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"COMPARISON OF THE RESISTANCE OF TEETH INSTRUMENTED USING DIFFERENT PHASES OF NICKEL -TITANIUM ROTARY SYSTEMS TO VERTICAL ROOT FRACTURE: AN IN VITRO STUDY".

Endodontic

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ABSTRACT

INTRODUCTION: This study compared the effect of different phases (M- wire, NiTi, R phase) of rotary systems to VRF instrumented with ProTaper Next (PTN, Dentsply Maillefer), Revo s (MicroMega, Besancon, France) and Twisted File (SybronEndo, Orange, CA) systems and obturated with compatible gutta-percha system and a resin sealer and tested under Universal testing machine to measure the force that is required to fracture the teeth in Newton's (N).

METHODOLOGY: This study included 40 single rooted premolar teeth. The coronal portions of all teeth were removed with a diamond-coated bur under water cooling, leaving roots approximately 13 ± 1 mm in length, the roots then covered with additive silicone and placed in Eppendorf tubes which were then filled with self-cure acrylic. The tubes were then evenly distributed to three experimental groups and one control group (n = 10), based on their weights and the homogeneity of the group:

GROUP I:Control Group

GROUP II: Instrumented with ProTaperNext

GROUP III: Instrumented with TF

GROUP IV: Instrumented with REVO S

The teeth will be prepared according to manufacturer's instruction till apical size 25/.06And then teeth will be taken under universal testing machine under cross head speed of 1mm/ N

RESULT: Group II was more Resistant to fracture and group I was least resistant. The difference between group I and II was statistically significant.

Conclusion: The teeth Instrumented with PTN were least resistant than those with TF which were More resistant to VRF

KEYWORDS

INTRODUCTION:

One of the main steps in root canal treatment is to access and perform mechanical instrumentation to create sufficient space for irrigating agents and intracanal medicaments and three dimensional obturation of root canal space. Microcracks can occur during the mechanical instrumentation of root canal systems, especially at the apical area, because of less dentine thickness and greater strain [3] It is inevitable that NiTi systems cause some force at the apex or the area surrounding it. These forces may increase the strain on the dentinal walls, resulting in microcrack formation in dentine. [1] As the prevalence of microcracks increases, the risk of several fractures, especially vertical root fractures (VRFs) occurrence, may increase in teeth. Various predisposing factors, such as the loss or dehydration of dentin and the negative effect of irrigation solutions and chelating agents, may enhance the possibility of VRFs. There are different file systems available in global market with different designs along with their cutting blades, body taper, and tip configuration of NiTi systems. There are plenty NiTi systems, with different production phases (M-wire, R, austenite, and martensite), alloys cutting edges, and working motion. These systems use specific single-cone gutta-percha and finishing files for root canal filling in a single-cone technique as a lateral condensation obturation technique may aid into formation of microcracks. [1] Many studies have confirmed the association between NiTi systems and dentinal microcracks, which may result in VRF. [1,2,3] Clinically, 10.9%–31% of root canal–treated teeth result in extraction because of VRFs that occur during or after root canal treatment procedure. [8]But there is insufficient information in the literature about the resistance of teeth instrumented with different phases of rotary NiTi systems to VRF. Thus, we aimed to compare the resistance of roots instrumented with three different phases rotary file systems and obturated using resin sealer against vertical root fracture resistance using following rotary systems ProTaper Next (PTN, Dentsply Maillefer), Twisted file (Sybron Endo) and Revo-S (MicroMega, Besancon, France) also to evaluate which file system causes least stress on dentinal walls which will resist the tooth against vertical root fracture.

Materials and Methods:

This study was performed on 40 teeth of extracted mandibular premolars, recently extracted from patients; no longer than 30 days after extraction. stored in distilled water (following biological waste management protocol). (fig. 1)

The teeth were then examined with a stereomicroscope under ×10 magnification to exclude any roots with open apices, root caries, cracks or fractures. Preoperative radiographs were obtained in the mesiodistal (MD) and buccolingual (BL) directions to confirm the presence of a canal without previous root canal treatment or calcifications. Teeth with such findings were excluded from the study. The coronal portions of all teeth were removed using diamond-coated bur under water cooling, leaving roots approximately 13 mm in length. The roots with standardized dimensions and weights are used to ensure homogeneity that BL and MD dimensions of the root canals were measured using a stainless-steel scale. (fig 2) Subsequently, the BL and MD diameters will be multiplied. The weights of the roots will be measured with a precision balance for the standardization of the samples using a method like that of Caper et al. [1]

Fig 1



Fig 2



Fig 3



The pulp tissue was eliminated using a 15k file. The roots then covered with a line of aluminium foil (fig 3) Tubes separated from their lid and a hole was made on the lid and the roots were placed into the tube up to the level of the cementoenamel junction (CEJ).(Fig 4). Roots were then placed tubes filled with self-curing acrylic. After the acrylic gets polymerized, the roots were taken out, and the aluminium foil was removed from the roots. (fig 5)

Fig .4



Fig. 5



The roots then covered with additional silicone impression material (Hydrorise Light, Zhermack, Italy) and returned to the tubes to create an artificial periodontal ligament The teeth evenly distributed to three experimental groups and one control group (n = 10), based on their weights and the homogeneity of the group.

GROUP I: CONTROL GROUP

Group I (n=10 teeth) not instrumented and served as control

GROUP II: INSTRUMENTATION WITH PROTAPER NEXT

- Group II (n=10) prepared using the ProTaper Next NiTi files at 300 rpm & 0.9 N/cm torque and a torque-controlled endodontic motor.
- Apical preparation till #25 would be done using X1 (17/.04) and X2(25/.06).
- Recapitulation and irrigation will be doing after each file.

GROUP III: INSTRUMENTATION WITH REVO-S

- Group III (n=10) prepared using Revo-S NiTi files at 300 rpm & 0.9 N/cm and a torque-controlled endodontic motor.
- Apical preparation till # 25 would be done using SU (25/.06).

GROUP IV: INSTRUMENTATION WITH TWISTED FILE

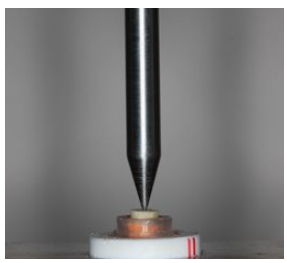
- Group VI (n=10)prepared using twisted files at 300 using a torque-controlled endodontic motor
- Apical preparation till 25 using # 25/.06 taper.

During biomechanical preparation, all root canals were irrigated with 2 mL 3 % NaOCl solution after each instrument. After instrumentation, a final flush applied using 5 mL 17% ethylenediaminetetraacetic acid (EDTA) for 1-min and 5 mL 2.5% NaOCl for 1min followed by the final rinse with 5 mL distilled water and then obturated with single cone gutta percha using MTA Fillapex sealer.

Placement of roots and fracture measurement

The canals then sealed with a temporary filling material, and the roots were kept in an environment of 100% moisture for 2 weeks. The roots then tested with a universal testing machine, and a force applied with a 1-mm/min crosshead speed until the roots fractured. (fig. 6) The load necessary to fracture recorded in newton's. (N)

FIG. 6



RESULT:

Differences among the groups will be analysed by Tukey and analysis of variance tests.

NiTi System	Mean (N)	SD	Maximum (N)	Minimum(N)
Control	214.590	68.0185	272.02	137.87
PTN	235.138	49.878	312.31	180.66
TF	260.48	35.366	333.12	209.62
RS	244.791	68.0185	272.02	137.87

(PTN= ProTaper Next, TF= Twisted File, RS= Revo S, N= Newton's, SD= standard Deviation.)

DISCUSSION:

Comparison of the resistance of the teeth to VRFs was evaluated quantitatively by using several NiTi files with different cross-sectional designs and phases but by keeping the constant taper in this study. Nickel-titanium alloy, first developed for the US Navy,[7] is in principle highly resistant against corrosion, and, more important, it is super elastic and has a shape memory. The latter two properties stem from an atomic arrangement that is different from conventional alloys such as stainless steel. The atoms in steel can move against each other by a small specific amount before plastic deformation occur; in contrast, Ni-Ti exists reversibly in two conformations, martensite and austenite, depending on ambient temperature and external tension. Steel can withstand up to 20 complete bending cycles, while Ni-Ti can be bent up to 1,000 times. This difference is related to the different atomic structure of the two alloys, the transition from austenite to martensite that occurs in Ni-Ti. The transformation characteristic depends on the ambient temperature and thermal pre-treatment of the alloy but usually takes place below temperatures in the dental setting so that the alloy is in the austenitic form. In addition to the transition from austenite to martensite under load, via twinned martensite, there is also a transition from the so-called R-phase temperature-dependent crystalline structure, to martensite. This transition further contributes to the ability of Ni-Ti to absorb stresses and thus to resist fatigue.[15]

ProTaper Next (PTN) work in a continuous rotational motion which is produced with M-wire technology and has an increasing or decreasing taper on the same file. This design hinders the screwing effect and prevents taper lock. In many comparative studies of the prevalence of microcracks with the ProTaper system, the PTN system caused slightly fewer micro cracks than the Pro Taper Universal (PTU). The results of study agreed with those of previously held studies on the relationship

between the taper of the file and microcracks. They also pointed out that the reduced number of microcracks in the apical one-third area of the teeth prepared with the PTN could be related to its design (i.e. having a smaller taper on the apical part of the file).[4]As the amount of root dentin removal increases, the risk of dentinal microcracks also increases. In a previous studies the system which has no taper, caused no dentinal damage. The cross-sectional design of the S-Apex system is similar to that of lightspeed files. Thus, no jamming occurs at the coronal part of the file. Based on the before mentioned findings, it could be concluded that microcracks in the apical area of the teeth are related to the activity of the file in the coronal part of the teeth. Yoldas et al stated that the prevalence of dentinal microcracks was similar with the, RS, TF and PTU systems. They also used a similar experimental model to that used in the present study during the instrumentation of the root canals.

In 2008 SybronEndo introduced the Twisted Files. With an advantage of Reduced stiffness and More fracture resistance compared with standard NiTi system. The company used R-Phase heat treatment technology, TF optimizes the strength and flexibility of NiTi, creating a highly durable and flexible file. TF cutting flutes are created by twisting the file, not grinding, eliminating micro fractures for greater strength.TF has ADAPTIVE MOTION TECHNOLOGY which allows file to adjust to intra-canal torsional forces depending on the amount of pressure placed on the file.Twisted files (TF) (SybronEndo, Orange, CA, USA) is a very different instrument than the previous generation of Rotary NiTi files that were ground from nickel titanium blanks with a triangular cross section. Through a proprietary process of heating and cooling, the molecular structure of nickel titanium can be modified to a state known as R phase. In R phase, nickel titanium can be twisted and this forms the basis for the TF which overcomes the limitations of ground file technology and opens new opportunities for file design.1) Optimism molecular phase structure and properties of nickel titanium.2) Employs a crystalline structural modification that maximizes flexibility and resistance to breakage and yet cuts extremely well.3) Increase surface hardness.4) Greatly reduces cyclic fatigue – a common cause of file separation. Early studies suggested significantly better fatigue resistance of size no. 25.06 taper Twisted File (R-phase) compared to K3 (NiTi) (Sybron Endo) instruments of the same size Moreover, as determined by bending tests according to the norm for hand instruments, ANSI/ADA No. 28 (ISO 3630-1), Twisted Files (R phase) size no. 25 .06 taper were more flexible than Profiles (NiTi) of the same size.

The effect of different instrumentation techniques on vertical root fracture resistance of endodontically treated teeth using NiTi hand K file, BioRaCe rotary file and Wave One reciprocating file and concluded that all three instrumentation techniques cause weakening of the structures of root, and rendered them susceptible to fractures under lesser load than unprepared root.[10]The Stereomicroscopic Evaluation of dentinal defects included by new rotary systems:" ProTaper Next" using Hand K files, ProTaper Universal, Hero Shaper, PTN and concluded all rotary files induced defects in root dentine whereas the hand instruments induced minimal defects.(11)The potential relationship between the design of Nickel – titanium rotary instruments and vertical root fracture using three rotary NiTi instruments with tree different cross sectional geometries and concluded that the ProTaper generated the highest von Mises stress values in the apical root dentine followed by Profile and light speed.[12]The Fracture strength of roots instrumented with three different single file systems in curved root canals using reciproc rotary files, Wave One and One Shape and concluded that the fracture load differences among the three files was not significant statistically whereas the difference between the fracture loads of control and one shape was statistically significant. [14]

Although it is difficult to simulate the periodontal ligament perfectly, use of Additive silicone in this study is create an artificial periodontal ligament to compensate some of the vertically applied force to the teeth's long axis makes this model more successful than previously used models. The use of the artificial periodontal ligament in the present study may explain the difference in resistance to VRFs Many previous studies have used a similar setup. Their findings could be correct in terms of the comparison of the effect of the techniques used on VRF resistance. However, we believe that the setup used in the present study is more reliable because the force applied to the teeth was directly reflected from the acrylic because of the absence of any material to mimic the periodontal ligament. The strong interest in developing mineral trioxide aggregate (MTA)-based endodontic materials is because of the excellent biocompatibility, bioactivity, and osteoconductivity of MTA, also it possesses good physical and antibacterial properties with low solubility and less working time. [17,18]

Most studies have found that microcrack formation appeared to be associated with VRFs however; a recent study stated that there was no causal relationship between dentinal microcrack formation and canal preparation procedures. Biting force is considered one of the most important factors in the occurrence of VRFs. In a study of the biting force of teeth, Ferrario et al found a force of approximately 216.31 N in mandibular premolar teeth. This finding may explain why VRFs did not clinically occur in every root canal–treated tooth with the NiTi systems. [16]

Conclusion

WITHIN THE LIMITATIONS OF THIS STUDY "R phase is more resistant to VRF when compared to M wire and conventional NiTi system, this could be because of systems improved mechano-physical properties which causes less stress onto the dentin leading to least dentinal microcrack propagation. As Twisted files works on adaptive motion technology which could be winning combination for safe and predictable root canal shaping, with an advantage of exceptional debris removal and less chance of file pull down and debris extrusion.

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