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Incidences of Root Microcracks Caused by Hand and Rotary File System at Different Lengths

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OBJECTIVES: The present research was conducted to assess incidences of root microcracks caused by hand and rotary file system at different lengths.

MATERIAL AND METHODS: This in-vitro study was undertaken to assess incidence of root microcracks caused by hand and rotary file system at different lengths. In total, 100 the mandibular premolar with straight roots determined with intact, fully formed apices were taken. Samples were randomly distributed into 5 groups based on the file system used: a) Group A: Control, b) Group B: Reciproc, c) Group C: WaveOne, d) Group D: One Shape and e) Group E: ProTaper. Pearson Chi-square test was used to determine the differences between groups. The dentinal defects were expressed as percentage of samples with microcracks in each group. Level of statistical significance was set at p-value less than 0.05.

RESULTS: The chi square test was used to compare the Distribution of the number of teeth in which cracks were observed on the horizontal sections. It was found to be significant with group ProTaper showing maximum cracks at 3,6,9 mm level as compared to other file system.

CONCLUSION: Nickel-titanium instruments causes cracks on the apical root surface or in the root canal wall. ProTaper causes maximum dentinal cracks as compared to other file systems.

KEYWORDS: Reciproc, WaveOne, One Shape, ProTaper, Microcracks

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INTRODUCTION

Endodontic treatment is fundamentally aimed for prevention and cure of apical periodontitis. The primary requisite is to achieve shaping and cleaning the root canal system effectively as well as maintaining the original anatomical configuration. The Clinical evidence from the existing literature reports that root canal systems is to be cleaned, shaped and obturated to achieve hundred percent success. The Knowledge, skill and desire of clinician also play major role in determine the predictability of successful treatment.¹⁻⁴

Careful manipulation of hand instruments within the root canal space and adhering strictly to the biologic and surgical principles, following essential disinfection procedures were incorporated so as to prevent any iatrogenic incidences such as instrument fracture, external transportation, ledge, or perforation. In recent times, mechanized and automated systems for preparation and sealing of root canal system have been developed.⁵⁻⁹

The Nickel-Titanium (NiTi) instruments result in complications such as perforations, canal enlargement, root canal transportation and vertical root fracture. Even the shaping procedures can damage the root dentin, resulting in dentinal cracks which under

dynamic oral environment progressing to vertical root fractures. During these procedures, a loss of tissue takes place that along with excessive occlusal forces, making the teeth highly prone to dentinal crack formation in the roots even. The susceptibility of the fracture in the root majorly depends on the apical preparation of canal and followed by its enlargement as they are stress concentration sites. Henceforth, different bio mechanical techniques employed in preparing root canal and varied instrument design, lead to different levels and severity of dentinal damage to the root canal wall.¹⁰⁻¹³

Recently, one shape files that are used in continuous rotation have emerged as a better alternative for curved canals. These are enhanced with different cross sections along the length of the file which provides better cutting action around the canal walls and further results in minimizing the instrument fatigue risk indirectly eliminating the chances of instrument breakage.¹²⁻¹⁴

Reciproc and WaveOne are two different reciprocating systems employing balanced force technique. These instruments are designed on use of clockwise and anti-clockwise motion for root canal preparation and



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achievement of complete shaping of the root canal can be done with a single file.^{8-10,11,13}

WaveOne NiTi file is another new single-file system for shaping the root canal completely till finish with a pre-programmed motor set for the angles of reciprocation and speed. Before it can lock into the canal, the clockwise movement of this file system disengages the instrument from the dentine.¹⁵

The Self-Adjusting File is a hollow file system, designed as a compressible cylinder. It has got a thin NiTi lattice with an abrasive surface. The vibrating file acts as a sandpaper helpful in scraping dentin and enlarging the canal with a back and forth grinding motion. Its easy adaptability to shape to the canal anatomy, helps in applying a mild but constant delicate pressure on the walls of the root canal.¹⁶

Unlike One Shape, Reciproc, and Self-Adjusting File that usually require a single file for shaping the root canal, the ProTaper system engages a sequence of files with different sizes.⁴ There is a multiple increasing percentage tapers over the length of cutting blades in each instrument which considerably increases the efficiency of cutting, flexibility and safety profile of the files.¹⁷⁻¹⁹

The concept of Single file system requires a gliding path and only a single file for finishing the instrumentation of root canals. This system saves both cost and time as it has an added advantage of reduced instrument fatigue which leads to decreased working time and lowers the cross contamination between subjects. The diagnostic methods of root microcracks used currently are based on optical assessment, with or without the surgical loupe aid, microscopes, dyes or transillumination. Enhanced magnification improves their detection. Hence in the present study stereomicroscope under a magnification of 20 was employed²⁰⁻²³ to assess the occurrence of microcracks in root caused by hand and rotary file system at different lengths.

MATERIAL AND METHODS

Sample Size: Based on the calculated variance of 1.5 (based on previous study), 5% level of precision, 95% confidence level and 80% power of the study. The sample size for the mandibular premolar with straight roots determined was 93, Rounding off to nearest whole number, the final sample size for the study was 100, with 20 in each group.

Preparation of Samples: Random allocation of human caries free single-rooted mandibular premolar with intact, fully formed apices was done. The teeth were disinfected in a 0.1% thymol solution for 24 hours. Throughout the experiment, the teeth were stored in purified filtered water. Periapical radiographs (Buccolingual and mesio-distal) of the teeth were obtained to confirm the presence of a single root canal. The same operator experienced with these instrumentation techniques performed the laboratory procedures.

To remove coronal portions of the teeth, a double-sided diamond disc was used. All the teeth were examined and compatible with a #10 K-file made from stainless steel. A file was inserted to determine the length of the canal until the tip became visible on the apical foramen. The distance between the tip of the file and the reference plane was defined as the canal length. To calculate the working length, 1 mm was subtracted from the obtained length.

Root canal preparation: Acrylic resin blocks were prepared for the samples. Initially, 2 mL of a 2.5% sodium hypochlorite solution was used to irrigate the root canals. A #10 K-file was used to make the glide path of all the samples. The tooth were worked upon in a wet environment. The coronal part of each canal was flared with #2 Gates-Glidden drills and one operator performed all root canal instrumentation. The experimental groups were prepared with the instruments, Reciproc, Wave one, one shape and ProTaper as per the manufacturer's instructions.²⁴ The motor that was used had 350 rpm and 5 N/cm² of torque. The preparation was performed with in-and-out pecking movements of the instrument with 3 mm of amplitude until the working length was reached with a brush motion on the buccolingual extension.

Group A: CONTROL GROUP

No preparation was made in the control group. Gates-Glidden drills #2 was used to flare the coronal part of each canal with no further instrumentation.

GROUP B: RECIPROC

Canals were prepared with NiTi flex K-files to #15 first and a single REC file (25/0.08) was used with reciprocating movements.

GROUP C: WAVEONE

Canals were prepared with NiTi flex K-files to #15 first and WOG primary single file (25/0.07) in a reciprocating movement.

GROUP D: ONE SHAPE

In the One Shape group, the canals were prepared with NiTi flex K-files to #15 first. One Shape rotary file #25/.06 at a low-torque motor with a constant speed of 300 rpm was used for root canal preparation to the apical foramina.

GROUP E: PROTAPER NEXT (PTN)

The ProTaper Next system was used in the X1 (17/0.04) and X2 (25/0.06) instrumentation sequence until the working length was achieved in a continuous rotary movement.

Irrigation of canal was done with 2 mL of 2.5% NaOCl with the use of each instrument and a final irrigation was performed at the end of the process using 17% EDTA and 2.5% NaOCl (2 mL each).

Sectioning and microscopic examination: All roots were horizontally sectioned first at 3mm from the apex with rotating diamond disc positioned perpendicularly to the root canal axis with water cooling.²⁵ To reduce the fine scratches produced by rotating diamond disc and to obtain a clear, highly magnified image, sectioned was polished with waterproof of 1000-,1200-,1500- grit abrasive paper (silicon carbide) and a fine polishing was performed with a diamond paste. Under running tap water debris was removed after fine grinding and polishing. Each sample was viewed through stereo microscope. Pictures was taken with camera attached to stereo microscope examine the sections for dentinal cracks. Similar procedure was performed by reducing the roots further at 6mm (middle) and 9mm (incisal). PowerPoint presentation for each root sections was prepared with three images on each slide for blind study by examiner. Any crack that originates from root canal was considered as having been produced by the instrument and was noted. The collected data was subjected to statistical analysis.

Statistical methods: Data was entered into Microsoft Excel spreadsheet and was checked for any discrepancies. Summarized data was presented using Tables and Graphs. The data was analyzed by SPSS (21.0 version). Shapiro Wilk test was used to check which all variables were following normal distribution (p value more than 0.05). Parametric test i.e. Pearson Chi-square test was used to determine the differences between groups. The results regarding the presence of dentinal defects was expressed as the number and percentage of samples with microcracks in each group. Level of statistical significance was set at p-value less than 0.05.

RESULTS

Table 1 describes the distribution of the number of teeth in which cracks were observed on the horizontal sections at 3, 6 and 9 mm.

The distribution of the number of teeth in which cracks were observed on the horizontal sections. It was found to be significant ($p < 0.001^*$) with group E showing maximum cracks at 3 mm, 6mm and 9 mm level as compared to other file systems.

DISCUSSION

In endodontics, while doing biomechanical preparation, a torque force is exerted on the root canal walls. This process initiates the formation of microcrack in the root dentin.²⁶

While shaping canals, both continuous rotating and doing a reciprocating movement has its own merit and. The commercially available files used in are manufactured from NiTi material. They are mechanically driven in continuous rotation. They require less inward pressure and improves hauling capacity auguring debris out of a canal.

Whereas clinically utilized stainless steel files, work on reciprocation principle i.e. repetitive back-and-forth motion.²⁷ The reciprocating motors and hand piece rotatory files operate in large equal angles of 90° clockwise and anti-clockwise rotation. With time, almost all available reciprocating systems began to make effective use of small but equal angles of rotation.^{28,29} The mechanical reciprocating motion is profitable as it imitates manual movement to some extent and decreases the risks related to continuous rotation of a file through the curvatures of canal.^{30,31}

For a motor driven drive, that reciprocates shaping files, multi-file sequences are required to prepare a canal in an adequate manner. Their small angles have decreased cutting intensity, require more inward pressure and have a restricted ability to dig debris out of a canal.

Working with NiTi engine-driven instruments for biomechanical preparation of the root canal has become the fundamental of today's endodontic treatments. These instruments have many benefits including less operating time, less procedure related accidents and increased cleanliness of root canal walls. They are being increasingly used as they cause less fatigue to the dentist and make the procedure less time intensive.^{5,9,10}

n=20	Group A n (%)	Group B n (%)	Group C (%)	Group D N (%)	Group E N (%)	P value
3 mm						
Yes	0 (0)	7 (35)	11 (55)	4 (20)	12 (60)	0.001*
No	20 (100)	13 (65)	9 (45)	16 (80)	8 (40)	
6 mm						
Yes	0 (0)	6 (30)	12 (60)	7 (35)	13 (65)	0.001*
No	20 (100)	14 (70)	8 (40)	13 (65)	7 (35)	
9 mm						
Yes	0 (0)	2 (10)	12 (60)	5 (25)	14 (70)	0.001*
No	20 (100)	18 (90)	8 (40)	15 (75)	6 (30)	

Table 1. Distribution of the number of teeth in which cracks were observed on the horizontal sections at 3, 6, 9 mm

Conventional ProTaper pioneers the realm of engine-driven instruments and they have got a convex triangular cross-section, engaging 360° rotation and multiple tapers inside the shaft.^{32,33}

The files are used at a particular speed and torque in a specific order that is catalogued by the manufacturing companies. Single-file systems such as, WaveOne, Reciproc, Neolix and One Shape are recently introduced to the market. It is claimed that Reciproc systems are highly capable of cleaning the root canals with varied anatomical variations and the alloy used in manufacturing of these systems enables high flexibility and also results in superior adaptation of files to the root canal walls.^{9,10,34}

WaveOne instruments have a special decreasing percentage tapered design which advances the adaptability and preserves the remaining dentin in the coronal 2-3rd section of the finished canal preparation. They have noncutting redesigned guiding tips permitting these files to safely move forward through any secured canal practically and also enhancing safety and efficiency in root canals that have a confirmed, levelled and reproducible glide path.³²

The Reciproc is the latest single file system enabled with reciprocating motion and has S-shaped cross-section with a non-cutting tip which shapes the canal by 150 degrees counter-clockwise followed by 30 degrees clockwise motion at speed of 300 rotations per minute.^{35,36}

When compared to multiple file systems, the single file systems show superior or no less than equal cleaning efficacy, act economical, cause low damage to root and save time. They are highly preferred as. Root canal preparation with NiTi rotary systems and every following additional procedure in endodontics as obturation and retreatment with rotary systems can create fractures or craze lines.⁹

Research data suggests that in the formation of dentinal fractures, shape and taper of the files as influencing factors could play an important role. Crack formation in the walls of root canal is of utmost concern during the use of rotary systems and it can further lead to Vertical Root Fracture and adversely affect the prognosis of the tooth in the long run and this kind of fracture is one of the annoying complications of root canal treatment leading to extraction of tooth in most of the cases.³⁷

Literature reports that resistance to tooth fracture is of prime importance in endodontic treatment because such fractures decrease the survival rate in the long run. Research work has shown that removal of dentin in excess during root canal preparation or obturation procedures with spreader can result in tooth fractures.³⁸

Bier et al. have also reported that fractures do not occur immediately after preparation of canal. Although, craze lines (4% to 16%), might develop into fractures during retreatment or after long term functional stresses like chewing and misbalanced occlusal forces.⁹

In the present research, the control group showed no incidence of dentinal cracks. Similar findings were reported by Khoshbin et al. (2018)³⁴ where they reported that no crack was found in the control groups, emphasizing the fact that the microcracks seen were as a result of the preparation procedures with nickel titanium rotary and reciprocating files.

In the present study, at 3,6,9 mm horizontal sections, of teeth the distribution of incidence of cracks were compared across five groups. It was found to be significant ($p < 0.001$) with ProTaper system showing maximum cracks at all levels These findings are in accordance to that reported by Liu et al (2013).⁸

No significant differences were noted for microcracks between other groups ($P > 0.05$). These findings of the present research are in agreement with the results of Capar et al. (2014)³⁹ and Kansal et al. (2014).⁴⁰ Similarly Bier et al. (2009)⁹ observed cracks in the horizontal sections instrumented with the ProTaper system (16%)

The probable reason could be that more manipulations in the canal could cause the accumulation of damage. It may be attributed to the fact that the tip of ProTaper finishing files has greater taper than other file system utilized. Also in the present study, rotary and Reciproc files were the same in terms of taper and the final file. Thus, differences in the frequency of cracks among different groups cannot be attributed to the taper of files. This difference in the percentage of cracks between experimental groups may be attributed to the design of the file tip, variable or constant taper of rotary file, geometrical shape of the cross-section of the file and flute shape, which are all related to crack formation in root canal walls. Also, the other files, are made of M-Wire NiTi. This alloy has higher cyclic fatigue resistance and greater flexibility than traditional NiTi, which may explain fewer crack formation in M-Wire NiTi compared to conventional NiTi files.

In the present research, maximum dentinal cracks were seen at apical section. In 2013, Liu et al. reported cracks at the apical root surface in 25% of the roots instrumented with the ProTaper.⁸ Cracks were observed in half of the roots instrumented with the ProTaper at apical surface when the apical root surface and horizontal sections of the roots were examined. One Shape and ProTaper files work in a continuous rotary motion and result in cracks. The Reciproc files work in a reciprocating movement similar to the balanced force technique. This kind of motion minimizes torsion and flexural stresses and decreases

canal transportation and causes less dentinal damage when compared to continuous rotation motion. This is also supported by Kim et al. (2013)¹⁰ confirmed that the new rotary systems with a modified design and alloy composition apply less stress to root dentin compared to older systems such as ProTaper and thus, it is expected to create fewer cracks in dentinal walls.

The present study was in vitro study design. It is difficult to create the highly dynamic conditions seen inside the oral cavity. This could have been one of the limitations of the present study. The present research employed the use of single rooted teeth, as they provide few anatomical variations when compared with multi-rooted teeth could have added to the disadvantage. This anatomic homogeneity does not reproduce true clinical presentations. Thirdly, the evaluation of different torque could have been employed to further add to the study. Contrast enhanced micros could have been used for further investigations to throw better light in this direction. Another possible bias from the clinical situation is the minimal coronal flaring used.

CONCLUSION

Instruments made up of nickel titanium can cause cracks on the apical portion of root surface or in the wall of root canal. The pioneer ProTaper results in maximum dentinal cracks as compared to other file systems commonly used in endodontic practice.

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