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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF EFFICACY OF THREE DIFFERENT RETREATMENT REGIMENS IN GUTTA-PERCHA REMOVAL WITH AND WITHOUT CHLOROFORM – AN *IN VITRO* STUDY

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ABSTRACT

Background: A growing interest in endodontic retreatment has been seen recently to preserve teeth where endodontic therapy has failed. Effective removal of gutta-percha in endodontic retreatment is a significant factor to ensure a favorable outcome from failed procedures.
Objective: To compare the efficacy of two nickel-titanium rotary retreatment systems versus stainless steel hand files for gutta-percha removal with or without solvent.
Materials and Methods: Ninety freshly extracted human mandibular premolar teeth were prepared and filled. They were divided into 6 groups according to the type of retreatment regimen used: Gates-Glidden and H-files, Gates-Glidden and H-files with chloroform, ProTaper Universal rotary retreatment system, and ProTaper Universal rotary retreatment system with chloroform, MTwo R rotary system and MTwo R rotary system with chloroform. The teeth were longitudinally sectioned and photographed. The images were analyzed under stereomicroscope and the filling remnants were quantified by using the IMAGE TOOL 3.0 software. ANOVA and unpaired 't' test were used for analysis.
Results: A significant difference between the rotary retreatment files and hand files in regard to the amount of the endodontic filling remnants ($p>.05$) was seen.
Conclusion: All of the techniques proved helpful for the removal of endodontic filling material, but MTwo R rotary system without chloroform left cleaner canals as compared to other techniques.

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INTRODUCTION

There has been massive growth in endodontic treatment in recent years as patients have become more confident because of the changing perception that pain can be managed as techniques have improved and long-term success is achievable. (Ruddle, 2004) However, the success rate of endodontic therapy has been shown to be between 62% to 96%. (Sjogren *et al*., 1990) This indicates that a certain number of cases do not respond to initial therapy for many reasons such as apical percolation, root perforation, unfilled canals, co-existing periodontal lesions, gross overextension and underextension of filling materials or coronal leakage due to loss of restoration or recurrent decay. Most of these causes for failure may be amenable to intracanal retreatment. (Kirkevang *et al*., 2001) Nonsurgical endodontic retreatment, when indicated, requires regaining of access to the entire root canal system through complete removal of the pre-existent endodontic obturating material. (Sae-Lim *et al*., 2000) Gutta-percha removal can be achieved by using several techniques such as use of stainless steel hand files (K-type or Hedstroem files), use of rotary Gates Glidden drills, heat pluggers and recently an ultrasonic technique has become popular. Additionally, various flexible rotary instruments can also be used in a slow-speed handpiece.

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(Saad *et al*., 2007) Various rotary systems (ProFile, Quantec, GT Rotary, K3, ProTaper and RaCe) have been evaluated for root filling removal and root canal reinstrumentation. More recently, ProTaper Universal rotary retreatment system [Dentsply Maillefer, Ballaigues, Switzerland], has been developed which offers retreatment files designed specifically to remove obturation materials from root canals. (Reis *et al*., 2008) One of the newest rotary system for the purpose of retreatment is Mtwo [VDW, Munich, Germany] retreatment instruments. In addition to use of NiTi rotary instruments, use of a solvent is recommended to facilitate the removal of gutta-percha by softening it. (Tasdemir *et al*., 2008) However, in clinical practice, chloroform is the most effective and the most widely used solvent for gutta-percha. (Sae-Lim *et al*., 2000) Thus, the purpose of this *in vitro* study was to evaluate the efficacy of NiTi rotary instrument systems (ProTaper Universal rotary retreatment system and MTwo R system) versus stainless steel hand files (Hedstroem files) with or without solvent, for endodontic filling removal from root canals.

MATERIAL AND METHODS

Ninety freshly extracted single rooted human mandibular premolars with single, straight, patent canal and completely formed apices were selected for this study. The teeth were cleaned with ultrasonic piezo scaler [Guilin Woodpecker Medical Instruments Co. Ltd., China] and stored in distilled water containing 1% thymol solution until use. The crowns were removed with a diamond disk to leave a standardized root length of 15-mm. A size 10 K-file [Dentsply Maillefer, Ballaigues, Switzerland] was introduced into the canal until it was visible at the apical foramen. The working length was determined by subtracting 1 mm from this measurement. The cervical third was flared with sizes 4 and 3 Gates-Glidden drills [Mani Inc., Japan] in decreasing order. Root canals were prepared using a crown-down technique up to a size 35 K-type file [Dentsply Maillefer, Ballaigues, Switzerland] apically. At each change of instrument, the canals were irrigated with 3% sodium hypochlorite solution [AMBLE Healthcare Pvt. Ltd., India] per sample followed by 2 mL of 17% liquid ethylenediaminetetraacetic acid (EDTA) [PREVEST DenPro Ltd., India] for 3 minutes for smear layer removal, and the canals were again irrigated with 5 mL of 3% sodium hypochlorite. The root canals were dried with paper points [Dentsply Maillefer, Ballaigues, Switzerland] and obturated with 2% gutta-percha cones [Dentsply Maillefer, Ballaigues, Switzerland] and zinc oxide–eugenol sealer by using cold lateral compaction technique. The coronal access cavities were sealed with a temporary filling material (Cavit G; 3M ESPE). All teeth were stored at 100% humidity and 37°C for a period of 72 hrs to allow the sealer to set completely. Afterwards, the temporary filling material was removed and the teeth were randomly divided into 6 groups with 15 specimens each on the basis of technique used for gutta percha removal and based on the fact whether the solvent was used or not.

Hedstroem Files Group (Group A1)

The gutta-percha was removed from the coronal and middle thirds with sizes 3 and 2 Gates Glidden drills. A size 35 H-type file [Dentsply Maillefer, Ballaigues, Switzerland] was then introduced into the root canal until the working length was reached.

Hedstroem Files with Chloroform Group (Group A2)

Gates-Glidden drills sizes 3 and 2 were used to remove the coronal and middle thirds of the filling material. A 0.1 mL of chloroform was placed in the canal to soften the gutta-percha. A size 35 H-type file was then used to penetrate the softened gutta-percha until the working length was reached.

ProTaper Universal Retreatment Instruments Group (Group B1)

ProTaper Universal retreatment instruments [Dentsply Maillefer, Ballaigues, Switzerland] were used to remove the filling material. D1, D2, and D3 were used sequentially, applying a crown-down technique, until the working length was reached. The instruments were used with an electric motor [X-Smart; Dentsply Maillefer, Ballaigues, Switzerland] at a constant speed of 500 rpm for D1, 400 rpm for D2 and D3, with a torque of 3 Ncm.

ProTaper Universal Retreatment Instruments with Chloroform Group (Group B2)

The technique used was similar to that used in group B1, but 0.1 mL of chloroform was placed into the root canal after using instrument D1. Next, the softened gutta-percha was removed by using D2 and D3 sequentially until the working length was reached.

MTwo Retreatment Instruments Group (Group C1)

Mtwo retreatment instruments [VDW, Munich, Germany] were used to remove the filling material. MTwo R25/.05 and Mtwo R15/.05 instruments were used sequentially in a brushing motion with an electric motor [X-Smart; Dentsply Maillefer, Ballaigues, Switzerland] at a constant speed of 280 rpm and torque 3 Ncm for MTwo R15/.05 instrument and torque of 2 Ncm for MTwo R25/.05 instrument till the working length.

MTwo Retreatment Instruments with Chloroform Group (Group C2)

The technique used was similar to that used in group C1, but 0.1 mL of chloroform was placed into the root canal and the softened gutta-percha was removed by using MTwo R15/.05 instrument and MTwo R25/.05 instrument sequentially until the working length was reached. On withdrawal, the files were cleansed of any obturating material before being reintroduced in the root canal. Each file was discarded after being used in 5 canals. Irrigation with 3% sodium hypochlorite was performed during the procedure at each change of instrument. Retreatment was considered complete for all groups when no filling material was observed on the instruments. The teeth were grooved buccolingually with a diamond disk and sectioned longitudinally with chisel and mallet. Both root halves were photographed with a camera [Sony PC 120, Sony Corporation, Japan] adapted to a stereomicroscope under 8X

magnification (Figure 1). To evaluate the area of remaining filling material, the images taken were transferred to Image Tool for Windows v.3.00 software that computed and expressed the area using square pixels. Mean percentage values were calculated and compared. One-Way Analysis of variance ANOVA (p<.05) was used to compare the mean scores between the groups followed by unpaired "t" test for pair-wise comparison between the groups.

RESULTS

All of the teeth examined had some endodontic filling remnants in the canals. The mean percentage area of remaining gutta-percha/sealer in each group is shown in Table 1. No statistically significant difference (p<.05) was observed between the two rotary groups used (Table 2). However, two types of rotary NiTi instruments were significantly more effective than Hedstroem files in removing Gutta-percha during retreatment (p>.05). Moreover, a statistically significant difference (p<0.001) was observed between groups that used solvent and those which did not (Table 3).

Table 1. Mean & S.D. of without & with solvent groups for their % area of remaining filling material

S.No.	Groups	MEAN±S.D.	S.E.M.	Total (MEAN±S.D.)
1	A1	31.3507±7.5054	1.9494	38.954±12.0770
2	A2	46.5573±11.0414	2.868	
3	B1	25.1327±5.0903	1.322	29.625±7.7630
4	B2	34.1173±7.4617	1.9381	
5	C1	18.4653±3.0038	.7802	28.414±10.6307
6	C2	38.3627±3.6029	.9358	

A1 - Hedstroem files without solvent
A2 - Hedstroem files with solvent
B1 - ProTaper Universal retreatment instruments without solvent
B2 - ProTaper Universal retreatment instruments with solvent
C1 - MTwo retreatment instruments without solvent
C2 - MTwo retreatment instruments with solvent

Table 2. Comparison of difference in area of remaining filling material between with & without solvent groups using unpaired "t" test

S.No.	Pairs of groups	Probability of unpaired "t"	p- value / significance
1	A & B	.00083	p<.05 (SIGNIFICANT)
2	B & C	.6164	p>.05 (N.S.)
3	A & C	.00069	p<.05 (SIGNIFICANT)

A – Hand files retreatment group
B – ProTaper Universal retreatment group
C – MTwo retreatment group

Table 3. Comparison of difference in area of remaining filling material b/w without & with solvent groups using unpaired "t" test

S.No.	Pairs of groups	Probability of unpaired "t"	p- value / significance
1	A1 & A2	.00017	p<.05 (SIGNIFICANT)
2	B1 & B2	.00072	p<.05 (SIGNIFICANT)
3	C1 & C2	.00000	p<.05 (SIGNIFICANT)

A1 - Hedstroem files without solvent
A2 - Hedstroem files with solvent
B1 - ProTaper Universal retreatment instruments without solvent
B2 - ProTaper Universal retreatment instruments with solvent
C1 - MTwo retreatment instruments without solvent
C2 - MTwo retreatment instruments with solvent

Figure 1. Magnified image of split tooth under stereomicroscope showing remaining gutta-percha and sealer

DISCUSSION

Root canal therapy, despite having a high degree of success, may not lead to the desired response, and failure may occur. (Saad *et al*., 2007) Several publications reported failure rates of 14%–16% for initial root canal treatment. (Torabinejad *et al*., 2007) A growing interest in endodontic retreatment has been seen recently, caused by an increasing demand to preserve teeth. (Huang *et al*., 2007) The evolution of retreatment techniques and instruments and a better understanding of the factors involved in endodontic failure have pointed to conventional endodontic retreatment as the best choice. (Somma *et al*., 2008) The main goal of retreatment is to regain access to the apical foramen by complete removal of the root canal filling material, thereby facilitating sufficient cleaning and shaping of the root canal system and final proper obturation. (Stabholz and Friedman, 1998) In the present study, all root canals were prepared initially to an apical size 35 with a 2% taper stainless steel K-file to represent rather narrow and often unprepared root canals which frequently are found in retreatment cases. Probably preparation to sizes of 30 or even 25 may have been more appropriate from a clinical prerogative, but this would have resulted in of some of the instruments used for gutta-percha removal cutting not only gutta-percha but also dentin. In this study, stainless steel H-type hand files and gates glidden drills, ProTaper retreatment system, MTwo R retreatment system each with and without solvent were compared. The greater cleaning efficacy of NiTi rotary instruments may be attributed to the specific design characteristics of their cross-section compared with stainless steel hand files. (Hulsmann and Bluhm, 2004) More recently, upgraded ProTaper Universal system, includes three retreatment instruments (D1, D2 and D3) that are designed for removing filling materials from root canals. They have various tapers and diameters at the tip, which are size 30, 0.09 taper, size 25, 0.08 taper and size 20, 0.07 taper with full lengths of 16 mm for D1, 18 mm for D2 and 22 mm for D3 recommended to remove filling materials from the coronal, middle and apical portions of canals respectively. The retreatment series have a convex cross section, however, D1 has a working tip that facilitates its initial penetration into filling materials. (Gu *et al*., 2007) The active tip of the D1 file might facilitate the

penetration of the subsequent files (D2 and D3), as opposed to the shaping files (S1–S2) of the original ProTaper System that cannot penetrate the gutta-percha without fracturing the file tip. (Hulsmann and Bluhm, 2004) The nonactive tips of D2 and D3 reduce the incidence of ledging, perforation, and stripping during the removal of filling materials, as opposed to another retreatment instrument system, which has active tips for all retreatment instruments. (Giuliani *et al*., 2008) More recently introduced Mtwo-Retreatment system consist of two instruments – R 25/.05, for medium canals and R 15/.05 for narrow canals with active cutting tip. They have an S-shaped cross-section as do the files of the basic sequence, but a shorter pitch length to enhance the advancement of the file into the filling material. These instruments are characterized by two cutting edges, which is claimed to cut dentine effectively. (Bramante *et al*., 2010; Marfisi *et al*., 2010) These instruments have a cutting tip so that the instrument can progress easily in the filling material, and they might open the way to other instruments that will be used in the future. (Tasdemir *et al*., 2008) To facilitate the removal of filling material without damage to the tooth, various chemical solvents like chloroform, xylene, halothane, eucalyptol, turpentine etc. have been used for solubilization of gutta-percha. (Anil Kumar and Aliveni, 2009) Though chloroform possesses antibacterial activity; on the other hand the International Agency for Research of Cancer has classified this solvent as group 2B of carcinogens which indicates inadequate evidence of carcinogenicity in humans, but sufficient evidence of carcinogenicity in experimental animals. (Glickman, 1997; Maseiro and Barletta, 2005) A study by Allard *et al*. (1992) indicates that chloroform exposure of dental personnel can be kept within recommended guidelines by limiting the surface area of chloroform exposed to the operatory air. (Allard and Andersson, 1992) In the present study, chloroform was used during the instrumentation because it is more efficient in dissolving gutta-percha than other chemicals. Different filling materials have been tested for the efficacy of retreatment techniques by different methods, including radiography, clearing, projection of photograph onto a screen, stereomicroscopy, scanning electron microscopy, evaluation of digitized images using a scanner, micro-computed tomography and computed tomography. (Duarte *et al*., 2010) In the present study, the amount of remaining filling material was evaluated by longitudinal cleavage and quantitative analysis as a radiographic analysis provides a 2-dimensional view and has proved less effective than the cleavage method. (Takahashi *et al*., 2009) The present study used a specific computer software Image Tool for Windows v.3.00 for analysis of area of remaining filling material in square pixels. Delineation of the remaining filling material with aid of softwares is more precise than the utilization of scores. (Fariniuk *et al*., 2011) The results of the present study show that the groups receiving retreatment with a particular system with solvent left greater percentage area of remaining filling material than their counterparts receiving retreatment without solvent (Table 3). This might be because chloroform-softened gutta-percha seemed to be inadvertently distributed throughout the canal and resulted in a "filmy appearance" on the canal walls. (Sae-Lim *et al*., 2000) The thin film of filling materials thus formed may reduce the action of intracanal antibacterial medicaments, and impair the adaptation of subsequent filling material on the canal walls. (Gu *et al*., 2007) The results showed that MTwo R group without solvent left least percentage of area covered by remaining filling material among all the other groups (Table 1)**.** MTwo has a small core diameter, great chip removal capacity and great chip space that can result in great cutting ability. It has been reported that Mtwo instruments with positive rake angles act more like Hedström files and tend to remove bulks of filling material. (Hulsmann and Bluhm, 2004; Dadresanfar *et al*., 2011) However, convex triangular cross section of ProTaper D series instruments reduce their contact area with canal walls; this might be another reason for more filling remnants found in ProTaper group in the present study. Also, in contrast, the results of study conducted by Somma *et al*. (2008) showed that use of H-files for retreatment resulted in cleaner canal walls in the apical third compared with the engine-driven NiTi rotary systems (ProTaper retreatment files and MTwo R files). (Somma *et al*., 2008) It may be related to the master apical file size selected for retreatment in this study. The master apical file size for the manual retreatment was the same size as the file selected for the root canal preparation, whereas tip size was 20 and 25 for ProTaper retreatment files and MTwo R, respectively. Thus, it may be suggested that the use of retreatment NiTi rotary files to remove filling material quickly should be followed by hand instrumentation to refine and complete its removal and to obtain better canal wall cleanliness especially in the apical third further increasing the size of apical preparation.

Conclusion

Under the limitations of the present study, all the instruments used in retreatment, whether hand or rotary, left some filling material inside the root canal. However, when solvent was used along with the three retreatment regimens for removal of Gutta-percha, their efficiency dropped significantly when compared to their use without solvent. Also, MTwo R System without solvent left least amount of filling material after retreatment as compared to other experimental groups.

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