ORIGINAL ARTICLE

Temperature increases on the external root surface during endodontic treatment using single file systems

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Abstract

Aims: The aim of this study is to evaluate increases in temperature on the external root surface during endodontic treatment with different rotary systems.

Materials and Methods: Fifty human mandibular incisors with a single root canal were selected. All root canals were instrumented using a size 20 Hedstrom file, and the canals were irrigated with 5% sodium hypochlorite solution. The samples were randomly divided into the following three groups of 15 teeth: Group 1: The OneShape Endodontic File no.: 25; Group 2: The Reciproc Endodontic File no.: 25; Group 3: The WaveOne Endodontic File no.: 25. During the preparation, the temperature changes were measured in the middle third of the roots using a noncontact infrared thermometer. The temperature data were transferred from the thermometer to the computer and were observed graphically. Statistical analysis was performed using the Kruskal–Wallis analysis of variance at a significance level of 0.05.

Results: The increases in temperature caused by the OneShape file system were lower than those of the other files ($P < 0.05$). The WaveOne file showed the highest temperature increases. However, there were no significant differences between the Reciproc and WaveOne files.

Conclusions: The single file rotary systems used in this study may be recommended for clinical use.

Key words: Infrared thermometer, one file systems, reciprocating motion, root canal preparation, rotational motion

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Introduction

The aim of endodontic treatment is to clean all pulpal tissue remnants, hermetically fill the root canal space and create an area without inflammation.[1] The complexity of the root canal system is due to the presence of accessory and lateral canals, isthmuses and apical deltas.[2] Therefore, root canal preparation is a difficult step, and many new file systems are being developed to eliminate these problems.

The clinical use of rotary nickel-titanium (NiTi) endodontic instruments improves the efficiency of endodontic treatment by reducing the time spent on treatment procedures, sensitivity and complication risks.[3] Previous studies have reported reduced intervention times, and there was little to no canal transportation when using rotary NiTi files.[4,5] During instrument use, frictional forces generate heat along the root canal, and higher rotational speed causes higher temperature increases.[6] Manufacturers have developed instruments made from new alloys and new working motions, such as reciprocation to improve the fracture resistance of NiTi rotary files.[7] The reciprocating motion is caused by special movements identified by counterclockwise (cutting action) and clockwise (release of the instrument) motions. It is reported that this

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movement reduces stress on the file and the risk of cyclical fatigue caused by tension.[8] The Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) instruments are examples of instruments that use this concept. Another new example of a single file instrument (or preparation) using continuous clockwise rotation is the OneShape (Micro Mega, Besancon, France).

During endodontic treatments, dental complications may occur in tooth structure and adjacent tissues. These complications include a tooth ankylosis, bone necrosis and resorption.[9] The study by Eriksson and Albrektsson[9] revealed the harmful effects of increased temperatures on alveolar bone and periodontal ligament. They reported that a temperature increase of 10°C on the outer root surface caused bone resorption and tooth ankyloses.[9] The authors indicated that the threshold temperature increase for alveolar bone is 19°C because this temperature increase results in alkaline phosphatase denaturation.[10] However, other authors have shown that temperature increases <19°C also cause alveolar bone necrosis.[9,11] Another study indicated that exposing the bone to a temperature of 53°C for 1 min interrupted the blood flow.[12] Exposure to a temperature of 43°C may result in protein denaturation in the periodontal ligament.[11]

There are several methods of measuring tissue temperature.[13-16] There are measurement instruments based on contact such as subgingival thermometers and thermocouples. These instruments may by inconvenient because of the difficulties involved in surgery and sterilization. Infrared thermometers can measure the tissue surface and determine only the superficial temperature without contact.

There are no studies in the literature examining the temperature increases that occur on the external root surface during endodontic treatment with a single file rotary system. The aim of the study is to evaluate the temperature changes on the external root surface during root canal preparation with three different single file rotary systems *in vitro*. The null hypothesis tested was that there are no differences among the temperature increases for the single file rotary systems examined.

Materials and Methods

The research proposal was submitted to review by the Ethics in Tokat Clinical Research Ethics Committee of the Gaziosmanpaşa University of Turkey (No. 14KAEK-134), and the study design was approved.

A total of 50 human mandibulary incisors with a single root canal and with anatomically similar root lengths were extracted for periodontal reasons. All teeth were stored at 4°C in physiologic saline for no longer than 4 weeks after extraction. Only teeth with fully formed apices were selected. All calculus and other remnants were removed completely from the surfaces of the teeth. An access cavity was opened using high-speed hand tools. The working length was established as 1 mm short of the root canal. The canal length was visually established by placing a size-15 K-type file (VDW, Munchen, Germany) into each root canal until the tip was visible at the apical foramen. All root canals were instrumented using a size-20 H-type file (VDW, Munchen, Germany) until the file moved freely within the canal. The canals were irrigated with 5% sodium hypochlorite solution (Whitedentmed, Erhan Kimya, Turkey). The teeth were mounted vertically into self-curing 4 mm acrylic resin blocks, and the root surfaces were exposed. The acrylic blocks are placed into a vice to prevent contact and heat exchange [Figure 1]. The samples were randomly divided into three groups of 15 teeth each according to the endodontic files used for root canal. The groups were the following:

Group 1: OneShape Endodontic File no.: 25 (Micro Mega, Besançon, France).

Group 2: Reciproc Endodontic File no.: 25 (VDW, Munchen, Germany).

Group 3: WaveOne Endodontic File no.: 25 (Dentsply Maillefer, Ballaigues, Switzerland).

Each instrument was used according to the manufacturers' instructions, and file systems were used inside the root canal for 60 sec in all groups. Before each canal preparation, RC-Prep (Stone Pharmaceuticals, Philadelphia, PA, USA) was used as a lubricant. During the tooth preparations, the temperature changes were measured using a noncontact infrared thermometer (Optris LS LT, Berlin, Germany) with a sensitivity of 0.1°C at the middle third of the roots. Preparations were finished in nearly 45 sec but instruments were used 60 sec in root canals to watch thermal changes

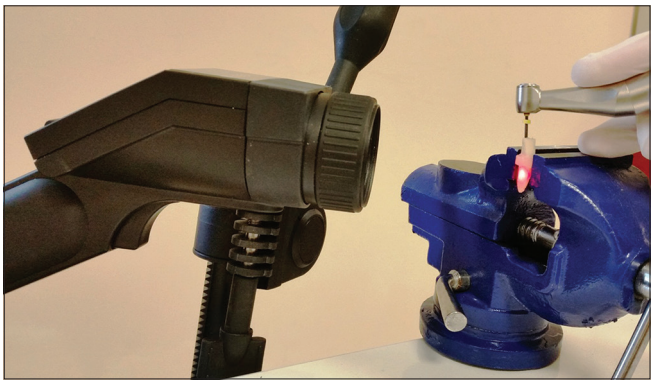

Figure 1: Experimental setup established for temperature rise in this study

after access to the apices. Five teeth were examined as controls by measuring the temperature alterations for 60 sec without any preparation. This was performed to determine whether the infrared thermometer caused any temperature change. The temperature alterations were transferred to a computer and were observed graphically.

Statistical analysis

The data were not normally distributed, and the Kruskal–Wallis analysis of variance was used for statistical analysis. A Bonferroni correction was applied to the results. The level of significance was 5% ($P < 0.05$).

Results

The mean temperature increases and standard deviations for the experimental groups are shown in Table 1. Figure 2 shows the results obtained in this experiment.

There were significant differences between Group 1 and Group 2 ($P < 0.05$, $P = 0.006$). There was also a difference between Group 1 and Group 3 ($P < 0.05$, $P = 0.001$). There were no significant differences between Group 2 and Group 3 ($P > 0.05$, $P = 0.202$).

The temperature increases caused by the OneShape file system were lower than those of the other files ($P < 0.05$). An evaluation of all groups showed that the WaveOne file caused the highest temperature increases. However, there were no significant differences between the Reciproc and WaveOne files.

Table 1: Mean and SD of temperature rise (°C)

Groups	*n*	Mean	SD	SE	95% CI for mean	
					Lower bound	Upper bound
OneShape system (G1)	15	5.8*	1.5	0.4	5.0	6.7
Resiproc system (G2)	15	8.6†	2.7	0.7	7.1	10.1
WaveOne system (G3)	15	10.3†	3.8	1.0	8.2	12.4
Total	45	8.2	3.3	0.5	7.2	9.2

There were no significant differences between the same symbols.
SD=Standard deviation; SE=Standard error; CI=Confidence interval

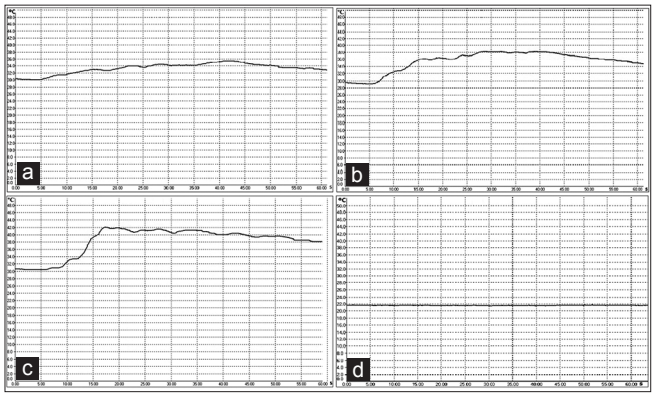

Figure 2: Temperature rise during preparation performed with (a) OneShape, (b) Reciproc, (c) WaveOne, and (d) Control

Discussion

This *in vitro* study investigated the temperature changes on the external root surface during preparation with three different NiTi rotary systems. The results of this study supported the hypothesis partially that there are no differences among the temperature measurements of the three rotary file systems. There were no significant differences between the Reciproc and WaveOne files. However, there were significant differences between the OneShape file and the other single file systems. The temperature increases caused by the OneShape file system were lower than those caused by the other files.

The heat produced during a root canal preparation may influence the root face and periodontal ligament. In addition, the adjacent bone may be adversely affected.[17,18] Therefore, in the thicker dentin, less heat is passed to the outer root surface. It has been reported that a temperature increase >10°C could be harmful for cementum, periodontal ligament, and alveolar bone tissues.[9,19] The amount of transmitted heat is affected by the following factors: the anatomy of the root canal and the amount of residual dentin thickness, the extent of contact between the instrument and the canal wall, intermittent or continuous instrument usage and the operator force.[9,18]

Due to its low thermal conductivity, residual dentin thickness is important because it acts as a protective coating against thermal damage. Periodontal tissue damage may occur when the amount of remaining dentine is <1 mm.[20] Thus, it is important to study tooth responses to protect the periodontal ligament from high temperatures. Lipski[14] stated that the temperature increase in mandibular incisor teeth exceeded 10°C during root canal procedures. However, the increase in temperature did not exceed the critical level for the maxillary central incisors and maxillary canines.[14] In the current study, mandibular incisor teeth were analyzed because they are the most critical teeth in terms of heat conduction.

Hardie[6] reported that the heat generated during the root canal preparation is directly related to the speed of the instruments. The recently developed single file NiTi systems Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) are able to prepare root canals with only one instrument. These instruments require less time for tooth preparation than the rotary full-sequence systems.[21] The main features of these systems are their single-use, reciprocating motion and M-wire alloys.[22] The M-wire alloy increases flexibility and improves resistance to cyclic fatigue of the instruments.[23]

The OneShape has a rotational speed of 400 rpm. The Reciproc instruments work at approximately 282–300 rpm, with a 150–158° counterclockwise rotation, followed by a 30–34° clockwise rotation.[24] The OneShape instrument has a constant taper of 0.06. The Reciproc R25 and the primary WaveOne instruments have a taper of 0.08 over the first 3 mm that decreases to 4.3% and 5.5%, respectively.[25] In the current study, two different single file NiTi rotary systems that use reciprocating movement and continuous clockwise rotation single file conventional NiTi rotary system were used. While the lowest temperature increase was shown in the OneShape file that is a conventional NiTi rotary system, the highest temperature increase occurred with the WaveOne file. The WaveOne file is a single file rotary system, and it increased the temperature by more than the critical level (10°C). The difference between the OneShape and the Reciproc instruments may be attributed to the different working motions and the different rotational speeds.

Although the WaveOne and Reciproc instruments have similar properties, such as tip size, alloy type and movement, they have different cross-sectional designs.[26] The Reciproc size 25 taper 0.08 file has a sharp double-cutting edge S-shaped geometry. However, the WaveOne file is characterized by a modified triangular cross-section with radial lands at the tip and a convex triangular cross-section in the middle and coronal portion of the instrument. The WaveOne modified cross-section results in lower cutting efficiency and less chip space.[27] Both the OneShape and the Reciproc have a markedly smaller core diameter than the WaveOne. Therefore, the chip space of these instruments is greater than that of the WaveOne.[25] Although there were no statistically significant differences between the single file rotary systems found in this study, the WaveOne file caused higher temperature increases than the Reciproc file. We hypothesize that because the WaveOne file system has a greater taper and removes less material, it increases the temperature more than the other systems do.

Several methods have been investigated to measure temperature changes.[15,28,29] Noncontact infrared thermometers measure the temperature in a short period of time and do not require other instruments or contact during the measurement. In addition, they do not cause infection, are less costly and do not require any preparation prior to the measurement.[30] Therefore, noncontact infrared thermometers are highly advantageous devices. In the study, the Optris LS LT thermometer was used, which is a noncontact infrared thermometer, to measure temperature alterations. According to the manufacturer's instructions, the portable infrared thermometer not only allows selection of close focus and standard focus, but it is also equipped with innovative sighting systems (double and cross laser) for exact spot size marking at any distance. These devices can easily measure the temperature of moving objects.

The present study was conducted using an extraoral environment. Thus, it was impossible to properly simulate the intraoral environment, periodontal status and patient habits. The results may be different for data obtained in an actual patient because periodontal and osseous blood circulation may influence the heat increases. Thus, further clinical studies are required to assess both the reciprocal and conventional root canal instruments for their potential risk factors.

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