Temperature Variation on Root Surface with Three Root-End Cavity Preparation Techniques

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SUMMARY

Introduction Thermal changes can occur on the external root surface when root-end cavity preparation is performed, which may damage periodontal ligament cells and alveolar bone.

Objective The purpose of this study was to evaluate the temperature changes during preparation of the root-end cavities at 1 and 3 mm to the sectioned apical root surfaces when either tungsten carbide round bur, diamond round bur or ultrasonic diamond tip was used.

Methods Root-end resection was performed at 90° to the long axis of the root, 3 mm from the apex. Specimens were randomly divided into three groups of 12 teeth each for three different root-end cavity preparation techniques to be used, i.e. tungsten carbide bur, diamond bur and ultrasonic diamond retro tip. Thermocouples were used to measure temperature changes at 1 mm (T1) and 3 mm (T2) to the cutting plane during the preparations.

Results For T1, the lowest and the highest mean temperature increases of 3.53°C and 4.34°C were recorded for the carbide and diamond burs, respectively. For T2, the lowest and the highest mean temperature increases of 2.62°C and 4.39°C where recorded for the carbide and diamond burs, respectively. The mean temperatures with the ultrasonic tip were 3.68 and 3.04 °C at T1 and T2 region, respectively. For root-end preparation, the ultrasonic preparation technique took the shortest preparation time (10.25 sec) and the diamond bur took the longest time (28.17 sec).

Conclusion Ultrasonic retro tips and burs caused temperature to rise from 2.62° to 4.39°C, and these rises were within safety levels.

Keywords: temperature; root-end cavity; preparation

INTRODUCTION

The management of the resected root-end during periradicular surgery is critical to successful outcome. Anatomical complexities of the root canal can lead to undesirable transfers between the contaminated root canal and the periodontal ligament, thus causing the apicectomy failures. A 3 mm root resection at 0° bevel angle removes the majority of anatomic entities that are potential causes of failure [1]. However, root-end cavity preparations and retro-fillings are the most important components for the success of the endodontic surgery. The main objective of the root-end preparation is to create a retrograde cavity for the insertion of root-end fillings, thereby ensuring that the root apex is adequately sealed [2].

The root-end preparations are performed in dental clinics by means of a small round or inverted cone tungsten carbide with low-speed hand piece or diamond burs with high-speed hand piece. These preparations are almost always done obliquely to the long axis of the root, with a high risk of perforation of the lingual portion of the root. In recent years, ultrasonic preparation techniques have been widely accepted as a popular method for retro-cavity preparation. The ultrasonic method facilitates more conservative and proper root-end cavity compared to preparation with a bur. It also requires a less angulated resection of the root apex [3]. In addition, the preparation of root-end cavities with ultrasonic tips facilitates the even distribution of the root-end filling material and provides more efficient apical sealing because it results in more parallel walls and deeper cavity improving the retention [4]. Moreover, the utilization of ultrasonic diamond tips results in faster and smoother retropreparation [5]. Essentially, ultrasonic root-end preparation techniques have been developed to resolve the major pitfalls of using the burs for root-end cavity preparation.

During this procedure, it is essential to assess thermal changes on the external root surface, because this dictates whether injury to periodontal ligament cells and alveolar bone will occur [6]. The threshold for damage to bone and periodontal ligaments is a temperature increase of 10°C for more than 1 minute [7]. Although the ultrasonic techniques have been widely recommended for root-end preparations, there are no reports of the evaluation of the temperature changes during root-end preparation.

OBJECTIVE

The objective of this study was to evaluate temperature changes when root-end cavities were

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prepared at 1 mm and 3 mm to the sectioned apical root surface with either tungsten carbide round bur, diamond round bur or ultrasonic diamond tip.

METHODS

Thirty-six anterior human teeth, with single straight roots and round apices were selected for the study; the roots with open apices or resorptive defects were excluded. Teeth were cleaned with curettes to remove any remnants of soft tissue and were stored in 0.9% saline solution incubated at 37°C. Ethical approval was obtained from Ondokuz Mayis University Ethics Board.

The canal systems were instrumented to the working length with up to a size 45 K-file (Dentsply Maillefer, Ballaigues, Switzerland) by using the step-back technique and irrigation with 2.5% sodium hypochlorite, and then dried with paper points (Sure Dent Corp, Kyeonggi-do, Korea). The roots were obturated with gutta-percha and AH-plus sealer (Dentsply DeTrey, Konstanz, Germany) by using cold lateral condensation techniques. The access cavities were filled with glass ionomer cement (Vitremer, 3 M ESPE, St Paul, MN, USA) and all teeth were subsequently stored in saline solution at 37°C for one week.

Root-end resection was performed at 90° to the long axis of the root and 3 mm from the apex with a Lindemann bur (Komet AG, Lemgo, Germany) by an operator using the magnifying loupes and under water coolant applied by the second operator.

Specimens were randomly divided into three groups of 12 teeth each for three root-end cavity preparation tips; tungsten carbide bur (Ela, Ergelskirchen, Germany) with low-speed handpiece set at 20,000 rpm (Group 1), diamond bur (Romidiamond FG, Kiryat, Israel) with high-speed handpiece (Group 2) and ultrasonic diamond retro tip (EIE Analytic Technology, Glendora, CA, USA) (Group 3).

Root-end cavities, 3.0 mm deep, were prepared using one of three techniques with water coolant. A plastic stop was placed on the cervix of the tungsten and diamond burs to create uniform depth (3 mm) root-end cavities with different burs. The cavity depth was also checked with a millimetric periodontal probe to standardize the retropreparation. The preparations were considered complete when no root obturation material remained on the cavity walls.

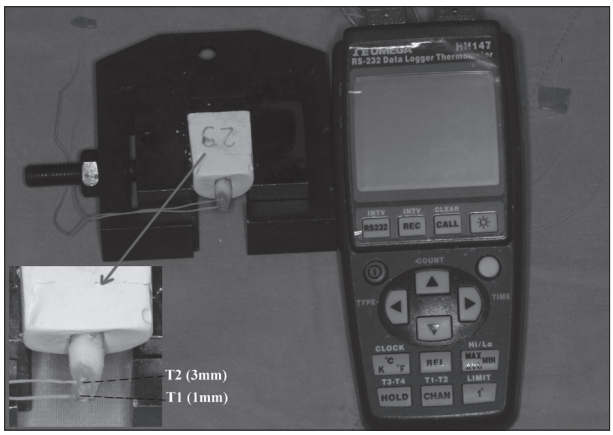

Figure 1. The experimental design to measure the temperature variation

Teflon insulated type K thermocouples (model 5SRTC-TT-KI-36, Omega Engineering, Manchester, UK) were used to measure temperature changes during the root-end cavity preparations. Silicon heat conducting paste was used to improve heat conduction from the root surface. Thermocouples mounted on the root surface were isolated with paraffin wax, which prevented external temperature effects. Data from thermocouples were read with a 4-channel, handheld data logger thermometer (model HH147, Omega Engineering, Manchester, UK) that enabled constant, real-time temperature readings. Room temperature was maintained at 20°C. Two tips of the thermocouple were placed at 1 mm (T1) and 3 mm (T2) from the cutting plane of the root-end. A third tip registered ambient air temperature (Figure 1). The maximum temperature was recorded during experimental process for each specimen.

The Kruskal-Wallis and Student-Newman-Keuls tests (a=5%) were used to compare quality of preparation among the groups.

RESULTS

The mean temperature variations at the T1 and T2 regions and also mean time values for the tested groups were shown in Table 1.

The lowest mean temperature increase at T1 of 3.53°C was recorded for the tungsten carbide bur and the highest mean temperature rise at T1 of 4.34°C was noted for the diamond bur (Table 1). For T2, the lowest and the highest mean temperature increases of 2.62°C and 4.39°C were recorded for the carbide and diamond burs, respectively. The mean temperature increases for ultrasonic tip were 3.68 and 3.04°C at T1 and T2 region, respectively (Table 1). Although there were no statistical differences between the groups at T1 region ($p>0.05$), there was a statistical difference between two groups (Groups 1 and 3) and the diamond bur group (Group 2) at T2 ($p<0.05$).

There was a statistically significant difference between the preparation times for root-end preparation ($p<0.05$). For root-end preparation, the ultrasonic preparation technique (Group 3) took the shortest preparation time and the diamond bur method (Group 2) took the longest time ($p<0.05$). All preparation techniques were completed in between 10 and 28 sec.

Table 1. Means and standard deviations of temperature (°C) and preparation times (sec) for the ultrasonic tip, tungsten bur and diamond bur groups in root-end resection

Preparation tips	Mean temperature ± SD (°C)		Mean time ± SD (sec)
	T1	T2	
Ultrasonic tip	3.68±1.62	3.04±0.86	10.25±2.67
Tungsten bur	3.53±0.68	2.62±0.80	15.50±2.58
Diamond bur	4.34±1.59	4.39±1.57	28.17±3.69
p-value	0.310	<0.01	<0.01

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DISCUSSION

Root-end resection is the most frequently performed surgical endodontic procedure and commonly includes root-end cavity preparation and retrograde filling [2]. Studies have shown that the root-end preparation should be 3 mm deep and followed the direction of the root canal to enable a successful apical seal [4, 8, 9]. For the current study, a 3 mm deep cavity was prepared in each resected root tip; the depth was selected to be consistent with previously mentioned studies.

The root-end cavity has been prepared with different clinical techniques and instruments in clinics [2]. Traditionally, root-end preparation has been carried out with the burs that have disadvantages in terms of limited access and the risk of perforation of the root [10]. Recently, ultrasonic retro-preparation techniques for endodontic surgery have gained popularity in endodontics surgery. Ultrasonic retro-tips produce cleaner, well-centered, and more conservative root end cavities than those prepared with the conventional burs [11]; ultrasonic techniques also remove bacteria significantly better than burs [12], thus improving the quality of treatment [13]. Batista de Faria-Junior et al. [14] showed that ultrasonic tips provided acceptable cavity design for root-end cavities. Wuchenich et al. [15] reported that root-end cavity preparation with the ultrasonic tips produced more parallel walls and greater depths for retention. Additionally, Khabbaz et al. [11] stated that ultrasonic tips produced cleaner, well-centered and more conservative root-end cavities than the rotary instruments with a slow-speed handpiece. Calzonetti et al. [16] stated that ultrasonic root end cavity preparation *in situ* did not cause root microfractures. In contrast, a few studies have reported that the use of ultrasonic tips during root-end cavity preparation had created cracks on the resected root surface due to the excessive vibration produced by this device [17, 18, 19]. Additionally, Peters et al. [20] stated that prototype ultrasonic diamond-coated retrotips removed more dentine than stainless-steel retrotips and should therefore be used with care to avoid over-preparation or perforation. However, Taschieri et al. [21] and Ishikawa et al. [22] found no significant difference between diamond and stainless steel retrotips in the preparation of root-end cavities. An investigation of the effects of ultrasonic root-end preparation in cadavers found no cracks around the cavity walls; it has been suggested that the periodontal ligament might help to dissipate stresses and thereby decrease the incidence of cracking [18]. Accordingly, three most commonly preparation techniques were chosen for the present study.

In vitro studies cannot totally replicate the clinical environment. Potential heat sinks exist *in vivo* from blood flow and the surrounding tissues, which are less vulnerable to thermal variations than air. Thus, thermal energy dissipates more rapidly *in vivo* than *in vitro* because of the circulation of blood in adjacent tissues [23]. Although there have been several studies on the temperature variations of root-end canal preparation, disinfection and obturation procedures on root surfaces [23, 24, 25], no information in available literature is found on the temperature changes on root surfaces during root-end cavity preparation. Sant'Anna-Júnior et al. [24] demonstrated that the medians of ΔT did not exceed 10°C during thermomechanical compaction of Resilon and gutta-percha. Abad-Galleos et al. [25] stated that the temperature increment variation was 3.84 to 5.01°C when Er,Cr:YSGG laser irradiation was employed for disinfection of the root canal system. In the present study, the maximum temperature rises in the tested groups at T1 and T2 were 4.34 and 4.39°C, respectively. These rises were not dangerous to bone tissue as the critical temperature of bone damage is 47°C *in vivo* [7]. Hence, all temperature rises were below the safety level of 10°C, which is considered safe. However, there are no reports that can be used to make direct comparisons with the present study's results regarding temperature variations during root-end cavity preparation.

Chairside time and expense have become factors to be more closely considered by both dentist and patient. Various techniques for root-end preparation have been developed to reduce operation time and increase the retrograde cavity quality. There is little information on the root-end cavity preparation time, hence the relevance of the second section of our study.

Peters et al. [20] reported that the mean preparation time for maxillary molar root-end cavities using diamond-coated and stainless steel ultrasonic tips varied from 1.62 and 2.85 min, respectively. These preparation times are highly compared with our results. This may be explained by the variation in power output of the used ultrasonic device, tooth types and different brands of the retrotips. Batista de Fario-Junior et al. [14] reported a mean time of 2.98 sec for ultrasonic root-end preparation. However, in our study, the ultrasonic group took a considerably more time relatively (10 sec). This discrepancy might be due to differences in the chosen brand of ultrasonic tip and the area of cross-section of the cut root surface. The lowest mean times in the current study were observed for ultrasonic and carbide bur root-end preparations. This can be explained by the drainage difficulties associated with the diamond bur with respect to the removal of filling material and dentine debris from the bur grooves. To further that point, root-end cavities prepared with the ultrasonic tip created less debris than those prepared with rotary instruments [26].

CONCLUSION

Ultrasonic retro tips and burs caused temperature rises within safety levels from 2.62 to 4.39°C.

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Промене температуре на површини корена зуба при примени три технике препарације кавитета краја корена

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КРАТАК САДРЖАЈ

Увод Током препарације кавитета краја корена зуба долази до термичких промена на спољашњој површини корена, што може да доведе до оштећења ћелија пародонталног лигамента и алвеоларне кости.

Циљ рада Циљ истраживања била је процена промена температуре током препарације кавитета краја корена на удаљености од 1 *mm* и 3 *mm* од ресециране површине апекса корена током примене тунгстен-карбидне округле бушилице, дијамантске округле или ултразвучне бушилице са дијамантским врхом.

Методе рада Ресекција краја корена рађена је под углом од 90 степени у односу на уздужну осу корена, 3 *mm* од апекса. Узорци су насумично сврстани у три групе од по 12 зуба у свакој ради примене три различите технике препарације кавитета краја корена: тунгстен-карбидном бушилицом, дијамантском бушилицом и ултразвучном бушилицом са дијамантским ретро-врхом. За мерење температурних промена на 1 *mm* (T1) и 3 *mm* (T2) у односу на раван ресекције током препарација коришћени су биметални мерачи температуре (термокупли).

Резултати Код T1 забележена су најнижа и највиша просечна температурна повећања од 3,53℃, односно 4,34℃, при примени карбидне и дијамантске бушилице. Код T2 забележена су најнижа и највиша просечна температурна повећања од 2,62℃, односно 4,39℃, приликом примене карбидне и дијамантске бушилице. Просечна температурна повећања када је коришћена бушилица с ултразвучним врхом била су 3,68℃ за T1, односно 3,04℃ за T2 регију. За препарацију краја корена најкраће време за припрему било је током примене ултразвучне технике (10,25 секунди), а најдуже дијамантском бушилицом (28,17 секунди).

Закључак Ултразвучни ретро-врхови и бушилице довели су до повећања температуре од 2,62℃ до 4,39℃, што је било у границама безбедности.

Кључне речи: температура; кавитет краја корена; препарација

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