The Effect of Canal Preparation using 2Shape, ProTaper GOLD and ProTaper Next File Systems on the Fracture Resistance of Obturated Roots

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Abstract

Root canal system (RCS) instrumentation is an important aspect of endodontic therapy. Instrumenting the RCS with motorized nickel-titanium (NiTi) files can weaken the dentin integrity leading to vertical root fractures (VRFs)

Sixty extracted human maxillary first molars from patient were used.The teeth were free from caries, carcks, open apices and with single straight palatal roots. The palatal roots were sectioned at a length of 11mm from the apex. The roots were divided into four groups of 15 roots, one control and 3 experimental groups (N=15): Group one was remain uninstrumented (control), Groups 2-4 were instrumented by 2Shape, PTN and PTG file systems, respectively, all canals were prepared to # 40 apical size.Roots in groups 2-4 were filled with their corresponding gutta-percha single cone and GuttaFlow 2 after that the roots were dipped in a molten wax and then placed into a mold that filled with self-cure acrylic and stored in wet environment until the test was done. The acrylic blocks were placed on the universal testing machine (LARYEE). The roots vertically loaded by a 0.8mm diameter spreader like tip at a speed 0.5mm/min into the root canal until fracture.

One Way ANOVA test showed there was no significant differences between the four groups ($P \leq 0.05$).

The file systems used in this study had no significant effect on the fracture resistance of obturated roots.

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Introduction

Root canal system (RCS) instrumentation is an essential aspect of endodontic therapy, preparation of the RCS with motorized nickel-titanium (NiTi) files can weaken the dentin integrity, resulting in vertical root fractures (VRFs) [1, 2, 3].

The predisposing factors for VRFs include the loss of tissue, dehydration of dentin, effects of irrigation solutions, and use of excessive pressure during root-filling procedures[4]. Another important factor is the stress generated on the radicular dentin when using endodontic instruments for shaping thus leading to the formation of microcracks [5].

PTN (Dentsply Sirona, Ballaiguses, Switzerland) shaping files have off-centered rectangular cross-sectional design and manufactured using M-Wire Nickel Titanium alloy [6]. PTG (DENTSPLY MAILLEFER, Switzerland) file system was developed with proprietary advanced metallurgy. It features a progressively tapered design to improve the cutting efficiency and safety [7].

2Shape (MicroMega, Besancon, France) is made of T-wire heat-treated alloy with a triple helix.The 2Shape system is composed of TS1 (25/.04), TS2 (25/.06), F35 (35/.06), and F40 (40/.04) files [8].

This study aimed to measure and compare the effect of canal preparation instrumented by using 2Shape, PTG and PTN file systems on the fracture resistance of obturated roots.

Materials and methods

Sixty extracted human maxillary first molars were used. The teeth were free for absence of caries, open apices and visible

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cracks or fractures. To ensure the standardization of the dimensions of the roots, the buccolingual and the mesiodistal width of the roots were measured at 3 points (3mm, 6mm and 9mm) by using digital caliper. The palatal roots were sectioned at a length of 11mm from the apex. The WL determined by subtracting 1mm from the actual length of the roots. The roots were randomly divided into four groups of 15 roots, one control and 3 experimental groups (N=15).

Root canal preparation

Group 1: roots were remain uninstrumented (control) only pulp extirpation was done. 2% NaOCl and distilled water were used as irrigants

Group 2: roots were prepared by 2Shape file system in sequence TS1 25/.04, TS2 25/.06 and F40 40/.04.

Group 3: roots were prepared by PTN file system in sequence X1: 0.17/.04, X2: 0.25/.06, X3: 0.30/.07 and X4: 0.40/.06

Group 4: roots were prepared by PTG file system in sequence SX: 0.19/.04, S1: 0.18/.02, S2: 0.20/.04, F1: 0.20/.07, F2: 0.25/.08, F3: 0.30/.09 and F4: 0.40/.06. 2% NaOCl (CERKAMED, Stalowa Wola, Poland) Glyde (Densply Sirona, Ballaigues, Switzerland) and distilled water were used as an irrigants for roots for 2-4 groups.

Root canal obturation

The geometrical root canal shape produced by the correct mechanical action of endodontic instruments against the canal walls allows the tapered master cone of gutta-percha to be fitted[9]. The roots in groups 2-4 were obturated by using single cone obturation technique by using the corresponding master gutta-percha cone of each file system with GuttaFlow 2 (Coltène/Whaledent, Langenau, Germany).

Fracture test

The roots were marked at 9 mm point of the root length. The surfaces of the roots were dipped into molten wax (dipping wax) (Shanghai New Century Material Co. Shanghai)[10] resulting in a wax layer of 0.2 to 0.3 mm thickness that which was confirmed by measuring the width of the root from the same 3 facing points after dipping with a digital caliper. Then self-cure acrylic (Shanghai New Century Material Co., Shanghai) mixed and placed into a mold and the samples were placed vertically with the aid of surveyor then when the acrylic reach the dough stage, the root was removed from the acrylic then the wax was removed with blade and the root reinserted into the acrylics again. The acrylic blocks were placed on the universal testing machine (LARYEE). The roots vertically loaded by a rod of 0.8 mm diameter spreader like (Fig.1) tip at a speed 0.5mm/min into the center of the root canal orifice until fracture had occure.

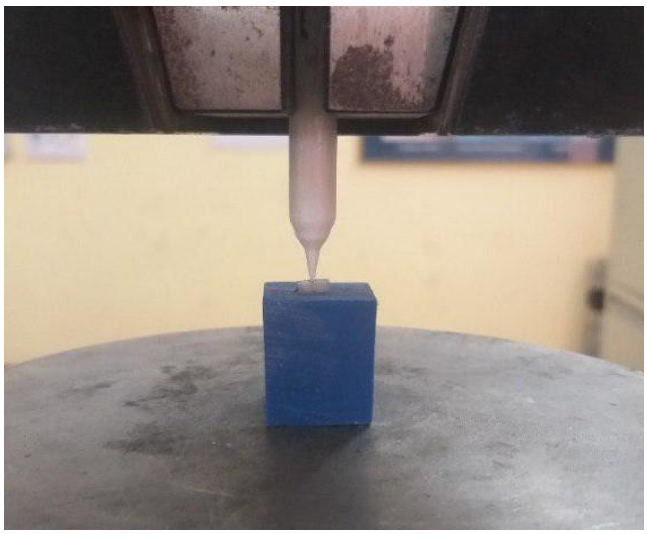

Figure 1. The roots vertically loaded by a rod of 0.8 mm diameter spreader like tip at a speed 0.5mm/min into the root canal until fracture.

Statistical analysis:

Shapiro-Wilk test was done to determine the normality of data and One way ANOVA test was done at $P \leq 0.05$.

Results

One Way ANOVA test showed there was no significant differences of the effect of canal preparation between the file systems used and the mean values of the groups present in Table 1.

Groups	Mean	Std. deviation	Maximum	Minimum
Control	155.33	83.19	324	34
2Shape	132.33	36.33	176	72
PTN	134.20	48.29	212	40
PTG	168.27	40.22	242	110

Table 1. Descriptive Statistics: Mean values, standard deviation, minimum and maximum values of fracture strength for each group in Newton (N).

Discussion

Root canal instrumentation cause excessive dentin removal [11] or as a result of inducing stress and generating apical cracks which leads to VRFs [12.] Different NiTi instrument design features used during root canal preparation including cross-section, taper, flutes form, types of the manufactured alloy, rotational motion and number of instruments can affect the resistance to VRFs[13.]

Rotary NiTi files used during root canal preparation increasing the risk of dentinal crack formation which can lead to VRFs [14]. The result of this study showed no significant differences of the effect of canal preparation among the rotary file systems used. In another study, Pawar et al., in 2018 [15] studied the fracture resistance of mandibular premolars instrumented by EndoStar E5 rotary and ProTaper Next file systems and reported that there was no significant differences of fracture resistance between these rotary files.

In this study a wide range of fracture resistance values had been seen in all groups this may be related to the morphology and anatomy of root canal which significantly affect the fracture resistance of teeth. Sathorn et al in 2005 [16] studied the effects of intrinsic factors of roots on fracture susceptibility and pattern, and found that dentinal removal is not the only factor associated with reduced fracture resistance, and does not always result in increased fracture susceptibility, vertical root fracture consequences from interaction between numerous factors and intrinsic aspects of the canal playing an important role.

Although there was non-significant differences between the control group and experimental groups, the results of this study showed that the samples prepared by PTG were more resistance to fracture than the samples of control group, this may be related to the smoothness of prepared canal walls which result in better dissipating of stress when compared with uneven stress distribution in the control group[16.]

ProTaper GOLD files produce gradually funnel shape of the canal related to file tapers as shaping file of ProTaper GOLD system work on the coronal and middle thirds of the canal which increase the canal taper in the coronal and middle thirds allowed the force better distributed in the apical third of the canal and potentially increase resistance to fracture while the finishing files work on the apical third of the canal in gradual sequence of the files.

Furthermore, the thermo-mechanical processing after machining of the file used have been utilized to overwhelm the defects of machining process and to reorganize the crystalline phase structure. After thermal process, martensitic transformation of NiTi alloys occurs in 2 stages in place of one. The 1-stage transformation (A-M) happens in Ni-rich NiTi alloys, while 2-stage transformation (A-R-M) happens after additional heat treatment. PTG has 2-stage transformation this lead to superelasticity of PTG [17] which may lead to less crack formation.

Although smooth walls also obtained by PTN and 2Shape file systems these files cause cracks during root canal preparation according to Nishad and Shivamurthy in 2018[18] that compare apical root crack propagation after root canal preparation at different instrumentation lengths using PTU, PTN and PTG rotary files and reported that PTG showed the least presence of cracks, this may explain the higher values required to cause fracture in samples prepared by PTG group when compared to samples prepared by PTN. Hussain and Al-Gharrawi in 2019[19] studied the incidence of dentinal defects after root canal preparation by using Reciproc blue, PTG, PTN file systems and showed that ProTaper GOLD produced less crack than ProTaper Next in spit of that there was non-significant differences between them.

PTN made from M-Wire NiTi alloy which was proven to increase flexibility and resistance to cyclic fatigue by 400%, a special design with variable taper and off-centered with an offset design generates an asymmetrical wave of motion along its active portion, resulting in only 2 points of contact between the file and dentin [20,21] while 2Shape rotary file system is made of T-Wire technology used that increase the resistance to cyclic fatigue up to 40%, 2Shape has a modern generation of cross-section with triple helix with 2 main cutting edges for cutting efficiency and one secondary edge for improved removal of debris. Although the differences in designs features between PTN and 2Shape file systems the result of this study showed that the means values of fracture resistance of these 2 files were comparable.

Compared to control group, the use of ProTaper Next file system caused a non-

significant reduction in the fracture resistance and this showed disagreement with another studies (Firoj et al. in 2017[22]; Çiçek et al. in 2015 [23]) which showed significant enhancement in the fracture resistance after use of ProTaper Next file system, this discrepancy may be related to the differences of the type of the teeth and the type of sealers used in these studies.

Conclusions

The file systems used in this study had no significant effect on the fracture resistance of obturated roots.

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Declaration of Interest

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