Detection of Dentinal Microcracks in Radicular Dentin after Shaping with XP-endo Shaper, Neoendo Flex Files, and Hero Shaper Using Scanning Electron Microscope: An In Vitro Study

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The study aimed to compare the extent of dentinal microcracks in the radicular dentin using hand K files and various types of rotary nickel-titanium (NiTi) file systems. Forty mandibular incisor teeth (human) were grouped for the study. The root apices were closed, and the canals were straight (<5°). The samples were divided into four groups (n = 10). Group 1—Hand K file system (SybronEndo, SA), Group 2—XP-endo Shaper (FKG Dentaire, La Chaux-de-Fonds, Switzerland), Groups 3—Neoendoflex file (Neoendo, Orikam, India), and Group 4—Hero Shaper files (Micro-Mega, Becacon, France). Sectioning was done at 3, 6, and 9 mm from the apex, perpendicular to the long axis using a diamond disc under water coolant. The cut samples were then observed through a scanning electron microscope at ×50 enlargement. The control group showed no microcracks except one sample in the coronal third, which was less significant. The difference in the amount of crack detected on comparing the different groups was significant. In the experimental groups, XP-endo Shaper group showed significantly less number of cracks than the Neoendo flex, and Hero Shaper groups. Within the limitations of this study, all the system, except hand K files, produced remarkable dentinal microcracks. Least cracks were seen in canals instrumented with XP-endo Shaper. It can also be noted that single file system causes less number of microcracks.

Keywords: Dentinal microcracks, Hero Shaper, Neoendo flex files, nickel-titanium files, scanning electron microscope, XP-endo Shaper

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has offered rapid endodontic training. The important asset of NiTi files was improved flexibility and shorter working time. Nevertheless, these systems inevitably mistreat the root canal walls. The traditional NiTi rotary files have the impression that increased stress on the dentin is proportional to the occurrence of dentinal defects.

This study intends to compare the incidence of dentinal defects using XP-endo Shaper (FKG Dentaire, La ChauxdeFonds, Switzerland), Neoendo flex files (Neoendo, Orikam), and Hero Shaper files (Micro-Mega, Becacon, France) with scanning electron microscope (SEM) analysis.

**PROCEDURE**

Forty mandibular central and lateral incisors (human) with straight canals were selected for the study. An informed consent was received from each individual after explaining the research protocol, in accordance with the Institutional Ethics Committee of AJ Institute of Medical Sciences and Research Centre, Mangaluru, Karnataka, India. Teeth were stored in 10% formalin solution. Radiographs of the samples were taken to rule out the existence of single canal and single apical foramen with closed apex. Teeth with cracks, severe curves or external defect, incompletely formed apex, and bifurcated canal were removed and replaced.

The crown part of all the samples were sectioned using a low-speed saw under water coolant leaving around 10 mm for sufficient standardization. All the cut samples were tested using a stereomicroscope (×15 magnification). Tooth with craze lines or cracks were eliminated and replaced by similar teeth.

**Group 1: Control group**

Working length was determined using a patency file (size, 10 K file). Canals were instrumented using a set of hand K files system (SybronEndo, USA), maintaining the master apical size up to #30, enlarged up to #80 in stepback technique. EDTA (ethylenediaminetetraacetic acid) gel was used as the lubricant. Irrigation was done using 5 mL of 5% NaOCl, by means of a 30 gauge side-vented needle, which is kept at 1 mm short of apex.

**Group 2: XP-endo Shaper**

Working length was determined using a patency file (size, 10 K file). Canals were prepared using XP-endo Shaper (up to #30, taper 4%) with torque control endodontic handpiece (NSK Endo-Mate DT, Japan) at 800 rpm and 1 N/cm with the use of proper lubricant (EDTA gel). Irrigation was done using 5% NaOCl (5 mL), by means of a 30 gauge side-vented needle, which is kept at 1 mm short of apex. Canals were finished up to the full working length. To complete the instrumentation, an XP finisher file was used for the XP community. The file was positioned in 35°C water before placing it in the canal to provide XP’s phase transformation. The XP was used for 1 min on each canal at a torque of 800 rpm and 1 N/cm.

**Group 3: Neoendo flex files**

Working length was determined using a patency file (size, 10 K file). Canals were instrumented using a set of Neoendo flex files (up to #30, taper 4%) with torque control endodontic handpiece (NSK Endo-Mate DT at 350 rpm and 1.5 N/cm) with the use of proper lubricant (EDTA gel). Canal irrigation was done using 5% NaOCl (5 mL), by means of a 30 gauge side-vented needle, which is kept at 1 mm short of apex.

**Group 4: Hero Shaper**

Working length was determined using a patency file (size, 10 K file). Canals were instrumented using a set of Hero Shaper file system (up to #30, taper 4%), with torque control endodontic handpiece (NSK Endo-mate DT at 600 rpm and 1.2 N/cm) with the use of proper lubricant (EDTA gel). Canal irrigation was done using 5% NaOCl (5 mL), by means of a 30 gauge side-vented needle, which is kept at 1 mm short of apex.

**Sectioning and scanning electron microscope analysis**

Sectioning was performed at 3, 6, and 9 mm from the apex using a diamond disc (Kerr Dental, Orange, California) under water coolant. Digital images of the cut sample sections were viewed at ×50 magnification using SEM (Figure 1). Two operators examined images for the existence of dentinal microcracks. If each of the two operators had a different score, an agreement was reached between them.

- “No defect”—root dentin free of craze lines, cracks, or defects on the root surface (inner and outer)
- “Defects”—all lines and cracks observed, which were extended or not extended to the external root surface, for example, a craze line or a partial crack, and complete crack

**Statistical analysis**

Collected data were evaluated using chi-square test. Statistical Package of Social Sciences (SPSS) software, version 17.0, was used.

**RESULTS**

Table 1 summarizes the percentage of microcracks in the samples after preparation. It is graphically represented in Figure 2. Less defects were found in the hand K file group (Group 1). On comparing all the groups, the prevalence of defect was significantly higher for the experimental groups (Group 2, Group 3, and Group 4). Group 2 (XP-endo Shaper) has comparatively less
Bal, et al.: Detection of dentinal microcracks with different NiTi file systems

Discussion

The VRF is one of the critical dilemmas, which results in tooth loss. It was therefore aimed at examining the dentinal cracks caused by different file systems in this study. Usage of rotary NiTi instruments activates a heavy rotational force on the canal walls, which can eventually lead to craze lines and microcracks. A higher degree of crack formation was correlated with instrumentation movement, tip size, cross-sectional geometry, taper, pitch, and instrument flute design. Advanced models with non-cutting tips, radial ground, various cross-sectional designs, high torsional fracture strength, and various tapers have been implemented to enhance the performance of these instruments. Most defects than Group 3 and Group 4. No significant difference was observed in the results between Group 3 and Group 4.

| Table 1: The number and percentage of microcrack formation after instrumentation |
|-------------------------------------------------|-----------------|-----------------|-----------------|
| 3 mm from the apex Group 1 | 0 Microcrack | 1 Microcrack | ≥2 Microcracks |
| 3 mm from the apex Group 2 | 9 (90%) | 1 (10%) | 0 |
| 3 mm from the apex Group 3 | 0 | 6 (60%) | 4 (40%) |
| 3 mm from the apex Group 4 | 0 | 5 (50%) | 5 (50%) |
| 6 mm from the apex Group 1 | 10 (100%) | 0 | 0 |
| 6 mm from the apex Group 2 | 8 (80%) | 2 (20%) | 0 |
| 6 mm from the apex Group 3 | 3 (30%) | 4 (40%) | 3 (30%) |
| 6 mm from the apex Group 4 | 1 (10%) | 5 (50%) | 4 (40%) |
| 9 mm from the apex Group 1 | 9 (90%) | 1 (10%) | 0 |
| 9 mm from the apex Group 2 | 9 (90%) | 1 (10%) | 0 |
| 9 mm from the apex Group 3 | 1 (10%) | 6 (60%) | 3 (30%) |
| 9 mm from the apex Group 4 | 0 | 5 (50%) | 5 (50%) |

Figure 1: (A) Representative microscopic image from Group 1-hand K file. (B) Representative microscopic image from Group 2-XP-endo Shaper. (C) Representative microscopic image from Group 3-Neoendo flex files. (D) Representative microscopic image from each Group 4-Hero Shaper files.
In intergroup statistical analysis, it was found that the number of observations with cracks greater than 2 is less and is considered as a single unit.

Interobservational correlation was performed during detection of microcracks. This was done to eliminate intraobserver error.

In this study, hand K files were used as a control group due to its 0.02 taper, noncontinuous rotational motion, and nonaggressive movements in the canal.\[18\]

According to our results, both hand K files system and XP-endo Shaper system produced less dentinal cracks than the Neoendo flex and Hero shaper system. This result is analogous with the research conducted by Liu et al.,\[23\] in which the single file created fewer damage than the sequential file.

The superelasticity combined with uttermost resilience and diminished torque of XP-endo Shaper ensures reduced stress on the dentin walls and lowers down the risk of microcracks. It has a continuous rotation at high speed (800 rpm) and a taper of 1%. XP has MaxWire alloy, that is, at body temperature, the martensite phase gets reformed into the austenite phase. The taper changes to 4% as a result of a “snake” shape.\[24\]

Hand K files produced minimal defects as a result of reduced force on dentin, reduced number of rotations, and zero screwing effect.

In our study, Hero Shaper files resulted in the highest incidence of defects compared to Hand K files, XP-endo Shaper, and Neoendo flex files. This is in line with the studies carried out by Jain et al.,\[15\] the use of Hero Shaper files resulted in the highest incidence of defects compared with One Shape and hand K files. The helical angle of cutting edges in Hero Shaper varies from tip to shank and adapted pitch, that is, pitch varies by taper and positive rake angle, large inner core, and three edges.\[11,19\] The increased stress development on the dentin combined with low flexibility generates more cracks.

The number of defects formed in the coronal and middle thirds were more than the apical thirds. The data could be interconnected with the study of Versluis et al.,\[25\] with regard to stress associated with microcrack formations.

Analysis of SEM seems to be an appropriate method for investigating the presence of dentinal defects. It provides high-resolution images and enables patent dentinal tubules. SEM at a magnification of $\times50$ was used in this study.

For this analysis, mandibular central incisors have been chosen because the roots are narrower mesiodistally, with thin dentinal walls and smaller apical dimensions. The canals have an oval configuration. These teeth are the most vulnerable to VRF. These were preferred also
because these teeth do not have drastic differences in canal design, allowing longitudinal dissemination of preexisting defects to be observed without anatomical intervention. If greater tapered files fail to affect these, it is improbable for other system to do the same. It is impressive that XP-endo Shaper (single-file system) caused less damage than the other rotary file systems. The data are in concordance with previous reports, which concluded that more instrumentation in the canal could build up damage of dentinal walls.

**CONCLUSION**

All the systems except hand K files produced dentinal microcracks. The XP-endo Shaper group was identified with limited dentinal microcracks than Hero Shaper and Neoendo flex files.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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