coating	Type of cracks
11	0	2	2	Complete
12	0	0	1	Complete
13	0	0	4	Complete
14	0	0	2	Incomplete
15	0	1	3	Complete
16	0	0	1	Incomplete
17	0	0	1	Incomplete
18	1	1	1	Complete
19	0	2	3	Complete
20	0	0	3	Complete
Total	1	6	21	

coated ultrasonic tips, 4 cracks were observed in the impressions of this group. Considering that two pre-operative cracks were noted after apicoectomy in the root-end surface (Table 1), it might be inferred that only 2 new cracks resulted from cavity preparation, both in the same root. In the impressions obtained after use of stainless steel ultrasonic tips, 6 cracks were observed (Table 2). As 1 crack was noted immediately after apicoectomy, 5 cracks resulted from ultrasonic root-end preparation, these cracks were present in 3 roots. No statistical difference was found between the root-end cavity preparation techniques ($p>0.05$).

Direct analyses of the apical surfaces showed that after the sputter-coating process all resected roots

presented cracks. There were 34 cracks in the group prepared with the diamond-coated ultrasonic tips and 21 in the group prepared with stainless steel tips. Out of this total, 9 cracks were classified as complete in the group prepared with diamond-coated ultrasonic tips and 7 in the group prepared with stainless steel tips (Tables 1 and 2).

Figure 1 (diamond-coated ultrasonic tips) and Figure 2 (stainless steel ultrasonic tips) show SEM from the impressions of resected root surfaces taken after apicoectomy (A) and after ultrasonic root-end cavity preparation (B), as well as direct images of the respective resected apical root segment (C). Cracking was observed only after sputter-coating of the specimen.

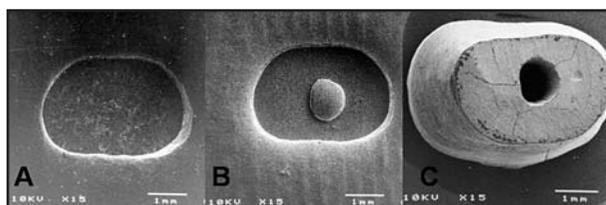


Fig. 1: SEM micrographs of impressions and specimen from the group prepared with diamond-coated ultrasonic tips. A: Impression taken after apicoectomy; B: Impression taken after root-end cavity preparation; C: Resected root apex after root-end cavity preparation and sputter-coating. Root dentin cracking was noted only in the sputter-coated root apex.

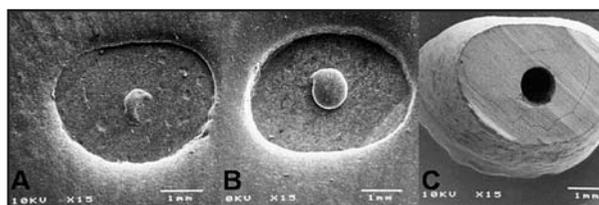


Fig. 2: SEM micrographs of impressions and specimen from the group prepared with stainless steel ultrasonic tips. A: Impression taken after apicoectomy; B: Impression taken after root end cavity preparation; C: Resected root apex after root-end cavity preparation and sputter-coating showing cracks.

DISCUSSION

Previous studies have shown that root-end cavity preparation with conventional burs has a number of difficulties, such as limited access due to radicular anatomy or tooth angulations³⁻⁵. Ultrasonic-activated retrotips have been developed to overcome these difficulties and they have been used with high clinical success in retrograde preparation³⁻⁵. In spite of the advantages of the ultrasonic retrograde preparation, the potential formation of root dentin microfractures during root-end cavity preparation has been mentioned as a disadvantage of the ultrasonic technique. Saunders et al.¹² showed that cracking of the root-end surface was more frequent after ultrasonic root-end preparation than after preparation with a low-speed round bur. This result was also shown by other studies¹³⁻¹⁵. On the other hand, no cracks could be seen in other studies with ultrasonic root-end preparation methods^{9,16-20}.

The causes of root dentin cracking during *in vitro* evaluation of ultrasonic retrograde preparation may include: the use of dehydrated extracted teeth, small-sized resected root ends, power settings of the ultrasound unit and sputter-coating process for SEM analysis^{5,8,10,18,21}. As in previous studies, we analyzed SEM images of polyvinylsiloxane impressions of resected root apices after apicoectomy and after retrograde cavity preparation. SEM images of the corresponding root-end surfaces were also studied in order to determine whether root dentin cracks were caused by the ultrasonic preparation or more likely resulted from the specimen processing for SEM analysis^{10,18,22}.

The accuracy of the polyvinylsiloxane impressions was confirmed because the root dentin cracks detected in impressions taken after apicoectomy (n=3) were consistently replicated in the impressions taken after the root-end cavity preparation. An additional advantage of the impression technique is that it enables comparison of the root surfaces before and after root end cavity

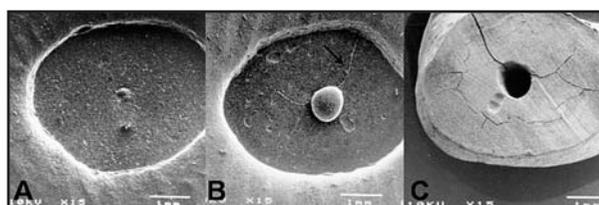


Fig. 3: SEM microphotographs of impressions taken after apicoectomy (A) and after retrograde preparation of the root-end cavity (B), as well as an image of the respective resected root-end surface after ultrasonic retrograde preparation with a diamond-coated ultrasonic tip. Cracks were noted after root-end cavity preparation. The number and extension of the root dentin cracks increased after the sputter-coating treatment (C).

preparation, and thus discrimination between preoperative and postoperative cracks²². Replicas have been used in other studies of ultrasonic root-end cavity preparation^{13,17,18,22}. In these studies, pouring resin over the impression produced “positive” replicas. “Positive” replicas were not prepared in the present study, because “negative” impressions were considered adequate to observe the occurrence of cracks in the evaluated specimens. The analysis of the sputter-coated resected root-end surfaces showed a great number and extension of cracks in all specimens independently of the type of ultrasound tip used for root-end cavity preparation. These findings demonstrate that most cracks actually resulted from artifacts rather than from ultrasonic root-end cavity preparation.

Wucheninch and Meadows⁵ and Bruyne and De Moor¹⁵ analyzed the integrity of root apices of cadaver and extracted teeth after resection and ultrasonic root-end cavity preparation at medium and low ultrasonic power settings at the scaling mode. Extracted teeth showed significantly more root dentin cracks than cadaver teeth, with no differences between the ultrasound intensities. In the present study, medium ultrasonic power setting was used for 2 min, which seemed to minimize the occurrence of microfrac-

tures, especially after the use of the diamond-coated ultrasonic tips, as indicated by the analysis of the impressions after root-end preparation, corroborating the findings of Waplington et al.¹⁷.

Based on the analysis of the impressions taken before and after root-end cavity preparation, the S12/90D diamond-coated tip produced a lower incidence of cracks (1 out of 10 impressions) than the non-coated stainless steel tip (3 out of 10 impressions). In spite of the fact that all root-end cavities were prepared under water cooling, the results of this study may be attributed to the ability of the diamond-coated tips to abrade the radicular dentin more quickly than non-coated metal tips, thus decreasing heat generation.

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CONCLUSIONS

The results of this study showed that cracks observed on dentin surface after ultrasonic root-end preparation can be artifacts created by the sputter-coating process required for SEM analysis. Impressions of the root-end cavities prior to the SEM analysis are more reliable for evaluating the effect of ultrasonic devices on dentin structure. The non-coated ultrasonic stainless steel retrotips showed a higher incidence of cracks (3/10 impressions) than those cavities prepared with diamond-coated retrotips (1/10 impressions). No statistical difference was found between the two apical preparation techniques.

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