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Fracture Resistance of Endodontically Treated Maxillary Second Premolars Restored with Corono-Radicular Stabilization Method (In vitro study)

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ABSTRACT

Purpose: This study aims to investigate the fracture resistance of endodontically treated maxillary second premolars using fracture resistance test**. Materials and Methods:** Fifty-five maxillary second premolars were selected. The teeth were divided into four groups (three experimental groups and one control group) each group consists of fifteen teeth. The control group consists of ten teeth. The experimental groups were divided according to the mechanical system used: Endo Star, Revo S, and Protaper. Each group was subdivided into two subgroups according to the presence of the crown or not. Endo star E5 group: (1.a) and (2.a), Revos group :(1.b) and (2.b), Protaper :(1.c) and (2.c).All groups were instrumented and obturated. The subgroups with crown preserved (1.a), (1.b), (1.c) were (MOD) prepared, only the first four subgroups were restored by corono-radicular stabilization method. All the samples were subjected to fracture resistance test. The significant level was set at P≤0.05. **Results**: In the first four subgroups: the control group (1.d) showed the highest values, there were no differences between the (1.a), the (1.b) and (1.c) groups. All the teeth fractures were favorable. In the second four subgroups, the highest mean fracture resistance value was obtained by the control group (2.d) followed by EE5 group (2.a). There was no significant difference between Revos (2.b) and Protaper (2.c) groups; both showed the lowest mean fracture resistance values. **Conclusion**: Although the various endodontically mechanical preparations didn't affect fracture resistance of the coronal portion of the teeth, the fracture resistance of the radicular part was affected.

KEYWORDS

Fracture resistance,
Endo star E5,
Revo S, Protaper,
Corono-radicular stabilization technique.

INTRODUCTION

Root canal (RCS) instrumentation is a necessary step in endodontic treatment. Instrumenting the RCS by rotary nickel-titanium (NiTi) files can lead to weakening in the dentin integrity, leads to vertical root

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fractures (VRFs) [1-3]. Moreover, factors that cause VRFs include; dehydration of dentin, loss of tissues, the use of massive pressure during root-filling procedures and the usage of irrigant solutions[4]. The currently used rotary file systems consist of a solid metal core, with rotating flutes and blades. These files are constructed with increasing taper which leads to relative removal of more dentine and active cutting. Moreover, an excessive taper leads to more removal of dentine reducing the fracture strength [5, 6]. Another important element directly related to the fracture resistance is the formation of microcracks in the root dentine [2, 4, 7]. All the currently used rotary files create micro cracks from 17% to 65% in the roots instrumented [1, 2, 7, 8]. The loss of anatomic structures, such as pulp roof and one or the two marginal ridges, resulting in a greater risk of fracture [9]. The main cause of failure in the majority of restored pulpless teeth was reported to be prosthetic rather than biological [10]. The amount of remaining tooth structure and fracture resistance after endodontic treatment is affected by restorative procedures [11].

Restoration of root-filled teeth can be a defying because of structural variations among vital and non-vital endodontically treated teeth. Irreversible chemical–physical and, in particular, bio-mechanical alternations (loss of proprioception; loss of tooth structure), caused by the root canal treatment, increase the chance of dental fracture and condition the restoration selections for the dentist [12]. Restoration of teeth with adhesive mechanisms and direct resin-bonded composites (RBC) decreases the need for over-preparation and sacrificing any tooth structure. Following caries removal and endodontic treatment, all the remaining tooth structure would be ready for adhesion [13]. A current trend toward conservative approaches to sustain the structural integrity of the teeth endodontically treated has led to an intracoronal strengthening of such teeth with mesio-occluso-distal (MOD) preparation by various adhesive restorations [14-16, 10].

Many authors assure that conserving the main bulk of dentine is a major issue in sustaining the structural integrity of post endodontically restored premolars [16, 17].The definitive question is how to rebuild the affected teeth to recover the original fracture resistance. A different new resin-bed composite post might be used in addition to composite core build-up, particularly in the esthetic zone like premolars.

The main advantage of this type over the other types of post and core systems include less tooth structure removal during canal instrumentation, greater adaptation post to the canal in the middle and coronal half of the canal, modulus of elasticity equal to dentin which decrease incidence of root fracture and good retention[18,19]. This concept can be fortified following advancements in the recent adhesive materials. Therefore restoring an endodontically treated tooth to its original fracture resistance without using full coverage restoration could have potential periodontal economic advantages to the patient [20].

MATERIAL AND METHODS

Teeth selection: Fifty-five extracted single-rooted maxillary second premolars human teeth with straight roots, fully formed apices, free of a crown or root caries and free of any fractures were used.

Samples grouping: The teeth were divided into 4 main groups (three experimental group and one control group) 15 teeth for each experimental group and 10 teeth for the control group, each group was subdivided into two subgroups:-

Endo star E5 (EE5) (Poldent, Poland) group was subdivided into: subgroup A: EE5 with crown preserved and restored by corono-radicular stabilization method (1.a). Subgroup B: EE5 with decoronation (roots only) (2.a).

Revo S (RS) (Micro-Mega, Besançon, France) group was subdivided into: Subgroup A: RS with crown preserved and restored by corono-radicular stabilization method (1.b).

Subgroup B: RS with decoronation (roots only) (2.b)

Protaper Universal (Dentsply**,** Mailefer**,** ball-igues**,** swiss) group was subdivided in to: Subgroup A: Protaper with crown preserved and restored by corono-radicular stabilization method (1.c).

Subgroup B: Protaper with decoronation (roots only) (2.c)

Control group was subdivided in to: Subgroup A: Sound teeth with crown preserved (1.d).

Subgoup B: Sound teeth with decoronation (2.d).

Sample preparation: In the second four sub-groups the crows were removed using a water-cooled, slow-speed diamond precision saw (Isomet 4000 liner Precision Saw), so as to adjust the length of the roots to a standardized length of 17 mm.

Samples instrumentation, obturation and restoration:

For the EE5 group; E5 1 file size 30, taper 0.08 was used at torque (3-4) Ncm; E5 2 file size 30 taper 0.06 was used at torque(2-3) Ncm; E5 3 file size 30 taper 0.04 was used at torque (1-2) Ncm; E5 4 file size 25 taper 0.04 was used at torque (.5-1) Ncm.

The canal orifices of the teeth were flared using E5 1 instrumenting the coronal one third. Then E5 2 and E5 3 in the sequence were used few millimeters more profound than E5 1. Using the E5 4 until the working length (WL), then E5 3 was reused: size 30 taper 0.04 as a finishing file to the full WL.

For the Revos rotary system: - The root canal orifices were pre-flared using ENDOFLARE® (Mi-cro-Mega). The canals were instrumented at a speed of 300 RPM and torque of 0.8 N/cm. The sequential files were used in the following order: - SC1 size 25 tapers 0.06 until the two-thirds length of the root canal in a free from any progression and without pressure, then SC2 size 25 tapers 0.04, then SU size 25 tapers 0.06 files without pressure to the full WL, finally AS30 (#30.06) till WL.

For Protaper Universal rotary system the samples were instrumented at a speed 300 RPM and torque of 2 N/cm. The coronal third was pre-flared using Sx, followed by sequential files until WL, S1 size 17 taper 0.06, S2 size 20, taper 0.06, F1 size 20,taper 0.07, F2 size 25, taper 0.08 and F3 size30 taper 0.09 .

Before entering a new file each time, the root canals were irrigated with three ml of 5.25% Sodium hypochlorite and recapitulated with a size 15 K-file (Mani k files, Japan). EDTA (Meta Biomed, Cheongju, Korea) gel was used as a lubricant with every reinsertion. After instrumentation, the canals were dried by using sterile paper points. The specimens were then obturated by single cone technique. The dentinal walls were coated with AD seal (Meta Biomed, Cheongju, Korea) sealer using spreader size 30, followed by placing the selected master-cone.

For the EE5 group, the selected gutta-percha (GP) was size 30 taper 0.04 (Meta Biomed, Cheon-gju, Korea).

For Revo s group, the selected GP was size 30 taper 0.06 (Meta Biomed, Cheongju, Korea)

For Protaper Universal rotary system the selected gutta-percha was F3 (Dentsply Maillefer). Excess Gutta-percha was shredded off using a hot hand plugger. The samples were allowed to set completely for 7 days at 37°C and 100% humidity.

For the first four subgroups the MOD cavity was performed then instrumentation and obturation were done according to each system group. Afterward, the gutta-percha was shredded off to a depth of three mm from each canal with size four Gates-Glidden bur. Natural undercuts in the pulp chamber were retained in order to accommodate with the core retention. The radicular and coronal portions were restored with dual cure Nanohybrid composite (Centrix dental EN-Core Dual cure injectable composite South Africa), the composite was injected into the three mm of root canals till the pulp chamber and then was light-cured for 40 seconds. The second incremental placement of left material till the occlusal surface of the MOD cavity was done and light-cured (Corono-radicular stabilization method).

After the root filling process and corono-radicular restoration were done the samples were be subjected to thermocycling dual time at (5-55° C), the samples were left in an incubator at 37°C for thirty days.

Samples preparation for fracture resistance test:

Acrylic blocks preparation:

The acrylic powder and liquid were mixed and inserted in a cylinder before the setting of the mixture, the teeth with roots were inserted in the center of the acrylic block, and about 3-4 mm below the cemento-enamel junction was exposed, after complete setting, the acrylic blocks were removed from the cylinders.

Fracture resistance test application:

The first fracture resistance test application: The first four subgroups were exposed to fracture resistance test:-

The samples in the acrylic blocks were applied to a load at angle 45° by the universal testing machine (Instron universal testing machine model 3345 England). The load was applied with a designed loading steel rod with a rounded end. This rod was attached to the loading cell of the upper member of the testing machine which was lowered to allow it to make contact the midline of the fissure till the cusp fracture. The maximum fracture load in Newton was recorded. Another mode of failure was also noted and categorized as a favorable and unfavorable fracture. The favorable fracture was noted if the fracture line is up to the cemento-enamel junction. The unfavorable fracture was noted if the fracture line was under the cemento-enamel junction.

The second fracture resistance test application:- The second four subgroups were exposed to fracture resistance test: - A cross-head at an angle of 90° was set, and the load was applied perpendicular to the long axis of the tooth until fracture occurred. The force necessary to fracture each tooth in Newtons (N) was recorded .

Statistical analysis

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Data showed normal (parametric) distribution. Parametric Data were presented as mean, standard deviation (SD) and 95% Confidence Interval for the mean (95% CI) values. Two-way Analysis of Variance (ANOVA) was used to study the effect of the system, tooth part and their interaction on mean fracture resistance. Bonferroni's post-hoc test was used for pair-wise comparisons when the ANOVA test is significant. Failure modes (Qualitative data) were presented as frequencies and percentages.the fisher Exact test was used to compare different systems.The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

RESULTS

1- Comparison between fracture resistance values of different systems regardless of the tooth part.

In the Endostar group (2.a) the mean value and standard deviation (SD) were 349.9 ±84.4, in the Revo s group (2.b) the mean and SD were 385.8 ± 85.6, in Protaper group (2.c) the mean and SD were 364.4±64.4 and for the control group (2.d) the mean and SD were 521 ±104.

Control group showed the highest mean fracture resistance, followed by EE5 group. There was no statistically significant difference between ProTaper and Revo-S groups; all showed a statistically significantly lower mean fracture resistance values.

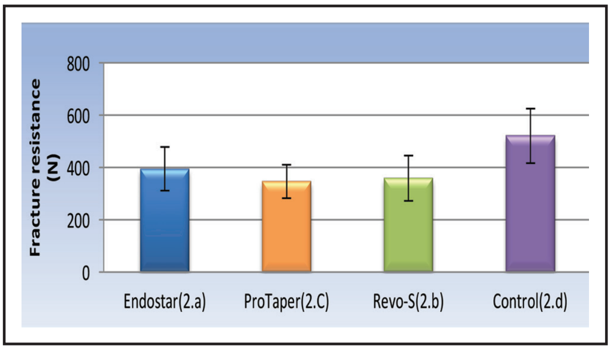

Figure (1) Bar chart representing mean and standard deviation values for fracture resistance of the different systems regardless of the tooth part.

***2-* Comparison between failure modes of different systems:**

For EE5 group(1.a), Revo s (1.b) and Protaper group(1.c) the percentage of the favorably fractured samples were 80% and the percentage of unfavorably fractured samples were 20%, in the control group all the sample were fractured favorably. There was no statistically significant difference between the failure modes of different systems.

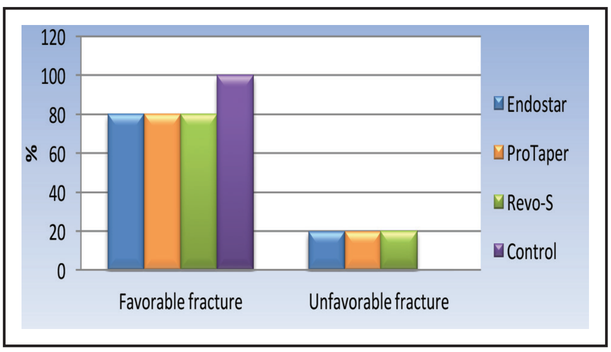

Figure (2): Bar chart representing failure modes of different systems

DISCUSSION

Endodontic success depends on many factors such as canal preparation, disinfection, and obturation, however, root canal cleaning and shaping is the most important step for endodontic success [21]. Several engine instrument systems based on rotary modified nickel-titanium have been developed with different designs of grooves, tips, tapers, and blades[22]. In the current study endodontic treated teeth restored by corono-radicular retentive technique were submitted to the fracture resistance test at angle 45°.This angle was used because it was the same angle in the clinical conditions in maxillary second premolars during mastication, however in case of evaluation of fracture resistance of roots (in the same conditions) the used angle was perpendicular to the long axis (90°) of the teeth.

In this current study, The EE5 rotary files were used because it had a long flute and safely rounded tip and a small-sized taper (0.04). These options minimized unnecessary removal of dentine, so it reduces the dentinal microcracks and increases the fracture resistance of the teeth treated with this system.

The Protaper rotary files that were used in the current study, had large -sized F3 file taper (0.09) might lead to removing of unnecessary dentine and formation of microcracks, that lead to a reduction in the fracture resistance of the teeth instrumented with this system.

Revo S rotary system that was used in this current study had a cross-section that helps in the debris elimination. The large-sized taper (0.06) used in the apical finishing file AS30 might be the main cause of increasing the dentinal microcracks and reduce the fracture resistance of the teeth. All these systems were used like manufacturer recommendation. Finally, all the samples were wrapped in saline-moistened gauze and were stored at 37° C for one month until the fracture resistance test was done.

From the results of the present study, for the first four subgroups (the subgroups with root and crown presented), it was found that there was no significant differences between the groups, except the control group which showed the highest value.

All samples showed a favorable fracture. These results revealed that added strength in Nayyar's technique could be attributed to the reinforcing the effect of Nayyar core from the radicular extension to the coronal surface acting as a single adhesive unit of composite material. This was contributing to good fracture strength. The same finding was found by another previous study [23] that studied the fracture resistance of endodontically treated teeth restored with resin composite using various corono-radicular techniques. Also, the type of fracture seen in maxillary premolars was detected. The results of the endodontically treated teeth and restored with Nayyar corono-radicular stabilization retentive method (in the previous study) were fractured under load (432.05±55.39) N. These results were in agreement with the results of this current study, where the samples were fractured under load (465.7±93).

However, the type of fracture in the previous study showed that all the samples had an unfavorable fracture but in this current study samples showed a favorable fracture in about all teeth. This difference might be due to the different angles used in these two studies, the angle used in the previous study was 30° and the one used in the current study was 45°. These results could be attributed to the angle of load application used in the aforementioned previous study (30°) that led to the unfavorable load direction that was the cause of the unfavorable fractures of about all the samples. Conversely, in the current study, the angle used was 45° that led to the favorable fractures of almost all samples.

In the present study, in the second subgroups, the highest fracture resistance values were recorded in the control group, followed by EE5 group, while the Revo S and PT groups showed the lowest fracture resistance values, This might be related to the differences in the tapers of the instruments used in the current study, which was responsible for the amount of removed dentine from the canals. This might lead to weakening the canals by producing microcracks that reduced the fracture resistance. The mean fracture resistance of the EE5 group was 369.7 ±91.3, Revo S 308.0 ±29.6 and PT was 294.5±47 and the tapers of the finishing files in each system were 0.04 for size 3 EE5 file system, 0.06 for size AS30 file in RS system and 0.09 for the F3 file in PT system. These results were in accordance with another previous study [24].Which showed that the mean fracture resistance of teeth instrumented with PT rotary system was 298.36±31.96 and the Revo S mean value group was 311.42±47.66 which are almost identical to the values in the current study.

CONCLUSIONS

Within the limitations of the present study the following could be concluded:

1. Although the various endodontically mechanical preparations didn't affect fracture resistance of the coronal portion of the teeth, the fracture resistance of the radicular part of the teeth was affected.
2. Fracture pattern of all the groups were favorable indicating that Nayyar's technique contributes to good fracture strength and the tooth has a chance to be restored again.
3. The corono-radicular stabilization technique reinforced the fracture resistance of the endodontically treated teeth.

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