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A quantitative analysis of apical debris extrusion in root canals with varying root canal curvature using rotary and reciprocating system - An in-vitro study

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Abstract

Background/Aim: Apical debris extrusion may lead to post endodontic pain which is an unpleasant situation in endodontics. The aim of this in-vitro study was to quantitatively evaluate the apical debris extrusion in root canals with variation in root canal curvature using rotary and reciprocating instrumentation system.

Methodology: The study was conducted on mesiobuccal (MB) and mesiolingual (MB) canals of curved mesial roots of extracted human mandibular molars (n=32). After access opening and achieving canal patency, digital radiographs were taken to measure the angle and radius of canal curvature. Based on curvature, the samples were assigned to Group I: Moderate curvature and Group II: Severe curvature and further divided into 2 subgroups A

and B based on instrumentation, One Shape (OS) rotary single file system and WaveOne Gold (WOG) reciprocating single-file system respectively. The extruded debris was collected in a pre-weighed eppendorf tube and the mean weight of debris was assessed with a microbalance. Data was analysed by Kolmogorov-Smirnov and Shapiro-Wilk tests followed by unpaired t-test.

Results: The WOG reciprocating file system produced significantly more debris compared to OS rotary file system in moderately curved canals (P =0.00). Severely curved canals produced significantly more debris extrusion compared to moderately curved canals (P =0.00). No significant difference was observed between the instrumentation systems in severely curved canals (P =0.1).

Conclusion: Within the limitations of this study, both systems caused apical debris extrusion in moderate and severely curved canals. However, moderately curved canals resulted in lesser debris extrusion than severely curved canals irrespective of the file system used.

Keywords: Apical debris extrusion, Moderate curvature, One Shape, Rotary, Reciprocating, Single file systems, Severe curvature, WaveOne Gold.

Introduction

A thorough root canal cleaning and shaping is the key to obtain complete debridement of the root canal system which leads to a successful endodontic treatment. However, during the root canal preparation procedures, dentin chips, pulp tissue, microorganisms and/or irrigants may get extruded into the periradicular tissues which lead to inflammatory reactions and post-operative pain.[1] Clinically, in multi-rooted posterior teeth, the practitioner is frequently faced with severely curved roots. However, single and straight roots have been commonly used in studies to evaluate the amount of debris extrusion during instrumentation.[2-10]

In-vitro studies comparing canal shaping ability and canal transportation in curved canals using reciprocating and full sequence rotary systems showed the significance of canal curvature in root canal procedures.[11,12,13] Hence it is inferred that canal curvature may have an influence on amount of apical debris extrusion.

In recent years, rotary endodontics has seen the advent of single file systems which has decreased the canal preparation time drastically.[14] WaveOne Gold (WOG) (Dentsply, Maillefer, Ballaigues, Switzerland) and One Shape (OS) (Micro-Mega, Besancon, France) are designed as single file system so as to complete root canal preparation with only one instrument. While WOG works in reciprocal motion whereas the OS works in a continuous rotation.

To date no study has quantitatively assessed the amount of extruded debris in moderately and severely curved canals. Hence the purpose of this in-vitro study is to evaluate the apical debris extrusion in root canals with variation in root canal curvature, with the two different instrumentation systems. The null hypothesis is that there is no significant difference in apical debris extrusion between rotary and reciprocating instrumentation systems with varying root canal curvature.

Materials and methods

Specimen preparation: With ethical consent from the Institution's Ethics Committee, thirty-two extracted human mandibular molars with separate mesiobuccal (MB) and mesiolingual (ML) canal having different angles of curvature (10^0 to 70^0) according to Schneider's criteria[15] with radius of curvature (1mm to 8mm) according to Pruett's criteria[16] were included in the study. After access cavity preparation, canal patency was achieved using a size 10 K-file [Mani, Japan]. The

crowns of all the samples were sectioned such that the total tooth length of 17 mm was obtained and the working length (WL) of the MB and ML canals were determined separately. A periapical radiograph of each tooth was taken using a digital sensor [Digora, Soredex, Hong Kong] and X-ray equipment [Xpress DG, Unicorn Denmart, India] with an exposure time of 0.4 s. The angle and radius of curvature of the MB and ML canals were determined radiographically with an image analysis software [Digimizer, MedCalc Software Ltd, Belgium]. The teeth were mounted in clear acrylic till the cemento enamel junction and Cone beam computed tomography (CBCT) [PlanMeca, Finland] scans were taken to confirm the inclusion criteria. CBCT images were obtained and viewed using Romexis viewer version 5.1.0.4. Coronal, proximal and axial planes were evaluated for the presence of Vertucci type Ⅳ root canal configuration and the presence of isthumus if any.

The teeth were then divided into two groups based on the canal curvature.

Group I (n=16): Moderate curvature (10^0 to 20^0) -radius of curvature(R) (4mm<R<8mm)

Group II (n=16): Severe curvature (25^0 to 70^0) – (R<4mm).

Each group was further divided into 2 subgroups A and B.

Subgroup A (n=8) -denotes rotary instrumentation. (OS)

Subgroup B (n=8) -denotes reciprocating instrumentation. (WOG)

Experimental model design and debris collection

A modified experimental model of Myers and Montgomery[17] as described by Verma et al[18] was used in the present study. Eppendorf tube was pre-weighed before collecting debris using electronic balance [Shimadzu, Japan], with accuracy of 0.0001g. Each individual tooth was held in a pre-weighed eppendorf tube by a rubber stopper and this assembly was fixed inside a glass vial and was sealed with a modelling wax. The teeth were inserted in the eppendorf tube till the cementoenamel junction. A needle was placed alongside of the tooth into the eppendorf tube to balance the external and internal air pressure. Amber colour glass vials were used to prevent any operator bias. For all groups, the apical foramen of each tooth was enlarged to size 15 prior to shaping with the respective file system.

1. For the sub group A, in each group the One Shape rotary file system, (LOT:032415) the primary file size 25 with 6% taper, was used according to the manufacturer instructions with a speed of 400 rpm and maximum torque of 2 Ncm using X-Smart Endomotor (DENTSPLY Maillefer, USA).
2. For the sub group B, in each group WaveOne Gold reciprocating file system, (LOT: 1529970) the primary file size 25 with a 7% taper, was used according to the manufacturer instructions (150^0 counter-clockwise and 30^0 clockwise) using VDW Gold Reciproc Endo motor (VDW, Munich, Germany).

A single operator who was trained to use both the file systems efficiently, carried out the entire procedure. According to manufacturer instruction each canal was instrumented with a new file. Irrigation was done with a 30 gauge open ended needle, inserted as far as possible without resistance until 2 mm short of the predetermined WL in both the groups, using double distilled water. After instrumentation, the teeth were removed from the eppendorf tubes and all tubes were incubated at 70^0C for 5 days to allow the evaporation of the remaining irrigant. Following this, a final weighing was performed. The weight of the debris was calculated by subtracting initial weight from final weight of the eppendorf tube.

Results

Statistical analysis: The statistical analysis was performed using the software SPSS for Windows (Statistical Package for Social Sciences, SPSS Inc., IBM, Chicago) version 23.0. Data were subjected to normality using Kolmogorov-Smirnov and Shapiro-Wilk test followed by unpaired t-test. (Level of significance P <0.05).

All instrumentation systems resulted in some amount of apical extrusion of debris. The WOG reciprocating file system produced significantly more debris compared to OS rotary file system in moderately curved canals (P =0.00) (Table 1). Severely curved canals produced significantly more debris extrusion compared to moderately curved canals (P =0.00) (Table 2). No significant difference was observed between the instrumentation system in severely curved canals (P =0.1). Pearson's correlation was applied to correlate the weight of debris and angle of curvature. Group Ⅰ A showed negative, non-significant moderate correlation (r=-0.49; P=0.21) between angle of curvature and weight of debris. Similarly, Group Ⅰ B showed negative, non-significant but very weak correlation (r=-0.08; P=0.84) whereas Group Ⅱ A showed positive, moderate and non-significant correlation (r=0.5; P=0.2) and Group Ⅱ B showed positive, non-significant and very weak correlation (r=0.11; P=0.78) between angle of curvature and weight of debris.

Table 1: Intra group comparison (OS vs WOG) of weight of debris in Grams using unpaired t-test

Groups	N	Minimum	Maximum	Mean	Std. Deviation	Mean diff	P value
Group Ⅰ A	8	0.0210	0.0432	0.03181	0.00648	-0.014	0.00*
Group Ⅰ B	8	0.0400	0.0560	0.04636	0.005110		

*significant

Table 1: It shows mean weight of debris was higher in Group Ⅰ B (0.04636 ± 0.005110) as compared to Group Ⅰ A (0.03181 ± 0.00648). Unpaired t test showed statistically significant difference between Group Ⅰ A and Group Ⅰ B (P=0.00).

Table 2: Inter group comparison (Moderately curved vs Severely curved) of weight of debris in Grams using unpaired t-test

Groups	N	Minimum	Maximum	Mean	Std. Deviation	Mean diff	P value
Group Ⅰ A	8	0.0210	0.0432	0.03181	0.00648	-0.028	0.00*
Group Ⅱ A	8	0.0581	0.0628	0.05982	0.00168		
Group Ⅰ B	8	0.0400	0.0560	0.04636	0.00511	-0.016	0.00*
Group Ⅱ B	8	0.0538	0.0667	0.06285	0.00455		

*significant

Table 2: It shows mean weight of debris was higher in Group Ⅱ A (0.05982 ± 0.00168) as compared to Group Ⅰ A (0.03181 ± 0.00648). Unpaired t test showed statistically significant difference between Group Ⅰ A and Group Ⅱ A (P=0.00) and mean weight of debris was higher in Group Ⅱ B (0.06285 ± 0.00455) as compared to Group Ⅰ B (0.04636 ± 0.00511). Unpaired t test showed statistically significant difference between Group Ⅰ B and Group Ⅱ B (P=0.00).

Discussion

Successful endodontics is based on the sound principles of debridement, disinfection, and obturation aimed at maintaining dentition and providing an environment conducive to periradicular healing. It was successfully demonstrated that the extrusion and formation of the 'worm' of necrotic debris as described by Ingle and Taintor, leads to flare up.[19]

The results of the present study indicated, both the file systems used in moderately and severely curved canals, caused apical debris extrusion. Regarding the mean weight of apical debris, the groups can be arranged in ascending order: Group Ⅰ A (0.03181g) < Group Ⅰ B (0.04636g) < Group Ⅱ A (0.05982g) < Group Ⅱ B (0.06285g). It is clear that apical debris increased from rotary instrumentation to reciprocating instrumentation and also from moderate curvature to severe curvature.

Intra group comparison between the instrumentation systems (OS and WOG) of Group Ⅰ (moderately curved) showed that, the reciprocating file system (WOG) exhibited significantly higher debris extrusion (P value=0.00) as compared to rotary file system (OS) (Table 1). While in group II (severely curved) showed that, the reciprocating file system (WOG) exhibited more debris extrusion but no statistical significance was observed. The current result for moderate canals (Group I), is in accordance with a previous study,[20] though it was investigated in straight canals. Hence, the null hypothesis stating that there is no difference between the apical debris extrusion and instrumentation systems was partially rejected as it was applicable only to severely curved canals.

The difference in apical debris extrusion between the instrumentation systems in moderately curved group, obtained in this study may be due to (i) the instrumentation technique, (ii) the cross-sectional design of the instruments and (iii) the different taper of the instruments.

WOG files due to their reciprocating and in-and-out filing motion, may act as a piston, extruding more debris than OS instrumentation technique. The reciprocating file system used in the current study removed the radicular dentin in short period of time by its aggressive ability of cutting action but was unable to displace debris generated coronally. This could have increased apical extrusion in combination with the reciprocal motion. The reciprocation movement in WOG system is formed by a wider cutting angle and smaller release angle. It cuts dentin by engaging in a 150° CCW direction and then disengage 30° in a CW direction.[21] While rotating in the release angle the flutes may not remove debris but push them apically. In contrast, the file with continuous rotation act like a screw conveyor improving movement of dentin chips and debris coronally.[22]

WOG reciprocating file has a parallelogram cross section with two 85^0 cutting edges in contact with the canal wall and 24° helical angle present at the active part of the file. The extra space around the instrument, because of the design gives space for debris removal.[21] Though the design served the purpose in group II (severely curved canals), but in group I (moderately curved canals) apical debris extrusion was significantly more in comparison to rotary files. OS rotary file has a triangular or modified triangular cross-section with three sharp cutting edges in the apical and middle part and an S-shaped design with two cutting edges near the shaft. It has a variable cross-section that present along the length of the blade, which may provide more space for better elimination of debris.[23]

WOG file is relatively big, rigid with a greater taper (0.07 taper primary file: tip diameter corresponds to ISO size 25)which is directed to reach the apex.[24] According to

previous studies, the taper of the instrument used has been correlated to the extrusion of debris, stating that files with greater taper could be associated with higher levels of extrusion.[25,26] A greater taper of instruments at the apical 3 mm might remove more dentin and might push more debris apically when the file is moved apically. OS taper is 6% which is lesser than 7% taper of WOG reciprocating file used in the study.

In the current study the inter group comparison (for both reciprocating and rotary files groups), showed that Group Ⅱ i.e., severely curved group exhibited significantly higher debris extrusion when compared with moderately curved group (P value=0.00) (Table 2). Hence, the null hypothesis stating that there is no difference between the apical debris extrusion and root canal curvature was rejected. The result is in accordance with a previous study which analysed the effect of curvature on the amount of debris extrusion during reciprocating preparation. The amount of extruded debris increased along with the curvature.[27]

This result could be related to the reduced coronal debris transportation in the curved part of the root canals. In moderate curve, root canal debris may be more easily removed coronally compared with severely curved root canals. In addition, more pecking motions are needed during the preparation of the curved canals to reach the full working length with files. This may be another reason for the increased debris extrusion in severely curved root canals compared with the moderately curved group. There was no increase in the apical debris extrusion in canals with isthumus (as verified in CBCT). The reason could be that, only conventional needle irrigation was performed and neither ultrasonic nor other irrigation systems were used in the present study.

In the present methodology, extruded material that is calculated is extremely low, often in fractions of a mg or μg. Hence there is always the possibility of additional influence by touching of the devices by fingers or even pollutant from the environment in which the specimens are preserved.[28] Physical properties such as hardness of the dentine may vary considerably between teeth which can also influence the results.

Further studies can be repeated with the use of closed end side vented needle instead of open-ended needle for irrigation. In vivo studies to evaluate apical debris extrusion, is possible only by evaluating post instrumentation pain in clinical scenario. Though post-operative pain can be attributed to various other reasons like microorganisms, presence of pre-operative symptoms, host response, tooth type, gender etc. in addition to apical debris extrusion. Hence in vitro study is ideal for evaluating apical debris extrusion.

Conclusion

Within the limitations of the present study, it can be concluded that,

- Both the single file systems caused apical debris extrusion in moderately and severely curved canals.
- Moderately curved canals resulted in lesser debris extrusion than severely curved canals irrespective of the file system used.
- Use of rotary single file system (OS), resulted in lesser amount of debris extrusion compared to reciprocating single file system (WOG) in moderately curved canals. However, in severely curved canals both the systems performed equally.

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