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Comparison of the Dentinal Defects After Preparationusing Different NiTi Rotary Files Manufactured with Controlled Memory Alloy

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Abstract:
Aim: *To compare the dentinal defect incidences of HyFlex CM, Extreme CM R3 and SANI S3 NiTi files during root canal preparation of maxillary first premolar teeth.*
Materials and Methods:*Eightymaxillary first premolars were selected. Twenty teeth were left unprepared and served as a negative control and the remaining 60 teeth were shaped with the following experimental groups with an apical size #25 file: HyFlex CM 25/.04, Extreme CM R3 25/.06 and SANI S3 25/.06. After root canal preparation, all of the roots were sectioned perpendicular to the long axis at 3, 6, and 9 mm from the apex, and the sections were then observed under a stereomicroscope. The absence/presence of cracks was recorded, and the data were analyzed with a chi-square test. The significance level was set at P = 0.05.*
Results:*All of the tested NiTi file systems caused statistically more dentinal defect than the control group (P < 0.05). No statistically significant difference was found between the groups in terms of observed dentinal defect (P > 0.05). No correlation between the slices obtained from different levels and the amount of dentinal defect was determined (P > 0.05).*
Conclusion:*All of the NiTi files tested in the present study were found to cause dentinal defect on root canal dentin.*
Keywords:*Endodontics,Extreme CM R3, HyFlex CM, Nickel Titanium, SANI S3*

I. Introduction

Besides many advantages of nickel-titanium (NiTi) rotary file systems, NiTifileshave been reported to have certain disadvantages such as creating dentinal defects during root canal preparation[1].However, there is not an exact consensus on whether the dentinal defects cause vertical root fractures[2, 3],but the common view on this subject is that preventing the formation of dentinaldefects would be useful[1, 4].

There are various commercially available systems made by different manufacturers and used for shaping the root canals. Kim et al.[5]have reported that the designs of NiTi file systems might influence the incidence of vertical root fractures. HyFlex CM (HCM; Coltene-Whaledent, Allstetten, Switzerland)rotary file system has asymmetric cross-sectionwith3 cutting edges. HCM is made of heat-treated Controlled Memory (CM) alloywithout shape memory. Thus, it is claimed that the cyclic fatigue resistance of the files and their efficiencies in shaping the curved root canals were improved.

The cyclic fatigue resistance of NiTi files made of CM alloy has been reported to be higher than NiTi files made of conventional alloy[6, 7]. Another feature of the CM files is that they do not have the shape memory that the files made of conventional alloy have[7]. Extreme CM R3 (ECM; Edge Endo, USA), which is one of the newly introduced file systems made of CM alloy, has convex triangular cross-section. This file system consists of 1 canal orifice enlarger (NX (25/.12), 2 pcs coronal enlargement files (N1 (17/.04) and N2 (17/.06)),and 4 pcs apical finishing files (C1 (20/.06), C2 (25/.06), C3 (30/.06) and C4 (40/.06)), all of which have constant taper. SANI S3 (SANI Dental Manufacturing Limited, China) system, which is also anewlyintroduced system thatismade of CM alloy, has files havingsquarecross-section. This file system consists of 4 heat-treated files with constant taper(SU (20.10), S1 (20.04), S2 (25.06) and S3 (35.04)).

In our comprehensive literature research, no study examining the dentinal defects created during root canal shaping procedure by ECM and SANI NiTi files was found. Thuds, the aim of this *in vitro*studywas to compare the dentinal defect incidences ofHCM, ECM and SANI NiTi files during root canal shaping of maxillary first premolar teeth. The null hypothesis was there would be no difference between the dentinal defect incidences of HCM, ECM and SANI NiTi files.

II. Material and Methods

Specimen Selection

Eightyfirst maxillary premolar teeth extracted due to periodontal reasons and having two separate and straight canals were selected for this study. The soft and hard tissue residuals around the teeth were mechanically removed using a periodontal curette. The crowns of teeth were removed from the cement-enamel junction under water-cooling, and the root lengths were set at 16 mm. The radiography images of teeth were taken in mesio-distal and bucco-lingualdirections. The teeth found to have calcification, having previous root canal treatment, internal and/orexternalresorption, or cracked and/or immature roots were excluded. The selected teeth were kept in distilled water at 4°C until the experimental procedures.

As well as in previous studies[8, 9],the roots of teeth were wrapped with aluminum foiland then embedded into acrylic resin (Imicryl, Konya, Turkey). After the acrylic setting, the teeth were taken out from the resin, and the foils were removed. For simulatethe periodontal ligament, the resin blocks filled with silicon impression material (Express XT Light Body Quick; 3M ESPE, Neuss, Germany) and the specimens were then placed into resin blocks again.

The canals of teeth were penetrated using #10 K-file (Dentsply Maillefer) until the tip of file is seen from the apex. The working length was set by subtracting 1mm from this length. For all of specimens, the glide path was formed ensuring the apical diameter to be #15. For each of specimens, 20 ml 1% sodium hypochlorite (NaOCl) was used during the preparation. Each of the canal files was used for preparation of 4 canals (2 specimens). All of procedures were executed by the same operator. The teeth were randomly divided into 4 groups (20 teeth each).

1: HyFlexCM

Root canal preparation of the teeth in this group was performed by using HyFlex CM NiTi rotary file system's 25/.08, 20/.04 and 25/.04 files at 500 rpm and 2.5 Ncm torque in accordance with the manufacturer instructions in torque-controlled endodontic motor (X-Smart; Dentsply Maillefer, Ballaigues, Switzerland)usingcrown-downtechnique.

Group 2: Extreme CM R3

Root canal preparation of the teeth in this group was performed using Extreme CM R3 NiTi rotary file system's N1 (17/.04), N2 (17/.06), C1 (20/.06) and C2 (25/.06) files at 300 rpm and 3 Ncm torque according to the instructions of manufacturer in torque-controlled endodontic motor (X-Smart).

Group 3: SANI S3

Root canal preparation of the teeth in this group was performedin torque-controlled endodontic motor (X-Smart) by using SANI S3 NiTi rotary file system's SU (20/.10), 1S (20/.04) and2S (25/.06) files at 500 rpm and 2.5 Ncm torque in accordance with the manufacturer instructions.

Group 4: Negative Control

The specimens in this group didn't receive any treatment and were assigned to be negative control group.

Evaluation of Dentinal Defects

Roots of 80 specimens were cut under water-cooling (Isomet; Buehler Ltd, Lake Bluff, IL, USA)perpendicular to the axis of teeth and 3, 6 and 9mm distant from the apex, and the three slices were taken from each of the specimens. The digital images of obtained slices were taken under x25 magnification usingdigitalcamera connected to stereomicroscope (Olympus BX43, Olympus Co., Tokyo, Japan). A total of 240 digital images (60 in each group) were examined from the aspect of presence of any crack. If there was no line on the canal walls or external surfaces, then the specimen was classified to "No Crack". Any crack seen on the slices was considered to be "Crack"[1].

Statistical Analysis

Chi-square test was used in statistically examining the incidence of dentinal defects among the groups. The level of significance was set to 5%. Moreover, Pearson correlation test was employed in order to determine the distribution of the number of dentinal defect between the groups by the slices (3, 6, 9 mm). SPSS 21 (IBM-SPSS Inc., Chicago, IL, USA) program was used for statistical analyses.

III. Results

The distribution of dentinal defects is presented in Figure 1, and the vertical fractures are presented in Figure 2. All of the tested NiTi file systems were determined to cause statistically more dentinal defect than the control group ($P< 0.05$). No statistically significant difference was found between the groups in terms of observed

dentinal defect (P>0.05). No correlation between the slices obtained from different levels and the amount of dentinal defect was determined (P> 0.05).

IV. Discussion

The forces emerging during preparation the root canals using NiTi rotary files may cause dentinal defects such as cracks and fractures. These defects are affected from the geometrical and mechanical features of designs of NiTi file systems being used[10].

CM process increases the files' austenite trespassing temperature above 37° and NiTi file is allowed to be in double martensitic phase in working temperature[11]. Martensitic phase of the file allows the file to have low or no shapememory. Thus, the file doesn't attempt to turn back to its original form while working within the canal. Then, the file becomes more flexible[11],and more resistant to cyclic andtorsionalfatigue[12]. For this reason, the aim of the present study to compare the dentinal defect incidences of various NiTi files made of CM alloy.

Vertical root fractures can be seen in any type of teeth, but the maxillary premolar teeth are the teeth group, where the vertical root fractures are most frequently seen[13, 14]. High convexity of the roots of maxillary premolar teeth is shown as a reason for this. It has been reported in studies that the teeth having high convexity are more prone to the vertical root fractures[15-17]. In studies, which have been carried out in order to examine the dentinal defects, mandibular premolar teeth have been used in general[18, 19]. Due to the thin roots that maxillary premolar teeth have, more amount of dentinal defect may occur in roots during the mechanical preparation. For this reason, first maxillary premolar teeth were used in the present study.

NiTi file manufacturers generally recommend using 1 file for each of the teeth. In the present study, in order to prevent the effects of deformation of files on the results, the files were replaced after being used in 4 maxillary premolar tooth canals (2 specimens) based on the preparation of 4-canal maxillary molar tooth[20, 21].

Using lagerfiles in root canal preparationhas been reported to increase the dentinal defects[22]. For this reason, the final apical diameter was determined to be #25 and no larger file was utilized. Moreover, in the present study, 1% NaOCl solution was used as irrigation solution in order to protect the microstructure of dentin. Thus, it was aimed to ensure that the dentinal effects occurring are mainly related with the mechanical preparation.

According to the results of the present study, no statistically significant difference was found between tested NiTi groups in terms of dentinal defect incidence. For this reason, the null hypothesis of the present study was accepted. In previous studies, the files made of CM alloy have been reported to be more flexible than those made of conventional NiTi files[23, 24]. We believe that the CM alloy used in manufacturing the files is the reason for observing less dentinal effect in comparison to other studies.

In our comprehensive literature research, no study examining the dentinal defects of SANI S3 and Extreme CM R3 NiTi file systems during root canal preparation was found. For this reason, the present study results cannot be directly compared to of previous studies. Çapar et al.[8]have examined the dentinal defects on mandibular premolar teeth by HCM, ProTaper Universal (Dentsply Maillefer) and ProTaper Next (Dentsply Maillefer) NiTi file systems, and reported that ProTaper Next and HCM files created less dentinal defect than ProTaper Universal files. Ashraf et al.[25]haveinvestigated the dentinal defects of ProTaper Universal, ProTaper Next and HCM NiTi file systems on mandibular premolar teeth by using sectioning method. Researchers have reported that HCM files caused less cracks than ProTaper Universal and ProTaper Next files. HyFlex CM file has triangular cross-section, while SANI S3 has modified quadrilateral cross-section and Extreme CM R3 has modified triangular cross-section. For this reason, it is very difficult to specify which one of these design characteristics influences the study results. Moreover, these design properties of files also affect the level of stress on root dentin during preparation procedure[26]. Furthermore, in a finite elements analysis, it has been shown that increasing taper of files increased the stress on root canals during preparation procedure[5]. Bier et al.[18]have stated that thetaper of files might affect the dentinal defects occurring during preparation procedure. Yoldaş et al.[10]haveclaimed that the tip structure, sectional cross-section, constant or variable taper, and groove and stripe structure of NiTi files might be related with the formation of dentinal defects. However, no difference was found between the dentinal defect incidences of NiTi files that have different geometrical characteristics and were tested in the present study. We believe that the differences observed in other studies originate from the differences in methodologies employed.

V. Conclusion

All of the NiTi files tested in the present study were found to cause dentinal defect on root canal dentin. However, the clinical effects and importance of dentinal defects occurring during root canal preparation on the endodontic treatment's success has not been revealed yet. For this reason, *in vivo* studies examining the role of dentinal defects, which occur during root canal shaping procedures, on the endodontic failure are needed.

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[27]. **Figure 1.** Number of dentinal defects after preparation with tested NiTi files. There are no statistically differences between groups (P> 0.05).
[28]. **Figure 2.**Number of vertical fractures after preparation with tested NiTi files. There are no statistically differences between groups (P> 0.05).