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Influence of different glide path techniques on the dentinal crack formation of hyflex EDM system using proglider, hyflex EDM GPF, Neoendo flex glide files - An vitro study

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Abstract
Introduction: Cleaning and shaping of the root canal is the single most important phase of endodontic therapy.
The goal of root canal instrumentation is to obtain a continuous tapering funnel flowing with the shape of the original canal from the coronal access to the apex, so the Glidepath is the answer. The present study evaluated the influence of different glide path techniques on the dentinal crack formation of Hyflex EDM system such as Hyflex EDM GPF, Proglider, Neoendo flex Glide files.
Aim: The aim of this study was to evaluate the influence of different glide path techniques on the dentinal crack formation of Hyflex EDM system such as Hyflex EDM GPF, Proglider, Neoendo flex Glide files.
Materials and Method: 50 single rooted teeth were selected for study. 10 teeth were left as unprepared as the control group.10 teeth were prepared with Hyflex EDM without glidepath, and the remaining 30 teeth were assign to 1 of 3 Glidepath shaping groups such as Hyflex EDM GPF, Proglider, Neoendo flex Glide files.All the specimens were sectioned perpendicular at 3, 6, 9mm. Digital images of each section were captured at 25X magnification using a digital camera attached to a stereomicroscope. The results were expressed as the number and percentage of cracked roots in each group. The Chi-square test with Yates correction was used to determine for difference between groups. *P* value of less than 0.05 was considered statistically significant for all tests.
Result: NeoEndo flex glide file led to highest rate of crack formation and least in Hyflex EDM GPF Files.
Conclusion: Within the limitations of this *in vitro* study, glidepath with Hyflex EDM GPF showed less incidence of cracks formation compared with ProGlider and Neoeno flex glide

Keywords: Glidepath, dentinal crack, NITI

Introduction
Cleaning and shaping of the root canal is the single most important phase of endodontic therapy.
The goal of root canal instrumentation is to obtain a continuous tapering funnel flowing with the shape of the original canal from the coronal access to the apex.
And so the Glidepath is the answer. It is the starting point of radicular preparations. Without it, cleaning and shaping becomes unpredictable or impossible because there is no guide for endodontic mechanics [1]. Endodontic glide path which has been defined as a smooth radicular tunnel from the canal orifice of the canal to the apical foramen of the root canal [2].
During biomechanical preparation, a canal is shaped by the contact between instruments and dentinal walls. These contacts create many momentary stress concentrations in dentin. Such stress concentrations may induce dentinal defects and micro cracks or craze lines. These in turn, were associated with increased susceptibility to Vertical root fracture (VRF) because of applied stresses caused by root canal obturation, retreatment, repeated occlusal forces and can be exponentially amplified at the tip of those defects and can initiate or propagate into cracks [3].
Nickel-titanium (NiTi) rotary instruments were introduced to improve root canal preparation. In clinical practice these instruments are associated with an increased risk of fracture, mainly

because of bending normal stresses (failure by fatigue) and torsional shear stresses (failure by torque) [4]. Initially, when rotary files were introduced there was no recommendation for glidepath creation. Subsequently, instrument fracture became a significant issue until glide path creation became known as an adjunct to safe rotary use.

Creating a manual or mechanical glide path was shown to be the first step for safer use of nickel titanium (Ni-Ti) rotary instrumentation because this procedure prevents fracture, shaping aberrations, and torsion of instruments. Additionally, creating a glide path is recommended to reduce the risk of taper lock and frictional forces to the canal walls especially in curved canals.

Several path finding rotary systems are available for use in creating a glidepath. Numerous studies have investigated the effects of different path finding systems on root canal anatomy preservation, remaining dentin thickness, and separation incidence of instruments. It was reported that glide path preparation reduced root canal modification, canal aberrations, excessive dentin removal, and separation incidence [5].

Another innovation has been introduced into HyFlex file series i.e. HyFlex EDM. HyFlex EDM files are produced using an innovative manufacturing process called Electrical Discharge Machining. The EDM process results in a file that is extremely flexible and fracture resistant. In fact, HyFlex EDM files are up to 700% more resistant to cyclic fatigue compared to traditional NiTi files. HyFlex EDM files follow the anatomy of the canal, which can significantly reduce the risk of ledging, transportation and perforation. Just like HyFlex CM files, HyFlex EDM files offer trusted controlled memory effect and regenerative properties. The built-in shape memory of HyFlex EDM files prevents stress during canal preparation by changing their spiral shape [6, 24].

The new ProGlider (PG) Ni-Ti rotary instrument for mechanical pre-flaring was recently introduced by Dentsply Maillefer. It is manufactured from M-Wire Ni-Ti alloy to enhance flexibility and cycle fatigue resistance. It has following advantages such as optimal cutting efficiency, efficient and time saving, reduced risk of file breakage, no risk of cross contamination. The system consists of a single instruments, with variable progressive taper. It is available with 21, 25, and 31mm length and tip size 16 with a taper of 0.02 at the tip of the file [7, 24].

Hyflex EDM GPF (Coltene) will permit the clinician to negotiate working length quickly and efficiently. This controlled memory files track well in the apical third and allow safer, more efficient preparations. They are available in 25mm length with tip size 10and taper of 0.05.

Neoendo Flex Glide file(Orikam) has enhanced flexibility, works perfectly well in narrow, severly curved and calcified canals, comes with standard tip sizes (13, 16, 19) with 0.02 taper at the tip of the file. It is manufactured using gold thermal treated NiTi alloy.

Furthermore, several studies have investigated the dentinal damage associated with different Ni-Ti rotary instruments. Thus far, there is no research dealing with the effect of glidepath on creating dentinal damage during root canal preparations with rotary Ni-Ti instruments.

Therefore, the aim of this study was to investigate the dentinal crack formation after using Hyflex EDM system with newly introduced glide path- finding files.

Materials and Methods

The present study was conducted in the Department of Conservative Dentistry and Endodontics, D.J. College of Dental Sciences and Research, Modinagar, Uttar Pradesh and Spectro-Analytical Lab New Delhi. 50 single rooted teeth that had been extracted for reasons unrelated to this study were collected and kept in distilled water. 10 teeth were left as unprepared as the control group.10 teeth were prepared with Hyflex EDM without glidepath, and the remaining 30 teeth were assign to 1 of 3 Glidepath Shaping groups. The external root surfaces were inspected under a Stereomicroscope (Olympus BX43; Olympus Co, Tokyo, Japan) to exclude the possibility of any external defects or cracks.

Specimen preparation: To ensure standardization, the teeth were section under water cooling with a diamond disc 16 mm from the apex. The roots were covered with a single layer of aluminium foil. The root inserted in acrylic resin set in an acrylic tube. The roots were then removed from the acrylic tube, and the aluminium foil suspended from the root surface. A light body silicon-based material was used to fill the space created by the foil and to simulate the periodontal ligament, and the root was replaced to the impression. The working length of the canals were determined by inserting a size 10 K-type file into the root canal terminus and subtracting 1 mm from this measurement.

Control Group

10 Teeth were left unprepared as control group.

Hyflex Edm [Group 1]: Ten teeth were prepared using Hyflex EDM system, without using glidepath files according to the manufacturer's instructions at 500 rpm and 2.5 Ncm torque with torque-controlled endodontic motor (X-Smart; Dentsply Maillefer).

ProGlider/Hyflex EDM [Group 2]: Using the torque-controlled endodontic motor (X-Smart; Dentsply Maillefer), a glidepath is created with Proglider (PG) (16/0.02) at 300rpm and 4Ncm then canal was shaped with Hyflex EDM system (25/.06) according to the manufacturer's instructions at 500 rpm and 2.5 Ncm torque.

Hyflex EDM GPF/Hyflex EDM [Group 3]: Using the torque-controlled endodontic motor (X-Smart; Dentsply Maillefer), a glidepath is created with Hyflex EDM GPF (15/0.05) at 300 rpm and 1.8 NCm torque, then canal was shaped with Hyflex EDM system (25/.06) according to the manufacturer's instructions at 500 rpm and 2.5 Ncm torque.

Neoendo Flex Glide/Hyflex EDM [Group 4]: Using the torque-controlled endodontic motor (X-Smart; Dentsply Maillefer), a glidepath is created with Neoendo Flex Glide (16/0.02) with a torque of 1NCm and rpm 200,then canal was shaped with Hyflex EDM system (25/.06) according to the manufacturer's instructions at 500 rpm and 2.5 Ncm torque.

The root canals are irrigated with 1% sodium hypochlorite solution after each instrument change. After preparation, the specimens from the prepared groups were rinsed with distilled water.

Sectioning and Microscopic Examination: All of the roots were sectioned perpendicular to the long axis at 3,6 and 9mm from the apex using a low-speed diamond disc under water cooling. Digital images of each section were captured by

using a digital camera attached to a stereomicroscope. Digital images of each section were captured at 25X magnification using a digital camera attached to a stereomicroscope.

Criteria for Detection of Cracks

In order to avoid confusing descriptions of root fractures, two distinct categories were made: "no defect" and "defect".

No defect: Root dentine was devoid of any lines or cracks where both the external surface of the root and the internal root canal wall did not have any evident defects**.**

Defect: The samples were classified as "with defect" if at least one of the three sections had a craze line, a partial crack, or a fracture.

Craze line: a line extending from the outer surface of the root into the dentine without reaching the canal lumen.

Partial crack: a line extending from the root canal walls into the dentine without reaching the outer surface.

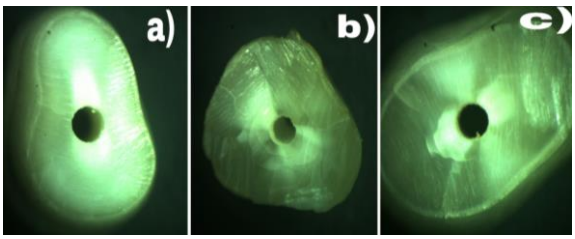

Fig 1: Representative stereomicroscopic images of the root cross-sections. (a) 'no crack'; (b) and (c) 'crack' formation.

Statistical Analysis: The results were expressed as the number and percentage of cracked roots in each group. The Chi-square test with Yates correction was used to determine for difference between groups. *P* value of less than 0.05 was considered statistically significant for all tests. Statistical analyses were performed using SPSS 19.0 software (SPSS, Inc., Chicago, IL, USA).

Results

No cracks were found in control group. There was significant difference between the control and the all other group. Neo Endo flex glide file led to highest rate of crack formation [table-1/fig-2]. There was no significant difference among Hyflex EDM GPF and Pro Glider group. The incident of dentinal defects amoung the groups was not different at the apical (3mm) level. There is no significant difference between with or without glidepath.

Table 1: Total crack formation

Group	n	Section level 3mm	From the apex 6mm	9mm	Total (%)
control	30	0	0	0	0
HyflexEDM	30	1	2	2	5(16.6)
Proglider/HyflexEDM	30	2	2	3	7(23.3)
HyflexEDMGPF/HyflexEDM	30	1	1	2	4(13.3)
Neoendoflex glide/ Hyflex EDM	30	2	3	5	10(33.3)

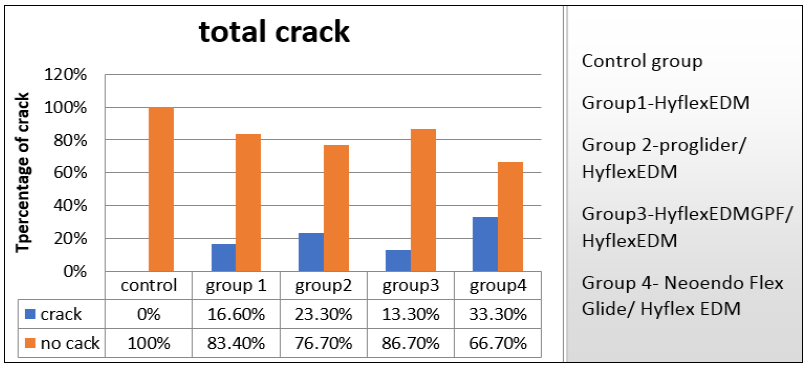

Fig 2: The numbers of roots with cracks according to the groups.

Percentage of crack was highest in group 4 followed by group 2 and in group 1 and least in group 3,whereas in control group there were no cracks. The difference between the group was stastically significant when analyzed using chi square test (p=0.01).

Discussion

The use of nickel–titanium (NiTi) instruments during root canal preparation causes cracks in root dentine. Coronal enlargement and pre-flaring to produce a glide path have been recommended as the initial procedures for safe use of NiTi rotary instrumentation as they prevent taper lock, shaping aberrations, fracture of instruments and excessive instrument binding in root canal. The dentinal crack formation may increase due to the excessive instrument binding and the maximum contact between the file and dentin. Therefore, the present study aimed to compare of the effect of different glide path Ni-Ti rotary systems on formation of dentinal crack on root canals [2].

In our study, we used ProGlider file, Hyflex EDM GPF and NeoEndo flex Glide file system to create glide path for Hyflex EDM system. There were no differences between Proglider file and Hyflex EDM GPF group significantly. But Hyflex EDM GPF file caused dentinal crack less than the other

groups.

HyFlex® EDM is a new development in rotary endodontics. These files are produced using an innovative manufacturing process called Electrical Discharge Machining. The EDM is a non contact machining procedure used in engineering for manufacturing the parts that would be difficult to machine with conventional techniques. The removal of material is performed by pulsating electric current discharges that flow between an electrode and the work piece are immersed in a dielectric medium. The electric current partially melts and evaporates small portions of the material in a well-controlled and repeatable manner. The material is therefore superficially removed, leaving an isotropic surface, characterised by regularly distributed craters. The EDM process results in a file that is extremely flexible and fracture resistant. HyFlex® EDM files are up to 700% more resistant to cyclic fatigue compared to traditional Ni-Ti files [6], because of their controlled properties they have the ability to follow the anatomy of the root canal and thereby reduce the risks of perforations, ledging and transportations. The combination of flexibility, fracture resistance and cutting efficiency of the HyFlex® EDM make it possible to reduce the number of files required for cleaning while preserving the anatomy. The built-in shape memory of HyFlex® EDM files prevents stress during canal preparation by changing their spiral shape. A normal autoclaving process is enough to return the files to their original shape and fatigue resistance [13, 14].

Hyflex EDM GPF (Coltene) will permit the clinician to negotiate working length quickly and efficiently. This controlled memory files track well in the apical third and allow safer, more efficient preparations. They are available in25mm length with tip size 10 and taper of 0.05 [6, 17].

Proglider (PG) is a new single NiTi rotary file system manufactured from heated M-Wire NiTi alloy to enhance flexibility and cyclic fatigue resistance. It has square cross section with variable progressive taper (from 0.02 to 0.08) by which preliminary pre-flaring of middle and coronal portion of canal occur during glide path management. The PG instrument has tip size 16 with a taper of 0.02 at the tip of the file [23]. ProGlider instruments demonstrated a tendency to create a preliminary enlargement of the root canal in the coronal and middle portions due to its progressive tapered design [2, 5, 7, 22].

Amoung the glidepath techniques**,** Neoendo flex Glide shows maximum dentinal crack formation as it is manufactured using heated super elastic NiTi wire. It has a triangular cross section [8].

Bier *et al*. (2012) stated that the taper of the files could be a contributing factor in dentinal crack formation [18]. Yoldas *et al*. (2012) claimed that the tip design of rotary instruments, cross-sectional geometry, constant or variable pitch and taper, and flute form could be related to crack formation [10].

Hyflex EDM and Hyflex EDMGPF have similar design, three different cross-sections over the entire length of working part (rectangular) in apical part, trapezoidal cross-section in middle part, triangular in coronal part to increase fracture resistance, and cutting efficiency. Pro Glider have rectangular cross-sectional design [6, 7]. Neoendo flex Glide has almost triangular cross-sectional design [7]. Thus, this difference in design could be attributed to more cracks in Neoendo flex Glide files.

The use of different speed and torque settings for each file system could be a limitation of the present study. Peters *et al* stated that increased rotational speed was associated with increased cutting efficiency [28]. Hyflex EDM GPF and Proglider have same rotational speed when compared to Neo Endo flex glide files which results in less cracks formation.

According to Capar *et al*. (2014), higher cutting efficiency might be related to less crack formation [29]. In contrast, Hyflex EDM GPF having more taper (0.05) and higher cutting efficiency than other two files results in less crack. This may be due to the manufacturing process.

In the present study, teeth were sectioned perpendicular to the long axis and the presence of dentinal cracks was evaluated under a stereomicroscope. Sectioning of specimens is a destructive method; however, there was no crack formation in the control group. A previous study used infrared thermography to detect dentinal cracks (Matsushita-Tokugawa *et al*. 2013) [16, 34].

The periodontal ligament with its viscoelastic property plays a major role in dissipating stress generated by load application. Therefore roots surfaces were coated with a layer of polyvinyl siloxane material before placing within the acrylic block to simulate periodontal ligament, as described by Milani *et al*. (2009) [9].

Unfortunately the *in vitro* condition of the study, limit the clinical relevance due to variability in study design and evaluation technique. In the present study only the roots are prepared instead of entire tooth which did not mimic the clinical situation. The absence of natural periodontal ligament was a significant limitation. However there is no consistent and standard experimental design for PDL stimulation. Stated that the elastomeric impression materials are insufficient to represent exactly both the natural PDL and what may be possible in clinical situation [27].

However the validity of this *in vitro* study is well appreciated by having more number of clinical trials and hence further randomized controlled clinical trials are recommended.

Conclusion

Within the limitations of this *in vitro* study, glidepath with Hyflex EDM GPF showed less incidence of cracks formation compared with ProGlider and Neoendo flex glide but with no significant difference between them. All file systems used to create glide path before Hyflex EDM system reduced the incidence crack formation in all levels (3, 6, 9mm) of root canal.

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