EFFECT OF FRACTURED INSTRUMENT REMOVAL ON TOOTH RESISTANCE TO VERTICAL FRACTURE USING DIFFERENT SEALERS – *AN IN VITRO STUDY*

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DOI: 10.47750/pnr.2023.14.02.378

Abstract

Aim: To investigate and compare the resistance of roots to vertical fracture after the retrieval of a separated instrument from the root canal, followed by endodontic treatment using different root canal sealers.

Methodology: Ninety extracted mandibular single-rooted premolars were collected and decoronated at CEJ. Roots were then randomly divided into six groups of 15 each: two control groups – Group A (negative control) and Group B (positive control) – and four experimental groups – Groups C, D, E, and F. In four of the experimental groups and one control group (Group B), the rotary instrument (orifice shaper) fractured in the middle third of the root canal. The fractured file was then removed with a Masserann kit. Following instrument retrieval, the canals were prepared with ProTaper up to F2, and obturation was done with gutta-percha (GP) points and four different sealers using lateral compaction, as follows: GROUP A (negative control): obturation was carried out with GP points and Tubliseal sealer; GROUP B (positive control): the instrument was retrieved and no obturation was done; GROUP C: obturation was carried out with GP points and Tubliseal; GROUP D: obturation was carried out with GP points and MTA; GROUP E: obturation was carried out with GP points and AH Plus sealer; and GROUP F: obturation was carried out with GP points and Resilon sealer. The coronal seal was done using GIC. Each specimen was tested for fracture resistance using the Instron universal testing machine.

Results: All the experimental groups, as well as the negative control group (Group A), showed higher ultimate strength compared to Group B. All the experimental groups, as well as Group B, had significantly lower ultimate strength compared to Group A. Among the experimental groups, the only significant difference observed was between Group D **(**Resilon) and Group F (MTA) ($p = 0.041$). Group F had significantly higher ultimate strength compared to Group D. None of the other differences were significant statistically.

Conclusion: All the fractured instruments were successfully removed from the middle third of the root canal with considerable loss of dentin. Resilon and MTA provided a replacement for root dentin when used as obturating materials.

Clinical significance: The prevalence of broken instruments ranges from 0.5% to 5%. If the broken file prevents adequate cleaning of the canal beyond the obstruction, the treatment outcome is adversely affected. Frequently, this leads to the failure of root canal therapy and increases patient anxiety. The definitive treatment in the management of root canal instrument fracture is therefore removal.

Keywords: ProTaper, Retrieval, Masserann Kit, Resilon, MTA, Tubliseal, AH Plus

INTRODUCTION

The introduction of nickel-titanium files, rotary instrumentation, "endosonics", radiovisiography, the endoscope, and the clinical microscope has changed how endodontics is practiced. These innovations have increased both productivity and the quality of care. However, there is an increased incidence of complex cases, with the result that new problems are being created.

"Re-treatodontics", "disassembly" and "procedural mishaps" are new terms that have been coined as the profession has attempted to correct these new problems. [1]

Every clinician who performs endodontics experiences a variety of outcomes, ranging from a case well done to a procedural accident such as the separation of an instrument – a "separated" or "disarticulated file". [1] Instruments break in the canal system, making penetration to the apical terminus difficult. Such instruments could be a file, a reamer, a Lentulo spiral paste filler, or a gutta-percha (GP) spreader. [2] Various factors have been associated with instrument separation: operator experience, rotational speed, canal curvature, inadequate access cavity preparation, instrument design and technique, torque, the instrument manufacturing process, repeated use, and the absence of a glide path. [3, 4]

Stainless steel instruments usually deform before they break and can be inspected for visible signs of damage, indicating that the elastic limit of the metal has been exceeded and the instrument should be discarded. [5] However, early signs of metal fatigue are not detected in nickel-titanium instruments, unlike their steel counterparts.

The breakage rate of stainless steel instruments has been reported to be approximately 1.6%, with a range of 0.7% to 7.4%. The breakage rate of NiTi rotary instruments is approximately 1.0%, with a range of 0.4% and 3.7%. [6] The difficulty involved in the retrieval of these instruments ranges from surprisingly easy to downright impossible. The potential for removing a separated instrument depends on many factors: the location of the separated instrument, root curvatures, external root concavities, and root thickness, which should be considered during the diagnostic workup for long-term success. [2]

Various methods and devices have been developed to retrieve separated instruments, for example, the Hemostat, the Steiglitz forceps, the Modified Castroviejo needle holder, the Perry plier, the Endo Extractor, ultrasonic devices, microtube delivery methods, extractor systems, instrument removal systems, and the Masserann Technique. [7] Although effective, these techniques may require the removal of an excessive amount of radicular dentin, leading to root weakening and the risk of perforation and fracture. Therefore, materials that can adhere to the root canal dentin surface will strengthen the remaining tooth structure and could be useful when used as an obturating material. GP has been the filling material of choice for root canals for years. AH26 (Dentsply De Trey, Trey, Konstanz, Germany) is representative of epoxy resin sealers commonly used with GP. Recently there is an increased focus on the adhesive properties of the root canal sealer. Materials that can adhere to the root canal dentin surface will strengthen the remaining tooth structure and prevent microleakage, as well as reduce the risk of fracture. [8]

The Resilon system and MTA cement have had some success in achieving the required goal of maintaining root strength. Resilon forms a monoblock between the intraradicular dentin and the obturation material, preventing both bacterial leakage and root fracture. MTA has a high modulus of elasticity that helps better distribute stresses and thus enhances root strength. [9]

Therefore, the purpose of this study was to investigate the resistance of the root to vertical fracture after the retrieval of instruments and endodontic treatment using different sealers.

MATERIALS AND METHOD

This study involved 90 extracted human single-rooted first and second mandibular premolars collected from the Oral and Maxillofacial Surgery Department at Seema Dental College and Hospital, Rishikesh.

PREPARATION OF SAMPLES

Teeth were decoronated at CEJ with a diamond disc **Fig.1**. The roots were then randomly divided into six groups (15 in each): two control groups – Group A (negative control group) and Group B (positive control group) – and four experimental groups [Groups C, D, E, and F]. In four experimental groups and one control group (Group B), the rotary instrument [orifice shaper] fractured in the middle third of the root canal. A cut to a depth of half the instrument thickness was made with a bur at a point 4 mm from the instrument tip and then placed at the appropriate middle third location in the root canal, with pressure applied while rotating at 400 rpm.

Instrument removal was done by enlarging the canal with Gates Glidden (GG) bur sizes (Nos. 1-3) coronal to the fractured instrument with a brushing motion to create a tapered shape and maximize visibility, and also to remove the same amount of dentin from the roots for the five removal groups. Files were then removed with a Masserann kit, which contains an assortment of color-coded, end-cutting trephan burs of increasing sizes and extractors. The preselected trephan was latched into a contra-angle handpiece and run in an anticlockwise direction to create a trough around the coronal end of the fragment by ditching the dentin. This exposed the fragment and space was created for an extractor. The extractor was then used to retrieve the fragment.

Following the retrieval of the instruments, the canals were prepared with ProTaper rotary instruments by using a 16:1 reduction handpiece at a speed of 250 rpm. Canal preparation was done using shaping files S1 and S2 till working length. Next, preparation was done using finishing files F1 and F2. Recapitulation was done using an ISO #15 K file after the use of each ProTaper file. In Group A, no instrument fracture and removal process were done, and canals were prepared till finishing file F2.

The following procedures were then performed on teeth in each group.

Group A (Negative Control): The root strength was evaluated after the canals were filled with GP points and zinc oxide-based Tubliseal sealer using lateral compaction.

Group B (Positive Control): The root strength was evaluated after retrieval of the instrument without obturation.

Group C (Experimental Group): The root strength was evaluated after instrument retrieval and after the canals were filled with GP points and Tubliseal sealer using lateral compaction.

Group D (Experimental Group): The root strength was evaluated after instrument retrieval after and the canals were filled with GP points and MTA sealer using lateral compaction.

Group E (Experimental Group): The root strength was evaluated after instrument retrieval and after the canals were filled with GP points and AH Plus sealer using lateral compaction.

Group F (Experimental Group): The root strength was evaluated after instrument retrieval after the canals were filled with Resilon and RealSeal sealer using lateral compaction and after being subjected to supplementary light curing for 40 seconds.

After the obturation, coronal 2mm all the roots were sealed with a glass ionomer cement as a temporary filling. They were placed in an incubator at 37˚C and in a 100% humidity environment for 14 days to allow the obturation material to set completely.

Three radiographs of each sample were obtained, one each, after the instrument fracture, instrument removal, and post-obturation respectively **Fig. 2**

Measurement of fracture resistance

All samples were set in self-cure acrylic resin in polyvinyl rings (2.8 cm in diameter). **Fig.3**

All the samples were then subjected to an evaluation of ultimate strength using a universal testing machine. The spherical tip of the machine was aligned with the center of the canal opening of each root **Fig.4**. A vertical loading force at a crosshead speed of 1.25mm/min was applied until it fractured the root. The force value was recorded in MPa. The force values were subjected to statistical analysis using the Kolmogorov-Smirnov test, the Kruskal-Wallis H Test, and the Mann-Whitney U test.

RESULTS

Intergroup comparison of ultimate strength in different groups revealed values in Group B to be of a lower order, while values in Group E and Group D were of the middle order. Values in Group A, Group C, and Group F were of higher order. Statistically, the intergroup difference was significant ($p < 0.001$). **Graph1**

All the experimental groups and the negative control group had significantly higher ultimate strength compared to Group B (positive control). All the experimental groups and the positive control group had significantly lower ultimate strength compared to Group A (negative control). Among the experimental groups, the only significant difference observed was between Group D and Group F ($p = 0.041$). It was observed that Group F had significantly higher ultimate strength compared to Group D. None of the other differences were significant statistically. Based on the above analysis, the following order of ultimate strength was observed in the present study:

Group A > Group F ~ Group D ~ Group C ~ Group E > Group B

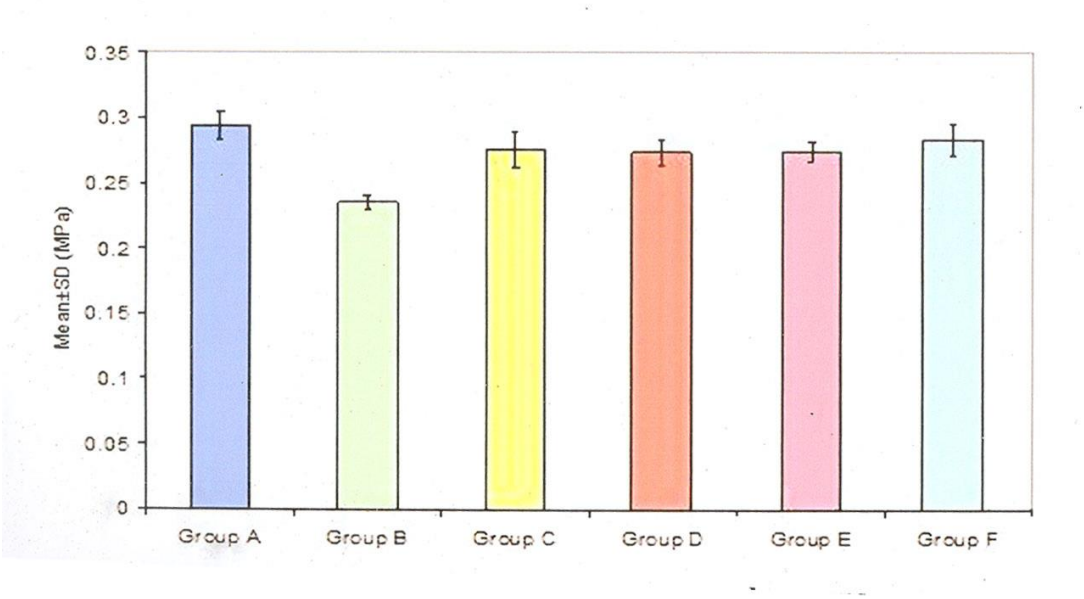

Table 1 shows Statistical Evaluation of Ultimate Strength (MPa) of samples in different groups

GR	N	Mean Rank
A	15	73.17
B	15	8

C	15	46.13
D	15	42.8
E	15	44.2
F	15	58.7
Total	90	

X2=58.569 (df=5); p<0.001 (Kruskal-Wallis-Non-parametric ANOVA)

Table 2 compares the ultimate strength of different groups.

Group	**No. of samples**	**Mean values of # resistance**	**Std. Deviation**	**Minimum**	**Maximum**
A	15	0.294	0.011	0.27	0.31
B	15	0.235	0.005	0.23	0.24
C	15	0.275	0.014	0.25	0.31
D	15	0.273	0.01	0.25	0.29
E	15	0.274	0.008	0.27	0.29
F	15	0.283	0.012	0.27	0.31
Total	90	0.272	0.021	0.23	0.31

Fig. 1: Decoronated Samples

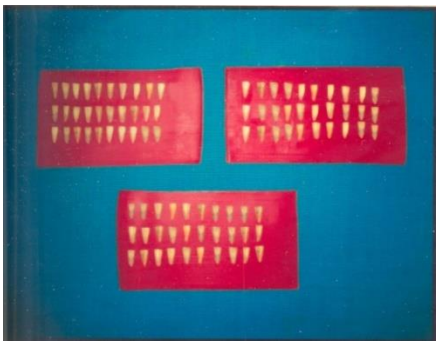

Fig. 2: Radiographs obtained at the time of # of instrument, after removal of instrument and after obturation of the sample

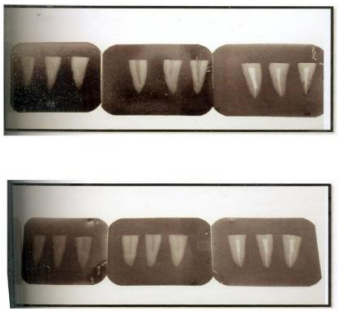

Fig. 3: Samples embedded in Acrylic Moulds

Fig. 4: Sample in placed in Universal Testing Machine

DISCUSSION

The removal of fractured instruments is sometimes a difficult and time-consuming procedure, with a reported success rate between 55% and 79%. Hulsmann M & Schinkel I.1999 evaluated the removal procedures for fractured instruments and found that no standardized procedure for successful removal exists. [10] There have been many reports on the methods of removing broken instruments in root canals, for example on the use of chemical agents such as iodine trichloride, mechanical methods such as the Masserann Technique, ultrasonics, and the canal finder system. [10, 11]

A Masserann kit was used in this study for the retrieval of fractured instruments from the middle third of the root canal. Such kits have been used for over 40 years for instrument removal and a success rate of 73% and 44% have been reported regarding their use in anterior and posterior teeth respectively. [12]

The Masserann kit has 14 hollow cutting-end trephine burs (sizes 11-24), ranging in diameter from 1.1-2.4mm, as well as two extractors. The trephine burs are used in an anticlockwise motion to prepare a groove around the coronal portion of the fragment. In this study, instrument removal was done by widening the canal coronal to the broken instrument using GG bur sizes 1-3 [No 1(0.5mm), 2(0.7mm), and 3(0.9mm)] with a brushing motion to create a tapered shape, maximize visibility and standardize the amount of dentin removed from the roots for the five removal groups. The files were then removed using the Masserann Technique. When the fractured instrument was removed, there was a potential loss of dentin, and tooth integrity was compromised. Thus, to reinforce the teeth against fracture, sealers were used in conjunction with GP. The sealers used were Tubliseal, AH Plus, Resilon, and MTA.

The results of the present study revealed that Group F (Resilon) increased the fracture resistance of roots when the fractured instrument was removed from the middle third of the root canal. This is per the results of studies by Monteiro et al, [13] Teixeira et al [14], and Baba et al [15], where the obturation of canals with Resilon increased the resistance of endodontically treated teeth to fracture compared with teeth that were obturated with GP and conventional sealers.

Group C (Tubliseal sealer) could not gain the required root strength and gave low resistance to vertical fracture, but was comparable to Group D (MTA sealer), Group E (AH Plus sealer), and Group F (Resilon).

Wadhwani and Gurung [16] found that all the materials Resilon, AH Plus sealer, and Tubliseal used in their study reinforced the prepared root canals. No significant differences were found among them.

GP with Group D MTA Fillapex® (Angelus, Londrina, PR, and Brazil) showed low resistance to vertical fracture compared to Group A (negative control), in which no instrument was fractured and routine endodontic treatment was done with Tubliseal sealer. This was higher than Group B (positive control) with no endodontic filling material, but comparable to Group C (Tubliseal sealer), Group E (AH Plus sealer), and Group F (Resilon). Thakur et al [17] revealed that MTA performs equally well when compared with zinc oxide eugenol sealer (Tubliseal) and AH Plus. Madarati et al [18] also found that Resilon and MTA, when used as canal-filling materials, compensate for the root dentin loss that takes place as a result of attempts to retrieve fractured instruments.

GP with AH Plus sealer showed low resistance to vertical fracture compared to Group A (negative control). It was higher than Group B (positive control) and comparable to Group C (Tubliseal sealer), Group D (MTA sealer), and Group F (Resilon). Previous studies by Halkai et al [19] also show no significant difference between AH Plus and Tubliseal sealer. Assmann et al [20] concluded that MTA Fillapex® (Group D) showed resistance to dislodgement similar to AH Plus sealer.

All the experimental groups and the negative control group had significantly higher ultimate strength compared to Group B (positive control). All the experimental groups and the positive control group had significantly lower ultimate strength compared to Group A (negative control). Among the experimental groups, the only significant difference observed was between Group D and Group F ($p = 0.041$). It was observed that Group F had significantly higher ultimate strength compared to Group D. None of the other differences were significant statistically. Based on the above analysis, the following order of ultimate strength was observed in the present study:

Group A > Group F ~ Group D ~ Group C ~ Group E > Group B

Hence, within the limitations of the present study, the results indicate that all the fractured instruments were successfully removed from the middle third of the root canal by using a Masserann kit. Resilon and MTA appeared to provide a replacement for the root dentin loss that occurred during instrument retrieval.

CONCLUSION

All the fractured instruments were successfully removed from the middle third of the root canal. A considerable amount of dentin loss occurred during the retrieval of the separated instrument using the Masserann kit, but Resilon and MTA compensated to some extent for this loss. In order of preference, the root canal filling materials that reinforce the roots after the retrieval of separated instruments are Resilon, followed by MTA, Tubliseal, and AH Plus.

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