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"COMPARATIVE EVALUATION OF APICAL DEBRIS EXTRUSION USING RECIPROCATING AND ROTARY SINGLE-FILE SYSTEMS: AN IN VITRO STUDY"

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ABSTRACT

Introduction: Chemomechanical preparation is indispensible in achieving desired outcome of root canal treatment; but inadvertent extrusion of intracanal debris, microorganisms and irrigants into the periapical area leads to flare-ups, pain, delayed healing or even treatment failures. Since all instruments and techniques are known to cause apical debris extrusion to some extent, this study was undertaken to evaluate the amount of debris extrusion during the canal shaping with two different single file systems – WaveOne Gold (WOG) and One Shape (OS) in reciprocating motion and continuous rotation respectively. **Methodology:** Fifty-two freshly extracted human mandibular premolars were randomly divided into two groups based on the file used for chemomechanical preparation: Group 1 used WaveOne Gold – WOG files whereas Group 2 used OneShape – OS files. These samples were suspended in a model defined by Myers and Montgomer. The tubes were subsequently stored at 70 °C in an incubator for a period of five days to ensure evaporation of water. The extruded debris were weighed at the preparation and the post preparation stage and the difference was measured. **Results:** The amount of debris extruded in WOG files groups was more as compared to OS file group but the difference between them is statistically non-significant. **Conclusion:** Reciprocating motion(WOG files) does not result in less debris extrusion as compared to rotary motion (OS files).

KEYWORDS: Reciprocating motion, Rotary motion, Debris extrusion, Instrument Kinematics, Chemomechanical preparation.

INTRODUCTION

The primary objective of root canal therapy is to achieve complete debridement followed by three-dimensional seal with obturation. Although chemo-mechanical preparation is a crucial step in endodontic treatment, it can unintentionally force intracanal debris, bacteria, and irrigating solutions beyond the root apex, potentially leading to postoperative flare-ups, discomfort, delayed tissue repair, or even unsuccessful treatment outcomes.[1-3] According to Reddy and Hicks, apical extrusion is influenced by several factors like instrument design, canal morphology, technique of instrumentation, choice of irrigant etc.[4]

Various instrument techniques and instrument designs have been evaluated and the evidence is inconclusive regarding the ideal technique or instrument design.[3, 5-8] Research states that minute quantities of debris extrusion is inevitable irrespective of the choice of technique and hence, the quest for ideal technique or instrument design is ongoing till date.[1,3,5-7,9-10] Al-Omari and Dummer reported that balanced force technique had less chances of extrusion of debris periapically while the highest amounts of debris extrusion were reported by linear instrumentation techniques.[11] Recent studies indicate reduced debris extrusion with the use of engine–driven NiTi instruments in both continuous rotary and reciprocating movements over manually-operated hand instruments, but contrary findings have also been reported.[12-14]

Although various studies evaluating debris extrusion in rotary and reciprocating instruments have been conducted, but to the best of our understanding, no study has compared WaveOne Gold (Dentsply, Malleifer, Ballaigues, Switzerland) and OneShape (Micro-Mega, France) rotary files. Therefore this study was carried out with the objective of evaluating the amount of debris

extruded apically during the canal shaping with two different single file systems – WaveOne Gold (WOG) and One Shape (OS).

METHODOLOGY

Sample preparation

Fifty-two human mandibular premolars which were recently extracted were selected for the study based on the following **inclusion criteria**-

- Standardized dimensions of 6.13±0.4 mm buccolingually and 4.8±0.5mm mesiodistally
- Length – 19 ± 1mm
- Teeth extracted for orthodontic purpose
- Teeth with mature apices, single canal and apical foramen
- No evidence of calcification, resorption or any previous root canal treatment
- Root or canal should be straight having less than 5° curvature.

The extracted teeth were rinsed thoroughly with distilled water, stored in saline, and cleaned using an ultrasonic scaler to remove stains, calculus, and residual periodontal tissue. All samples were then immersed in a 0.1% thymol solution for five days at 4°C and subsequently preserved in saline until they were used. Access cavity was prepared endodontically and patency was ensured with a #10 K file. A #15-K file was used to establish the working length until just noticeable at the major apical foramen and subtracting 1mm from that length. The samples were then randomly allocated into two groups based on the file used for chemomechanical preparation:

Group 1 – Wave One Gold - WOG
Group 2 – One Shape – OS

Preparation of the root canal

All the samples were prepared by a single operator using torque controlled endomotor (X Smart Plus, Dentsply Malleifer). The samples in Group 1 were instrumented using WaveOne Gold file. The WOG Primary file (#25.07) was used alongwith the endomotor set to reciprocating motion of 170° conterclockwise (CCW) and 50° clockwise (CW). This was repeated until the working length(WL) was reached while cleaning the flutes after every three pecks. After several strokes, the instrument was withdrawn and cleaned followed by canal irrigation using distilled water. The samples in Group 2 were prepared using One Shape file - #25/0.06 in in-and-out movements without pressure at a speed of 250 rpm and 2 N/cm torque till the WL. Finally, the canals were thoroughly irrigated using 3ml of DW. To avoid cross-contamination of debris through the file flutes, each instrument was used for shaping only one canal. The patency of the canals during the instrumentation was sustained with a #10 K file.

Test Apparatus

The experimental setup was based on the model proposed by Myers and Montgomery (1991). A layer of nail polish was applied to the external surfaces of all specimens, leaving a 1 mm area around the apex uncoated. The specimens were then suspended in empty Eppendorf tubes using rubber stoppers. The stoppers were pierced and a 27-gauge needle was introduced through to keep the air pressures balanced. The whole apparatus was subsequently suspended in a glass flask shielded with an aluminium foil to eliminate any bias from the operator by seeing through during the instrumentation process. The tubes were numbered and pre-weighed using an analytical precision balance with accuracy of 10^5 and an average of three readings was obtained to arrive at the final value.

All tubes were then kept at 70 °C in an incubator for a period of five days to ensure the water evaporates. The Eppendorf tubes containing extruded debris were then weighed again using the same analytical balance to obtain average of three values. The value obtained by measuring the difference in the weights is the amount of debris extruded.[15,16]

Statistical analysis

Data analysis was conducted using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as Mean ± Standard Deviation and Median with Interquartile Range. The Mann-Whitney U test was applied to assess differences between the two groups, with a p-value of less than 0.05 considered statistically significant.

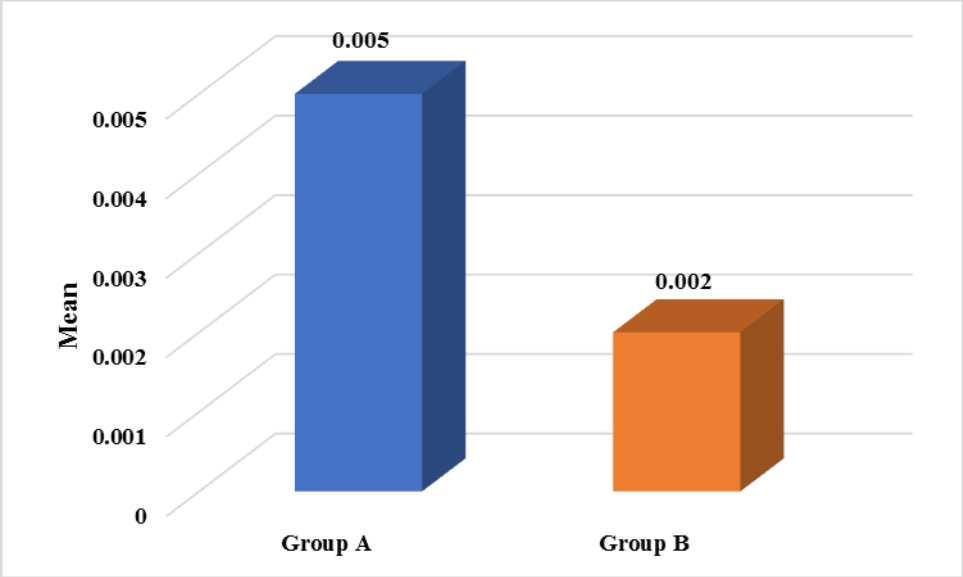
RESULTS

The mean amount of debris extruded in WOG files (0.005±0.002) group was more as compared to OS (0.002±0.009) file group. (Graph 1). But the difference between them was statistically non-significant (p>0.05). (Table 1)

Table 1: Comparison Of Extruded Debris In Both Groups.

Group	Mean±SD	Median(IQR)	p-value
Group 1=WOG	0.005±0.002	0.005(0.004-0.007)	0.114
Group 2=OS	0.002±0.009	0.004(0.003-0.006)	

Note: SD: standard deviation, IQR- interquartile range, p<0.05 is considered significant



Graph 1: mean value of extruded debris in group 1 and 2.

DISCUSSION

Inadvertently extruded debris, consisting of microorganisms, dentinal chips, pulp remnants, necrotic tissue and irrigants, can often be expelled into the periapical area evoking an inflammatory response.[1,10] Release of neuropeptides like substance P and CGRP along with dilation of vessels causes plasma extravasation, leading to distension of collagen fibers in the apical periodontal ligament. Subsequently, chemokines, histamines and immunoglobulins result in flare up and postoperative pain, thereby delaying the process of healing or sometimes causing a failure of the endodontic treatment. Although this reaction is often influenced by a variety of host-dependent and operator-dependent factors, but a vital influence is exerted by the instrument factors.[1,17-18] Available research data is divided upon whether reciprocating files extrude more debris than rotary files.[1,3,10] Therefore, in the present study two single file systems, one continuous rotary (OS) and a reciprocating system (WOG) were compared to assess the amount of extrusion of debris.

WOG Primary file is a single file operating in reverse reciprocation at a speed of 350 rpm, in 150° counterclockwise followed by 30° clockwise measure. It has an off-centered parallelogram cross section with a 24° helical angle and 85° cutting edges resulting in efficient cutting through one-point contact with canal walls. Additionally, the file also has regressive taper of 7% which minimizes contact of the file with canal walls, resulting in adequate space for expulsion of debris coronally.[16,19] Additionally, special heat treatment of M-wire results in greater flexibility and higher resistance to cyclic fatigue and torsional stresses as compared to its predecessor WO file, subsequently reducing the preparation time, thereby adding to its benefits.[20]

In contrast OS is a single file system operating in a continuous rotary motion leading to coronal transportation of debris. It has triangular cross-section with 3 cutting edges in apical 2mm zone transitioning into 2 cutting edges in the coronal zone along with variable helical angle which furthers expulsion of debris coronally. Increased cutting efficiency is ensured by a positive rake angle in conjunction with variable, progressive pitch and constant 6% taper; which reduces the preparation time resulting in reduced debris generation and thus decreasing apical debris extrusion.[18,21-23]

Reciprocating motion has the benefits of balanced force instrumentation which is expected to result in reduced apical debris extrusion due to pressure-less technique.[24] But when compared to rotary instrumentation technique, the screw-conveyor effect results in transportation of debris coronally. [21,25] Continuous rotation also results in coronal flaring corresponding to crown down technique which increases the amount of chip space available for coronal extrusion of debris.[1]

Based on the results obtained, it is observed that amount of debris extruded apically by OS is less as compared to WOG and the difference is statistically non-significant. This may be attributed to the above-mentioned reasons. While progressive pitch in OS file may have increased the amount of debris extrusion, the reduced taper in WOG may have counteracted the same leading to non-significant differences between them. The findings of our study are in line with the observations made by Burklein and Schafer, Kucukyilmaz et al and Surakanti et al where reciprocating instruments were found to allow for more extrusion of debris than rotary instruments but our results were statistically insignificant.[6,22,26] Non-significant differences have also been observed by Kocak et al and Kirchhoff et al.[17,27]

Although the association between instrument factors and apical debris extrusion is well established, several other

factors including the study design have also been found to have exerted a substantial impact on the outcomes.[1,3] In this study, the mechanical setup used to evaluate the amount of debris extrusion was based on the model given by Myers and Montgomery (1991).[15] This model simulates the clinical environment by concealing the periapical area which leads the operator to rely on the determined working length for chemomechanical preparation. Pre-weighing the tubes helped us to evaluate and compare the amount of extruded irrigant along with the extruded debris and quantify the same. One pertinent disadvantage with this model is its inability to simulate the periapical tissues. An alternative has been suggested in literature by using the floral foam, but it has also shown to absorb the irrigant and debris leading to bias.[1,3,10] Lu et al suggested use of 1.5% agar gel but it did not allow for differentiated estimation of irrigant and debris; therefore, periapical simulation was not carried out in the present study.[29]

The working length was established at 1 mm short of the apical foramen, as this has been shown to reduce the amount of debris pushed beyond the apex compared to instrumentation up to the foramen.[3,10,18] In the absence of periapical tissue simulation the natural back-pressure is eliminated and gravity may allow for extrusion of irrigant or debris from the canal leading to overestimation of results.[21] Also apical patency was maintained throughout as debris generated can block the apical segment of root canal resulting in procedural errors. While previous studies demonstrate conflicting results, recent evidence indicates no untoward effects with respect to postoperative pain or flare-ups.[1,30]

Sodium hypochlorite crystals, formed after evaporation, cannot be separated from the debris generated; therefore in addition to the use of distilled water to eliminate antimicrobial effect, side-vented needles were utilized to ensure passive irrigation.[18,20] Presence of curvature or variable anatomy can potentially result in overestimation of results.[16] Therefore to eliminate bias, single rooted teeth having single canals and standardized dimensions, mesiodistally and buccolingually, were selected for the study.

While all these measures were undertaken to obtain most reliable results, the present study has the inherent disadvantage of being an in-vitro study which makes it challenging to account for the various in-vivo factors. Additional limitation of this study is the inability to simulate periapical tissues. Therefore, clinical implication of these results must be made discretely.

CONCLUSION

Although the OS system demonstrated a marginal reduction in apical debris extrusion compared to the WOG system, the difference was not statistically significant. This suggests that reciprocating motion does not confer a clear advantage over rotary instrumentation in minimizing the extrusion of debris during root canal preparation.

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