



COMPARATIVE EVALUATION OF DENTINAL MICROCRACK FORMATION DURING ROOT CANAL PREPARATION USING HAND 'K' FILES AND THREE DIFFERENT NITI ROTARY SYSTEMS: AN IN VITRO STUDY

Endodontic

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ABSTRACT

AIM: To evaluate and compare the amount of dentinal defects (microcracks) formed during the canal preparation using hand stainless steel 'K' files and Mtwo, Hyflex CM and K3XF, NiTi rotary files.

MATERIALS AND METHODOLOGY: 100 extracted teeth were randomly divided into 5 equal groups and canals were prepared in the following manner, GROUP 1- Control group – Canals unprepared, GROUP 2- Hand Files, GROUP 3- Mtwo Files, GROUP 4- HYFLEX CM Files, and GROUP 5- K3XF and all roots were cut horizontally at 3, 6, and 9 mm from the apex and were viewed under stereomicroscope, each specimen was checked for the presence of dentinal defects.

RESULTS AND CONCLUSION: Maximum defects were found in Mtwo rotary system group followed by K3Xf and Hyflex CM groups, the control and the hand files group did not show any defect. All the three experimental rotary systems caused dentinal microcracks.

KEYWORDS

Dentinal Microcrack, Craze Lines, Dentinal Defect.

INTRODUCTION:

The endodontic triad consisting of biomechanical preparation, microbial control and complete obturation of the canal space remains the basis of endodontic therapy. Perfect designing of the canal diameter and canal form that allows us to conquer this objective is of prime importance.

At times, in the zeal of bio mechanical preparation of the canal we inevitably end up damaging the root dentin which becomes a gateway to dentinal cracks and minute intricate fractures that may lead to failure of the treatment.

Dentinal defects which are in the form of microcracks, craze lines and root fractures are a clinical complication that may be associated with biomechanical preparation and may have the potential to develop into fractures and should therefore be prevented.

Several factors may be responsible for the formation of these dentin cracks. Firstly, the different types of root canal shaping procedures and systems, second, the high concentration of sodium hypochlorite and third, the obturation techniques in root canal filling especially lateral compaction technique¹.

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 are other factors which result in dentin crack formation².

Two elements play major roles in the development of dentinal defects. These are the force applied to the tooth and the characteristics of the tooth itself. It is intuitively obvious that a very thin root is more prone to fracture than one with more bulk, given the same parameters of force applied to it³.

Rotary instruments by their innate behaviour in the canal may result in more friction between the files and the canal walls which may lead to increase in dentinal defects and micro cracks in comparison to hand instruments⁴.

Although there are numerous studies describing the nature and incidence of cracks produced by the ProTaper Universal file system, but there is a lack of evidence in the literature comparing the incidence of dentinal defects caused by, Mtwo, Hyflex CM, and K3XF rotary file systems.

MATERIALS AND METHODS:

Hundred extracted mandibular premolar teeth were selected and stored in purified filtered water until use. Decoronation was done using diamond coated disc, leaving the tooth approximately 16mm length. Teeth were randomly divided into five groups of 20 each (n=20). And the canals were prepared in the following manner.

GROUP 1- Control group – Canals were left unprepared
 GROUP 2- Stainless steel HAND 'K' FILES (Mani inc, Japan)
 GROUP 3- Mtwo FILES (VDW, Munich, Germany)
 GROUP 4 – HYFLEX CM FILES (Coltenewhaldent Alstatten, Switzerland)
 GROUP 5- K3XF (Sybronendo Glendora, USA)

A silicon impression material (Aquasil LV Dentsply caulk, U.S.A) was used for coating the cemental surface of roots to simulate periodontal ligament space. Then all roots were embedded in acrylic blocks made of self-cure acrylic resin (DPI, Mumbai, India).

Twenty root canals were left unprepared to serve as control (group 1), and the remaining 80 teeth (groups 2, 3, 4 and 5) were subjected to the procedures described below.

For all the experimental teeth canal patency was established with a K-File (Mani inc, Japan) of ISO size 15. The working length was established 1mm shorter than the length of size 15 K-file was visualised at apical foramen. This length was noted as working length. In the HAND FILE group, stainless steel Hand K files (Mani inc, Japan) was used to prepare the canals to ISO file size 30. In Mtwo (VDW, Munich, Germany) group, HYFLEX CM (Coltenewhaldent, Alstatten, Switzerland) group and K3XF (Sybronendo Glendora, USA) group, canal preparation was performed with rotary files till

apical size of 30 with 6% taper using a torque and speed controlled motor at a torque and speed recommended by the manufacturer for each specific system used. In all the groups, irrigation was performed with 3% sodium hypochlorite (Asian acrylates, Mumbai, India) between each instrument during the preparations of root canals.

All roots were sectioned perpendicular to the long axis at 3, 6, and 9mm from the apex using a diamond coated disc under water cooling. The teeth were examined under stereo microscope of 40X magnification connected to a digital camera the results were statistically analysed.

RESULTS:

Table 1 compares the percentage of dentin defects found in all the groups taken in the study.

	Defect seen N(%)	No defect N(%)	Total N(%)
Group 1	0	20(100%)	20 (100%)
Group 2	0	20(100%)	20 (100%)
Group 3	8 (40%)	12 (60%)	20 (100%)
Group 4	5 (25%)	15 (75%)	20 (100%)
Group 5	7 (35%)	13 (65%)	20 (100%)

Chi-square value - 85.70 and 'P' value - 0.00. i.e. **highly significant**

Group 3 has shown more defects followed by Group 5 and Group 4 whereas Group 1 and Group 2 showed no defects.

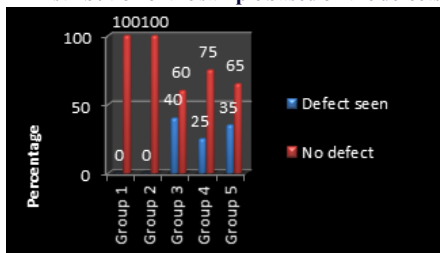
Table 2 compares the percentage of defects found in all rotary system groups at three different levels of root.

Name of Rotary system used	No. of defects at 3mm distance from apex	No. of defects at 6mm distance from apex	No. of defects at 9mm distance from apex	Total No. of defects
Group-3	5	2	1	8
Group-4	4	1	0	5
Group-5	4	3	0	7

Chi-square value with Yates correction-34.03 and 'P' value-7.3 i.e. **Not significant**

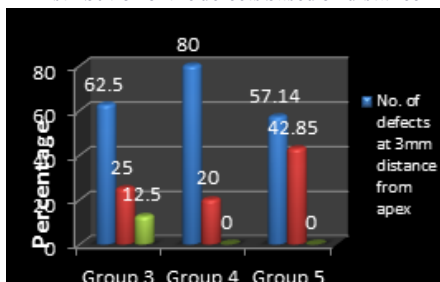
Only Group-3 has shown defects at the level of 9mm distance from apex

GRAPH -1 Distribution of the sample based on the defects seen



Group 3 has shown more defects followed by Group 5 and Group 4 whereas Group 1 and Group 2 showed no defects.

GRAPH -2 Distribution of the defects based on distance from apex



Only Group-3 has shown defects at the level of 9mm distance from apex and most of the defects are seen at 3mm level in all the three groups.

STATISTICAL ANALYSIS:

Chi-square test is applied for proportions when there are two

categorical variables (Defect present/absent) from a single group. It is used to determine whether there is a significant association between the two variables.

Yates correction is used because the expected cell frequency is below 10 or even 5.

The level of significance set at 'P' value ≤ 0.05

DISCUSSION:

Dentinal defects are produced as a result of iatrogenic harm during biomechanical preparation. These defects are in the form microcracks, craze lines and root fractures and should be prevented. Several factors may be responsible for the formation of dentinal defects: instrumentation, filling and high concentration of sodium hypochlorite.

Resistance to tooth fracture is also 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 also create microcracks and fractures in teeth.⁵

The introduction of nickel-titanium (NiTi) rotary files to endodontics almost two decades ago has changed the way root canal preparations are performed. Since then many new NiTi rotary instruments have been developed and introduced by various manufacturers such as Profile, Lightspeed, Greater Taper, Prot aper universal, K3, K3Xf, Hero shaper, Twisted file, Mtwo and Hyflex CM systems. Most clinicians prefer these systems because of their advantages such as saving time and better cutting efficiency over hand files. Nevertheless, some disadvantages of NiTi rotary systems such as cleaning ability, increased stress resulting in craze lines/dentinal cracks and the inability to adequately prepare oval shaped canals cannot be neglected.⁶

The present study compares and evaluates the various dentinal defects seen after the root canal preparation with stainless steel hand 'K' files (Mani inc, Japan) and three different rotary instrument systems Mtwo, K3Xf and Hyflex CM.

The highest number of dentinal defects is shown by Group 3 samples prepared by Mtwo rotary files (40%) followed by Group 5 samples prepared by K3Xf files (35%) and least by Group 4 samples prepared by Hyflex CM (25%). One tooth from Mtwo group showed complete fracture. These results of our study are in accordance with other studies done previously.^{7,8}

The probable reason for highest percentage of dentinal defects with Mtwo files attributed to its cross section which is italic 'S' shape with sharp cutting edges, this cross section design makes the file to cut the dentine more aggressively and efficiently resulting in more dentine removal from root canal wall and weakening the root dentine.⁹

In Mtwo group 12% of defects was seen at 9mm distance from apex whereas no defects observed in K3Xf or Hyflex CM groups at same level, this unique type of defects observed with Mtwo may be because of the filing technique we follow with Mtwo system, where canals are prepared by 'Single length' technique which results in greater amount of dentine removal from coronal portion of root than that of canals prepared using 'Crown down' technique.⁶

In Group 5 (K3Xf) 35% (7 out of 20 Teeth) of defects has been seen, which is less than Group 3 (M two) and more than Group 4 (Hyflex CM) Which is similar to the results obtained in other study.⁷

Probable reason for lesser defects compare to M two group may be because of design of K3Xf file which has wide 'Radial land' and increased flexibility which resist the rotary stress produced on root canal wall during preparation.^{11,12}

'Radial land relief' of this file reduces the contact area of file to canal walls which thereby reduces the friction of file with root canal.¹¹

At 6mm distance from apex (42.85%) of defects found which is significantly more than Mtwo group i.e. is 25% and Hyflex CM group i.e. 20%.

The probable reason for this Mtwo removes lesser dentine from middle 3rd of root than K3XF.¹³

In Group 4 (Hyflex CM), fewer amounts of dentinal defects were seen compared to other two rotary groups i.e. 25% (5 out of 20 teeth).

The reason for this lesser amount of defects seen with Hyflex CM files may be because this file has manufactured with CM (control memory) technology which makes this file highly flexible and enables it to follow canal curvature freely.^{14,15,16,17.}

Another reason may be because of its high speed (500rpm) recommended for canal preparation than other two files, which enables it to cut the dentine more efficiently without causing more stress on root canal walls.¹⁵

Even with all the added advantage with Hyflex CM file system, it has caused some amount of dentinal defects.

Plausible explanation for this may be because of its high torque (5N/cm) at which file is operated which is in accordance with one of the study which concluded that more dentinal defects were formed in root canal when file is operated at high torque than the defects formed in root canal when same file is operated at lower torque.¹⁸

In our present in vitro study, extracted teeth were inspected under operating microscope for the presence of fractures and cracks, ruling out their presence before the start of the study. But still some of these cracks could be internal and not visible on the outside surface of the root. However, the unprepared and the hand files group showed no cracks. This implies that the sectioning method did not induce damage and it may be concluded that the cracks seen were a result of preparation procedure.¹⁹

In our present study, the roots were surrounded with silicon impression material during preparation in an attempt to simulate the periodontal ligament space. This is in accordance with a study done by Soros et al who confirmed that periodontal simulation by acrylic resin and elastomeric impression material was deemed to be reliable and it will help in force distribution around the tooth when external forces are used.^{6,20}

Sim et al concluded that, 5.25% NaOCl reduced the elastic modulus and flexural strength of dentin. Irrigation of root canals of mature, single rooted premolars with 5.25% NaOCl affected their properties sufficiently to alter their strain characteristics when no enamel was present.²¹ hence in the present study 3% NaOCl was used as the irrigant.

The sectioning method used in our present study allowed the evaluation of the effect of root canal treatment procedures on the root dentin by direct inspection of the roots and is in agreement with methodology described in previous studies.^{5,10,12}

Stereomicroscopes provide the user with an erect (upright and unreserved) stereoscopic image. This is particularly useful to see the cross sections and dentinal defects of tooth.

CONCLUSION:

As apparent from the results of our study, instrumentation with hand files amounts to the least stress on root dentine whereas rotary systems created varying amount of stresses in root dentin in the form of dentinal defects. This finding is noteworthy as there can be an attached clinical significance to the fact that rotary systems, that have become the main armamentarium of modern endodontics, have a potential chance of weakening of root dentine. Further studies are necessary to substantiate better outcome.

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