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Dental Science

KEY WORDS: Debris extrusion, Single file systems, One Shape, Reciproc, WaveOne Gold.

QUANTITATIVE EVALUATION OF APICALLY EXTRUDED DEBRIS DURING BIOMECHANICAL PREPARATION OF ROOT CANAL USING THREE SINGLE FILE SYSTEMS - AN IN-VITRO STUDY.

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ABSTRACT

Introduction: Root canal therapy comprises 3 main steps- access preparation, biomechanical preparation, and 3D obturation. During this process, debris is pushed out from the canals causing inter-appointment flare-ups and postoperative pain.

Materials And Method: 60 extracted mandibular premolars with straight single canal were selected; the Eppendorf tubes were pre-weighted before instrumentation and were allocated into 3 groups along with the sample teeth. All the samples were instrumented with 3 single file systems i.e. Oneshape, Reciproc, and WaveOne Gold, and debris was collected in the Eppendorf tubes.The debris collected was weighed in an analytical balance to determine the extruded debris.

Results: The results of this study showed that WaveOne Gold resulted in the least amount of periapical debris extrusion while Reciproc extruded the maximum amount of debris as compared with other file systems.

Conclusions: A thorough comparison of various systems in the extrusion of debris may be beneficial so that the best method with the lowest incidence of extrusion may be selected.

INTRODUCTION:

At the modern time various methodologies have been introduced for endodontic treatment, but one inherent problem related to all root canal shaping and cleaning procedures is the apical extrusion of intracanal debris and irrigants into the periradicular tissues.[1]

According to Seltzer & Naidrof, the extruded material is referred to as "worm of necrotic debris" as this debris is related to periapical inflammation and post-operative flare-ups.[2] According to Ladley et al. and Imura et al. apical extrusion of debris in the form of necrotic pulp, bacteria, or irrigants appears to occur with all instrumentation techniques.[3] The recent trend is to use a single instrument for the entire cleaning & shaping procedure. There is different such an instrument with the varied design used along with both the kinetics of continuous and reciprocating motion. The advantage of a single file system is to biomechanically prepare the canals with only a single file that is pre-sterilized thus eliminating the chance of cross-contamination, preventing iatrogenic errors, and making the whole procedure fast.

The present study is designed to evaluate the quantity of apically extruded debris of 3 single file systems i.e. single file system with continuous motion – One Shape(OS) [Micro Mega, France]; and a single file system with reciprocating motion i.e. WaveOne Gold(WOG) [Dentsply Sirona] and Reciproc. [VDW, Germany]

MATERIALS AND METHODS:

Sample Selection:

The randomly selected 100 single straight rooted human mandibular premolars were radiographically evaluated in buccolingual(BL) and mesiodistal(MD) aspect. Then 60 teeth among 100 teeth having a single canal were selected by analyzing through CBCT scan for confirmation for a single canal with curvature, not more than 10 degrees (by conventional Schneider's method)[4] and single apical foramen. 60 selected sample teeth were randomly divided into 3 groups, 20 samples in each.

Coronal access preparation was done with suitable round bur and pulp tissues were removed with help of barbed broaches. Apical canal patency was checked with a size 15 K-file. The working length (WL) was determined as 1 mm short of the length of a size 15 K-File that was visible at the major apical foramen.

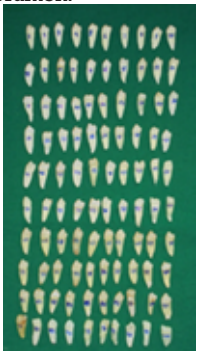


Fig 1:100 Premolars

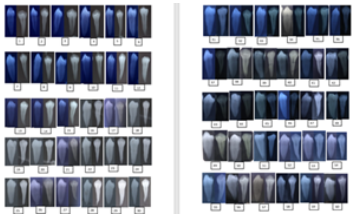


Fig 2:BL & MD X-ray of 100 premolars

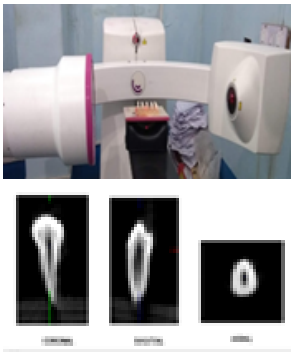


Fig 3:CBCT procedure

Fig 4:Test Apparatus

Test Apparatus Preparation:

The experimental model described by Myers & Montgomery (1991) was used in this study. Each Eppendorf tube was identified against the corresponding sample tooth which was labeled by digital number and the Eppendorf Tube without a lid was weighed for 3 consecutive times in Electronic microbalance with an accuracy of 10^{-5}g and average weight was recorded. The same procedure was repeated for all Eppendorf tubes without lid in three groups.

Biomechanical Preparation Of Sample:
BMP of the root canal OS Group was done using 400 rpm with 2.5Ncm torque Endonmotor (X smart plus, Dentsply) as per manufactures guidelines. The file was used with progressive in and out movement not more than three to four times until it reaches the WL.

BMP of the root canal for the Reciproc group was done with R25 using Reciproc All mode with the same Endonmotor with progressive in and out movement not more than three to four times until it reaches the WL.

The same Endomotor was used in the "WaveOne Gold" mode to prepare the canal with the help of a WaveOne Primary file system as per manufactures guidelines. It was used with slow in and out pecking motion till the WL was reached. The flutes of the instrument were cleaned after 3 pecks with a sterile gauge soaked with distilled water.

To avoid variations in the sample, a total of 2 ml of distilled water was used for each canal as an irrigant with a 30gauge side venting needle keeping its tip 2-3 mm away from the root apex by using a rubber stopper and delivered in 2 minutes.[5] Needle tip was inserted passively without resistance and never allowed to bind the walls of the canal [6,7]

Fig 5: 3 single file systems used in the study

Fig 6: BMP of Reciproc group using Reciproc all Mode

Fig 7: Drying in Incubator

Collection Of Dry Debris:
After instrumentation is completed, the debris adhering to the root surface was collected by washing off the apex with 1 ml of distilled water into the Eppendorf tube. The sample was then placed in an incubator at 70°C temperature for 5 consecutive days to evaporate the moisture.

Each Eppendorf tube with dry debris after removing from the glass vial was then weighed by the same electronic microbalance and was repeated for 3 consecutive times and was recorded in three groups. The weight of debris of each sample was calculated by subtracting the average weight of each Eppendorf tube with debris from the average initial weight of the empty Eppendorf tube and was recorded. This procedure was repeated for all 60 samples. The data thus obtained in 3 file systems were subjected to statistical analysis.

Fig 8: Dry debris of 3 groups

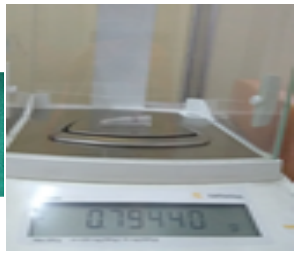
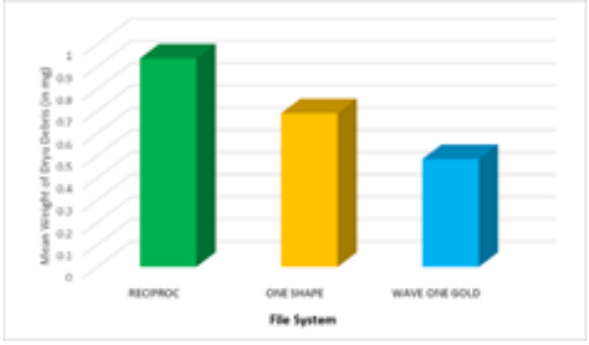


Fig 9: weighting of dry debris on electronic microbalance

RESULTS:
Distribution Of Weight Of Dry Debris Of Different Groups In Descending Order

Group	Weight of dry debris (mg)
Reciproc	0.9357
One Shape	0.6893
WaveOne Gold	0.4838

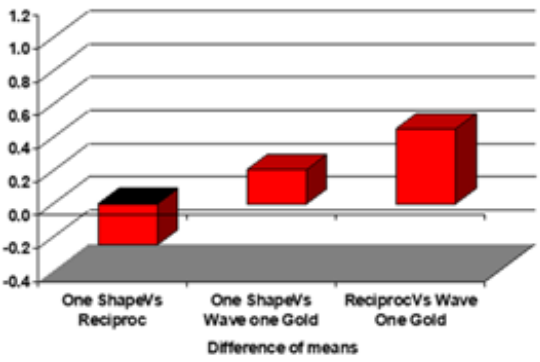


The weight of dry debris of Reciproc was the highest of all groups and that of WOG was the lowest of all groups.

Comparison Of Differences Of The Mean Weight Of Dry Debris Of Different Groups And Corresponding P-values

Group	Difference of means	p-value
One Shape Vs Reciproc	-0.2464	0.18 NS
One Shape Vs WaveOne Gold	0.2055	0.10 NS
Reciproc Vs WaveOne Gold	0.4519	0.014 S

NS-Not Significant; S-Significant



DISCUSSION:
Reciproc is one of the oldest reciprocating single file system introduced back in the year 2011. Whereas **One Shape** is the single file system with a unique design that works in continuous rotation, introduced in the year 2013. **WOG** is one of the newest reciprocating single file system marketed in the year 2016.

There are very limited studies available evaluating or comparing the apical extrusion of debris by these three single-file systems. In the present study, instrumentation was confined to 1mm short of the apical foramen [6,7] because WL 1mm short of canal length contributed to significantly less debris extrusion. In contrast, more debris is forced apically when the instrumentation is performed to apical foramen. [8,9,10]

Since the maturity and patency of the root canal will greatly affect the amount of debris extruded, in this study, # 15 K file is the largest file size that could pass through the apical foramen of all the samples taken and considered as the size of the apical foramen.

Sodium crystallization phenomenon can affect the results if sodium hypochlorite is used as irrigant. Therefore, distilled water is used as irrigant. [11,12] Distilled water was used after

each instrument file for 3 pecks [13] to avoid variations in the sample.

To minimize the variables through the study, all the canals were instrumented by one operator (the researcher).[14]

According to **Tanlap & Gungor**[1] standardization of apical foramen is an important issue and should be considered. So, to standardize the final size of the apical preparation, the Primary file of WOG, R25 file of Reciproc, and OS file were selected for the study. All of them have the same tip size (#25).

BMP was done according to manufactures guidelines and no extra step of glide path preparation was done as suggested by **Prof. GhassanYared(2011)**[13] and by **Dr. Clifford J. Ruddle.**[15] To avoid the fluctuation temperature and humidity effect during the weighing of dry debris, the weighing was done with a temperature between 24°C - 28°C and humidity between 48% - 55%.

Among the 3 file systems, that the Reciproc extruded the highest amount and WOG extruded the least amount of debris also has been confirmed by the study of Tomer et al.[15] who included these 3 file systems only. Again, similar to their study mean difference of extruded debris by Reciproc and WOG has also been revealed to be statistically significant in the present study.

Burklein et al.[16], Nayak et al.[17], and Ebru et al.[18] conducted studies with different single-file systems including Reciproc and One Shape. That former extruded more amount of debris than the later was the common findings with the present study.

The Reasons For The Greatest Extrusion By The Reciproc File System Can Be Explained By The Following Points:
'S' shaped cross-section, sharp 2 point cutting edges, and no/minimum radial land resulting in maximum space for dentin removal. Files with aggressive cutting ability remove a substantial amount of dentin in a relatively shorter period, but they are unable to displace the debris when used in combination with reciprocal motion,[19] leading to more amount of apical extrusion.

Reciproc has the highest taper of 8% compared to WOG(7%), and OS(6%). According to Silva et al.[19], greater taper results in more aggressive preparation thus leading to greater debris extrusion compared to a smaller taper file system.

According to **Burklein et al.,** Reciprocating & in-and-out motion, may act as a piston extruding more debris towards the apex. Contrarily, continuous rotation may improve the coronal transportation of dentin chips and debris acting as a screw conveyor.[8]

Reasons For Lesser Extrusion By OS Than Reciproc File System Can Be Explained By The Following Points:
OS has a unique innovative instrument design characterized by 3 asymmetrical cross-section zones over the entire length of the working part.[20] It also has a long and variable pitch and continuous rotation which increases the available volume for upward coronal debris elimination.

When the results of OS and WOG was compared, the study by **Mehmoud et al.**[21] found to be consistent where the extruded debris by OS was more than WOG.

Reasons For Greater Extrusion By OS Than WOG Primary File System Can Be Evaluated With The Following Points:
Carper and Arslan (2016) found that files with rectangular cross-section produced less debris extrusion than those with triangular one.[22] OS has a positive rake angle, progressive pitch, and constant taper of 6%. According to Mehmoud et al.[21], all these features may contribute to increased production and apical extrusion of debris.3 point contact of the blades at the tip with changing cross-section of OS may result in the greater generation of debris as compared to WOG which has an ogival, roundly tapered, and semi-active tip.[23]

Finally, The Reasons For The Least Extrusion Of Debris By The WOG File System Can Be Explained By The Following Points:
The cross-section of WOG is a parallelogram-with 85° active cutting edge with alternate 1 and 2 point contact with canal walls which leads to lesser cutting efficiency and thus lesser apical extrusion of debris. The constant helical angle of WOG & additional space around the instrument that provides space for debris accumulation & coronal removal of debris. According to **Dincer et al.**[24] movement kinematic of equal clockwise(cw)/counter clockwise (ccw) angles, the unequal cw/ccw (30°/150°) angle enables a file to move without using excessive and potentially dangerous inward pressure. Thus, resulting in less Apical extrusion of debris and also, unequal cw/ccw angles strategically enhance auguring debris out of the canal.[14] Again, the Gold Wire technology of WOG makes the Primary WOG file at least 80% more flexible, 50% more resistant to cyclic fatigue, and 23%more efficient, compared to its Primary WaveOne M-Wire predecessor[25]. Now according to **Karatas et al.**[25] the higher flexibility may be one of the reasons for a smaller amount of debris apically extruded by the WOG file.

But the results of this present study are not in accordance with the study by **Keles et al.**[26] The reasons why the results are not consistent with the present study may be due to the different parameters such as-root type sample size, amount of Irrigants, and also the influence of glide path was not mentioned in this study.

Another study by **Mendoca et al.**[27] also does not support the results of the present study when Reciproc and WOG were compared. In their study WOG extruded more amount of debris than Reciproc though the difference is not statistically significant.

Since no attempt was made to simulate the presence of vital pulp or periapical tissues as an in vivo model may give different results as the periapical tissue serves as a natural barrier inhibiting debris extrusion. Results may also differ because of the negative and positive pressure of the apex and with the normal and pathological conditions.

CONCLUSIONS:

Under the conditions of this study, all the techniques tested caused apical debris extrusion to some degree. The WOG reciprocating system was associated with less debris extrusion compared with the Reciproc and One Shape single file system and the difference between WOG and Reciproc was statistically significant.

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