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Evaluation of Dentinal Defects after Root Canal Preparation Using Various Rotary Nickel Titanium Files – An Invitro Study

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ABSTRACT

AIM

To evaluate the incidence of dentinal defects after root canal preparation using various nickel titanium files.

MATERIALS AND METHODS

Sixty mandibular first premolars were selected and stored in purified filtered water. The coronal portions were removed by using a diamond disc, leaving roots of approximately 16 mm in length. Sixty teeth were divided into 4 experimental groups (n=15) according to the instrument system that used for preparation. Control group (n=15), Hyflex EDM group (n=15), Protaper Next group (n=15) and Waveone Gold group (n=15). After instrumentation roots were sectioned using Hard tissue microtome. Coronal, Middle and Apical sections of each roots were inspected under stereomicroscope to evaluate Dentinal defects. Results were expressed as the number and percentage of defected roots in each group. A chi-square test was performed to compare the appearance of defected roots between the experimental groups by using the SPSS/PC version 15 (SPSS Inc, Chicago, IL).The level of significance was set at p value < 0.05.

CONCLUSION

Within the limitations of the present study, Hyflex EDM files manufactured using Electric Discharge Machining (EDM) process showed promising results compared to Protaper Next and Waveone Gold. Prudent selection of file system for instrumentation is of utmost importance for long term endodontic success.

Keywords: Dentinal Defects, Dentinal Cracks, Hyflex EDM, Waveone Gold, Protaper Next.

INTRODUCTION

The main objective of chemo-mechanical root canal preparation includes the preservation of the original canal anatomy and cleaning of the entire root canal system. One of the most common complications associated with mechanical preparation of root canal is vertical root fractures (VRF) leading to tooth loss.[1] A major goal in chemo-mechanical root canal preparation is to overcome the potential problem of dentinal microcrack formation while instrumenting with rotary or reciprocation instruments.

Hyflex EDM (Coltene/Whaledent, Switzerland) are the recently introduced continuous rotation single file system made of controlled memory (CM) treatment, which has been proven to increase the flexibility and cyclic fatigue resistance.

Protaper Next (Dentsply Maillefer, Switzerland) are the continuous rotary NiTi files made of M-Wire technology, thus enhancing the flexibility and cyclic fatigue resistance of the alloy over conventional NiTi.

Wave one Gold files are the updated version of Wave One files (Dentsply Maillefer). While maintaining the reciprocation motion of files and the cross section of the file was modified to an alternate offset parallelogram with 2 cutting edges.

Hence the aim of this study is to evaluate the incidence of dentinal defects after root canal preparation using Hyflex EDM, ProTaper Next and Waveone Gold Nickel titanium files.

MATERIALS AND METHODS

The following were used:

(1) Sixty extracted human mandibular first premolar.

(2) Rotary files:

- ProTaper Next (Dentsply Malleifer, Ballaigus, Switzerland),
- Waveone Gold (Dentsply Malleifer, Ballaigus, Switzerland), and
- HyFlex EDM (Coltene Whaledent, Altstetten, Switzerland).
- Proglider (Dentsply Malleifer, Ballaigus, Switzerland).

(3) K-file number #10.

(4) Acrylic resin.

(5) Polyvinyl siloxane impression material.

(6) Endo motor X-smart Plus (Dentsply Malleifer, Ballaigus, Switzerland).

(7) 30 gauge needle and syringe (5 mL).

(8) 5.25% sodium hypochlorite.

(9) 17% EDTA.

(10) Normal Saline.

(11) Hard tissue microtome (Leica SP 1200).

(12) Stereomicroscope.

(13) Camera.

Sixty mandibular first premolars were selected and stored in purified filtered water. The coronal portions were removed by using a diamond disc, leaving roots of approximately 16 mm in length. All roots were inspected with stereomicroscope under 12X magnification to detect any pre-existing craze lines or cracks. Teeth with such findings were excluded from the study. A polyvinyl siloxane impression material was used to coat the cemental surface of roots for simulating periodontal ligament space. Then, all the roots were embedded in acrylic blocks. Canal patency was established with a #10 K-File. Sixty teeth were divided into 4 experimental groups (n=15) according to the instrument system that used for preparation.

Canal preparation:

Control group (n=15) :

Control group was left unprepared.

Wave One Gold file group (n=15):

In this group the following sequence of Wave One Gold reciprocating files (Dentsply, Maillefer, Switzerland) were used to prepare the canals with Xsmart plus motors and 6:1 reducing handpiece. With an estimated working length and in the presence of a viscous chelator, size #10 file was inserted and simply worked within any region of the canal until it was completely loose. After that Proglider was inserted to the working length according to the manufacturer's instructions. The primary 25/08 Wave One Gold file was used with a gentle apically pressure to allow this instrument to run 2, 3, 4, mm inward with a brushing motion to eliminate the interferences.

Protaper Next group (n=15):

With an estimated working length and in the presence of a viscous chelator, size #10 file was inserted and simply worked within any region of the canal until it was completely loose. After that Proglider was inserted to the working length according to the manufacturer's instructions. The root canals were enlarged using the instruments X1 (17/0.04) and X2 (25/0.06) in sequence in a continuous rotary movement until the WL was reached, and all the canals were instrumented on the buccolingual and mesiodistal extensions. The motor used was a Xsmart plus with 300 rpm and 2Ncm of torque.

Hyflex EDM group (n=15):-

In this group the following sequence of Hyflex EDM files were used to prepare the canals with Xsmart plus motors and 6:1 reducing handpiece. With an estimated working length and in the presence of a viscous chelator, size #10 file was inserted and simply worked within any region of the canal until it was completely loose. Hyflex EDM orifice opener is used to enlarge the orifice and after that Hyflex EDM glidepath file was inserted to the working length according to the manufacturer's instructions. Hyflex EDM one file (25/~) was used to shape the canal to full working length, The HyFlex EDM files were

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used in a gentle in-and-out motion with a rotational speed of 500 rpm and 2.5Ncm torque.

After instrumentation roots were sectioned using hard tissue microtome. Coronal, Middle and Apical sections of each root were inspected under stereomicroscope to evaluate Dentinal defects.

RESULTS

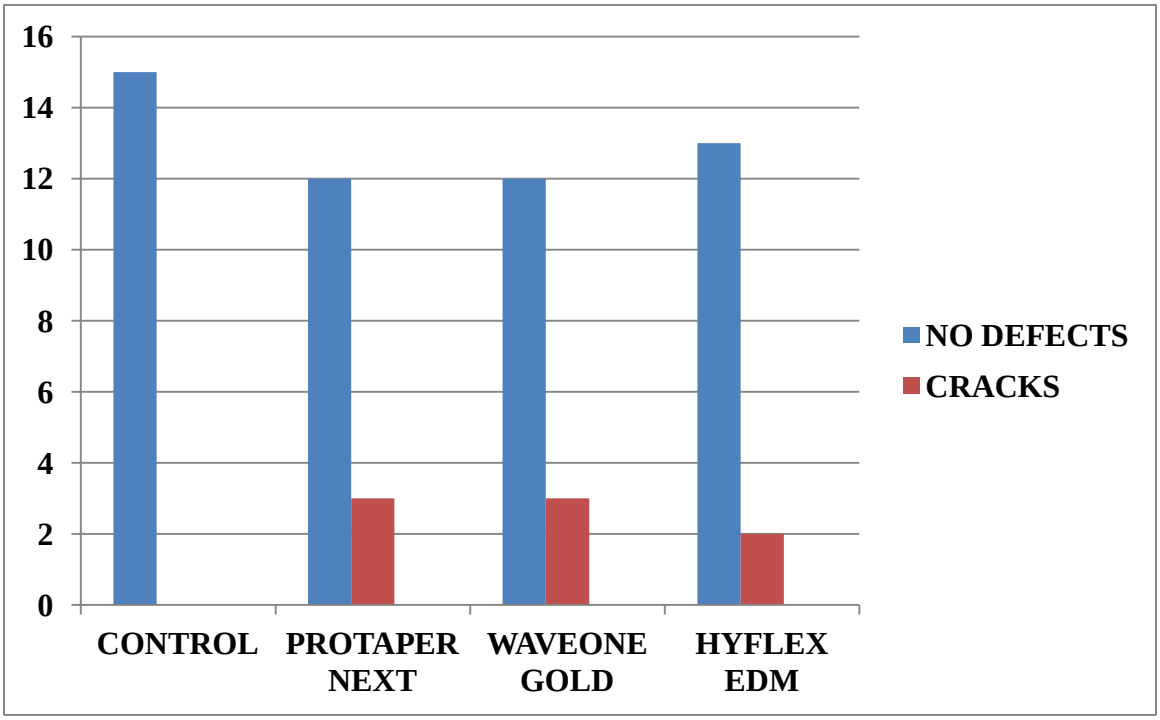
Each specimen was checked for the presence of dentinal defects (microcracks). ‘‘NO DEFECT’’ was defined as root dentin devoid of any craze lines or microcracks either at the external surface of the root or at the internal surface of the root canal wall. ‘‘DEFECT’’ was defined if any lines, microcracks, or fractures were present in root dentin. A total of 45 sections were examined in each group.

Results were expressed as the number and percentage of defected roots in each group. A chi-square test was performed to compare the appearance of defected roots between the experimental groups by using the SPSS/PC version 15 (SPSS Inc, Chicago, IL).The level of significance was set at p value < 0.05.

CORONAL THIRD

CORONAL	CONTROL GROUP	PROTAPER NEXT	WAVEONE GOLD	HYFLEX EDM	TOTAL	*P* VALUE
NO DEFECT	15 (100%)	12 (80%)	12 (80%)	13 (87%)	52 (86%)	**0.326**
DEFECT	0 (0%)	3 (20%)	3 (20%)	2 (13%)	8 (14%)	

Table.1Pearson chi square test for coronal third region.



Bar diagram 1. Coronal third region

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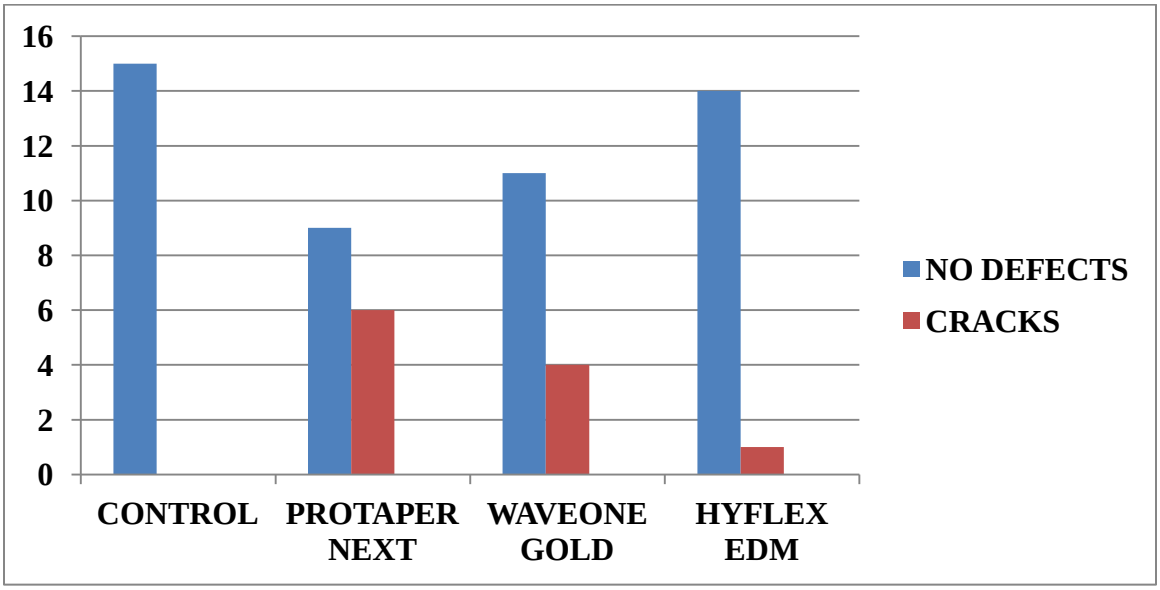
MIDDLE THIRD

MIDDLE	CONTROL GROUP	PROTAPER NEXT	WAVEONE GOLD	HYFLEX EDM	TOTAL	*P* VALUE
NO DEFECT	15 (100%)	9 (60%)	11 (73%)	14 (93%)	49 (82%)	0.017
DEFECT	0 (0%)	6 (40%)	4 (27%)	1 (7%)	11 (18%)	

Table.2 Pearson chi square test for middle third region.



Bar diagram 2. Middle third region

APICAL THIRD

APICAL	CONTROL GROUP	PROTAPER NEXT	WAVEONE GOLD	HYFLEX EDM	TOTAL	*P* VALUE
NO DEFECT	15 (100%)	11 (73%)	11 (73%)	14 (93%)	51 (85%)	0.083
DEFECT	0 (0%)	4 (27%)	4 (27%)	1 (7%)	9 (15%)	

Table.3 Pearson chi square test for apical third region.

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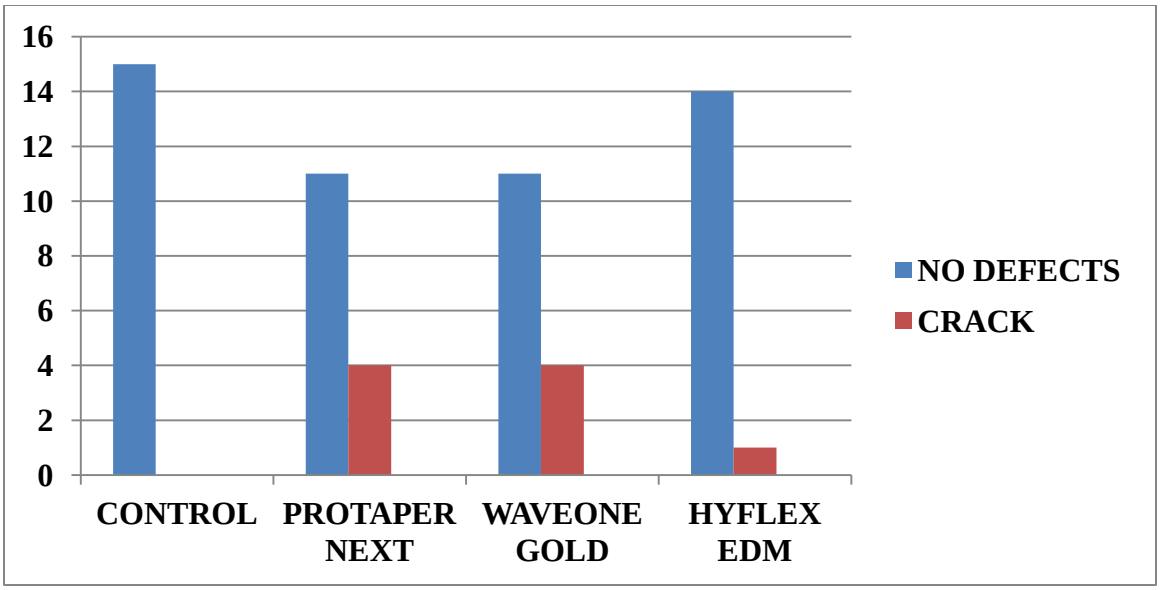
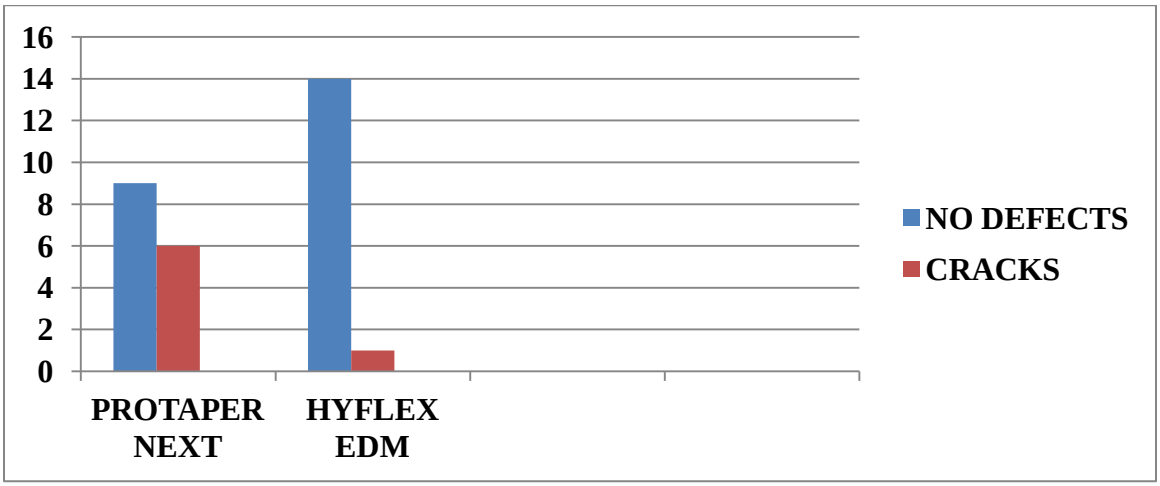


Bar diagram 3. Apical third region

MIDDLE THIRD (POST HOC TEST)

GROUPS	PROTAPER NEXT	HYFLEX EDM	P VALUE
NO DEFECT	9 (60%)	14 (93%)	.040
DEFECT	6 (40%)	1 (7%)	

Table 4: Post hoc test for middle third region



Bar diagram 4.Post hoc test for middle third region

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The findings of the present study is summarized as follows:-

- There was no statistically significant difference seen in coronal third and apical third region among the three groups.
- There was a significant difference seen in middle third region between Hyflex EDM and Protaper Next. Hyflex EDM showed least number of cracks.
- Although there was no statistically significant difference between Hyflex EDM and Waveone Gold. Hyflex EDM showed least number of cracks when compared with Waveone Gold in the middle third region.

DISCUSSION

Traditionally, root canal preparation was carried out using stainless steel endodontic files manipulated by hand. In recent years, advances in rotary nickel titanium instruments have led to new designs and techniques of root canal preparation. But the major drawback associated with rotary nickel instrumentation is the incidence of dentinal defects which further leads to vertical root fracture (VRF). Another problem with nickel titanium instrument is instrument separation. Cyclic fatigue and torsional fatigue are the main causative factors for instrument separation.

To overcome the instrument separation and to improve the flexibility of Ni-Ti rotary instruments, manufacturers have been taking efforts to make Ni-Ti files of superior mechanical properties by using various cross sectional designs, surface treatment and different manufacturing processes. Till date, the incidence of dentinal defects associated with rotary NiTi instruments manufactured using different techniques has been reported in several studies.

When NiTi rotary instruments are used, a rotational force is applied to the root canal walls. Thus, they can create microcracks or craze lines in the root dentin. The extent of such a defect formation may be related to the tip design, cross-section geometry, constant or progressive taper type, constant or variable pitch and flute form.[2]

The stresses generated from inside the root canal are transmitted through the root to the surface where they might overcome the bonds holding the dentine together.[3]

Fracture occurs when the tensile stress in the canal wall exceeds the ultimate tensile strength of dentine.[4]

Hence, the present study aimed to evaluate the incidence of dentinal defects after root canal preparation using various nickel titanium instruments such as Hyflex EDM, Waveone Gold and Protaper Next.

In the present study, there is no statistically significant difference among the three groups in coronal and apical third region. Based on the mean values, Hyflex EDM showed least number of cracks than Protaper Next and Waveone Gold in the apical third region.

Results of this study showed that in middle third region there is statistically significant difference between Hyflex EDM and Protaper Next. Hyflex EDM showed least number of cracks than Protaper Next. Although there is no statistically significant difference, Hyflex EDM showed least number of cracks than Waveone Gold.

In the present study, the least number of cracks associated with Hyflex EDM in the apical third region could be attributed to the flexibility of the nickel titanium instruments achieved from heat treatment. Eventhough the entire three file systems are heat treated, the greater flexibility of Hyflex EDM is probably due to the synergistic effect of controlled memory wire and electric discharge machining process.[5]

Hyflex EDM showed significantly least number of cracks than Protaper Next in middle third region in the present study. This might be due to the variable taper of the Hyflex EDM file.[5] Eventhough all the three files are variable tapered, Protaper Next showed higher number of cracks than Hyflex EDM. This could be attributed to the lesser taper of Protaper Next instruments compared with Hyflex EDM. This result is in accordance with Adorno et al, who found that cracks were mostly initiated with smaller instruments rather than larger ones.[6]

Several studies reported that continuous rotary instruments produced more cracks than reciprocating instruments.[7,8,9] But in the present study, although there is no statistically significant difference, Hyflex EDM (Continuous rotary) showed least number of cracks when compared to Waveone Gold (Reciprocating) in middle and apical third region.

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This might be due to the fact the alloy from which the instrument is manufactured was an important factor in determining the damaging potential of single-file instruments rather than the motion of instrumentation.[10]

Yoldas et al stated that cross sectional geometry of the files could be a contributing factor in dentinal crack formation..[2] The off-centered rectangular design of Protaper Next and offset parallelogram shaped cross section of Waveone Gold instruments minimizes the contact between file and dentin which reduces stress thereby reducing the dentinal defects.[11,12,13] Despite these advantages of Protaper Next and Waveone Gold, in the present study, Hyflex EDM showed least number of cracks. This showed that the alloy type, flexibility achieved from heat treatment and manufacturing process plays a major role in reducing the occurrence of dentinal defects than cross sectional geometry of the instruments.

Creating a glidepath provides several advantages such as preserving original canal anatomy, lower incidence of canal aberrations, less post-operative pain, lower incidence of separation of Ni-Ti rotary instruments and less instrument binding in the canal. The possibility of dentinal defects might be increased due to the excessive instrument binding and maximum contact between file and dentin. Hence in the present study, glidepath was used in all the three file systems according to the manufacturer's instructions.[14]

In the present study, Proglider was used to create glidepath in Waveone Gold group and Protaper Next group. Hyflex EDM glidepath was used in Hyflex EDM group. The least number of cracks associated with Hyflex EDM files in the middle third region can be attributed to the Hyflex EDM glidepath files. Similar to Hyflex EDM shaping files, glidepath files also manufactured using EDM process with controlled memory wire technology.[15]

It should be noted that in the present study, root canal instrumentation was performed 1mm short of the apical foramen, because the incidence of apical root cracks could be related to different instrumentation lengths. [16] In the current experiment, the roots were surrounded with an impression material to mimic the bony socket that might change the force distribution around the tooth when external forces were used. However, the clinical situation is more complex because of the presence of periodontal ligament that could further influence the distribution of forces.[17]

The most susceptible roots to fracture are those with narrow mesiodistal diameter compared with the buccolingual dimension as in maxillary premolars, mesial roots of mandibular molars and mandibular incisors.[18] In the present study, mandibular first premolars with straight canals were chosen and Hyflex EDM showed least number of cracks in middle third region than Protaper Next and Waveone Gold when compared with the other two regions. So, further studies are needed to evaluate the dentinal defects caused by Hyflex EDM in most susceptible roots to fracture such as roots with narrow mesiodistal diameter and curved canals.

CONCLUSION

Within the limitations of the present study, Hyflex EDM files manufactured using Electric Discharge Machining (EDM) process showed promising results compared to Protaper Next and Waveone Gold. Prudent selection of file system for instrumentation is of utmost importance for long term endodontic success.

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