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Crack propagation in radicular dentin after the root canal preparation with the different NiTi rotary files an *ex vivo* study

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Abstract
Cracks that occur during endodontic procedures can propagate by occlusal forces, with repeated stress finally resulting in VRFs. At times, we inevitably end up damaging root dentin which becomes a Gateway for infections like perforation, zipping, dentinal cracks and minute intricate fractures or even vertical root fractures, thereby resulting in failure of treatment. Several factors may be responsible for the formation of dentinal cracks like high concentration of sodium hypochlorite, compaction methods and various canal shaping methods. The prognosis of a tooth with a VRF is poor. The final apical preparation size is an important factor in root canal cleanliness. This article discusses the current concepts in the usage of NiTi rotary files in endodontic therapy and their comparison with hand files in order to draw some clinical inferences.

Keywords: Radicular dentinal cracks, root canal treatment, NiTi rotary files (Protaper universal, protaper next, M-two), instrumentation

Introduction
Success of any endodontic treatment depends on strict adherence to 'endodontic triad'. Preparation of root canal system is recognized as being one of the most important stages in the root canal treatment [1]. The main aim of endodontics is air tight seal of the root canal system which is achieved by proper anatomical form of the root canal system. Root canal instrumentation and irrigation are important procedure in disinfecting the canals [2].
Currently, the popularity of NiTi rotary file systems has increased because of their superiority over stainless steel files. Thus, NiTi files are widely used in root canal preparation and retreatment procedures.
Despite many advantages of NiTi rotary file systems, NiTi rotary files were reported to cause dentin defects such as cracks during root canal shaping and retreatment procedures [3, 4].
The susceptibility fracture depends primarily on the apical preparation of canal and its enlargement and the method used to elimination of mishaps, which are stress concentration sites [5]. Thus, different bio mechanical techniques of root canal preparation and systems, with different instrument design, lead to different levels and severity of dentinal damage to the root canal wall [6].

Aim
The aim of the study was to evaluate and compare the incidence of crack formation after root canal preparation with different NITI rotary files in the radicular dentin.

Materials and Methodology
The present *in vitro* study was carried out in the Department of Conservative Dentistry and Endodontics at Farooqia Dental College and hospital, Mysuru from October 2019 to March 2020 after the approval by the Ethical Committee of the institution.
A total of 40 freshly extracted premolars with complete apices and single, straight root and root canal were selected and stored. RVG was taken to exclude teeth with curved roots and anatomic irregularities.

The teeth were decoronated to ensure straight line access, to provide a reference plane and uniformity of root lengths of 16mm. The root tip was cut approximately 1mm and stained with methylene blue for better visualization under the stereomicroscope (X20). Initial photographs of cut apex were taken using stereomicroscope (X20) connected to a computer. The roots were examined for cracks and discarded if many cracks were present. In case of few cracks, the teeth were included in the study and the position of cracks were noted. The teeth were randomly distributed into 4 experimental and a control group of 10 teeth per group. A 10 size K file was inserted into the canal until the tip of the file was visible at resected root tip. The distance between the reference point and the tip of the file was defined as Root Canal Length (RCL).

Teeth in groups A was instrumented using Stainless Steel (SS) files up to RCL respectively. Teeth in groups B was instrumented using ProTaper Universal (NiTi) rotary files up to RCL. Teeth in C groups was instrumented using ProTaper Next (M wire) rotary files up to RCL. Teeth in the group D was instrumented using M-two rotary files up to RCL All the samples were examined under stereomicroscope with 20X magnification and photographs of samples taken both pre–operative and post–operative at incremental sequence of file sizes.

Once the instrumentation length was reached, teeth were stained with methylene blue and viewed under stereomicroscope (X20) and photographs were taken after each file change. Slide show was prepared and photographs were compared with preceding photographs and a note of cracks was made regarding presence or absence, number of cracks, originating at resected root tip and the file size inducing cracks was made. Roots were classified as 'no crack formation', 'incomplete root crack formation – when the crack line extends from canal wall into dentin without reaching outer root surface; 'propagation of existing crack – when there is crack visibly longer compared to previous image; 'complete crack formation – when the crack extending from canal wall reaches the outer root surface. Samples were considered defected when any of the above-mentioned condition was noted.

Statistical analysis

For the analysis of data Students t-test for the quality of variances among the experimental group and control group (One-Way ANOVA) were employed.

Results

Control group showed no crack formation while experimental groups showed crack formation.

In group A, the samples were instrumented using stainless steel hand K files instrumented 1mm short of RCL showed cracks in four out of 10 samples.

In group B, the samples were instrumented using ProTaper Universal rotary files instrumented 1mm short of the working length showed cracks in three out of 10 samples. [Table/Fig-2].

In group C, the samples were instrumented using ProTaper Next rotary files showed cracks in four out of 10 samples.

In group D, the samples were instrumented using M-two rotary files showed cracks in five out of 10 samples.

The M-two showed highest number of the cracks and least by Protaper universal followed by Stainless steel group and ProTaper Next group. But the statistical analysis showed no significant difference between the groups.

Table 1: Greater number of cracks was seen in samples instrumented with size #30 file compared to instrumentation done using #25 and #20 size files.

Groups	#20	#25	#30	Total
A	-	1	3	4
B	1	1	1	3
C	-	2	2	4
D	1	2	2	5
Total	2	6	8	

Table 2: One way ANOVA showed no significant effect of hand and rotary instrumentation methods and instrumentation length on crack formation [Table 2].

Groups	N	Mean	Std. deviation	Min	Max	P value
A	10	.40	.966	0	2	.921
B	10	.30	.483	0	1	
C	10	.40	.966	0	2	
D	10	.50	.972	0	3	
Total	40	.33	.682	0	3	

Discussion

The present study examined the dentinal defects caused by NiTi rotary file systems, which have different kinematics, on the dentin during treatment procedures. According to the results of the present study, no significant difference was found between the NiTi rotary file systems in terms of the incidence of dentinal defects. Thus, the null hypothesis was accepted.

In previous studies, it was reported that dentinal defects occurred during root canal preparation with NiTi rotary file sys-tems [7, 8]. In contrast, it was also reported that no dentinal defects occurred during root canal preparation with hand files [3, 9]. For this reason, the crown-down technique was used for root canal preparation with the use of hand files, ensuring an apical diameter of 0.40 mm.

The final apical preparation size is an important factor in root canal cleanliness. However, enlargement of the apical region with larger instruments may cause excessive crack formation and root canal transportation, especially in curved canals. There is currently no consensus on the optimum final apical preparation size [10].

Varying degree of taper to endodontic canal shaping instruments are one of the most common contributing factors for crack formation in root dentin [3].

Rotational force is applied to the canals of the root by NiTi rotary instruments, thus creating craze line or micro cracks in root dentin. Formation of dentinal defects may be associated with the design of tip, cross-sectional geometry, taper type, flute form, and pitch [11].

Cross-sectional anatomy of root canals varies; flat, oval and C-shaped canals are commonly found. Although rotary systems tend to produce rounder canal preparations and smoother canal walls, the Self-Adjusting File (SAF) (ReDent-Nova, Ra'anana, Israel) was specially designed to overcome this problem. The SAF works with an up-and-down grinding motion that removes dentin from the canal walls [12].

The incidence of crack formation in the stainless-steel hand group may be attributed to the rigidity of the instrument in contrast to the ProTaper Universal, which is more flexible. A recent finite element analysis study concluded that stiffer file designs generate higher stress concentration in the apical root dentin, which could lead to higher risk of crack initiation [13].

Despite having the advantage of M–wire technology and lesser taper compared to ProTaper Universal. ProTaper Next has an offset mass of rotation which generates a mechanical

wave of motion analogous to the oscillation noted along a sinusoidal wave. As a result of this design, ProTaper Next file cuts a bigger envelope of motion compared to a similarly-sized file with a symmetrical mass and axis of rotation [10].

The absence of coverage of the apex during instrumentation procedures because the periodontal ligament might ''protect'' the apex against crack initiation. Also, the thickness of the cellular cementum increases with age. Additionally, compensatory cementum deposition, which occurs in the apical area to counter balance occlusal attrition, might cover the crack and it's unknown whether or not it might limit its progression [14].

Methylene blue stain could not be washed away completely from the samples in between subsequent staining using alcohol and water which may lead to misinterpretation as additional crack. Increase in the number of crack formation was seen when the samples were instrumented with size #30 file compared to #25 and #20 size files.

Conclusion

During various endodontic procedure such as biomechanical preparation, canal obturation, post space preparation and re treatment can causes dentinal defects. Care should be taken during endodontic procedure by using appropriate technique, material and instruments which creates less or no dentinal defects.

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