Comparative evaluation of apical extrusion of debris and irrigant with three rotary instruments using crown down technique – An in vitro study

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ABSTRACT

Aims and objective: The purpose of this study was to evaluate and compare the apical extrusion of debris and irrigant using various rotary instruments with crown down technique in the instrumentation of root canals.

Material and Method: Thirty freshly extracted human permanent straight rooted mandibular premolars with minimum root curvature of 0–10 ° were divided in three groups with 10 teeth in each group. Each group was instrumented using one of the three rotary instrumentation systems: Rotary Hero shapers, Rotary ProTaper and Rotary Mtwo. One ml of sterile water was used as an irrigant after using each instrument. Debris extruded was collected in pre weighed glass vials and the extruded irrigant was measured quantitatively by Myers and Montgomery method and was later evaporated. The weight of the dry extruded debris was calculated by comparing the pre and post instrumentation weight of glass vials for each group.

Statistical analysis: Statistical analysis was done by using by a Kruskal–Wallis One-way ANOVA test.

Results: Statistical analysis showed that all the rotary instruments used in this study caused apical extrusion of debris and irrigant. A Statistically significant difference was observed with Rotary ProTaper and Rotary Mtwo groups when compared with Rotary Hero shapers. But no significant difference was observed between Rotary ProTaper and Rotary Mtwo groups.

Conclusion: After instrumentation with different rotary instruments, Hero shapers showed a less apical extrusion of debris and irrigant.

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INTRODUCTION

Main objective for a successful root canal treatment is to obtain a clean root canal system devoid of pulp tissue remnants, necrotic tissue, and microorganisms.¹ For cleaning and shaping of root canals various hand and rotary endodontic instruments are required. Vande Visse &

Brilliant found that all instrumentation techniques extrude some debris apically but there is a difference between the techniques.² When instrumentation is coupled with irrigation, it tends to generate a significantly greater amount of debris extrusion apically.² Seltzer & Naidorf reported that material extruded from the apical foramen may be related to post instrumentation pain or a 'flare-up'.³

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Alper Kustarci et al reported that mechanical instrumentation with rotary movements significantly reduced the amount of debris extrusion because these techniques tend to pack dentin chips within the grooves of the file and expelled them in a coronal direction from the root canal.⁴ Various studies have shown that crown down technique leads to minimum apical extrusion of debris but various instrument designs may affect the extrusion.⁵

A thorough comparison of various rotary systems in extrusion of debris and irrigant may be beneficial so that the best instrument with the lowest incidence of extrusion and post-operative flare-up may be selected.

MATERIAL AND METHODS

Criteria for selection of teeth and storage

Thirty freshly extracted human permanent straight rooted, single canal mandibular premolars extracted for orthodontic purpose were collected from the outpatient department of oral and maxillofacial surgery. The collected teeth were washed under tap water to remove blood stains and soft tissue tags. The external root surfaces of experimental teeth were cleaned of adherent tissue tags and debris with periodontal curette. Teeth were stored in 3% sodium hypochlorite for 2 h before experimentation. Care was taken to exclude teeth which had open apices, severely curved and dilacerated roots, presence of root fillings, internal resorption, and calcified canals.

Method for sectioning of teeth

Coronal access was prepared conventionally with a high-speed bur and canal patency was established with a size 15 K-file. The pulp tissue was removed before instrumentation with a barbed broach (Dentsply Maillefer, Ballaigues, Switzerland). A size 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) with a rubber stop was introduced carefully into each canal until it was just visible in the apical foramen. This length was noted and 1 mm was subtracted to give the apical extent of the root canal. The crown of each tooth was sectioned at 21 mm from apical foramen. The coronal portion was removed with a water-cooled double-faced diamond disk operated at low speed.

Method of group division

For stratified randomization of the sample, the specimens were assigned to three groups of 10 teeth each. Group 1 was instrumented with Rotary ProTaper. Group 2 was

instrumented with Rotary Mtwo and instrument system and Group 3 instrumented with Rotary Hero shaper instrument system. Regardless of the technique used; all canals were irrigated with 1 ml distilled water after the use of each instrument using a 28-gauge needle. The needle was placed as far into the canal as possible without binding. The crown-down instrumentation technique was used. The files were used with X-Smart endo motor (Tulsa dental, Dentsply, Switzerland) at recommended speed and torque following the manufacturer's instructions. Last apical file of tip size 30 was used in all the systems.

Rotary ProTaper instrument system (Group 1)

This group comprised of 10 teeth. All the teeth were instrumented with Rotary ProTaper (Dentsply Maillefer, Ballaigues, Switzerland). Instruments were used following the manufacturer's instructions till apical size # 30.

Mtwo Rotary instrument system (Group 2)

This group comprised of 10 teeth. All the teeth in this group were instrumented with Mtwo NiTi rotary instruments (VDW, Munich, Germany). Instruments were used following the manufacturer's instructions till apical size # 30.

Rotary Hero shaper instrument system (Group 3)

This group comprised of 10 teeth. All the teeth in this group were instrumented with Hero Shaper InGeT series (Micro-Mega, Besançon, France). This system consists of two files that were used in a sequence without any preflaring. Instruments were used following the manufacturer's instructions till apical size # 30.

DEBRIS COLLECTION

Debris collection was performed following the technique developed by Fairbourn et al and modified by Myers and Montgomery.⁵ The teeth with patent apices were inserted on the removable rubber stopper tops of glass tubes. The teeth were fixed to the rubber stopper tops with self-cure acrylic in order to create a hermetic seal. The teeth attached to rubber stopper could be removed manually from the test tube for weighing extruded debris and irrigant. A 19 gauge needle was inserted in the tube's top next to the fitted root to equalize the external and internal pressures. These tubes

served as collecting containers for the debris produced during instrumentation. The experimental teeth were numbered randomly. The numbers were marked both on the glass tubes and tops. The tube was hand held vertically during instrumentation. The system was sealed with rubber dam to avoid leakage of the irrigant into the tube (Fig. 1).

Measurement of extruded irrigant

Immediately after canal instrumentation, the tubes with the removable rubber stops where the roots were attached were removed from the system. A significant amount of irrigant was present in the collection tube. A clean tube was filled with irrigant in 0.05 ml increments using micropipette and calibrations were marked at each level. Volume of extruded irrigant was measured by placing the collection tube next to this calibrated tube. The volume of irrigant extruded was recorded in milliliters.

DEBRIS WEIGHING

Immediately after measuring the irrigating solution, each tooth was then removed from the tube and debris adhering to the root surface was collected by washing off the apex with 0.5 ml of distilled water into the tube. The tubes were stored in an incubator at 90 °C for 12 h to evaporate the moisture. Tubes were then kept at room temperature for 24 h in an incubator (Panapolytech Co., Bangkok, Thailand) with anhydrous CaCl_2 crystals to absorb the moisture present in incubator before final weighing. Therefore a standard protocol was followed due to the fact that even moisture in the air may influence the final weight. Test tubes were weighed on an Analytic microbalance

(Citizen Scale (I) Pvt. Ltd, India). The difference in the weight of the collection tube before canal instrumentation and after instrumentation gave the weight of the dry debris extruded periapically. Weight of debris was measured in milligrams.

Data collection

The mean extrusion values (mg) and standard deviations of each group for debris weight are given in Table 1.

Statistical analysis

Data obtained were then subjected to statistical analysis using Kruskal–Wallis One-way ANOVA to determine the amount of apically extruded debris and irrigant amongst the groups. The level of statistical significance was set at $P = 0.05$.

RESULTS

Data regarding the weight of debris and volume of irrigant extruded are presented in Table 1. The results in Table 2 indicate that all instruments tested cause a measurable apical extrusion of debris and irrigant. No statistically significant difference was observed between ProTaper (RP) and Mtwo group (RM) ($P > 0.05$) in terms of extrusion of debris and irrigant. But a statistically significant difference was observed with ProTaper (RP) and Mtwo groups (RM) ($P < 0.05$) when compared with Hero shapers (RH). The lowest extrusion of debris and irrigant was observed with Hero shapers.

DISCUSSION

The inter-appointment flare-up is a complication characterized by the development of pain, swelling or both, which commences within a few hours or days after root canal procedure and is of sufficient severity to require an unscheduled visit for emergency treatment. Studies have reported varying frequencies of flare-ups, ranging from 1.4 to 16%.³ The causative factors of inter-appointment

Fig. 1 X-Mart with tube during instrumentation.

Table 1 Mean debris weight (mg) and irrigant volume (ml) of the groups.

Groups	N	Mean (mg)	S.D.	Mean (ml)	S.D.
Group 1 (RP)	10	23.9	2.58	2.10	0.39
Group 2 (RM)	10	21.5	3.76	1.80	0.37
Group 3 (RH)	10	10.4	4.36	0.88	0.37

Table 2 Comparison of (1) mean debris weight (mg) and (2) mean irrigant volume (ml) between the groups.

Groups compared	P value	Significance
(1) Mean debris weight (mg)		
Group 1 & 2	0.1134	NS
Group 2 & 3	<0.0001	HS
Group 1 & 3	<0.0001	HS
(2) Mean irrigant volume (ml)		
Group 1 & 2	0.094	NS
Group 2 & 3	<0.0001	HS
Group 1 & 3	<0.0001	HS

The bold HS represents as Highly significant values.

flare-ups comprise mechanical, chemical and/or microbial injury to the pulp or periradicular tissues.⁶

Apical extrusion of infected debris to periradicular tissues is one of the principal causes of post-operative pain. It has been proved that maximum apical extrusion of debris and irrigating solution occurs with step-back technique using hand instruments in comparison to crown down technique done with rotary instruments.⁴ During step-back technique, the file acts as a plunger in the apical third to force the debris ahead of the file; thus leading to greater apical extrusion of debris.⁴

Majority of the studies have measured only the amount of debris extruded. In the present study amount of extruded debris and irrigant both were considered because both of them are responsible for periapical inflammation, post-operative pain and possible delayed healing.

In this study 1 ml of distilled water was used as an irrigant after use of each instrument irrespective of the technique used and working length for all specimens was determined 1 mm short of the apical foramen as it has been proved that least amount of extrusion was found in teeth that were instrumented 1 mm short of the foramen where apical plug was frequently found rather than the tooth instrumented to the apical foramen where an apical plug formation was usually not present.⁷ In this study, the pulpal tissues were removed before instrumentation to make sure that the debris extruded was dentinal shavings and not pulpal remnants. Decoronation of teeth after working length determination and before instrumentation also confirmed that an easy reference point was established. All the teeth were of similar length i.e. 21 mm and the size of master apical file was the same in all groups. Although sodium hypochlorite has been proved to be one of the best irrigating solution, it was not used in this study to avoid any possible weight increase due to NaOCl crystal formation. Thus, distilled water was used as an irrigant. In this study, three rotary systems were evaluated and it was observed that ProTaper (RP) followed

by Mtwo (RM) caused significant debris extrusion as compared to Hero shapers (RH). Though similar technique was used in all the groups for canal preparation but instrument design may affect the extrusion of debris. According to Walsch, the files with positive rake angle along with a variable helical flute angle enabled better dentin cutting efficiency and debris removal from the canal system.⁸ This could be a probable reason of less extrusion in Hero shapers as only two rotary files complete the canal preparation whereas both ProTaper and Mtwo system consists of 5 instruments. Placing in the canal could be a factor responsible for less apical extrusion of debris and irrigant.

Statistical analysis showed no significant difference between Mtwo (RM) and ProTaper (RP) but significant difference was observed when these two groups were compared with Hero shapers (RH).

The results obtained in this *in vitro* study, should not be directly extrapolated to clinical practice. In keeping with other authors, it may be considered that the persistence of residual pulp tissue in vital cases or the presence of periodontal tissue or even granulation tissue in chronic periodontitis could act as natural barriers and limit apical extrusion of debris and irrigant *in vivo*.

CONCLUSION

Within the limitations of this study it can be concluded that:

- All the rotary instruments tested produced apical extrusion of debris and irrigant.
- Hero shapers produced a minimum amount of extrusion among the tested groups.
- There was no significant difference among Mtwo and ProTaper groups.

A clinical study on post-operative flare-ups and complications with these three contemporary NiTi instruments would probably give a better understanding and clinical extrapolation of the results of this *ex vivo* study.

CONFLICTS OF INTEREST

All authors have none to declare.

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