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Original Research Article

Thermal alteration on the external root surface during endodontic treatment using three different rotary file systems: An in vitro study

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Abstract: The aim of this study is to evaluate increases in temperature on the external root surface during endodontic treatment with three different rotary file systems. Fifty human mandibular first premolars with single root canal were selected. All root canals were instrumented using a size 20 H 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 Protaper Next Rotary Files X1 and X2; Group 2: The Mtwo rotary File 20/06 and 25/06 Group 3: The Hyflex rotary File 20/06 and 25/06. 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 oneway ANOVA analysis of variance at a significance level of 0.05. The increases in temperature caused by the Hyflex rotary file system were lower than those of the other files. The Mtwo rotary file showed the highest temperature increases. However, there were no significant differences were noticed between the Protaper Next and Hyflex rotary files in terms of temperature increase during root canal preparation. Mean temperature increases no higher than 3.4ºC were recorded for any of the system examined, which indicates that these instruments are safe for the surrounding periodontal tissues.

Keywords: infrared thermometer, Protaper Next, Mtwo, Hyflex.

INTRODUCTION

The aim of endodontic treatment is thorough debridement and cleaning of the root canal system of any infected pulp tissue so the canal space can be shaped and prepared to be filled with an inert material thus preventing or minimizing any chances of reinfection [1]. Nowadays, there is an extensive array of nickel-titanium instruments available to the endodontist and appear promising as effective instruments for cleaning and shaping [2]. During rotary instrumentation frictional force generates heat along the root canal walls due to difference in velocities between the two sliding surfaces [3]. Surface and near-surface temperatures can become raised enough to cause changes in the structure and biological behavior of the adjacent tissues. These complications include tooth ankylosis, bone necrosis and resorption [4]. The study by Eriksson and Albrektsson reported that a temperature increase of 10°C on the outer root surface caused bone resorption and tooth ankylosis [4]. In 1972, Matthews observed that the threshold temperature increase for alveolar bone is 19°C because this temperature increase results in alkaline phosphatase denaturation [5]. However other studied observed that even temperature rise less than 19° may also results in protein denaturation and alveolar bone necrosis. In 1982, Eriksson and Albrektsson in another study indicated that exposing the bone to a temperature of 53°C for 1 min interrupted the blood flow [6]. In 1988; Sauk et al observed the exposure to a temperature of 43°C may result in protein denaturation in the periodontal ligament [7]. There are several methods of measuring tissue temperature with or without contact [8]. Infrared thermometers can measure the tissue surface and determine the superficial temperature without contact. The aim of the study is to evaluate the temperature changes on the external root surface during root canal preparation with three different rotary file systems (Protaper Next, Mtwo and

Hyflex) *in vitro*. The null hypothesis tested was that there are no differences among the temperature increases for the s rotary file systems examined.

MATERIALS AND METHODS

Fifty human mandibular first premolar tooth which have been extracted for orthodontic reasons within a period of one month were collected from the department of Oral and Maxillofacial Surgery, KMCT Dental College, Mukkam, Calicut were used for this study. Soft tissue debris and the calculus were mechanically removed from the surface of the root with help of an ultrasonic scaler and cleaned under running tap water. The teeth were stored in purified distilled water. Radiographs were taken to confirm the full development of tooth, absence of root filling, internal resorption and calcification and to verify the presence of single canal. Those teeth with aberrant root canal anatomy, more than one canal and tooth having more than 30° curvature were excluded from the study for the uniformity. Initial access obtained with a No.2 round bur and apical patency of each specimen was obtained by inserting an ISO size-10 K file (Mani Inc, Tochigi, Japan) until the tip was observed at the apical plane. Working length was then determined by placing a size-15 K file (Mani Inc, Tochigi, Japan) into the canal space until it is appeared at the apical plane. All root canals were instrumented using a size-20 H-type file (Mani Inc, Tochigi, Japan) until the file moved freely within the canal. The canals were irrigated with 3% sodium hypochlorite solution (Hyposol Prevest DenPro Limited [=], India). The teeth were mounted vertically into self curing 4 mm acrylic resin blocks, and the root surfaces were exposed. 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: Protaper NEXT rotary files (X1 (17/04) and X2 (25/06), Dentsply Maillefer, Ballaigues, Switzerland).

Group 2: Mtwo rotary files (20/06 and R25/06; VDW, Munich, Germany)

Group 3: Hyflex Rotary files (Dentsply Maillefer, Ballaigues, Switzerland).

The temperature of each specimen were recorded before preparation (T^0) of root canal using a noncontact infrared thermometer (Optris LS LT, Berlin, Germany) with a sensitivity of 0.1°C at the middle third of the roots. Before each canal preparation, Endoprep-RC® (Anabond Stedman, Pharma Research (P) Ltd, India) was used as a lubricant.

Preparation of root canal

Each instrument was used for 60 seconds in the canal. The temperature during preparation was measured while doing instrumentation with first and second rotary files of each system using a noncontact infrared thermometer (Optris LS LT, Berlin, Germany) with a sensitivity of 0.1°C at the middle third of the roots and recorded as T^1 and T^2 respectively for each sample. Preparations were finished in nearly 45 sec but instruments were used 60 sec in root canals to watch thermal changes after access to the apices.

Group I: Protaper NEXT rotary files

Initial preparation with X1 rotary files (17/04) followed by preparation using X2(25/06) at 200rpm and 2Ncm torque. T^1 and T^2 recorded separately and recorded.

Group II: Mtwo rotary file group

Instrumentation where performed using M2 rotary files 20/06 followed by 25/06 at 200rpm and 2Ncm torque and temperature measured using infrared thermometers and recorded as T^1 and T^2 for 20/06 and 25/06 respectively.

Group III: Hyflex Rotary file group

The instrumentation was performed using 20/06 and 25/06 at 200rpm and 2Ncm torque. Temperature during preparation was measured using infrared thermometer and recorded as T^1 and T^2 for 20/06 and 25/06 respectively.

Control Group

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 whole procedure of the experiment was conducted in air conditioned room at a constant temperature to reduce the effect of ambient temperature. The temperature alterations were transferred to a computer and were observed graphically.

Fig-1: Measurement of temperature during root canal preparation using infrared thermometer

RESULTS

The difference in temperature, ΔT between initial temperature (T^0, temperature before preparation) and temperature after preparation (T^2) was calculated from the recorded data for each sample. 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.

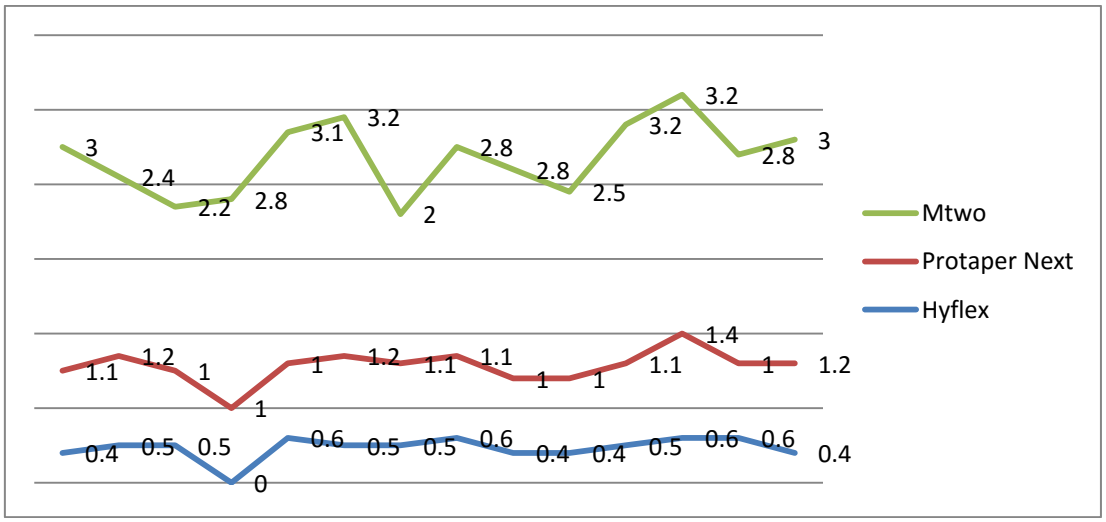

Fig-1: Temperature changes during preparation performed with Hyflex, protaper Next and Mtwo rotary files

Statistical analysis

The difference in Temperature, ΔT for each group was analyzed using one way ANOVA test. The level of significance was 5% ($P < 0.05$). There were no significant differences between Group 1 and Group 2 ($P > 0.05$, $P = 0.065$). There was a difference between Group 2 and Group 3 ($P < 0.05$, $P = 0.038$). There were no significant differences between Group 1 and Group 3 ($P > 0.05$, $P = 0.074$).The temperature increases caused by the Hyflex rotary file system were lower than those of the other files.

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

Groups	n	mean	SD	95% CI of the difference	
				Lower	upper
Protaper Next	15	1.09	.116	1.02	1.15
Mtwo	15	2.8	.377	2.5	3.0
Hyflex	15	.47	.08	.43	.52

SD = Standard Deviation, CI = Confidence Interval

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 Protaper

Next and Hyflex rotary files. However, there was a significant difference between the Mtwo rotary files and Hyflex file systems. Even though, the results were not significant between Mtwo and Protaper Next, the temperature increases caused by the Mtwo rotary file system were higher 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 [9]. It has been reported that a temperature increase >10°C could be harmful for cementum, periodontal ligament, and alveolar bone tissues [10]. 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 [9,10]. Mean temperature increase ranging from 0.4°C to 3°C was produced with a base line recorded at 34°C and highest temperature recorded were 37.4°C. Özkoçak reported that temperature increases during endodontic treatment is due to part of the friction generated inside the root canal during instrumentation [11]. Gokturk also reported that the heat generated is also directly proportional to the frictional contact with the canal walls [12]. Among the three rotary NiTi files Mtwo rotary files caused more generation of heat. The main features of NiTi which are contributing to high cutting efficiency of Mtwo are the two cutting blades, simultaneous shaping both on penetration and lateral and italic '*S'* cross section. Due to the presence of two cutting blades and the cross sectional design the surface of contact made by the Mtwo rotary files on the canal wall may be comparatively higher than other rotary files tested in the experiment and this may be the reason for higher heat generation while doing preparation with Mtwo rotary files. Protaper Next rotary files showed less heat generation than the Mtwo rotary files may be due to the off centered rectangular cross section and asymmetric 'Swaggering' rotation. These features gives the file a snake-like "swaggering" movement as it moves through the canal and results in optimization of root canal tracking as only two points of the rectangular cross section touch the canal wall at a time. The M-Wire NiTi material improves file flexibility, while still retaining cutting efficiency and also reduced the frictional heat generated during canal prepration. Hyflex rotary files produced least amount of heat generation may be due to the greatest flexibility of the rotary files. Pongione reported that the CM-wire manufacturing process produced NiTi rotary instruments (Hyflex files) more flexible and more resistant to cyclic fatigue than instruments produced by a traditional manufacturing process or a thermally treated NiTi alloy (M-wire) [13]. But Elnagy reported that the new protaper Next had resistance to cyclic fatigue compared with Hyflex CM files [14]. And the result of the present study revealed there was no significant difference in temperature increase between Protaper Next and Hyflex rotary file may be due to the comparative flexibility of these rotary files. The temperature measured T^2 was always higher than T^1 may be due to the difference in residual dentin thickness. Due to its low thermal conductivity, residual dentin thickness is important because it acts as a protective coating against thermal damage [15]. Periodontal tissue damage may occur when the amount of remaining dentine is <1 mm [16]. Several methods have been investigated to measure temperature changes [17,18]. 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 [19]. The present study demonstrated that none of the systems tested (Protaper Next, Mtwo and Hyflex) produced temperature increases higher than the established critical value of 10ºC. This is probably due to the fact that dentine is a poor heat conductor [15] and the 95% of the energy dissipation occurs within the top 5 µm of the contacting bodies [20]. However, according to Eriksson and Albrektsson [4], some additional factors can contribute to higher or lower temperature dissipation, such as anatomical diameter of the root canal and the amount of remaining dentine. Moreover, the presence of tissular fluids in the dentinal tubules and the vascularization at the periapical region can decrease the thermal effects produced by the rotary instrumentation [15]

CONCLUSION

Thus conclude that the heat generated by the Protaper Next, Mtwo and Hyflex rotary systems was below the maximum values tolerated by the surrounding periodontal tissues and, thus, may be considered biologically safe and free of harmful thermal effects.

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