

STEREOMICROSCOPIC EVALUATION OF DENTINAL MICRO-CRACK FORMATION DURING ROOT CANAL PREPARATION BY NEW NITI ROTARY INSTRUMENTS: AN IN VITRO STUDY

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ABSTRACT:

Aims: The aim of this study was to evaluate dentinal defects formed by new rotary system- HyFlex EDM

Methods and Material: Seventy Five single-rooted premolars were selected. All specimens were decoronated and divided into Five groups, each group having 15 specimens. Group I – Control Group(Unprepared Canals) Group II were prepared by Hand K-files (Mani), Group III with ProTaper Universal (PT; Dentsply Maillefer), Group IV with ProTaper Next (Dentsply Maillefer), and Group V with HyFlex EDM (Coltene/ Whaledent, Alstatten, Switzerland). Roots of each specimen were sectioned at 3, 6, and 9mm from the apex and were then viewed under a stereomicroscope to evaluate presence or absence of dentinal defects.

Statistical analysis used: Chi-square test was used for the statistical analysis of the groups.

Results: Hand files showed lowest percentage of dentinal defects (13%); whereas in roots prepared with ProTaper Universal, ProTaper Next, and Hyflex EDM it was 47%, 27%, and 20%, respectively. There was significant difference between the ProTaper Universal group when compared with ProTaper Next and HyFlex EDM group ($P < 0.05$). There was no statistical difference when ProTaper Next was compared with HyFlex EDM ($P > 0.05$).

Conclusions: The new rotary system - HyFlex EDM and ProTaper Next induce less dentinal defects than ProTaper Universal while defects were comparable when compared with Hand files.

Key-words: Dentinal defects; Hand files; NiTi instruments; ProTaper nextTM; HyFlex EDMTM, Root canal preparations.



INTRODUCTION:

Shaping and cleaning is believed to be a key for a successful endodontic therapy.^[1] It includes removing the pulp tissues and debris from the canal to achieve three dimensional obturation of root canal system.^[2] Shaping of the

canals can be done using hand instrument (stainless steel) or rotary (NiTi) instrument.^[2]

Stainless steel hand files clean the canal superficially and create canal aberrations

such as ledges, zips, and elbows.^[3] To overcome this disadvantage, nickel titanium (NiTi) instruments with shape memory and superelasticity were developed.^[4]

Rotary Ni-Ti instruments demonstrate increased canal cleanliness and fewer straightening, apical canal transportation and perforations.^[5] It requires less time as compared to hand instrumentation to prepare canals.^[6] But these NiTi instruments carry hazard of instrument fracture and root dentinal crack formation.^[7,8] These dentinal cracks can result in vertical root fractures which is a clinical complication that can lead to extraction of tooth.^[9] Fuss et al(1999) reported the prevalence of vertical root fractures with endodontically treated which was 10.9%.^[1,5]

Shemesh^[10] reported various root canal shaping systems damage the root canal wall to various degrees. Kim et al^[11] have reported increase in apical stress and strain concentrations during root canal instrumentation with respect to various file design.

Recently, HyFlex EDM files (Coltene/Whaledent) have been manufactured via an electro discharge machining (EDM) process. EDM files has an irregular and a 'craterlike' surface that is characteristic superficial morphology of ED-machined materials. Hyflex EDM is a 5th generation NiTi technology with controlled memory, greater flexibility and higher cyclic fatigue resistance.^[11] The ProTaper next

(PTN, Dentsply, Maillefer) files are recently introduced with 5th generation NiTi technology with a completely new offset design and has greater flexibility.^[12]

Various studies have reported the effect of various NiTi rotary system on crack formation but there is no literature documentation in our knowledge regarding the effect of the new rotary system –i.e. Hyflex EDM. Hence, the aim of this study was to compare the incidence of root cracks after root canal instrumentation with the Hand files, ProTaper Universal, ProTaper Next, and HyFlex EDM.

MATERIALS AND METHODS:

Seventy five freshly extracted human mature mandibular premolars were selected with mature apices and straight root canals (<5) were selected and stored in physiologic saline. Periapical radiographs of the teeth were taken, and only single-rooted teeth with a single canal were included in the study. The coronal portions of all the teeth were removed by using a diamond disk under water coolant leaving roots approximately 12 mm in length.

All the roots were inspected with a stereomicroscope with 40x magnification to detect any pre-existing external defects or cracks. Patency of the canal was established using a #10 K-File (Mani, Japan) in the canal. The surface of the roots was coated with a silicone impression material to simulate the

periodontal ligament space. All the roots were then embedded in acrylic blocks

The specimens were then divided into five groups; each group containing 15 specimens each.

Group I: Unprepared canals. (Control group).

Group II: Hand files (Mani, Japan).

Hand instrumentation was done using a step back technique. Coronal enlargement was done with Gates Glidden burs, apical preparation was done to the master apical file ISO size 30 with K files to working length. Then the working length was gradually decreased by (modified step back technique) 1mm to create a tapered shape till ISO size 50. After each step recapitulation was done with a smaller number K-file.

Group III: ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland).

In this group, a ProTaper Universal rotary system was used to prepare samples with a crown down technique. The instrument sequence used was SX instrument at two third of the working length, followed by S1 S2 F1 F2 and F3 till 1 mm short of working length. (F3 corresponds to ISO size 30)

Group IV: ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland).

In this group, a ProTaper Next rotary system was used to prepare samples with a crown down technique. The instrument sequence used was SX

instrument at two third of the working length, followed by X1 X2 and X3 till 1 mm short of working length. (X3 corresponds to 30/07) at (as recommended by manufacturer) 300 rpm; 5.2Ncm)

Group V: HyFlex EDM. (Coltene/Whaledent, Alstatten, Switzerland)

In this group, HyFlex EDM rotary system was used to prepare with crown down technique. The instrument sequence used was HyFlex Orifice Opener (25/.12) followed by Glidepath File (10/.05) and Hyflex One file (25/~) at (as recommended by manufacturer) 500 rpm; 2.5 Ncm.

Irrigation was done using 5ml of saline after each instrument.

Sodium hypochlorite (NaOCl) was not used for irrigation as it can cause decrease in microhardness and can result in more crack formation.^[13]

Sectioning and Microscopic Evaluation

All roots were sectioned perpendicular to the long axis at 3mm, 6mm and 9 mm using a diamond disc with water coolant. Digital images of each sectioned root was captured using a ×40 stereomicroscope by using a digital camera (Olympus, Tokyo, Japan). Two operators checked each specimen for the presence of dentinal defects.

Dentinal defects were classified as follows:

NO DEFECT: Root dentin without any lines or cracks on the external or the internal surface of the root.

INCOMPLETE CRACK: A line extending from the canal wall into the dentin without reaching the outer surface.

COMPLETE CRACK: A line extending from the root canal wall to the outer surface of the root.

CRAZE LINES: All other lines that did not reach any surface of the root or extend from the outer surface into the dentin but did not reach the canal wall.^[14]

Statistical Analysis

The results were stated as the number and percentage of defects in each group. Chi-square test was used for the statistical analysis of the groups. The level of significance was set at $P = 0.05$ using Statistical Package for Social

Sciences (SPSS) 20.0.

RESULTS:

Figure 1 is a bar chart representing the number of root defects in each group. Unprepared canals showed no defects. Hand Files group showed lowest defect (2/15) followed by, HyFlex EDM (3/15), ProTaper Next (4/15) and ProTaper universal (7/15). There was statistical significant difference when ProTaper Universal was compared with Handfiles, ProTaper Next and HyFlex EDM Groups $P < 0.05$. But there was no statistical difference when Hand Files were compared with ProTaper Next and

HyFlex EDM and when ProTaper Next was compared with HyFlex EDM Group ($P > 0.05$).

The Stereomicroscopic images of Group I, II, III, IV & V are shown in Figure 2.

DISCUSSION:

Recent studies have suggested that Vertical Root fracture is most likely not an immediate phenomenon after root canal preparation.¹⁶⁻¹⁷ These craze lines may advance into fractures during any additional procedure such as preparation, obturation, and retreatment or by repeated stress of occlusal forces.

In the present study, unprepared canals, Hand Files, ProTaper Universal, ProTaper Next and hyFlex EDM showed 0/15(0%), 2/15(13%), 7/15(47%), 4/15(27%) and 3/15(20%), respectively. In group I (control group), no cracks were observed which inferred that sectioning method did not induced any microcracks. Hence, It may be concluded that the microcracks observed were as a result of the preparation procedures. ProTaper Universal (47%) showed significantly more defects than ProTaper Next (27%) and HyFlex EDM (20%).

Sodium Hypochlorite (NaOCl) was not used for irrigation as it can cause decrease in microhardness and can result in more crack formation.^[5,18]

Stainless steel hand files prepare the canals superficially and also create canal aberrations, such as ledges, perforations,

zips and elbows.^[3] But hand files does not cause much harm to root canal wall. As in present study, hand file group showed least defects of about 13% (2/15). This result are in agreement with studies reported by Yoldas *et al.*^[19] Hin *et al.*^[20] This can be attributed to less aggressive actions of the hand files in the canal, lesser taper of 2%, slower speed, better tactile sensation and less stress generated as compared to rotary instruments.^[19,20,23]

ProTaper Universal have active rotary movement which results in high stress concentration in root canal walls and progressively greater taper causing more coronal dentin removal and leading significantly more number of cracks.^[21] This observation are in accordance with Hin *et al.*^[20] & Shori DD *et al.*^[22] reported 35% and 40% of defects with ProTaper Universal rotary system respectively.

ProTaper Next(27%) showed lesser defects as compared to ProTaper universal (47%). This could be due to ProTaper Next rotary system has off-centered rectangular cross section producing swaggering movement, thus reducing the screwing effect preventing the unwanted taper lock, and torque on the given file thus decreasing the file-root dentin contact while ProTaper universal has triangular cross section and a greater taper.^[12,24] Bier *et al* stated that taper of the files can influence dentinal cracks formation.^[23]

HyFlex EDM is a one file system manufactured using Electro discharge

machining technology. It has greater flexibility with controlled memory effect and higher cyclic fatigue resistance. HyFlex EDM is unique file having a variable cross section design. Almost triangular cross section at top, trapezoidal in middle and rectangular at tip.^[11]

HyFlex EDM & ProTaper Next showed least amount dentinal defects of about 20% (3/15) and 27% (4/15) respectively. No previous study evaluated the effect of the Hyflex EDM instruments on the formation of dentinal defects. According to our results, Hyflex EDM system caused 20% defects which is less than the ProTaper NEXT system but it was not statistically different. This result are in accordance with Capar *et al*, that ProTaper Next and Hyflex instruments produced less microcracks than ProTaper universal system. This could be due to HyFlex EDM has a controlled memory, constant and a lesser taper than ProTaper Universal and ProTaper Next.^[25]

LIMITATIONS:

- 1) Recommended speed and torque cannot be standardized for all files used in the study.
- 2) Instrumentation downward force cannot be standardized which can also influence dentinal crack formation.
- 3) Teeth with only straight root canals were selected which did not replicate true clinical presentation.

CONCLUSION:

Within the limitation of this in vitro study, the new rotary system - HyFlex

EDM and ProTaper Next induce less dentinal defects than ProTaper Universal while defects were comparable when compared with Hand files.

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TABLES AND FIGURES

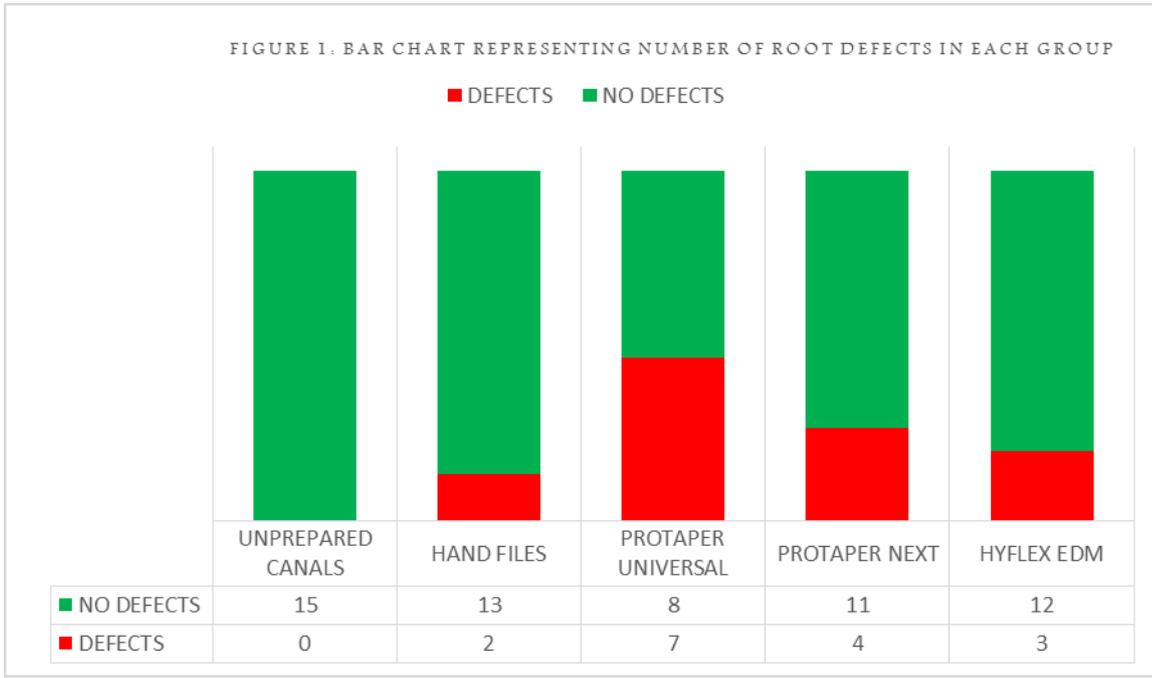


Figure 1: Bar chart representing the number of root defects in each group.

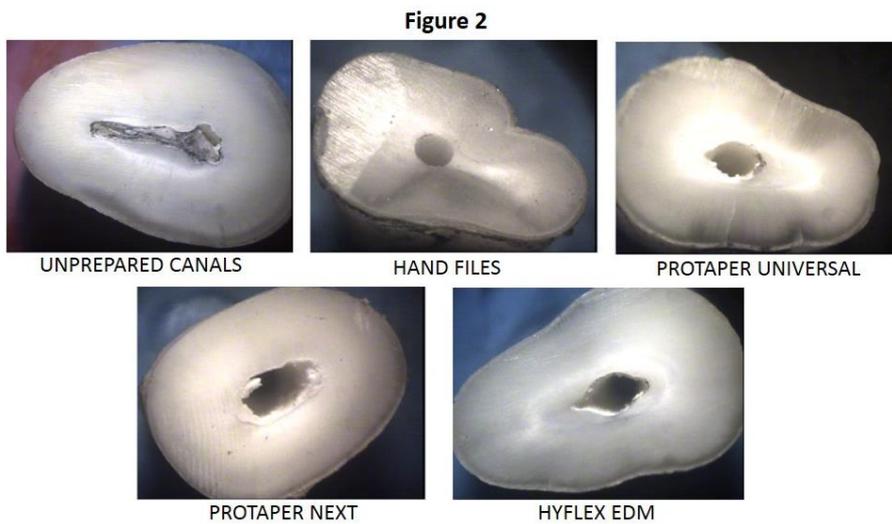


Figure 2: Stereomicroscopic images of Group I, II, III, IV & V.