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A Stereomicroscopic Evaluation of Root Dentin Defects Caused by Hand Files and Different NiTirotary Instruments - An In Vitro Study

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Abstract: ***To compare dentinal cracks caused by hand and rotary nickel titanium instruments using Hyflex ,Pro Taper and K3 sysrems after root canal preparation. Methodology: Eighty mandibular premolarswith single canalwere randomly divided into 4 groups and were mounted in acrylic tubes with simulated periodontal ligaments and the apex was exposed. The root canals were instrumented with different rotary files, namely (Protaper files, Hyflex CM files, K3 files) and K files short of apex. All specimens were kept moist throughout the procedure to prevent dehydration. All roots will be cut longitudinally in two halves and sections will be seen under stereomicroscope. Appearance of dentinal damage will be registered by pictures that will be taken digitally.All the data was statistically analyzed using one way chi square test. Conclusion: Hyflex CM rotary files caused more dentinal cracks thanprotaper and K3 Files. hand files caused least dentinal cracks.***

Keywords: Dentinal defects, Dentinal damage, Cracks, Fracture, Niti rotary instruments

1. Introduction

The primary aim of chemo mechanical preparation is to completely remove the microorganisms, pulp tissue and debris and enlarging the canal diameter to receive an obturating material. Biomechanical preparation is very important step in root canal preparation and determines the efficacy of all procedures, we end up damaging the root dentin which becomes gateway to dentinal cracks and minute intricate fractures or vertical root fractures thereby leading to failure of treatment.[1]

Complexities in canal preparation may be attributed to variation in the design of the cutting instrument, taper, or difference in composition of the material from which it is made, Active tapered shaft removes more dentine in the middle to apical portion of the root canal compared to smooth flexible design.[2]Hand instrumentation which was very important in the past; though has lost its popularity, still remains an integral part of canal preparation.[3]

Dentinal defect is a clinical complication that may be associated with root canal treatment and lead to extraction.[4]Endodontic procedures might contribute to the development of root fracture as well as other localized defects such as craze lines or incomplete cracks in root dentin. These localized defects may have the potential to develop into fractures and should therefore be prevented.

Several factors may be responsible for the formation of dentinal defects: instrumentation and root filling, high concentration of hypochlorite that is (3-5%) reduced the modulus of elasticity and flexural strength of dentine, calcium hydroxide reduces flexural strength of dentine but not modulus of elasticity, variation in the design of the cutting instrument, constant or progressive taper, tip design, cross-section geometry, constant or variable pitch, flute form and composition of the material from which it is made.[5] However, laboratory stress distribution studies consistently conclude that the pressure applied during lateral compaction is insufficient to cause vertical root fracture. Thus, it remains unclear whether lateral compaction can cause VRF.[6]

Various rotary systems have emerged since the past few decades in order to improve the efficacy of cleaning and shaping of the root canals. Although there are numerous studies describing the nature and incidence of cracks produced by the ProTaper™ Universal file system and Hyflex system, but there is a lack of evidence in the literature comparing the incidence of dentinal defects caused by ProTaper™, Hyflex and K3 file systems

Hence there is need for evaluation and comparison of dentinal defects caused by hand and different nickel-titanium rotary instruments

2. Methodology

80 extracted human premolar teeth were selected and angulated radiographs taken to verify the presence of single canal. All teeth were decoronated using a diamond disc, leaving roots approximately 14 mm in length. All teeth were observed under stereomicroscope to exclude teeth presenting with cracks.

Then the specimens were segregated as follows:-
GROUP 1: Hand Files (Control Group)
GROUP 2: ProTaper Rotary File
GROUP 3: Hyflex Rotary File
GROUP 4: K3 Rotary File

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Group I: 20 specimens were prepared with hand instrument. The initial length was determined by placing #10 K file into the canal until it penetrates the apex. The working length was set at 1mm short of the apex. Canal was prepared with step back technique up to 40K file size.

Group II: 20 specimens were prepared with ProTaper™ rotary files (DentsplyMaillefer) using a crown down technique up to file F4 (0.4 mm) according to the manufacturer's instructions.

Group III: 20 specimens were prepared with Hyflex rotary files (Coltene) using a crown down technique up to file 40 (0.4 mm, 0.06 taper)according to the manufacturer's instructions.

Group IV: 20 specimens were prepared with K3 rotary files (Sybron Endo, CA, USA) using a crown down technique up to 40 (0.4mm, 0.06 taper) according to the manufacturer's instructions.

In all groups canals were irrigated with a freshly prepared 2.5% solution of sodium hypochlorite (NaOCl) between each instrument during the instrumentation procedure. All roots were kept moist throughout the experimental procedures in order to prevent dehydration.

Sectioning and Microscopic Observations:
All roots were cut horizontally at 3, 6 and 9 mm from the apex. Sections were then viewed under stereomicroscope. The appearance of dentinal defects was registered by the pictures that were taken digitally. categories will be made: "no defect," "fracture," and "other defects".[9]

Roots were classified as "defective" if at least one of the three sections were showing either a craze line, partial crack, or a fracture. Results were expressed as the number and percentage of defective roots in each group.

No defect	root dentin devoid of any lines or cracks where both the external surface of the root and the internal root canal wall were not be present any evident defects
Fracture	a line extending from the root canal space all the way to the outer surface of the root
Other defects	all other lines observed that were not be seem to extend from the root canal to the outer root surface (e.g. a craze line, a line extending from the outer surface into the dentin but were not reach the canal lumen, or a partial crack, a line extending from the canal walls into the dentin without reaching the outer surface).

Statistical Analysis
Statistical analysis was done with SPSS (version 17) using Chi-square test.

3. Results

Table 1: Percentage distribution of defects in Coronal section (9 mm)

Group	Total no of specimens	Fracture	%	Other Defects	%	No defects	%
Hand Files	20	0	0	1	5	19	95
ProTaper™RotaryFile	20	0	0	1	5	19	95
Hyflex Rotary File	20	0	0	4	20	16	80
K3 RotaryFiles	20	0	0	1	5	19	95
Chi-square=1.3, DF=3, P=0.39, NS							

Percentage distribution of defects among different groups in **coronal section (9mm)** was evaluated and the result showed that no fracture was found in any group. Maximum other defects were found in Hyflex followed by ProTaper™, K3 & Hand files. Chi-square value is 1.3.

Table 2: Percentage distribution of defects in middle section (6mm)

Group	Total no of specimens	Fracture	%	Other Defects	%	No defects	%
HandFiles	20	0	0	1	5	19	95
ProTaper™RotaryFile	20	0	0	3	15	17	85
HyflexRotary File	20	0	0	4	20	16	80
K3RotaryFiles	20	0	0	2	10	18	90
Chi-square=2.3,DF=3, P=0.23, NS							

Percentage distribution of defects among different groups in **middle section (6mm)** was evaluated and the result showed that no fracture was found in any group. Maximum other defects were found in Hyflex followed by ProTaper™, K3 & Hand files. Chi-square value is 2.3.

Table 3: Percentage distribution of defects in apical section (3mm)

Group	Total no of specimens	Fracture	%	Other Defects	%	No defects	%
Hand Files	20	0	0.00	0	0.00	20	100.00
ProTaper™ Rotary File	20	0	0.00	0	0.00	20	100.00
Hyflex Rotary File	20	0	0.00	0	0.00	20	100.00
K3 Rotary Files	20	0	0.00	0	0.00	20	100.00
Chi-square=N.A,DF=3, P=1.00, NS							

Percentage distribution of defects among different groups in **apical section (3 mm)** was evaluated and the result showed that no fracture and other defects were found in any group. Chi-square value is Not Applicable.

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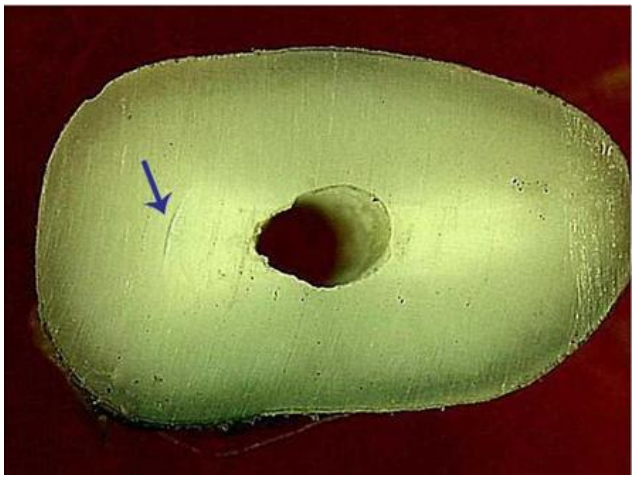
Dentinal Defects



4. Discussion

Endodontic treatment of an inflamed or infected tooth is beneficial in creating a healthy environment that is conducive to the tooth's continual performance as a functional member of the masticatory apparatus. However, it is also important to ensure that iatrogenic harm to the root dentin be minimized in order that the tooth may be sufficiently strong for a long term function.

Complexities in canal preparation may be attributed to variation in the design of the cutting instrument, taper or difference in composition of the material from which it is made. Active tapered shaft removes more dentine in the middle to apical portion of the root canal compared to smooth flexible design.[2] Hand instrumentation which was the essential in the past; though has lost its popularity, still remains an integral part of canal preparation.[3]

Various rotary systems have emerged since the past few decades in order to improve the efficacy of cleaning, shaping of the root canals, improve working safety, shorten preparation time and to create continuously tapered, conical flare of preparations, advanced instruments designs with noncutting tips. The Rotary nickel titanium file systems which are at the peak of their evolution with improved clinical applications. However rotary instrument by causes more friction which may lead to increase in dentinal defects and micro cracks in comparison to hand instruments.[7]Whether rotary or hand files, they are assumed to cause frictional forces within the canal, hence creating dentinal defects. So there is need for evidence for the behavior of different instruments on root dentin in vivo conditions after endodontic preparations with hand files and different nickel-titanium rotary files.

Although there are numerous studies describing the nature and incidence of cracks produced by the ProTaper™ Universal file system and Hyflex system, but there is a lack of evidence in the literature comparing the incidence of dentinal defects caused by each file system. Hence there is need for evaluation and comparison of dentinal defects caused by each of the rotary instruments using the authentic and accurate measure like the stereomicroscope.

When Ni- Ti rotary instruments are used, a rotational force is applied to root canal walls. Thus, they can create microcracks or craze lines in root dentin. The extent of such a defect formation may be related to the tip design, cross-section geometry, constant or progressive taper type, constant or variable pitch, and flute form.[83] Resistance to tooth fracture is an important aim in endodontics because such fractures may decrease the long-term survival rate. Experimental studies have shown that excessive removal of dentin during root canal preparation, post space preparation, and obturation procedures with spreader can create fractures in teeth.[6]

Kim et al suggested that file design affected apical stress and strain concentrations during instrumentation, which were linked to an increase in dentinal defects and canal deviations. These in turn, were associated with increased vertical root fracture susceptibility because root canal obturation and final restoration can initiate or propagate cracks from such defects. Furthermore, significantly more rotations in the canal are necessary to complete a preparation with rotary Ni-Ti files as compared with HFs.[7]This in itself, may contribute to the formation of dentinal defects.

Tooth samples prepared for mechanical testing are usually stored in aqueous solutions to maintain hydration.*Kempf et al* suggested in 2005 that the choice of storage medium is important to preserve micro elastic tissue properties. Minerals are rapidly dissolved in dentin when it is stored in saline solution. HBSS and artificial saliva are suitable storage media if micro-elastic properties of tooth tissues are of concern.[8]

Carlos G et al in 2009 conducted a study and found that instrumentation of root canals alone significantly weakens the roots. Root stresses generated from inside the root canal are higher in the apical region and along the canal wall than on the external surface. The pattern of stress distribution in the apical area could lead to the development of cracks and fracture propagation. In addition, a debilitated root, as a result of flaring and instrumentation, could suffer vertical root fractures during obturation procedures. This study showed that canal preparation techniques, either crown down or step back, had no significant effect on the development of root cracks.[9]

Ruddle C. et al ProTaper™NiTi instruments represent a new generation of instruments for shaping root canals. A unique feature of ProTaper™ instruments is each one has changing percentage tapers over the length of its cutting blades. These instruments also have convex, triangular cross-sections, a changing helical angle and pitch over their cutting blades and a non-cutting, modified guiding tip.[10]

Hyflex CM are new nitinol file is a metal alloy of nickel and titanium with controlled memory. This file is more resistant to cyclic fatigue which reduces the incidence of fracture. It is new nitinol rotary instrument, with two types of flute blades, which may be used to perform root canal and simplified instrument sequence,It has accelerated flute deasign and positive rake angle.[11]

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The K3 file has an asymmetrical design with a slightly positive rake angle for optimum cutting efficiently with a non-cutting tip. The increased radial land of it has a positive effect on the instrument's resistance during rotation. The third radial land allows the operator more control by centering and stabilizing the instrument while rotating.[12-13]

In this study the percentage distribution of craze lines in canal which were prepared with Hyflex rotary files showed more craze lines in coronal and middle 27% each & no defects in apical portion of the tooth structure. The Hyflex rotary files showed highest dentinal damage with 33.33% specimens among different groups followed by ProTaper™ rotary with 27%, K3 with 20.00%, Hand files with 5%; which was proved statistically not significant.

Yodals et al (2012) compared dentinal microcrack formation while using hand files (HFs), 4 brands of nickel-titanium (Ni-Ti) rotary files [Hero Shaper (HS), Revo S (RS), Twisted file (TF) &ProTaper™ (PT)] and Self adjusting file (SAF). Result showed the control, HF and SAF groups did not show any microcracks. In roots prepared with the HS, RS, TF and PT, dentinal microcracks were observed in 60%, 25%, 44%, and 30% of teeth respectively. There was a significant difference between the control / HF / SAF groups and the 4 Ni-Ti rotary instrument groups ($P < 0.0001$). However, no significant difference was found among the 4 Ni-Ti rotary instruments each ($P > 0.005$).[14]In contrast to our study, *Burklein S et al (2013)* evaluated dentinal defects after root canal preparation with reciprocating (reciproc and waveone) and rotary instruments and study showed that root canal preparation with both rotary and reciprocating instruments resulted in dentinal defects.[15]

In this study percentage distribution of other defects among different groups in different sections (9 mm, 6 mm & 3 mm) were evaluated and the result showed that maximum other defects were found in middle (6 mm) sections followed by coronal (9 mm) and apical (3 mm) sections. In coronal section maximum other defects were found in Hyflex, rest all files shows same defects. In middle section maximum other defects were found in Hyflex followed by ProTaper™, K3 & Hand file.And in apical section no defect was found.

The Hyflex rotary files have accelerated flute design and positive rake angle which causes more stress on dentinal wall which leads to more damage while Protaper has active but partial cutting and K3 files have radial lands which causes less cutting and less damage.

It is generally accepted that the strength of an endodontically treated tooth is directly related to the amount of remaining sound tooth structure. Several treatment procedures such as caries removal, access preparation, instrumentation of the root canal, irrigation of the canal with sodium hypochlorite, and long-term intracanal dressings with calcium hydroxide, instrument design, instrument taper lead to a loss of tooth structure or may weaken the dentine.

Sim et al (2001) concludes that, 5.25% NaOCl reduced the elastic modulus and flexural strength of dentine. Irrigation of root canals of single, mature rooted premolars with 5.25% NaOCl affected their properties sufficiently to alter their strain characteristics when no enamel was present.[5]Hencein the present study 2.5% NaOCl was used as the intermittent.

As apparent from the results of this study, instrumentation with hand files amounts to the least stress on root dentine and rotary instrumentation showed more damage to root dentin. This finding is noteworthy as there can be attached a clinical significance to the knowledge that rotary systems, that have become the mainstay of modern endodontics, have a potential, however small, of weakening root dentine.

5. Summary

Vertical root fracture is an important clinical problem leading to extraction or root amputation. The most potent cause for vertical root fracture is excessive canal preparation, specially in the pericervical area, which involves dentin removal and may compromise the fracture strength of the roots. With the help of the data, the statistical analysis revealed that Hyflex rotary files showed the maximum number of defects followed by ProTaper™ rotary system, K3 rotary system & Hand files being the least with 33.33%, 27%, 20% & 5% respectively.

6. Conclusion

Within the limitation of the study it can be concluded that,

- Hyflex consistently generated the highest stresses and strains in root section. The higher incidence of damage was reported for Hyflex compared with other (constant taper) rotary instruments.
- Percentage of defects among different groups showed that Hyflex rotary files showed highest dentinal damage with 33.33% followed by ProTaper™ rotary with 27%, K3 with 20%, Hand files with 5% respectively.

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