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An In-Vitro Evaluation of Incidence of Dentinal Defect After Root Canal Preparations with Different Engine Driven Instrumentation Techniques

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ABSTRACT

Aim: The aim of the present study was to evaluate the incidence of dentinal defects after root canal preparation with Hand K-files (HFs), ProTaper-Next files (PTN), T-One file in reciprocating motion and T-One file in continuous rotary motion using a new study model. **Methods:** Sixty extracted human maxillary molar teeth were selected. Only distal roots (9mm length) of all the teeth were used for the study. These roots were mounted in an acrylic resin block (7mm X 7mm X 9mm) and were randomly divided into 4 groups to receive the treatment with four different instrumentation techniques. All samples were sectioned in three blocks of 3mm thickness each and were examined under stereomicroscope to observe the dentinal cracks developed due to sectioning. The sections of each sample were reassembled in a putty mould and the instrumentation was done as per the study protocol. The sections were again examined under stereomicroscope after instrumentation for presence of dentinal cracks. **Results:** The stereomicroscopic examination revealed minimum dentinal cracks in hand K-file group and maximum dentinal cracks in T-One rotary group. Statistically significant difference was observed in hand K-file group with all other groups. **Conclusion:** The ProTaper-Next file system produces less dentinal microcracks compared to T-One file system and so reduces the danger of post-operative vertical root fracture.

KEYWORDS Dentinal microcracks, NiTi alloy, Pro-Taper Next, T-One file, Reciprocating motion, Instrumentation technique

INTRODUCTION:

The purpose of root canal therapy is to eliminate intracanal microorganisms. Chemomechanical preparation is an essential and indispensable step for disinfection of the root canal system. During endodontic treatment, roots are susceptible to dentinal damage.

Dentinal damages can be influenced by various factors like physical properties of teeth, preparation technique or various endodontic instruments used, etc. Thus, each preparation technique can have an effect on damage to root dentin.[1]

Several rotary nickel-titanium (Ni-Ti) file systems have been introduced for the preparation of root canals. Ni-Ti instruments provide many advantages compared to conventional files. Increased flexibility, and shortened working time are the major advantages of Ni-Ti files however, due to the different tip design, taper, and cutting blade configuration of these systems, stress on the root canal walls may arise and this can result in microcracks or craze lines.[1] 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 (continuous rotation, reciprocation with different angles, and adaptive motion) may change the incidence of dentinal defects.[2] Protaper Next files are made of M-wire alloy, which shows more flexibility than those made from conventional Ni-Ti wire. Previous studies reported that endodontic instruments manufactured with M-wire alloy and controlled memory Ni-Ti wire have more flexibility than those made from conventional Ni-Ti wire.[3] In the year 2014, T-One file was introduced. This file has been made with convex triangular design, which is efficient in rotation with proficient cutting. T-One file is nano-electroplated, which makes the instrument more flexible and cutting edges sharper. The intention of using T-One file in this study was that it is a single file system and the same instrument can be used in both continuous-rotary and reciprocation motion.[4]

A crucial goal in endodontic research is to overcome the potential problem of dentinal microcrack formation during instrumentation with rotary or reciprocating instruments.[5]

The purpose of this study was to determine whether there was a causal relationship between the use of ProTaper-Next

and T-One instrumentation system and microcracks formation and to compare the incidence of dentinal microcracks after the use of these systems. Methodology used in this study has not been used before

All the previous stereomicroscopic studies related to the effect of rotary files on dentinal cracks have been done without considering the pre-existing cracks and craze lines. We propose a new model to rule out the existing cracks and evaluate new ones developed after instrumentation.

Materials and Methods:
For this in vitro investigation, 60 human maxillary molar teeth that had been extracted for periodontal reasons were selected. Teeth having fused roots, roots with external root resorption, fracture lines, severe curvature and open apex were excluded from the study. Only distal roots of approximately 9mm length were used for the study.

Acrylic blocks in dimension of 7mm X 7mm X 10mm (width x length x height) were prepared with roots embedded in and a putty mould for each block was made. This mould was used to reorient the sections.

Sectioning and Microscopic Examination:
All the blocks were marked at 3mm, 6mm from apex for sectioning. To identify the correct side and sequence from apical to coronal areas of the blocks were marked with dots at each section and the samples were sectioned perpendicular to the long axis at 3mm and 6mm from the apex as marked using a diamond coated disc (0.2 mm thickness) under water-cooling. The sections of samples thus obtained were observed under a stereomicroscope at 15X magnification for dentinal microcracks developed either during extraction and sectioning. These stereomicroscopic images were used to compare the postoperative images so that the preexisting defects could be eliminated during analysis of data.

The evaluation of the preoperative dentinal microcracks was done using following scoring system:

0 = "No defect"
1 = "Defect present"

The sections were reoriented in the previously made putty mould for biomechanical preparation. For biomechanical preparation in each group, the working length was established 0.5 mm short of anatomic foramen. Before root canal instrumentation procedures, all root canals were prepared with #8 and #10 K-files to establish a glide path. Between the use of each instrument, root canals were irrigated with 2 ml of 2.5% NaOCl. All these samples were randomly divided into 4 groups (n=15) according to the instrument techniques to be used, as follows: Group A: Hand K-file, Group B: Protaper-Next, Group C: T-file in Reciprocating motion, Group D: T-file in continuous Rotary motion.

Postoperative microscopic examination:
After completion of root canal preparation of all samples, all three sections of each sample were observed under stereomicroscope at 15X magnification. Position of the samples on microscope was maintained as preoperative examination for easy comparison of preoperative and postoperative images.

The evaluation of the postoperative dentinal microcracks was done using following scoring system:

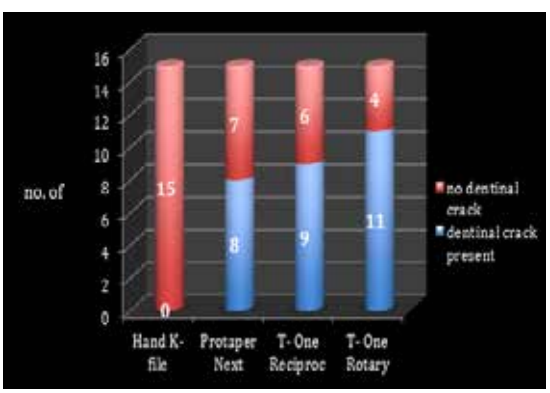
0 = "No defect" was defined as root dentin devoid of any new craze lines or microcracks

1 = "Defect" was defined if any lines were observed on the section that extended either from the outer root surface into the dentin or from the root canal lumen to the dentin (other than preoperative).

One examiner compared all the preoperative and postoperative images for incidence of new dentinal microcracks and propagation of pre-existing cracks. The data thus obtained was subjected to statistical analysis.

RESULTS:
The distribution of the different defects is summarized in Table 1.

	Absolute number of cracks (%)			Total numbers of samples showed cracks/ group
	3 mm	6 mm	9 mm	
Hand K-file	0 (0)	0 (0)	0 (0)	0 (0)
Protaper Next	6 (40%)	3 (20%)	1 (6.7%)	10 (22.2)
T- One Reciproc system	7 (46.7%)	4 (26.7%)	4 (26.7%)	15 (33.3%)
T- One Rotary system	4 (26.7%)	8 (53.3%)	4 (26.7%)	16 (35.6%)



DISCUSSION:
The primary aim of this study was to check the incidence of dentinal cracks after preparation of canal with Hand K-files, ProTaper-Next system and T-One file system. None of the previous studies have compared the ProTaper-Next and T-One file system. No study has compared the effect of reciprocation with rotary motion, using the same file system, on dentin crack formation.

Several microscope studies have reported that there is a causal relationship between instrumentation with rotary or reciprocating instruments and dentinal microcracks **(Bier et al. 2009, Yoldas et al. 2012, Ashwinkumar et al. 2014, Capar et al. 2014, Karatas et al. 2015, Ustun et al. 2014).** Contrary to these microscopic observation studies, **De-Deus et al. (2014, 2015)** reported that there was no causal relationship between instrumentation with rotary/reciprocating instrumentation systems and microcrack formation according to their microcomputed tomography (micro-CT) studies.[6] Dentinal microcracks can occur during tooth extraction and tooth-sectioning procedures, and pre-existing defects may not be detected using root sectioning and microscopic observation techniques **(Bier et al. 2009, Shemesh et al. 2009).**[5] The present in-vitro study also showed dentinal microcracks in the unprepared specimens in all four groups. None of the previous stereomicroscopic studies considered the pre-existing cracks in experimental groups. Most of the previous studies in this field have used direct observation of teeth by digital microscopy after sectioning the root with a saw at different levels **(Adorno et al. 2009, 2011, Bier et al. 2009, Shemesh et al. 2009, Ashwinkumar et al. 2013, Liu et al. 2013).**[7]

In this in-vitro study we attempted to create a new study model to eliminate the pre-existing cracks in the samples. TO observe the preexisting cracks, we sectioned the roots before

instrumentation and examined under a stereomicroscope. Sections were reoriented for biomechanical preparation in the putty mould, which was stabilized in a stainless steel block with the help of a vise. The number of pre-existing dentinal microcracks or craze lines was deducted from the total number of micro-cracks or craze lines after instrumentation.

In the present study; in HF, PTN, T-One Reciproc and T-One Rotary, the number of incidence of cracks observed in the root dentin was found to be 0 (0), 8 (53.3%), 9 (60.0%) and 11 (73.3%).

All rotary and reciprocating NiTi files caused significant microcracks whereas hand K-files caused no microcracks at all. This result could be related to avoidance of the continuous rotational motion and 0.02 taper of hand files. This is in agreement with previous studies, which reported no defects in the hand file groups **(Bier et al., 2009; Yoldas et al., 2012; Ashwinkumar et al., 2013).** (**Sathorn et al.)** [8]

ProTaper-Next group (B) showed least number of cracks amongst rotary Ni-Ti instruments. The reason for less cracks in PTN files could be due to its off-centered rectangular design, which generates a swaggering motion decreasing the screw-in effect, dangerous taper lock and torque minimizing the contact between the file and the dentin **(Capar ID, Arslan H, Akcay M, Uysal B).** In addition, Protaper Next files are made of M-wire alloy, which shows more flexibility than those made from conventional Ni-Ti wire **(Pereira ES, Peixoto IF, Viana AC, Oliveira II, Gonzalez BM, Buono VT, et al.).**[9]

T-One Reciproc (Group C) and T-One Rotary (Group D) of our study showed more number of microcracks as compared to PTN. As T-One files have a triangular cross-sectional geometry which might be responsible for increased contact between file and the dentin and greater threading effect of file. Amongst group C and D the T-One reciproc files showed comparatively less number of microcracks than T-One rotary. These results are in accordance with study by **Ashwinkumar et al. (2013)**.[10] Reciprocating motion has been shown to have many advantages: Increasing the resistance of Ni-Ti files to cyclic fatigue compared to continuous rotational motion. Root canal instrument can work with the reciprocation movement in root canal with more centered position. And owing to the nature of reciprocation motion that contains CW (clockwise) and CCW (counter clockwise) rotation consequently and repeatedly, file can release when it is engaged in the inner surface of the root canal during the preparation process.

T-One Rotary group (D) showed more number of dentinal cracks than group C. The higher incidence of microcracks after instrumentation using continuous rotary motion compared to reciprocating motion can be attributed to many factors. The continuous motion of the instrument will have a greater threading effect than the reciprocating motion **(Yared 2008, De-Deus et al. 2010, You et al. 2010, Berutti et al. 2012, Plotino et al. 2012).**[10]

Within the limitations of the present study, with the exception of the hand file all experimental groups showed microcrack formations. Although, ProTaper Next files showed least number of crack formations, there was no significant statistical difference between all engine-driven techniques, and systems and motions did not affect the microcrack formations.

CONCLUSION:

We can conclude that the ProTaper-Next file system produce less dentinal microcracks compared to T-One file system and so reduces the danger of post-operative vertical root fracture.

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