

To compare the Incidence of Dentinal Cracks after Instrumentation with Rotary, Reciprocating Twisted File Adaptive System

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ABSTRACT

Aim: To compare the incidence of dentinal cracks after instrumentation with rotary, reciprocating Twisted File Adaptive (TFA) system using stereomicroscope.

Materials and methods: Forty single-rooted human teeth with mature apices were collected. Ten teeth were left as the control group and 30 teeth were divided into three groups: group I—ProTaper Next file, group II—WaveOne file, and group III—TFA. For standardization, apical enlargement of all teeth was done till 25 tip size. WaveOne file—size of 0.25/0.08; ProTaper Next—Sx, X1 (17/0.4), and X2 (25/0.06) TFA—ML1 (20/0.04), ML2 (25/0.06). Canals were irrigated with 5.25% NaOCl and saline. All the roots were horizontally sectioned at 3, 6, and 9 mm from the apex with a low-speed disk under water spray. The slices were viewed under stereomicroscope at 25× magnification.

Results: There was no statistically significant difference among the three file systems. Overall, ProTaper Next produced the most complete microcracks and WaveOne produced incomplete microcracks. The TFA system caused less root microcracks than the other groups.

Conclusion: Under the study limitations, there was no significant difference among the three file systems. The TFA system caused less root microcracks than the ProTaper Next and WaveOne groups.

Keywords: ProTaper Next, Twisted file adaptive, WaveOne.

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INTRODUCTION

Eliminating infections and preventing reinfections are critical for the long-term success of root canal treatment.¹ Shaping the root canal system with a greater

taper and larger apical foramen size is recommended, likely to remove more of the infected dentin, and create space for the irrigants and antibacterial medicaments to eradicate bacteria.² Therefore, various nickel–titanium (NiTi) rotary and reciprocating files with a greater taper and larger apical diameter were developed.³ However, mechanical instrumentation with large taper files may remove excessive dentin, exert more stress on the canal wall, and generate cracks on the dentin and the apical surface, which could lead to vertical root fractures and even require tooth extraction.^{4,5}

With the newly introduced single file NiTi system, WaveOne, it is possible to shape canals with only one instrument, thereby requiring less time than rotary full sequence systems.⁶ These files are produced with a special NiTi alloy (M wire) subjected to a special thermal treatment process to increase the flexibility of the instrument.⁷ WaveOne files are used in a reciprocating motion, in order to reduce stress on the instrument and to minimize the fracture of cyclic fatigue.^{8,9} Another new generation of NiTi instrumentation system has been introduced called the TFA. The TFA are produced by transforming the NiTi wire from the austenitic crystalline structure to the super elastic crystalline R phase structure by a method of heating and cooling.^{10,11} The TFA is used in a combination of both reciprocating and continuous rotation.

Because the incidence of dentinal cracks after root canal instrumentation may differ according to the preparation technique, design and taper of the file, and instrumentation length, it might be speculated that the root canal instrumentation with different movement kinematics may change the incidence of dentinal defects.¹²

Hence, the purpose of this study is to compare the formation of dentinal cracks after root canal instrumentation with ProTaper Next, WaveOne, and TFA.

MATERIALS AND METHODS

Forty single-rooted human mandibular premolar teeth with mature apices and straight root canals were selected. The teeth were stored in distilled water. The coronal portion of the teeth was removed using diamond disk at low speed under water cooling, leaving roots approximately 13 mm in working length measured by inserting

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a 10 k file into the canal until the tip became visible at the apical foramen. The teeth were randomly divided into four groups. Ten teeth served as the control, and the remaining 30 teeth were divided into three groups based on the root canal preparation technique.

1. Group I—WaveOne primary files
2. Group II—ProTaper Next
3. Group III—TFA

For standardization, apical enlargement of all teeth was done till 25 tip size according to the manufacturer's instructions using 128:1 reduction geared hand piece.

- WaveOne file—size 0.25/0.08
- ProTaper Next—Sx, X1 (17/0.4) and X2 (25/0.06)
- TFA—ML1 (20/0.04), ML2 (25/0.06)

During instrumentation, canals were irrigated with 5.25% NaOCl and saline. All the roots were horizontally sectioned at 3, 6, and 9 mm from the apex with a low-speed disk under water spray. The slices were viewed under a stereomicroscope with 25× magnification. Sample were photographed with a camera to determine the presence of crack.

Defects were categorized as follows:

- “No Crack” root dentin devoid of any lines or Discontinuity in both the external surface of the root and in the canal space (Fig. 1A).

- “Crack” was defined as a line extending from the root canal space to the outer surface of the root (Fig. 1B).
- “Other defects” were defined as all other lines observed that did not extend from the root canal space to the outer root surface. For example, External craze line—line extending from the outer surface into the dentin that did not reach the canal lumen (Fig. 1C) or Internal craze line extending from the canal wall into the dentin without reaching the outer surface of the root (Fig. 1D).

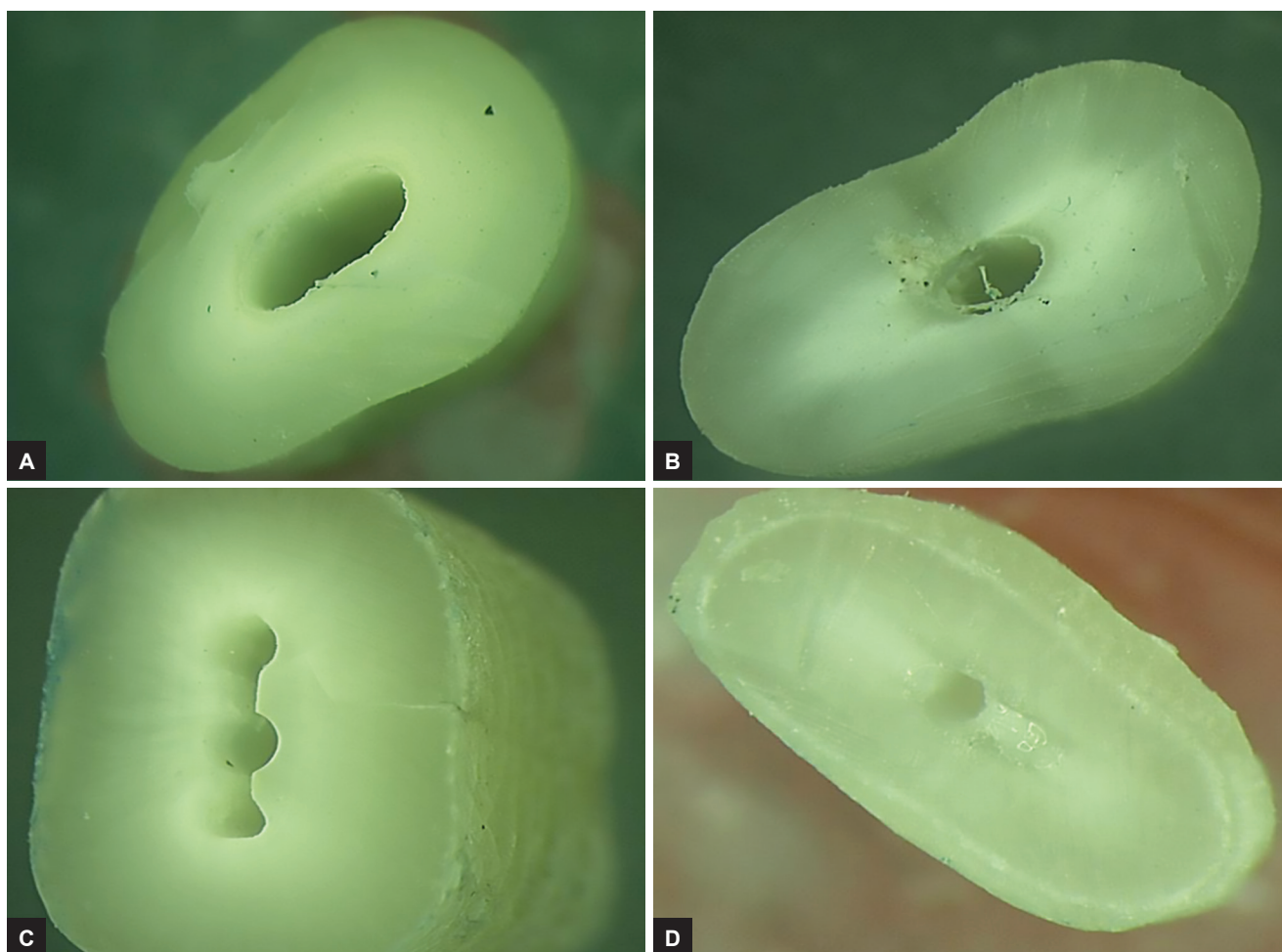
Statistical Analysis

The results were evaluated statistically using Kruskal–Wallis and chi-square tests. The significance level was set at $p < 0.05$.

RESULTS

The distribution of the defects is summarized in Table 1.

There was no statistically significant difference among the three file systems. Overall, ProTaper Next rotary group produced significantly more complete cracks in the coronal, middle, and apical third compared with WaveOne and TFA, and in the apical third, WaveOne



Figs 1A to D: (A) No crack; (B) complete crack; (C) external craze line; and (D) internal craze line

Table 1: The distribution of defects summarized

	3 mm	6 mm
Control	0	0
Protaper Next	4	5
Wave one	2	2
TF Adaptive	2	1
p-value	0.36	0.62

group showed more incomplete cracks compared with ProTaper Next and WaveOne groups. The TFA system showed less dentinal cracks in coronal, middle, and apical third compared with the other two groups.

DISCUSSION

Vertical root fracture is not an instant phenomenon, but rather a result of crack propagation.¹³ The presence of microcracks and dentinal defects after instrumentation has been reported. These dentinal defects can become high stress concentration areas, which may propagate to the root canal surface when an external force is applied.¹⁴

Studies done by Touré et al⁴ and Yoldas et al¹⁵ indicated that instrumentation with hand files did not cause dentinal cracks. Rotary and reciprocating NiTi instrumentation induced more root cracks than hand files, which were attributed to the NiTi instrument properties and motion.

In the present study, continuous rotation caused more cracks than reciprocation and adaptive motion. Applying a rotational force to the root canal wall can create microcracks and craze lines in root dentin. Continuous rotation might have increased the stress concentration on the root canal wall because of applying more rotational forces to the root canal wall, resulting in more crack formation.¹² Arbab-Chirani et al¹⁶ also reported that ProTaper rotary files were associated with significantly more microcracks than other NiTi instruments because of their larger cross-sections, greater stiffness, and higher levels of torque and bending force.

In addition, it has been reported that dentinal cracks can be related to instrumentation techniques.¹⁷ Liu et al¹⁸ evaluated the incidence of dentinal cracks after root canal instrumentation with different file systems and reported that reciprocating motion caused less dentinal damage than continuous rotation motion. The WaveOne and TFA systems are relatively new file systems that shape root canals with a reciprocating movement, which is different from a rotary motion. The hypothesis behind their design was that reciprocal motion could relieve stress on the instruments, and therefore reduce the risk of cyclic fatigue caused by tension and compression. At the same time, the reciprocal motion, which works in

a counterclockwise direction when cutting dentin and in a clockwise direction when the instrument is being released, reduces excessive pressure on the root canal walls.¹⁹

In the apical part of the canals, reciprocating files produced significantly more incomplete cracks compared with the rotary and adaptive motion. This result is in accordance with our study. The differences between the instruments tested regarding the incidence of dentinal defects may be due to the preparation technique and the cross-sectional design of instruments. The reciprocal motion seems to enhance debris transportation toward the apex and may increase torsional forces.¹³ It should be evaluated in further studies whether these increased torsional forces are associated with an increased risk of creating dentinal defects.

According to the results of the present study, the TFA motion produced the least dentin defects. The lowest incidence may be due to the new adaptive reciprocating motion. The file uses continuous rotation when it is exposed to a minimal or no applied load, and uses reciprocal motion when it engages dentin and load is applied. The adaptive motion combined with the high flexibility and the multi file system seems to decrease the torsional forces resulting in less dentin defects.²⁰

The tapered files may generate an increased stress on the dentin wall. And it was found that the amount of dentin removed by tapered files at the coronal part of the root canal is more than that at the apical part of the root canal.¹²

The sectioning method used in the study allowed evaluation of the impact of root canal treatment procedures on dentin root by direct inspection of the root. This method is in agreement with a methodology described in a previous study. The method in the present study differed from other approach because no external forces were applied, and the influence of root canal preparation on the root canal walls and the adjacent dentin was observed directly.

CONCLUSION

Under the study limitations, there was no significant difference among the groups in the formation of dentinal microcracks. Overall, ProTaper Next produced the most complete microcracks and WaveOne produced incomplete microcracks. And the TFA system caused less root microcracks than the ProTaper Next and WaveOne files. Further studies are required to assess the advantage of single file reciprocating root canal instrumentation and TFA system concerning its impact on the incidence of root microcracks.

CLINICAL SIGNIFICANCE

The TFA system caused less root microcracks than the ProTaper Next and WaveOne files.

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