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Effect of hand files, rotary protaper universal and protaper retreatment files on crack formation in dentin- An in vitro study

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Abstract--Background: The aim of the study was to compare the effect of hand files, rotary protaper universal files and protaper retreatment files on crack formation in dentin. Methods: Eighty mandibular premolar teeth with single canals are selected and mounted on resin blocks with simulated periodontal ligaments. The teeth were divided into four groups of twenty samples in each group. Un-instrumented group serves as control group while group two and three consists of hand file and rotary protaper universal file system respectively. Group 4 consists of retreatment group consisting of two sub groups of ten samples in each group. Subgroup 4a consist of samples prepared with hand file while subgroup 4b consist of samples

prepared with rotary protaper universal system. Thereafter, retreatment is performed with protaper retreatment file system in both the sub groups. All the roots were sectioned perpendicular to the long axis at 4mm from apex using a low speed saw (Isomet) under water cooling. Digital images of each sections were captured at 25X magnification using a digital camera attached to a stereomicroscope and cracks were noted. Results: Although the result is statistically non significant, hand files show less number of cracks as compared to rotary protaper universal file. Also, when compare with retreatment, number of cracks increases irrespective of the file system used but again more with protaper universal file as compared to conventional stainless steel hand file. Conclusion: Within the limitations of this in vitro study, it may be concluded that conventional stainless steel hand files showed less number of cracks in apical root dentin when compared to rotary protaper universal group. Also, the percentage of newcrack formation are further increased after retreatment procedure. Even in retreatment group, again hand files showed better results i.e. less number of cracks in comparison to rotary protaper universal group.

Keywords---Crack, Protaper Universal, Retreatment, Stereomicroscope.

Introduction

The prime requisite for a successful endodontic treatment and predictable prognosis is the apical seal which in turn depends on proper instrumentation and cleaning of the root canal system. During biomechanical preparation, a canal is shaped by the contact between instruments and dentin walls. These contacts create many momentary stress concentrations in dentin. Such stress concentrations may induce dentinal defects and microcracks or craze lines.¹ It is speculated that these dentinal defects have the potential to propagate in vertical root fracture.² The mechanical stresses acting on a hand-operated instrument might differ from those on engine driven instruments.³ Clinical usage suggests that substantially more force is applied to the tooth when engine driven root canal instruments are used versus hand instruments during root canal instrumentation.^{4,5} Root canals prepared by NiTi instruments have an edge over the traditional hand files in terms of fewer aberrations such as the ledge and zip formation, canal transportation and perforations. These superior results are attributed to the increased flexibility and superelasticity of the NiTi alloy and specific geometric design feature of each instrument.⁶

Protaper universal is one of the commonly used NiTi rotary system worldwide and represents a new generation of instruments for shaping root canals and provide unique geometries that when sequenced and used correctly, afford extraordinarily flexibility, efficiency, safety and simplicity.⁷ Non-surgical endodontic re-treatment is often indicated as the first choice to eliminate or reduce microbial infection when initial root canal treatment fails. More recently,

Protaper universal system including shaping, finishing and retreatment files has been introduced for this purpose.⁸

Numerous studies have assessed the effect of endodontic procedures including canal preparation and obturation on apical crack initiation. However, to the best of our knowledge, there has been no study in the literature till now evaluating the effect of hand file, protaper universal (rotary) and protaper retreatment files on crack formation in root dentin. Thus, the aim of this study was to determine the incidence of crack initiation in apical root dentin after root canal preparation with hand files, rotary protaper universal and also compare them with cracks after retreatment using protaper retreatment files.

Material and Method

Tooth selection and preparation

Eighty extracted human mandibular premolar teeth of similar length and with straight roots were selected (Figure 3). Radiographs were taken from buccolingual and mesiodistal angles to verify the presence of single canal. The root surfaces of each tooth were observed under a stereomicroscope at 20X magnification for evidence of fracture lines, open apices or anatomic irregularities and discarded if any of these characteristics were found. Teeth with a deviated apical foramen were excluded from the study to ensure standardization. Teeth are then stored in purified filtered water throughout the study. Twenty teeth were left unprepared which serve as control group. The surfaces of all the roots were coated with a silicone impression material to simulate periodontal ligament space. These teeth were then embedded in a tube filled with self curing acrylic resin. (Figure 3)

Access cavity preparation was done using large round bur. A size 10 K-file (Dentsply Maillefer) was introduced into the canal until the file tip was observed at the apical plane. This measurement was determined as the working length. The root canals are irrigated with 1% NaOCl after each instrument change. The root canal shaping procedures were performed using standardization technique. Eighty samples were divided under four groups of twenty samples in each group.

1. Group 1: CONTROL GROUP

Consist of twenty mandibular premolars and are left unprepared.

2. Group 2: HAND FILE GROUP

Twenty teeth which comes under this group were prepared with hand files of 0.02 taper upto size K-file no. 30 following standardized technique for shaping procedure.

3. Group 3: ROTARY PROTAPER UNIVERSAL FILE GROUP

Twenty teeth which comes under this group were prepared with NiTi rotary instruments i.e; protaper universal system (Figure 8). For each protaper universal file, the rotational speed of 250 rpm were used. The sequence is as follows: SX, S1, S2, F1, F2 and F3. The first three shaping files were used with a brushing motion away from root concavities before light resistance was encountered, and the last three finishing files were used until the working length was reached.

4. Group 4: RETREATMENT FILE GROUP

In this group, the canal filling material was removed by using protaper universal retreatment instruments. Group 4 is further sub divided into two subgroups.

- Subgroup 4a:
In this group, ten samples are included which are cleaned and shaped using group 2 method i.e.; conventional hand files upto K – file no. 30 at 0.02 taper using standardized technique After completing cleaning and shaping of these 10 samples, obturation is done in this group using respective gutta percha cones of no. 30 in sub group 4a and with F3 cones in subgroup 4 b) and AH Plus sealer .
- Subgroup 4b:
In this group, the remaining ten samples are cleaned and shaped using group 3 method i.e.; with rotary protaper universal file and obturation is done using respective gutta percha of size F3 and AH Plus sealer.
After completion of obturation in both the sub groups ,now is the turn of retreatment. The retreatment instruments were used at a constant speed of 500 rpm for D1,400 rpm for D2 and D3 with a torque of 3Ncm. These instruments were used in a brushing action with lateral pressing movements, according to manufacturer's instructions. D1 (30/0.09) worked in coronal third, D2 (25/0.08) worked in the middle third while D3 (20/0.07) worked in the entire working length.

Sectioning and Microscopic Examination

To ensure standardization, all the roots were sectioned perpendicular to the long axis at 4mm from apex using a low speed saw (Isomet) under water cooling. Digital images of each sections were captured at 25X Magnification using a digital camera attached to a stereomicroscope.

To define crack formation, two different categories were made i.e., Crack and No Crack.⁹

- Crack: was defined as all lines observed on the slice that either extended from the root canal lumen to the dentin or from the outer root surface into the dentin(Figure 1).
- No Crack: was defined as root dentin without crack or craze lines either at the root internal surfaces of root canal wall or external surface of the root (Figure2).

Results

Results of the study conducted revealed 30% of cracks with hand files group. 50% with rotary protaper universal file group. The result is statistically significant when hand file group is compared with control group (P=0.020)(Table 1, Graph 1) and highly significant when rotary protaper universal group is compared with control group (P=0.000)(Table 2 ,Graph 2) . However, the result is statistically non-significant (P=0.333) when hand file group is compared with rotary protaper universal group (Table 3 ,Graph 3)

Moreover, current study also showed that percentage of new crack formation further increased after retreatment irrespective of the file system used. But again the number of new crack formation after retreatment is more with rotary protaper universal file group as compared to conventional stainless steel and file group i.e. 40% with hand file group and 60% with the rotary protaper universal file group. However, the result is statistically non-significant ($P=0.656$), hand files show better results. (Table 4, Graph 4)

The results were expressed as the number of cracks and percentage of cracked roots in each group. The data were analyzed with a chi-square test. Fischer exact test was used to analyze crack incidence between the groups and to analyze propagation of cracks after retreatment. The testing was performed at 95% confidence level ($P=0.05$). All statistical analysis were performed using SPSS software.



Figure 1: Image showing No Crack

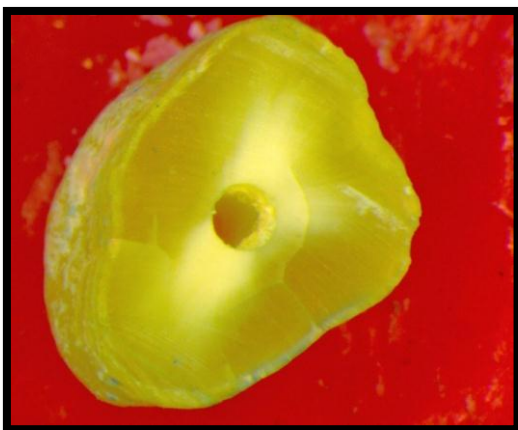


Figure 2: Image showing Crack



Figure 3: Acrylic Mould

Table 1
Comparison of frequency of the cracks between control to
cleaning and shaping of the hand file group

Groups	No change	Number of new cracks	Total specimens
Control	20 (100%)	0 (0.0%)	20 (100%)
Hand file group	14 (70%)	6 (30%)	20 (100%)

Table 2
Comparison of frequency of the cracks between control
and protaper universal group

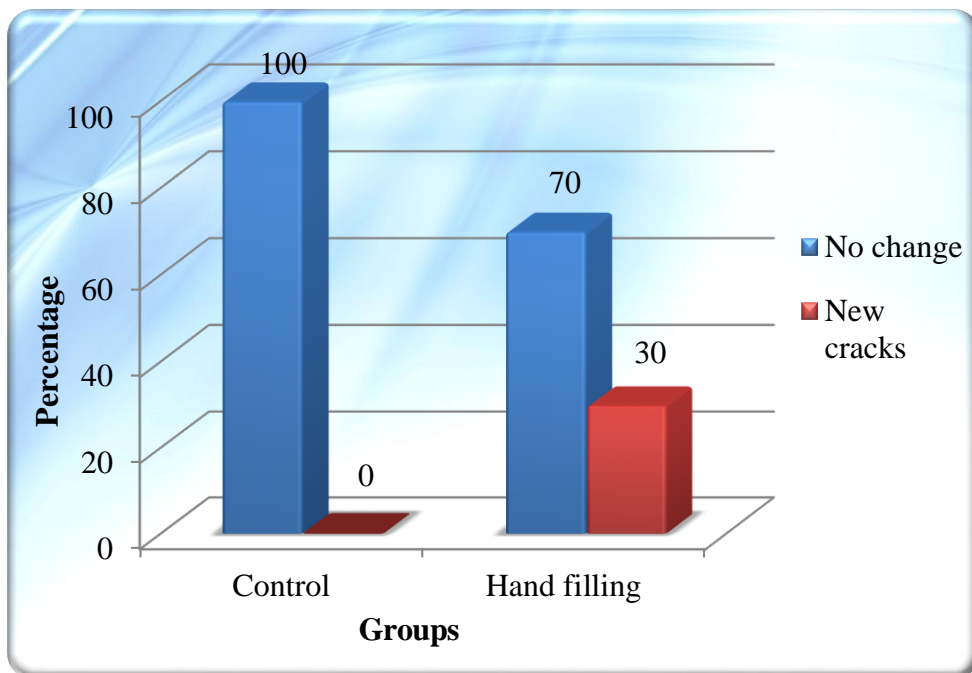
Groups	No change	Number of new cracks	Total specimens
Control	20 (100%)	0 (0.0%)	20 (100%)
Protaper universal group	10 (50%)	10 (50%)	20 (100%)

Table 3
Comparison of frequency of the cracks between hand filing
and protaper universal group

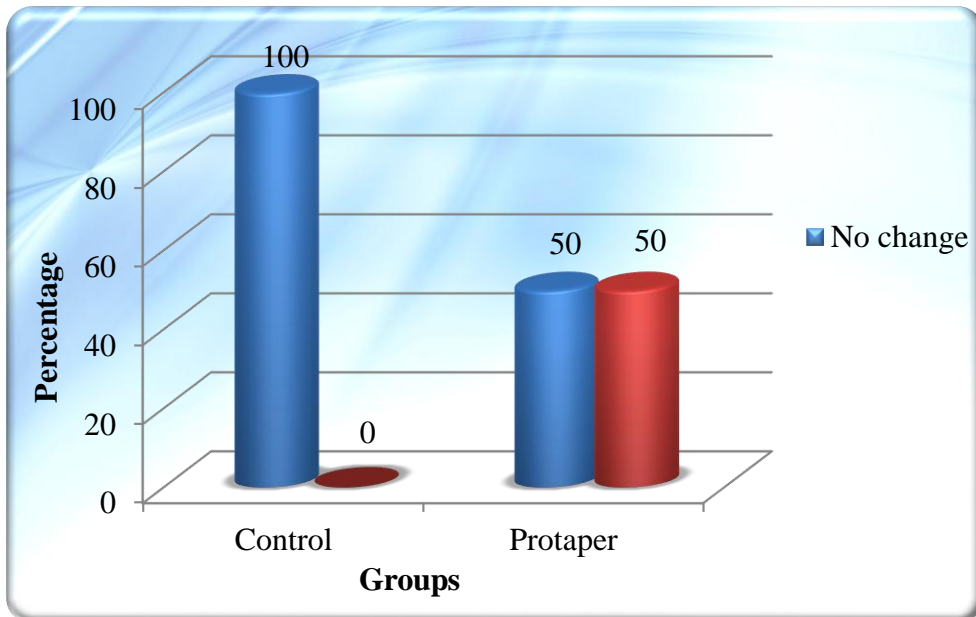
Groups	No change	Number of new cracks	Total specimens
Hand file group	14 (70%)	6 (30%)	20 (100%)
Protaper universal group	10 (50%)	10 (50%)	20 (100%)

Table 4
Comparison of frequency of the cracks between hand filing and protaper universal group after retreatment

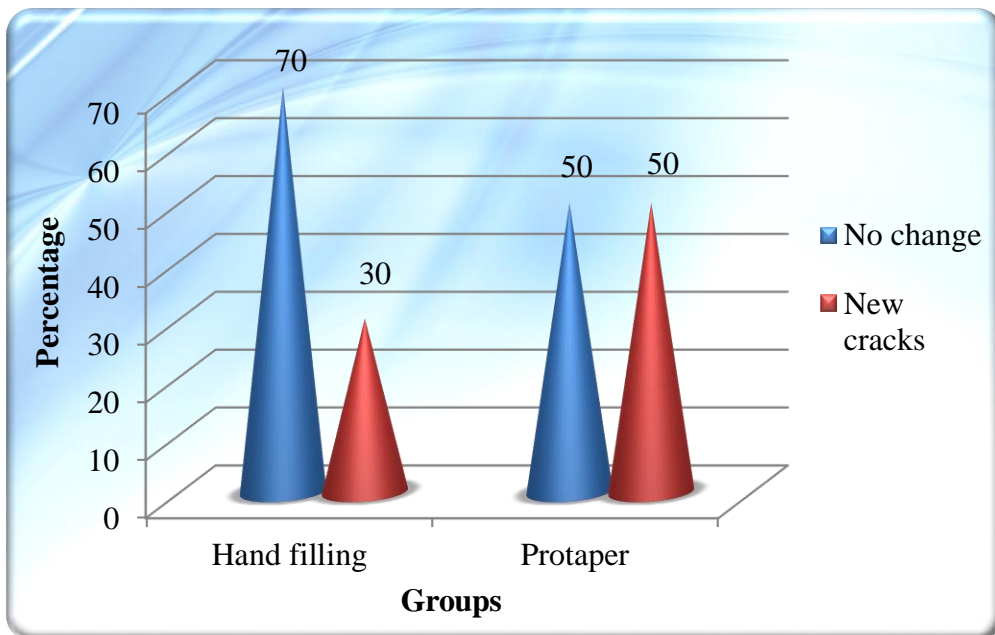
Groups	No change	Number of new cracks	Total specimens
Hand file group	6 (60%)	4 (40%)	10 (100%)
Protaper universal group	4 (40%)	6 (60%)	10 (100%)



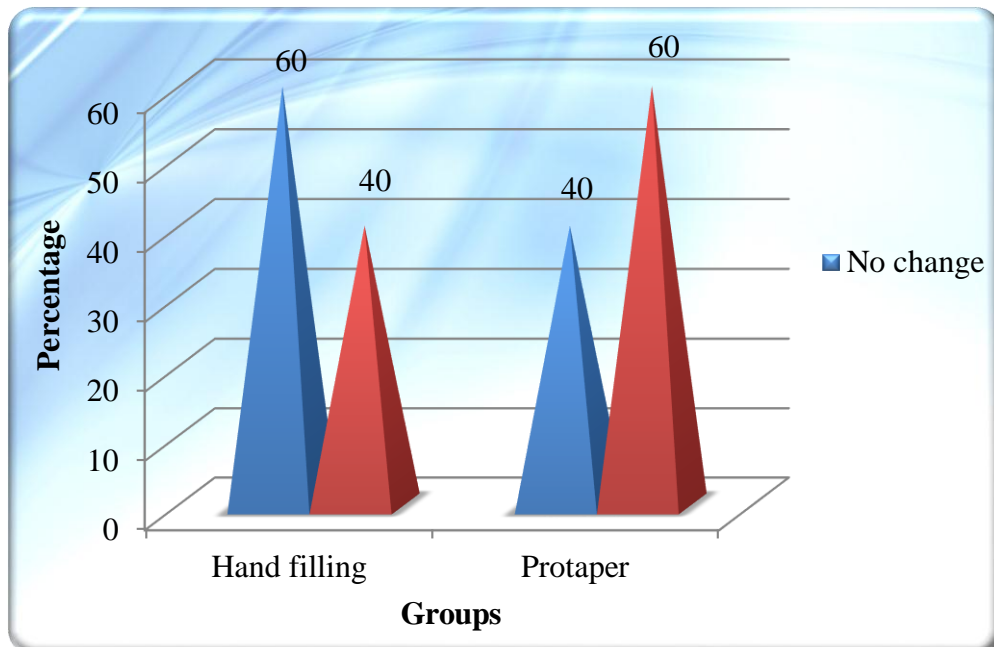
Graphs 1: Comparison of frequency of the cracks between control to cleaning and shaping of the hand file group



Graph 2: Comparison of frequency of the cracks between control and protaper universal group



Graph 3: Comparison of frequency of the cracks between hand filing and protaper universal group



Graph-4 Comparison of frequency of the cracks between hand filing and protaper universal group after retreatment

Discussion

Mechanical instrumentation of the root canal system is an important phase of the root canal preparation because it creates space that allows irrigants and antibacterial medicaments to more effectively eradicate bacteria and eliminate bacterial by products.¹⁰ However, it has been stated that root canal instrumentation has potential to induce dentinal damage and generate cracks on the apical surface.¹⁰ However, it is understood that as dentin is removed during instrumentation phase as a weakening effect on the root is inevitable.¹² Orthograde retreatment procedures are performed when initial root canal treatment fails.¹² It seems plausible that undergoing these procedures twice for an endodontic retreatment will increase the number of defects.¹⁴

In the present study, effect of hand files, rotary protaper universal and protaper retreatment files on crack formation in apical root dentin was evaluated. In the current study, the incidence of crack in radicular apical dentin is 50% with rotary protaper universal system while just 30% with hand file group (Table 2,3, Graph 1,2). Similar to our findings, Liu et al reported cracks in 50% of the roots instrumented with the protaper (Table 3, Graph 2).¹⁵

However, Yoldas et al observed cracks in 30% of the mesial roots of mandibular teeth instrumented with the protaper.¹⁵ Moreover, Bier et al found cracks in 16% of the roots of mandibular premolar instrumented with protaper system.⁴ These contradictory results may be attributed to a number of reasons and the most likely one is the use of teeth with different root canal anatomy.¹⁶ Additionally, we performed a glide path upto size 15 hand file whereas, Bier et al

performed a glide path with upto size 20 hand file. Previous studies showed that hand instrumentation cause less cracks than rotary instrumentation which were similar to the results of current study (Table 4, Graph 3).^{5,18}

The NiTi protaper system comprises five instruments with multiple taper design. Protaper consists of one auxillary shaping file (SX), two shaping files (S1 AND S2) and three finishing files (F1, F2 and F3).⁷ Protaper universal rotary files are made from a conventional superelastic NiTi wire and have been used for years, have a triangular cross-section design and various percentage tapers that enable an active cutting motion and removal of more dentin coronally.¹⁹

In previous studies, the protaper universal system was associated with more cracks than other rotary NiTi instruments.² Formation of dentinal defects may be associated with the design of tip, cross sectional geometry ,taper type ,flute form andpitch.²⁰

In the present study, we also compared the hand files and rotary protaper universal to protaper retreatment instruments. The rotary protaper retreatment system is a dedicated NiTi rotary instrument that is used for removal of filling material from the root canal. It comprises three retreatment files, one on each third of the canal. These instruments have a convex triangular cross section similar to protaper universalshaping and finishing files.¹⁴

Retreatment procedures could significantly damage the root and results in cracks and fractures. When assessing the outcomes of endodontic retreatment and prognosis of retreated teeth, the substantial damage to the root canal wall should be considered.¹³ There are a number of limitations present in the study evaluating dentinal defect formation:

- It is possible that the defects occurred during the extraction of the teeth.
- It is possible that defects occurred during sectioning procedure
- It was not possible to evaluate at which point during the instrumentation procedures, the cracks were produced.
- It is not possible with the current methodology (root sectioning and direct observation with optical microscope) to detect the pre- existing defects.

Micro-CT imaging has a much higher definition than stereomicroscopy and also a large number of sections can be analysed per tooth without creating defects. As preservative dentist, we should be careful to adopt the best available evidence for supporting clinical treatment plans. Ignoring science for the sake of speed and simplicity may place the final outcome for our patients in jeopardy.

Conclusion

Within the limitations of this in-vitro study, it may be concluded that conventional stainless steel hand files showed less number of cracks in apical root dentin when compared to rotary protaper universal group. Also, the percentage of new crack formation are further increased after retreatment procedure. Even in retreatment group also, again hand files showed better results i.e. less number

of cracks in comparison to rotary protaper universal group. But still further researches are required in this field to overcome the limitations.

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