EFFECT OF PASSIVE ULTRASONIC IRRIGATION ON THE CLEANLINESS OF DENTINAL TUBULES IN ENDODONTIC RETREATMENT WITH AND WITHOUT SOLVENT – SEM STUDY

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CERTIFICATE

This is to certify that this dissertation titled **"EFFECT OF PASSIVE ULTRASONIC IRRIGATION ON THE CLEANLINESS OF DENTINAL TUBULES IN ENDODONTIC RETREATMENT WITH AND WITHOUT SOLVENT –SEM STUDY"** is a bonafide record work done by **ABHILASH. A** under our guidance during the study period between 2008-2011.

This dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY** in partial fulfillment for the degree of **MASTER OF DENTAL SURGERY – CONSERVATIVE DENTISTRY AND ENDODONTICS, BRANCH IV.** It has not been (submitted partially or full) for the award of any other degree or diploma

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CONTENTS

INTRODUCTION

Endodontic retreatment is indicated in cases where initial root canal treatment has failed and where there appears to be a deficiency in the initial treatment which may be correctable by retreatment.[89] Non surgical retreatment is a procedure to remove previously placed obturation materials, correct reasons for failure , clean / shape and re-obturate. (AAE)

Several explanations for failure of root canal treatment have been proposed including apical percolation, root perforations, unfilled canals, co-existing periodontal lesions and gross over and under extension of filling materials. Coronal leakage due to the loss of a restoration or recurrent decay may also contribute to endodontic failures.[33,17,20,68,59]

The main goals of orthograde retreatment are regaining access to the apical foramen by complete removal of the root filling material thus facilitating sufficient cleaning and shaping of the complete root canal system and final obturation and to reseal all portals of entry to prevent recurrence.[36]

Although various materials have been proposed for root canal obturation, gutta-percha in combination with a variety of sealers, mainly zinc oxide and resin based sealers are the most commonly used materials.[49]

The successful removal of gutta-percha and sealer is an important step in retreatment in order to uncover remaining necrotic tissues or bacteria that may be responsible for the persistant disease and enable thorough chemo mechanical reinstrumentation and redisinfection of the root canal systems[28,33,52,34,17]

Gutta percha removal can be effected by endodontic hand files, heat carrying instruments, ultrasonic devices, or rotary nickel-titanium retreatment instruments like Protaper , M2, R-Endo files with and without the aid of solvents.[49,66,43,68,17]. Removal of gutta-percha using hand files with and without solvents is time consuming, especially when the filling materials are well condensed . Nickel-titanium rotary instruments used successfully in root canal cleaning and shaping has also been proposed for removal of root filling materials. They have been proved to be more efficient and safer than traditional hand files.[28]

More recently , the Protaper NiTi rotary system has been upgraded to the Protaper universal retreatment system, which includes files for retreatment procedures. The results of various studies revealed that Protaper retreatment files removed gutta-percha more efficiently and faster compared to other retreatment techniques , even though none of the retreatment techniques completely removed the filling materials from the root canal walls.[28, 52,34,68]

Solvents for gutta-percha are used to adapt the apical portion of the master cone to the canal, to make a paste of gutta-percha that can be used for obturation, and to expedite the removal of gutta-percha from the canal during retreatment.[15] Few studies have revealed that the use of solvents have an adverse effect on bond strengths of adhesive cements to root canal dentin and also leads to more gutta-percha and sealer remnants on root canal walls and inside dentinal tubules[33,15,16,90] . But solvents are still used to soften and dissolve gutta-percha in the root canal to facilitate penetration of instrument and favouring removal of guttapercha.[33,15,16,90,86]

The use of solvent, Endosolv-R was introduced for removing resin based sealers like AH Plus sealer. This solvent has shown to penetrate deep into the dentinal tubules and remove the unfilled resin

sealer [94]. The removal of sealer cements from canal walls and from anatomical ramifications is necessary for effective disinfection and resealing of root canal. The removal of the root filling material from dentinal tubules seems to be essential in order to uncover bacteria , remove the smear layer that might be responsible for post treatment infection . Furthermore, root filling material remnants might reduce adaptation and adhesion of sealers and cements used for posts.[33,23,35,53,59,43]

Microorganisms remaining in the smear layer after the instrumentation of an infected root canal space can survive and re-infect the canal. The use of chemicals, ultrasonics and Lasers in combinations or alone , has been evaluated for the removal of the smear layer with varying results.[51,85,7.] Sodium hypochlorite has become the most widely used irrigating solution in endodontics due to its tissue dissolving and antibacterial properties.[48] The effectiveness of NaOCl to remove infected tissues from the root canal system may be enhanced by passive ultrasonic activation. The enhanced effectiveness of an irrigating solution to remove infected tissues by passive ultrasonic activation can be beneficial since

ultrasonic irrigation removed 86% of bacterial spores from the root canal while hand syringe irrigation removed only 62% of spores[48].

The use of passive ultrasonic irrigation has been found to eliminate bacteria from the canal more efficiently than hand instrumentation alone due to its ability to penetrate and distribute irrigating solution to apical third of canal and in uninstrumented areas. The 1 minute use of ultrasonically activated irrigation, following hand / rotary root canal cleaning and shaping, has been shown to improve canal and isthmus cleanliness in terms of necrotic debris /smear layer removal. [11,51,7,48,80]

Till date, there is no literature regarding the use of passive ultrasonic irrigation on evaluating the cleanliness of dentinal tubules after gutta-percha removal in endodontic retreatment

The aim of this in-vitro study was to evaluate, the effectiveness of passive ultrasonic irrigation on the cleanliness of dentinal tubules in endodontic retreatment with and without solvents in curved root canals using scanning electron microscope.

The objectives of this study were

1. To evaluate the cleanliness of mesiobuccal and distobuccal root canal walls of maxillary 1st and 2nd molars during endodontic retreatment using protaper universal retreatment files with and without the use of Endosolv-R solvent using SEM.
2. To evaluate the efficacy of passive ultrasonic irrigation on the cleanliness of mesiobuccal and distobuccal root canal walls of maxillary 1st and 2nd molars ; after endodontic retreatment using protaper universal retreatment files with and without the use of Endosolv-R solvent using SEM.
3. To compare the time required for gutta percha removal in endodontic retreatment using protaper retreatment files with and without Endosolv-R solvent.

REVIEW OF LITERATURE

Cameron [10] (1983) evaluated the efficacy of ultrasonics in the removal of the smear layer from the root canal walls using SEM study. The root canals of 35 extracted human teeth were chemo-mechanically prepared to clinical standards and then subjected to ultrasound for either 1, 3 or 5 minutes. The results indicated that one minute of ultrasound removed the superficial smear layer, but left the dentinal tubules sealed off. Three minutes of ultrasound, removed all of the superficial smear layer and most of the dentinal tubule plug layer. 5minutes of ultrasound removed all debris in instrumented and uninstrumented areas except for a few dentin chips.

Tamse et al [78] (1986) did a comparative study on various solvents. A method is presented in which four gutta-percha solvents (chloroform, xylene, Endosolv-E and orange terpenes) were compared for their effect on three brands of gutta-percha discs. The three brands were Hygenic, De-Tray and D.M.S. The results showed that chloroform was the most effective solvent for all gutta percha brands tested. D M S gutta percha was twice as soluble in chloroform as Hygienic ,while De – Trey was less soluble than either of the other

two brands. Endosolv – E is a relatively efficient solvent for De – Trey gutta percha.

Wilcox et al [87](1987) examined the appearance of root canal walls after retreatment (by taking photographs under uniform conditions using Kodachrome 25 film. Tracings of the root canal space, sealer, guttapercha and unknown debris were made for each sample at a magnification of X12 by projecting the slides onto a piece of white paper). Results showed that all teeth examined had some debris remaining in the canals. Using AH26 sealer had large amounts of debris, especially in the apical third.

Cameron [9] (1987) evaluated the synergistic relationship between ultrasound and NaOCl by Scanning Electron Microscope. The results indicated that 4%NaOCl, or ultrasound with water did not remove the smear layer. 4% or 2% NaOCl activated by ultrasound did not remove the smear layer from uninstrumented areas of canal wall. The study concluded that a synergestic relationship exists between sodium hypochlorite and ultrasound when they are combined during ultrasonic irrigation, while either component used by itself is unable to remove the smear layer.

Alacam [2](1987) compared the efficacy of different endodontic irrigating systems using SEM study.Results showed significantly cleaner canal wall surfaces in middle and apical levels in groups irrigated with Endomate and Ultrasound. The use of 3 minutes of Ultrasound or its combination with the Endomate system showed significantly cleaner surfaces and the smear layer was significantly reduced compared with syringe irrigation.

Stamos et al[75] (1988) presented two case repots in which Ultrasonics was used for retreatment. Cavi-Endo Ultrasonic unit was used for retreatment. A 15 size endodontic file was placed into the canal and activated with continous irrigation utilizing 2.6%NaOCl as irrigant which bypassed the canal blockage in the first case whereas a #15 Endosonic file activated with continuous water irrigation in the second case report. In both cases endosonic unit proved to be beneficial in retreatment.

Krell et al [45](1988) examined the irrigation patterns of K type endosonic files in 20 straight and 20 curved artificial canals. Results showed that#15 file required the greatest time for complete canal

penetration. Curved canals required less time for complete irrigant penetration than did the straight canals.

Ciucchi et al[12] (1989) compared the effectiveness of different irrigation procedures on the removal of smear layer on 40 curved canals. All canals were irrigated with 1ml of 3% NaOCl followed by 5ml of deionized water. After which the canals were irrigated with either 15% EDTA, EDTA combined with ultrasonic or NaOCl combined with ultrasound. SEM evaluation showed that neither NaOCl and EDTA, nor their combination with ultrasound succeeded in completely removing the smear layer apically in the canals.

Wourns et al [90] (1990) evaluated new or previously identified solvents like chloroform for effectiveness in dissolving Guttapercha. Each solvent was tested at 22^0 c(room temp) and 37^0 c (body temp). At 22^0 C Chloroform, tetrachloroethylene and trichloroethylene completely dissolved the gutta percha samples. At 37^0 c, complete dissolving of the gutta-percha occurred with solvents like chloroform, trichloroethylene, tetrachloroethylene, xylene, methylchloroform, Coe paste remover, halothane, orange oil and cineole.

Thomas et al [83] (1991) histologically evaluated the percentage of canal wall planning and the amount of soft tissue debridement of an Ultrasonic instrumentation system using tap water or NaOCl (2.6%) on extracted human mandibular 1st and 2nd molars with mesial canal curvatures of 18-35 degrees.Results showed that NaOCl, in conjunction with ultrasonic instrumentation was more effective than tap water in wall planning when the entire root length was considered. NaOCl in conjunction with ultrasonic instrumentation was more effective than tap water in soft tissue debridement in the middle third of the canal.

Wilcox et al[89](1991) evaluated the effect of retreatment in small and large canals on canal size, canal deviation and direction of canal movement. Results showed that most canal enlargement took place during the initial preparation. Less enlargement was significant only in the middle region, with small canals enlarging significantly more than large canals. The deviation away from the original canals were similar for both small and large canals. There was a trend for the canals to deviate more in the apical level , but it was not significant.

Abbott et al [1](1991) studied the effects of different irrigation sequences and ultrasonics on root canals of 30 extracted human teeth with single canals. The canals were irrigated with either savlon or savlon and ultrasound or EDTAC /NaOCl/EDTAC or EDTAC/NaOCl/EDTAC and ultrasound or NaOCl/EDTAC/NaOCl and ultrasound.Results showed that the most effective irrigation regime tested was EDTAC/NaOCl/EDTAC.

Wilcox et al [88](1991) studied the change in original canal size and location after canal preparation and after reinstrumentation using a step back technique. The results indicated that all canal areas increased after retreatment. The retreated canal increased in apical area significantly more (25.4%) than middle (4%) or coronal (3%) regardless of whether canal was large or small.

Jose et al [38](1993) assessed the retrievability of the plastic solid core of the Thermafil material using various organic solvents and hand instruments. Retreatment was done with one of the four solvents like chloroform, xylene, eucalyptol and halothane. K file was used to advance the solvent into the guttapercha and plastic carrier. Results showed that when chloroform ,halothane and xylene were

used as solvents the Thermafil plastic carriers were easily retrieved from the canal in approximately 2-3 minutes

Friedman et al [21](1993) assessed the efficacy of ultrasonic retreatment in canals obturated with single cone gutta-percha and ketac endo sealer. 42 straight roots of freshly extracted single and multirooted teeth obturated with guttapercha and ketac endo sealer. Either a size 40 guttapercha cone was used with or without lateral condenation. After 14 days, the canals were retreated using chloroform and ultrasonic instrumentation. The study concluded that root canal obturations were effectively removed by ultrasonic retreatment when condensed or single cone guttapercha was used together with ketac endo sealer.

Wilcox [86] (1995) compared the gutta-percha retrieval ability of halothane and chloroform and compared the time necessary for retreatment with both the solvents. After 14 months, gutta-percha was removed using either halothane or chloroform and the retreatment time was recorded.The results showed that neither method completely removed guttapercha from the rootcanals and no statistical difference were found between chloroform and halothane retreatment in

removing guttapercha from the rootcanal. Retreatment time with halothane was significantly slower than with chloroform, taking an average of 3.1 minute longer.

Farge et al [18] (1998) evaluated the effectiveness of Nd: YAP laser in endodontic retreatment. 35 freshly extracted straight and single rooted teeth were obturated with either guttapercha by lateral condensation or with zinc oxide eugenol and silver cones. Neodymium: Yttrium aluminium perovskite laser was used, alone or in combination with hand instruments, to remove various canal sealers. It is concluded that in combination with hand instruments, the Nd: YAP laser is an effective device for rootcanal preparation in endodontic retreatment.

Whitworth et al[85](2000) evaluated the disssolution of rootcanal sealer cements in volatile solvents chloroform and Halothane. The sealer used were AH plus Apexit, Tubliseal and ketac endo. Results showed that there are significant differences in the solubility profiles of major classes or root canal sealers in common organic solvents. Chloroform is a more effective solvent of root canal sealer than halothane.

Lim et al[49] (2000) investigated the retreatment effectiveness of profile.04 Taper rotory instruments. Retreatment was done with either using profile alone or using profile and chloroform solvent or with hand files and chloroform. Results showed that the whole canal mean score for profile group lower than the other two groups. It was concluded that profile with or without chloroform seemed to be a viable alternative retreatment method.

Metzger et al[29](2000) evaluated the efficacy of Hemo-De(which is a xylene substitute containing 4-isopropenyl-1-methyl-1-cyclohexane as the active ingredient) in softening guttapercha. Results showed that the highest solubility of all kinds of gutta-percha was in chloroform.It was concluded that Hemo-De can be used to as a alternative for xylene since it permits slow softening of guttapercha, less volatile and biologically safe material.

Imura et al [39](2000) examined the cleanliness of root canal walls after retreatment using two engine driven instruments (Quantec and profile) and compared with Hedstrom file and K file using streomicroscope. Results showed that in all groups cervical and middle thirds were free of debris. The results showed that all

instruments leave filling material inside the rootcanal and during retreatment there is a risk of instrument breakage, especially with the rotary instruments.

Barrieshi[4] (2002) examined and compared the removal of guttapercha and sealer from the rootcanal system after retreatment with stainless steel hand files versus NiTi rotary instruments. Results showed that all the teeth examined had some debris remaining in the canals, most being sealer. The study concluded that both NiTi and SS hand files were as effective in removing guttapercha /sealer from the rootcanal system, but hand files were a bit faster.

Guerisoli et al[29](2002) evaluated the smear layer removal using sodium hypochlorite associated with EDTAC irrigation and ultrasonic agitation on 20 recently extracted mandibular incisors with single root canal. Results showed that 1.0% NaOCl associated with 15% EDTAC is efficient in removing the smear layer from root canal walls.

Viducic et al[82](2003) examined the use of an Nd:YAG laser in removing gutta percha and sealer root fillings without solvent or with eucalyptol or dimethylformamide (DMF) as solvents. The root canal

filling were removed with pulsed Nd:YAG laser irradiation of 20Hz/ 1.5W from the roots where different solvents like eucalyptol or DMF were used.. The study concluded that use of and Nd:YAG laser alone is capable of softening guttapercha *in vitro*, but the addition of solvents did not improve its removal.

Hulsmann et al[35](2004) evaluated the efficacy, cleaning ability and safety of three different rotary NiTi systems with and without eucalyptol versus hand files in the removal of guttapercha root fillings. The three different rotary systems used were Flexmaster, GT rotary, and Protaper. Results showed that all three rotary NiTi systems proved to be helpful and safe devices for guttapercha removal in orthograde endodentic rettreatment. Flexmaster and Protaper instruments proved to be more efficiant and time saving devices for the removal of guttapercha. The use of eucalyptol as a solvent helped to reduce working time and to ennhance root canal cleanliness.

Lee et al[48] (2004) evaluated and compared the ability of syringe irrigation and ultrasonic irrigation to remove artificial dentine debris from simulated canal extensions and irregularities. Results

showed that both forms of irrigation reduced the debris score significantly and debris score was significantly lower for ultrasonic irrigation than syringe irrigation.

Gambrel et al[22] (2005) determined if any of six common endodontic solutions have a significant softening effect on the set resorcinol formalin paste in extracted teeth, and if there were any differences in the solvent action between these solutions. The solutions tested were chloroform, Endosolv R, 5.25% NaOCl, 0.9% sodium chloride, 3% H_2O_2 and 70% isopropyl alcohol. Results showed that none of the groups differed in the penetration depth at 2 or 5 minutes. At 10 and 20 minutes, the mean change in penetration with H_2O_2 was significantly less. At 20 minutes Endosolv R had significantly greater penetration than 5.25% NaOCl and Chloroform.

Gutarts et al[30] (2005) histologically compared the *in vivo* debridement efficiency of hand/rotary canal preparation versus a hand/rotary/ultrasound technique in mesial root canals of 36 vital mandibular molars. The results showed that addition of 1 minute of ultrasonically activated irrigation significantly improved the overall mean canal cleanliness values at all 10 apical levels. The addition of

ultrasonic irrigation also produced more consistent cleaning of the canals. Isthmus cleanliness values improved from the 1 mm to 3mm level within the hand/rotary group, however the cleanliness values only ranged from 15 to 38%.

Masiero et al[53] (2005) evaluated the effectiveness of various techniques for removing guttapercha during retreatment from 80 extracted mandibular premolars. The amount of filling debris remaining on the rootcanal walls was assessed radiographically. Results showed that none of the technique removed all filling materials from the root canals. The apical third had the most remaining material,whilst the cervical and middle thirds were significantly cleaner. The teeth instrumented with K3 rotary instruments had a lower ratio of remaining filling material in the apical third.

Maciel et al[52] (2006) compared manual and automated instrumentation technique for removing filling materials (guttapercha and sealer 26 and Endofill) from 100 extracted human single rooted canal walls in rootcanal retreatment. The filling material was removed using the following techniques. Group 1 gates glidden and K-type

files, Group2-profile, group3-Protaper, group4-K_3, group 5-Micromega Hero 642. The remaining filling material was evaluated using stereomicroscope by Epiluminescence and photomicrographs. Results showed that no significant differences were found between the amount of filling debris removed when comparing the sealers. Manual instrumentation left more filling debris on the rootcanal walls when compared to K3 and Protaper.

Zmener et al [92](2006) compared *ex vivo* the efficiency of hand versus automated instrumentation when retreating oval shaped root canals. Retreatment done with either Profile 0.4 taper rotary instruments or with an Anatomic endodontic technology. The results showed that complete clean canal walls could not be achieved with any of the three techniques used for retreatment. The mean percentage of remaining guttapercha/ sealer was significantly higher for the profile group in the canal and middle third of the canal.

Kosti et al [43] (2006) compared the efficacy of Profile rotary system and Hedstrom file used in combination with Gates-Glidden drills during the removal of root fillings comprising of guttapercha and different sealers. The results showed that AH26 left more debris

than the other sealers. Endion, Roth 811 and Roekoseal were associated with approximately the same amount of filling materials in the middle third of the root canal, whereas in the apical 3rd the Endion was associated with significantly more remnants of filling material than the other two sealers with either Profile or H-files.

Neto et al[57](2006) evaluated invitro, by histological and morphometrical analysis, the cleaning capacity of profile GT rotary system associated with different irrigation protocols in the apical third of 36 human mandibular incisors. The results showed that the rotary instruments with NiTi-files associated with final irrigation of 1% NaOCl energised by ultrasound leads to better debris removal from the apical third of mandibular incisors. The use of profile GT system combined with the irrigation with 1% NaOCl energised by ultrasound for 5 minutes, showed a higher cleaning capacity of the canal apical third, followed by the protocols that used ultrasound for 3 minutes and 1 minute respectively.

Schirrmeister et al[68](2006) evaluated the efficiency of Flexmaster, ProTaper and Race rotary instruments compared with Hedstrome files for removal of guttapercha during retreatment. The

results showed that Race instruments showed less remaining obturation materials and were faster compared to Hedstrome files. Protaper and race instruments required significantly less time for retreatment than Flexmaster and Hedstrome files.

Ezzie et al[17](2006) determined the effectiveness of rotary instrumentation in conjunction with heat or solvent in Resilon/ Epiphany obturation retreival as compared to guttapercha during root canal retreatment. The result showed that chloroform combined with rotary files was more efficient in material removal compared to heat. Canals obturated with Resilon had cleaner walls in the apical 3rd after the material was removed by either of the technique. Resilon was faster to remove guttapercha.

Burleson et al[7] (2007) histologically compared biofilm/necrotic debris debridement efficacy of a hand/rotary instrumentation technique to a hand/rotary instrumentation plus one minute ultrasound technique in the mesial roots of human, necrotic mandibular molars. The 48 mesial roots were divided in to 3 groups. Group 1 consisted of 20 teeth, where canal prepared with K hand files and rotary Profiles GT. In Group 2 canal were prepared with K hand

files and rotary profiles GT followed by one minute of ultrasonic irrigation, per canal utilizing needle in a Miniendo unit. Histological examination showed that for canal cleanliness there was a significant difference at apical levels between the two techniques and even with isthumus cleanliness.

Huang et al[34](2007) quantitatively evaluated the amount of debris extruded beyond the apical foramen during endodontic retreatment when comparing the Protaper universal system with traditional hand filling/ solvent techniques. In group A, guttapercha removed using protaper universal retreatment system and canals were reprepared with protaper rotary files. In group B, retreatment alone with Hedstrom files with choloroform, and canals were reshaped with protaper rotary files. In group C, retreatment done with H files and choloroform, and canals were reshaped with k flex files and apical debris collected were compared. The results showed the amount of apical debris presented for all groups and no statistical difference observed between the groups when chloroform was used as a solvent.

Gergi et al[23](2007) compared the effectiveness of hand files, Protaper and R – Endo rotary instruments for removing guttapercha in

curved root canals. 90 extracted teeth with severe angles of curvature between $25^0$and 70^0 were instrumented with K files and Hero 642 rotary instruments and obturated with vertically condensed guttapercha (System B technique) and with Kerr EWT sealer. The results showed that all the instrument left filling material inside the root canals. The apical 3rd of the canal had the most remaining filling material compared with the middle and cervical 3rd.

Sluis et al [72] (2007) evaluated the influence of Passive ultrasonic irrigation on the seal of root canal fillings. A total of 40 mandibular premolars were divided into two groups and instrumented with K file and GT rotary system. After instrumentation 20 teeth filled with 2% NaOCl (using a syringe and needle) and canals were ultrasonically activated with 15 size stainless steel wire for 1 minute. This was repeated thrice resulting in a total irrigation time of 3 minutes and total irrigation volume of 6ml. In another 20 teeth, were irrigated with 6ml of 2% NaOCl by syringe irrigation instead of passive ultrasonic irrigation(PUI). After irrigation, canals were obturated with gutta percha and AH26 sealer using the warm vertical compaction technique with the System B device. Results showed that after the first month, the root fillings in teeth when PUI had been used

sealed the root canal significantly better than in the teeth where PUI had been not used.

Cunha et al [13](2007) evaluated the obturation removal and reinstrumentation working time of canals filled with Resilon/Real seal in comparison with canal obturated with guttapercha /AH plus sealer. Results showed that Resilon/Real seal system was better removed from the canal walls than the guttapercha/AH plus group. No significant statistical difference noticed in the time needed for retreatment in both the groups. The SEM analysis showed presence of debris in the canal walls, which were not observed in the radiographic image.

Lui et al[51] (2007) compared the in vitro efficacy of Smear clear (17% EDTA with surfacants) to 17%EDTA, with and without the use of ultrasonics, in removal of smear layer. SEM evaluation showed that addition of surfacants to EDTA in Smear clear did not result in better smear layer removal when compared to EDTA alone. The study concluded that a 1 minute application of ultrasonic irrigation with 17% EDTA followed by a final flush of NaOCl was

very successful in obtaining clean, smear free walls in instrumented and relatively straight root canals.

Saad et al[66] (2007) evaluated the efficiency of Protaper and K3 in the removal of guttapercha during root canal retreatment in comparison with hand Hedstrom files. Results showed that Protaper and K3 left significantly less remaining filling material than Hedstrom file. The Protaper and K3 required almost similar time period for retreatment but less time required for retreatment compared to Hand instruments.

Gu et al [28](2008) evaluated the efficacy of the Protaper universal rotary retreatment system for guttapercha removal from the root canalsThe results showed that all techniques left 10 -17 % of the canal area covered by guttapercha/sealer remnants and mostly sealer. Mean operating time for Protaper retreatment system was significantly shorter (6.73min) compared to other groups.

Tasdemir et al[79] (2008) evaluated the efficacy of two rotary nickel titanium instruments(R-Endo, M two)and hand instruments to remove guttapercha and sealer. Computer image analysis showed that all instruments left filling materials inside the rootcanal. The Protaper

group had less filling material inside the rootcanals, but significant difference was found between the Protaper and M two groups even in the retreatment time. R-endo was significantly faster than manual instrumentation.

Reis et al[65] (2008) evaluated the efficacy of Protaper universal rotary retreatment system and handfiles for removal of filling material during retreatment and the influence of the type of sealer on the presence of filling debris in the reinstrumented canals. 60 palatal roots of maxillary first molars were obturated with gutta-percha and either a zinc oxide eugenol based sealer (Endo fill) or a resin based sealer(AH plus sealer) using thermoplasticized guttapercha technique. Results showed that debris was left in all canal thirds, regardless of the retreatment technique. The greatest difference between technique and sealers were found in the middle third, with less amount of debris in canals obturated with Endofill and reinstrumented with hand files. Both Protaper universal rotary retreatment files and handfiles had similar cleaning efficacy in the apical third, regardless of the sealer.

Somma et al[73](2008) compared the effectiveness of the M two R and the Protaper retreatment files with a manual Hedstrom files in

the removal of three filling materials (guttapercha, Resilon and Endorez) during retreatment. Optical stereo microscopy and SEM analysis showed that all instruments left remnants of filling material and debris on the rootcanal walls mostly in middle and apical third irrespective of the root filling used. The M two R, Protaper retreatment files and Resilon filliing material had a positive impact in reducing the time for retreatment. Both Protaper and Mtwo R showed a greater extrusion of debris. EndoRez filling material resulted in cleaner canals than teeth filled with Resilon.

Giuliani et al [24] (2008) evaluated the efficacy of the Protaper universal rotary retreatment system and of Profile 0.06 and hand instruments (K files) in the removal of the root filling materials. The study showed that Protaper and Profile rotary systems were significantly faster for retreatment than the K hand files. The Protaper universal system for retreatment files left cleaner root canal walls than the K file hand instruments and the Profile rotary instruments, although none of the devices used, guaranteed complete removal of the filling materials.

Unal et al[81] (2009) compared the efficacy of conventional and rotary NiTi instruments (Profile, Protaper and R endo) to remove guttapercha in curved rootcanals. The results showed that none of the techniques completely removed the root filling materials. The greater amount of filling material remained in the apical third than in the middle and cervical third. No significant difference was found regard to apically extruded material. Time required for retreatment was more rapid for Protaper and manual instruments than Profile group. Five fractured instruments and two perforations were noted when using Protaper and remaining filling material was significantly less following manual instrumentation than R-Endo and Protaper instrumentation.

Horvath et al [33](2009) determined the influence of solvents on gutta-percha and sealer remaining on root canal walls and in dentinal tubules. The results showed that open dentinal tubules were more prevalent in control group, followed by the non solvent group, the eucalyptol group and the chloroform group. Less surface was covered by root filling remnants in the non solvent group than in the eucalyptol group and the chloroform group again.

Pirani et al[63] (2009) evaluated the root canal wall morphology under SEM magnification after removal of 2 types of root canal fillings by using Ultrasonic tips, NiTi rotary instruments and hand K files. The results showed that none of the technique completely removed filling debris from the dentinal tubules of apical third. All retreatment techniques showed similar performances in terms of smear layer morphology, amount of debris and surface profile. Retreatment techniques for teeth with filled with AH Plus/Thermafil produce a dentin morphology similar to that obtained with AH Plus/Warm condensed guttapercha.

Takahashi et al[77] (2009) evaluated the efficacy of Protaper University rotary retreatment system with or without solvent versus stainless steel hand files for gutta-percha removal from root canal. Results showed that all techniques had some endodontic filling remnants in the canals, but the Protaper Universal retreatment system without chloroform was faster.

Kuah et al [46] (2009) evaluated in vitro the various regimens for the removal of the smear layer at the apical 3rd of the instrumented root canal. The effectiveness of EDTA irrigation with and without

the use of Ultrasonic and the efficacy between a 1minute and 3 minute application of ultrasonics was examined. The study concluded that 1minute application of EDTA with ultrasonics followed by a final flush of NaOCl is efficient for smear layer and debris removal at the apical region of the instrumented root canal.

Fenoul et al[19](2010) evaluated the efficacy of R-Endo rotary NiTi instruments and hand instruments to remove guttapercha or Resilon from root canals. SEM results showed that remnants of the root filling materials were observed in all the specimens regardless of the root filling material or retreatment technique used. The filling debris was found mainly in the apical 3rd than in middle or coronal 3rd. However time to reach working length and for removal of filling material were lower with R-Endo than with Hedstrom files.

Jiang et al [41] (2010) evaluated the removal of dentin debris from the root canal by Sonic or Ultrasonic activation of the irrigant and the physical mechanism of Sonic activation by visualizing the oscillations of the Sonic tip. Results showed that 89% of the canals were completely free of dentin debris ,in groups activated with

ultrasonic , whereas from the Sonic group 5.5%-6.7% were free of debris.

Zou et al [93] (2010) evaluated the effect of concentration ,time of exposure and temperature on the penetration of NaOCl into dentinal tubules. 108 stained blocks were treated by 1%,2%,4% and 6% NaOCl for 2, 5 and 20 minutes at 20º c, 37º c and 45ºc respectively. The depth of penetration of NaOCl was determined by bleaching at the stain and measured by light microscopy at 20X and 40X magnification. The results showed that shortest penetration (77µm) was measured after incubation with 1% NaOCl for 2minutes at room temperature. The penetration(300µm) was obtained with 6% NaOCl for 20 minutes at 45ºc. After the initial penetration during the first 2minutes ,the depth of penetration doubled during the next 18 minutes of exposure. Within each time group,depth of penetration with 1% NaOCl was about 50-80% of the values with the 6% solution.

Sluis et al[71] (2010) evaluated dentin debris removal from the root canal during Ultrasonic activation of NaOCl (2% and 10%) , carbonated water and distilled water and to determine the influence of

3 Ultrasonic activation cycles of the irrigant by using the intermittent flush technique. The results showed that Ultrasonic activation of the irrigant combined with the intermittent flush method produces a cumulative effect over 3 activation cycles. NaOCl as an irrigant is significantly more effective than carbonated water, which is significantly more effective than distilled water, in removing dentin debris from the root canal during Ultrasonic activation.

MATERIALS

1. Freshly extracted mesio-buccal and disto- buccal roots of human maxillary molars (1st and 2nd molars, 15- 30 degree curvature)
2. Glyde (Denstply)
3. 3% NaOCl solution
4. Saline
5. Gutta-percha points(2% taper) (Dentsply)
6. AH Plus sealer (Dentsply)
7. GIC cement(Type II) (GC)
8. Endosolv-R solvent (Septodent)
9. Mixing pad
10. Cement spatula
11. Spreader 15,20 size (mani)
12. Disposable Syringe and needle
13. Paper points(Denstsply)

ARMAMENTARIUM

1. Hand K- files (21mm length -10,15,20,25 size) (Mani)
2. Protaper universal rotary files SX,S1,F1 and F2 (Denstply)
3. Protaper universal Retreatment files (D1,D2 and D3) (Denstply)
4. Ultrasonic irrigating tip , K file - 15 size (Satelec)
5. Airotor (Kavo)
6. Ultrasonic unit (Satelec)
7. Scanning Electron Microscope (Hitachi , S 3400)

METHODOLOGY

Sixty freshly extracted human maxillary molar teeth (both 1st and 2nd molars) were selected for the study. The teeth were cleaned ultrasonically for removing calculus and debris. Following decoronation, the mesiobuccal and distobuccal roots were separated using a double sided flexible diamond disc.

Selection criteria of teeth

From the above roots, 36 roots(either mesiobuccal or distobuccal) fulfilling the following selection criteria were selected for the study:

Mesiobuccal and distobuccal roots of maxillary molars having curvature more than 15ºto 30º (curvature determined by radiograph){*Schneider method*}, teeth with no calcification, no internal resorption, no previous rootcanal filling, and fully formed apices were used in this study. The average length of root selected were 16mm.

The distobuccal and main mesiobuccal canals were only included in this study. The incidence of second mesiobuccal canals or

any additional canals were not considered in this study.

All 36 root samples were inserted with 10 no:K file until it could be seen at the apical foramen. The working length was established 1mm short of this length.

Canal preparation

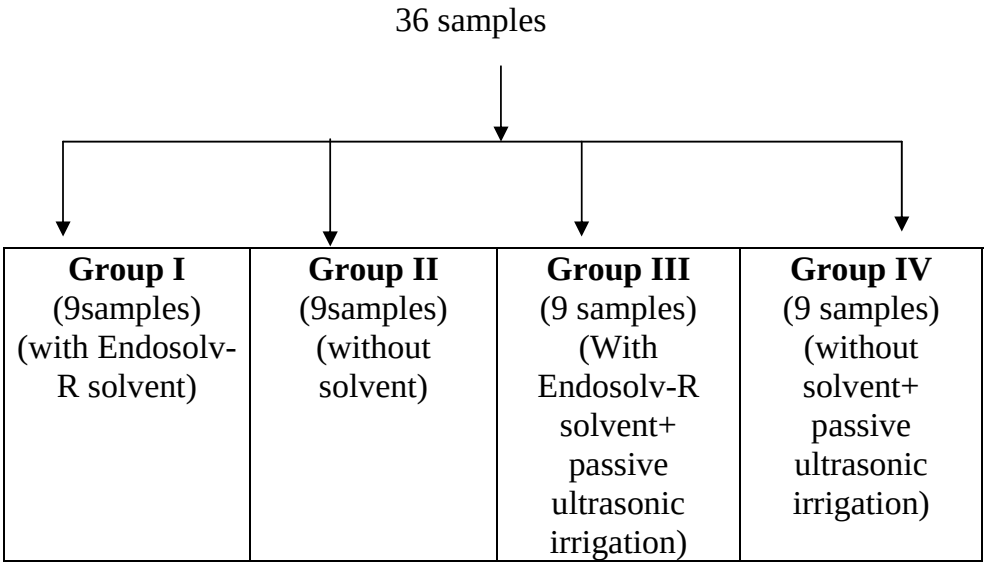
Root canals (distobuccal and main mesio-buccal) were prepared with protaper rotary instrument upto size F1 in a crown down technique under copious irrigation with 3% NaOCl(2ml) and Glyde. Final rinse was done with saline solution (1ml) in all the canals using disposable syringe and needle.

Canal obturation

All roots were dried with paper points, then obturated with gutta-percha (2% cones/Dentsply) and AH Plus sealer (Dentsply) by lateral condensation method. The extent of the root filling was limited to 14mm from the apex for standardization. Excess gutta-percha was removed and the roots were radiographed in order to confirm the adequacy of root filling. The access cavities were filled with Type II GIC (GC). All roots were stored at 37°centigrade in 100% humidity for 2 weeks before commencing the retreatment programme.

Endodontic retreatment protocol

The 36 root samples were randomly divided into 4 groups of 9 samples each.



Group 1

The 9 samples were instrumented with Protaper retreatment files D1, D2 and D3 with crown down technique to remove gutta-percha until the working length with 0.5ml of Endosolv-R solvent (66.5% Formamide and 33.5% Phenylethelic acid). 2 drops of solvent was used in between retreatment files to soften the filling materials. The gutta-percha was removed using light apical pressure at 500-700 rpm. During instrumentation 17% EDTA followed by 3% NaOCl

was used as irrigants. After gutta-percha removal ,the canals were irrigated with saline solution (1ml). Further instrumentation was done with protaper rotary file size F2 upto the working length. Finally canals were dried with paper points Time was recorded from the beginning of instrument use till the use of paper points to dry the canal.

Group II

The 9 samples were instrumented with Protaper universal retreatment files (D1, D2, and D3) with crown down technique to remove gutta-percha until the working length, without using any solvent.The gutta-percha was removed using light apical pressure at 500-700 rpm. During instrumentation 17% EDTA followed by 3% NaOCl was used as irrigants. After gutta-percha removal, the canals were irrigated with saline solution (1ml). Further instrumentation done with protaper rotary file size F2 upto working length. Finally canals were dried with paper points. Time was recorded from the beginning of instrument use till the use of paper points to dry the canal.

Group III

The 9 samples were instrumented with Protaper universal retreatment files (D1, D2, and D3) with crown down technique to remove gutta-percha until the working length, with Endosolv-R solvent as group 1. The 9 samples of this group were then irrigated with passive ultrasonic irrigation (Satelec Ultrasonic Unit) using 3%NaOCl as an irrigant.

Passive ultrasonic irrigation protocol

Passive ultrasonic irrigation with intermittent flow was used in this study. A total volume of 4 ml of 3% NaOCl was used. The canals were initially irrigated ultrasonically using 1ml of 3%NaOCl with K 15 size files ,which was placed 2mm above the apical end; for 1minute. Then canals were irrigated with 1ml of 3% NaOCl using disposable syringe and needle. Passive ultrasonic irrigation with 1ml of 3 % NaOCl for 1 minute was repeated and final irrigation with 1ml of 3%NaOCl using syringe and needle.

Group IV

The 9 samples were instrumented with Protaper universal retreatment files (D1, D2, and D3) with crown down technique to

remove gutta-percha until the working length, without using any solvent as group II. The 9 samples of this group were then irrigated with passive ultrasonic irrigation using 3%NaOCl as an irrigant as in group III.

SCANNING ELECTRON MICROSCOPE (SEM) EVALUATION

The root surfaces of 9 samples from each group were grooved horizontally at a distance of 3,6 and 10mm from the anatomical apex, in order to define the apical, middle and coronal position for the SEM images . The roots were split longitudinally using safe sided flexible diamond discs. After splitting, the root halves were washed with 0.5ml of saline solution in order to remove any cutting debris during splitting.

For SEM analysis , one half of the split root of all the specimens were dehydrated at 37 degree C for 7 days and sputtered with gold(SCD 050 Sputter Coater) and the coronal middle and apical thirds of root halves were examined using SEM ((Hitachi ,S-3400) and at a standard magnification of 2000X. The total number of dentinal tubules and the number of dentinal tubules either completely

or partially filled with materials were evaluated for the coronal, middle and apical third of each root half.

Parameters evaluated

1. The cleanliness of dentinal tubules on root canals at coronal, middle and apical level after endodontic retreatment with and without Endosolv-R solvent.
2. The cleanliness of dentinal tubules on root canals at coronal, middle and apical level after endodontic retreatment with and without Endosolv-R solvent and after passive ultrasonic irrigation
3. Time required in minutes (using stop watch) for gutta-percha removal on endodontic retreatment using protaper universal retreatment files with or without Endosolv-R solvent.

Statistical analysis

For statistical analysis, the ratio of total number of dentinal tubules and the number of dentinal tubules either completely or partially filled with materials were recorded for all 4 groups. The mean time of gutta-percha removal was also evaluated. Parametric one-way analysis of variance (ANOVA) test was used to identify significant differences among the four groups. Tukey's post hoc

multiple range test was used to determine which group was significantly better. All calculations were completed using Proc mixed with the repeated statement from the statistical software SAS 9.1.2(USA).The significant level was set at $p<0.05$.

Fig. 1 : ARMAMENTARIUM

Fig.2:DECORONATION OF TOOTH USING FLEXIBLE DIAMOND DISC

Fig.3: DECORONATED MESIOBUCCAL AND DISTOBUCCAL ROOTS

Fig.4: INSTRUMENTATION OF ROOT CANAL WITH PROTAPER FILE

Fig. 5: PROTAPER UNIVERSAL ROTARY RETREATMENT FILES

Fig. 6 : GUTTAPERCHA AND SEALER REMOVING WITH PROTAPER RETREATMENT FILE

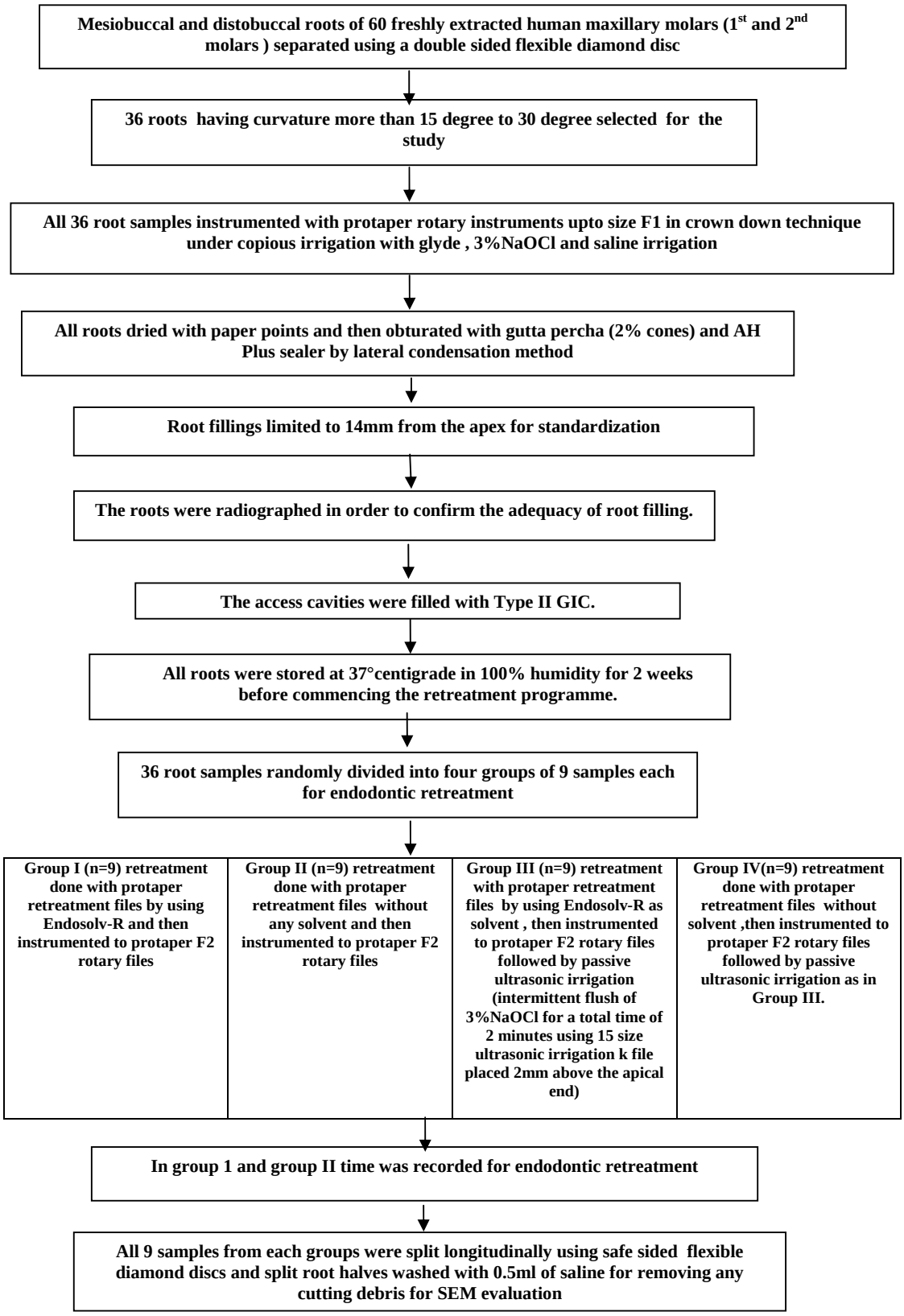
Fig. 7: SATELEC ULTRASONIC UNIT

Fig. 8: PASSIVE ULTRASONIC IRIGATION WITH 15 K FILE ULTRASONIC TIP

Fig.9: LONGITUDINALLY SPLITTED ROOTS IN BUCCOLINGUAL DIRECTION

Fig. 10:SCANNING ELECTRON MICROSCOPE

Methodology –Flowchart



RESULTS

1. Figure11 and Figure 12 shows the representative SEM images of all the four groups in this study. The SEM images showed more number of open tubules in Group IV (without solvent+ passive ultrasonic irrigation). All the groups in all the sections showed partially or completely blocked dentinal tubules with debris. The images in all the groups showed more number of open tubules in middle third and least in apical third of the canal walls. None of the groups completely removed the filling materials from the canal walls.
2. Table 1 shows the comparison of mean and standard deviation of ratios of open dentinal tubules/total number of dentinal tubules in all the four groups. Between the solvent(Group I) and without solvent(Group II) , without solvent group showed more open dentinal tubules which was statistically significant($p<0.05$). Between the solvent+ passive ultrasonic irrigation group (Group III) and without solvent+ passive ultrasonic irrigation group (Group IV) , Group IV showed more open dentinal tubules which was statistically significant($p<0.05$). Among the four groups, Group IV showed the highest rate of open dentinal tubules.

3. Table 1 also indicates that more number of open dentinal tubules were found in the middle third of the canal and least in the apical third for all the four groups. This was statistically significant ($p<0.05$). When comparing all the four groups in Table 1, it is seen that more open tubules were present in Group IV followed by Group III, Group II & Group I respectively. The mean differences between all the groups were statistically significant.($p<0.05$)
4. Table 2 shows the ratio of number of open tubules/total number of tubules between coronal, apical and middle (multiple comparison) within the groups.

   The mean difference between the coronal, middle and apical third in each group is found to be statistically significant. The middle third has more number of open tubules which indicates that cleanliness of dentinal tubules are more in middle third.
5. Table 3 shows the mean time (in minutes) required to remove the gutta-percha and AH Plus sealer, with and without Endosolv-R solvent. The retreatment time has been shown less for the samples where Endosolv-R is not used. The time difference is statistically significant.

All the four groups in this study did not remove the filling materials completely from the root canals. The without solvent + passive ultrasonic irrigation (Group 1V) (mean ratio .4928±.11034) left more open tubules among the four groups followed by solvent +passive ultrasonic irrigation (Group III) (mean .4167±.10754). The group with solvent alone (Group I) (mean .2439±.07309) showed less number of open tubules followed by without solvent group (Group II) (mean.3483±.10629). The difference between the groups were statistically significant ($p<.0.05$). More open tubules were found in middle third of all the four groups followed by coronal third and apical third. Coronal (mean.3825±.08548), middle (mean .4875±.11745) , apical (mean .2563±.08360). The difference were statistically significant for coronal, middle and apical third ($p<0.05$).

Regarding the retreatment time for gutta-percha and AH Plus sealer removal from the root canal, the groups without using any solvent performed faster than the groups using Endosolv-R solvent. The retreatment time was significantly shorter for without solvent group (mean 4.3304±.48336) compared with solvent group (mean 5.3361±.31561). The mean difference is statistically significant ($p>0.05$)

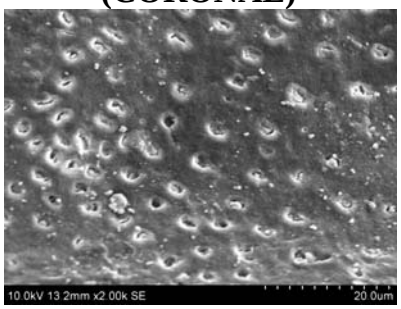
SEM IMAGES

The SEM images of all the four groups are shown in Figure 11 and Figure 12.

FIGURE 11

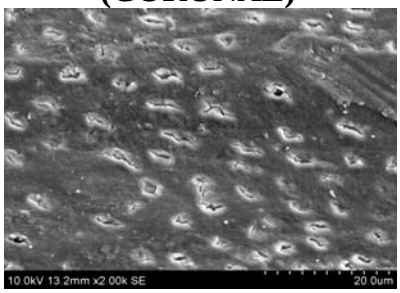
Group I(solvent)

(CORONAL)

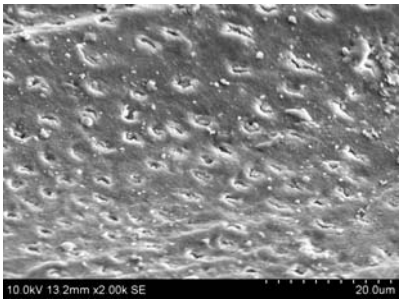


Group II(without solvent)

(CORONAL)



(MIDDLE)



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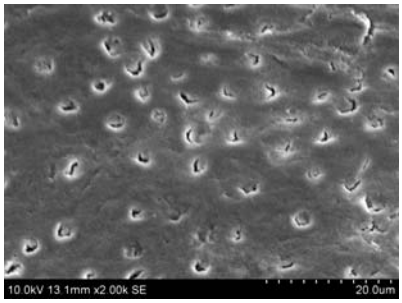
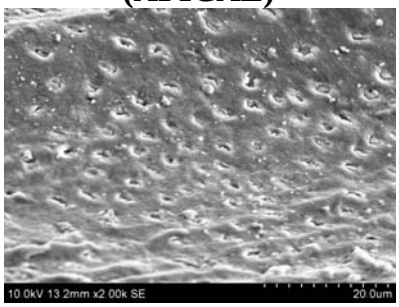


(APICAL)



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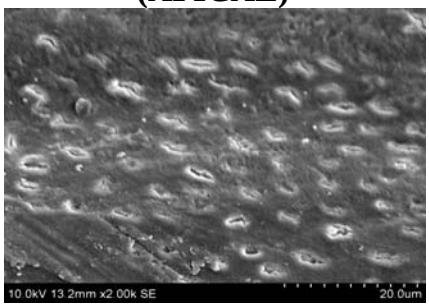
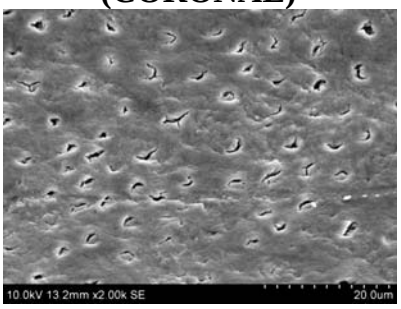


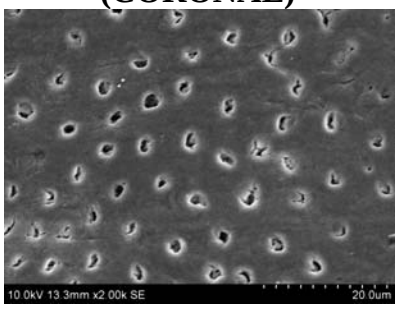
SEM IMAGES

Figure 12

Group III (solvent+passive ultrasonic irrigation) (CORONAL)



Group IV(without solvent+passive ultrasonic irrigation) (CORONAL)



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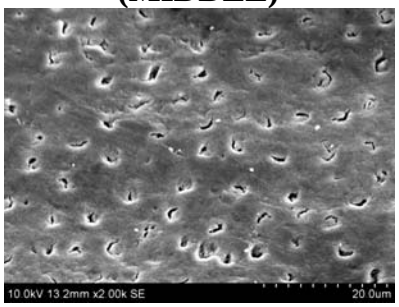

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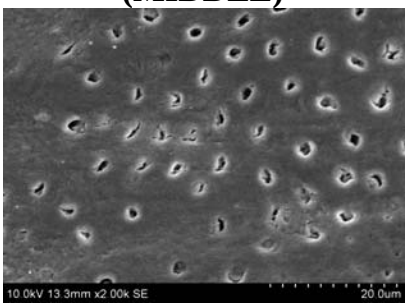

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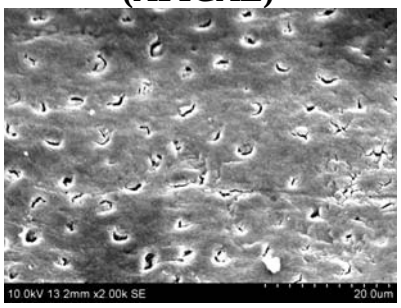

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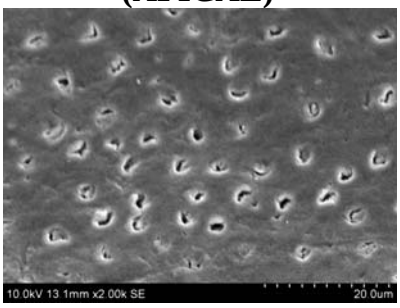

The results of the SEM analysis for the cleanliness of the dentinal tubules are summarized in Table 1 and Table 2.

Oneway Anova

Table 1: Estimated least square mean(mean) and standard deviation of the ratios evaluated in SEM (number of open tubules/total number of tubules in mm^2) between groups.

Groups	Region	Mean± SD
Group 1(solvent)	Coronal	.2600±.01897
	Middle	.3183±.01835
	Apical	.1533±.02582
	Total	.2439±.07309
Group11(without solvent)	Coronal	.3683±.02317
	Middle	.4617±.02317
	Apical	.2150±.01378
	Total	.3483±.010629
Group111(solvent+ passive ultrasonic irrigation)	Coronal	.4150±.00548
	Middle	.5450±.00548
	Apical	.2900±.01549
	Total	.4167±.10754
Group1V (without solvent + passive ultrasonic irrigation)	Coronal	.4867±.01506
	Middle	.6250±.02739
	Apical	.3667±.01751
	Total	.4928±.011034

The mean difference is significant at the .05 level.

Table 2: Estimated ratios of mean difference evaluated in SEM (number of open tubules/total number of tubules in mm^2) between coronal, middle and apical third of each group.(Post Hoc Test)

Groups	Subgroup	Subgroups	Mean difference
Group 1(solvent)	Coronal	Middle Apical	-.05833* .10667*
	Middle	Coronal Apical	.05833* .16500*
	Apical	Coronal Middle	-.10667* -.16500*
Group2(without solvent)	Coronal	Middle Apical	-.09333* .15333*
	Middle	Coronal Apical	.09333* .24667*
	Apical	Coronal Middle	-.15333* -.24667*
Group3(solvent+passive ultrasonic irrigation)	Coronal	Middle Apical	-.13000* .12500*
	Middle	Coronal Apical	.13000* .25500*
	Apical	Coronal Middle	-.12500* -.25500*
Group4 (without solvent+ passive ultrasonic irrigation)	Coronal	Middle Apical	-.13833* .12000*
	Middle	Coronal Apical	.13833* .25833*
	Apical	Coronal Middle	-.12000* -.25833*

The mean difference is significant at the .05 level.

Table 3: Mean time required for removing gutta-percha and AH Plus sealer in **minutes (T test)**

Group	N	Mean±SD
Solvent	18	5.3361±.31561
Without solvent	18	4.3304±.48336

DISCUSSION

The retreatment of root filled teeth is indicated when there is persistence of disease resulting from micro-leakage, incomplete cleaning and shaping, technical shortcomings, or complex anatomy[17.] When non surgical retreatment is indicated, efficient removal of the filled material from the root canal system is essential to ensure a favourable outcome [77.] In curved root canals, the removal of filling materials and further cleaning and shaping are more difficult when compared with straight canals. Further more it may cause instrument distortion or instrument separation[81.] Nevertheless, removal of root fillings in curved and narrow canals are time consuming operation especially when the filling material is well condensed[35.] Literature survey reveals that studies on the efficiency of removing root fillings in curved root canals are limited.

Various materials like Gutta-percha, Resilon,are being used for the filling of root canals of which gutta-percha with a variety of sealers is the most common[79]. Root canal sealers are necessary to seal the space between the dentinal wall and the obturating core interface. Sealers also fill voids and irregularities in the root canal, lateral and accessory canals and space between gutta-percha cones.

The most popular sealers are zinc oxide eugenol, calcium hydroxide sealers, glass ionomers and resin based sealers [94.] Resin based sealer like AH Plus sealer have a long history of use. They provide adhesion with good sealing ability when compared to other sealers [94] AH Plus is an epoxy resin sealer which polymerises to a very hard consistency. In roots obturated with resin sealer, the better adhesion to dentinal walls makes its removal from canal wall difficult[65] and even a red hot heated plugger usually could not penetrate far enough into the canal to allow a file to be inserted next to the gutta-percha to facilitate its removal from canal walls[87]

The root fillings can be removed from the root canals by endodontic hand files, heat carrying instruments, ultrasonic devices, rotary instruments with or without the aid of solvents or by combining any above instruments [6,49]. Different rotary systems like Profile, Quantec, GT Rotary, K3, Protaper, Race, R-endo , M-Two have been evaluated for root filling removal and root canal re-instrumentation[65].Recently introduced Protaper Universal Retreatment Files (Dentsply, Tulsa), a NiTi rotary system includes D1, D2 and D3 as retreatment files. The 3 files are designed to facilitate the removal of filling material. Each file of this system has

different lengths, tapers and apical tip diameters. The D1 has an active tip to facilitate initial penetration into the filling material which has a length of 16mm , tip of 0.30 mm and a 0.09% taper. The D2 files are for removing the filling material at the level of middle third and has a length of 18mm, a tip of 0.25mm and 0.08% taper. The D3 files are used for removing the apical filling material with a length of 22 mm, a tip of 0.20mm and a 0.07% taper is used to reach the working length[24]. Till date, there have been very few studies investigating the behaviour of Protaper universal retreatment files in non surgical endodontic retreatment. Gu et al proved that protaper retreatment system removed guttapercha more efficiently compared to other traditional techniques and left only a smaller percentage of area covered by guttapercha/sealer remnants than those treated with other techniques [28].

Gutta-percha solvents like chloroform, xylene, eucalyptol, orange wood oil, rectified turpentine, etc, are used in a variety of endodontic procedures. These procedures may be grouped as solvent softened gutta-percha, or customized master cone filling methods or as total removal of root canal filling for renewal of endodontic treatment and partial removal of root canal filling while preparing

post space[78]. Endosolv is a solvent for gutta-percha and sealer (Septodont,France) which is available as Endosolv-E(for eugenol based sealers) and Endosolv-R (for resin based sealers). Endosolv-R is formulated from formamide and phenylethylic alcohol and its composition is similar to Resosolv, which is made of dimethylformamide and cinnamon oil.

The manufactures recommend the use of Endosolv-R can be done by either one visit method or two visit method. In one visit method, clean out by mechanical means, the pulp-chamber and entrance to the canal. Place a drop of Endosolv-R into the chamber and dip the tip of the instrument in Endosolv-R before application. The instrument must be removed from the canal as soon as a certain resistance is felt, then wipe and repeat the operation a number of times, until reaching the apex. In two visit method, on the initial visit, clean out by mechanical means, the pulp-chamber and entrance to the canal. Place into the cavity a small cotton pellet soaked in Endosolv-R. Compress slightly and fill with a sealing cement. Re-open either the next day or some days later. The paste will have disintegrated and the mechanical reaming will present no difficulty.

Irrigation is an essential part of root canal debridement in both endodontic treatment and non surgical retreatment cases, because it allows for cleaning beyond what might be achieved by root canal instrumentation alone. Effective irrigant delivery and agitation are prerequisites for successful endodontic treatment[27]. The effective irrigation removes the vital and necrotic remnants of pulp tissues, microorganism and microbial toxins from the root canal system. Thorough chemo-mechanical debridement reduces the nutrition for the biofilm in the root canal with the potential to reduce the occurance and severity of apical periodontitis. (Yamauuchi et al)

Ultrasonic devices had long been used in periodontics before Richman introduced ultrasound to endodontics as a means of canal debridement in 1957. Ultrasonics is used in endodontics for - Access refinement, finding calcified canals, and removal of attached pulp stones, removal of intra-canal obstructions (separated instruments, root canal posts, silver points, and fractured metallic posts), increased action of irrigating solutions, ultrasonic condensation of gutta-percha, placement of mineral trioxide aggregate (MTA), surgical endodontics, root-end cavity preparation and refinement and

placement of root-end obturation material and root canal preparation[64].

Passive ultrasonic irrigation can be done by either continous flush technique or intermittent flush method. During continous flow of irrigants it is not known how much irrigant actually enters the root canal and flows through the apical part. Also too many variables are involved which are impossible to standardize because the irrigant is always delivered outside the rootcanal. These variables include the placement of the suction tube, the width of irrigant jet and the location and dimension of the root canal orifice[69]. In the intermittent flush technique, the irrigant is injected into the root canal by a syringe and replenished several times after each ultrasonic activation cycle. The amount of irrigant flowing through the apical region of the canal can be controlled because both the depth of syringe penetration and the volume of irrigant administered are known. This is not possible with the use of the continuous flush regime. Sluis et al proved that syringe delivery of irrigant during ultrasonic is as effective as continous flow of irrigant in the removal of dentine debris from extensions and irregularities in the apical third[69]. According to

literature till date there is no investigation done on the efficiency of ultrasonic irrigation used in non surgical retreatment of the root canal.

The objectives of the present study was to evaluate the cleanliness of dentinal tubules with and without Endosolv-R solvent , and to determine the efficiency of passive ultrasonic irrigation in non surgical retreatment with protaper universal retreatment files. The time required for removing gutta-percha and AH Plus sealer using protaper retreatment files was also recorded. In this study curved canals (either main mesio-buccal or disto- buccal) of maxillary molars were choosen without considering the incidence of second mesiobuccal canals or any additional canals . The use of curved canals in this in vitro study will also have more clinical relevance. Most previous retreatment studies are mainly done on single rooted teeth[13,17,19,24,28,31] and studies on retreatment in curved canals are very few[23,81]. A study by Reis et al, evaluated the efficacy of protaper retreatment system on palatal roots of maxillary molars of curvature less than 5 degree[65]. In curved root canals, the removal of filling materials, and further cleaning and shaping are more difficult and more likely to cause instrument distortion or breakage[81].

AH Plus sealer was used in this study, which have a long history of use, good adhesion and sealing ability. AH Plus is a resin sealer which polymerises to a very hard consistency. In roots obturated with resin sealer, the better adhesion to dentinal walls makes its removal from canal wall difficult.[65]

Even though , in vitro studies do not fully reproduce in vivo conditions, and decoronation further reduces their clinical relevance. Decoronation in this study assured standardization of specimens as it eliminated some variables, such as the anatomy of the coronal area and the access to the root canals allowing a more reliable comparison between retreatment techniques.[59,53]

In this study Endosolv-R is used as solvent since it is recommended particularly for softening resin type filling. Tamse et al and Gambral et al done comparative study using various solvent and found Endosolv is more effective solvent in dissolving guttapercha[78,22]. Protaper Ni-Ti rotary universal retreatment file system is used for removing gutta-percha and AH Plus sealer in this study. Gu et al proved that protaper retreatment system removed gutta-percha more efficiently compared with other traditional

techniques and left only a smaller percentage of area covered by guttapercha/sealer remnants than those treated with other techniques[28]

In passive ultrasonic irrigation (0.5% - 5.25%) NaOCl is the most efficient irrigant for mechanical removal of dentine debris during Ultrasonic activation[51]. In this present study an intermittent flow of 3% NaOCl was used for 4minutes during ultrasonic irrigation. 3% NaOCl was used in this study, since 3% NaOCl is refreshed every minute it is possible that sufficient free chlorine is present in the root canal to dissolve the organic component of the dentine debris and that one refreshment of NaOCl has enough flushing effect to remove the dentine debris[69].

The total of 4minute use of Ultrasonic irrigation was used in this study. The smear layer consists of two separate layers. A superficial layer which is loosely attached to dentine and the other layer which is dentin/debris plugs in the mouth of dentinal tubules. Studies have shown that one minute of ultrasound removed the superficial smear layer, but left the dentinal tubules sealed off. 3minutes of ultrasound removed all of the superficial smear layer and most of the dentinal tubule plug layer. 4 minutes of ultrasound

removed all debris in instrumented and uninstrumented areas except for a few dentin chips[10].

Many recent studies used light microscope, visual inspection, and other techniques such as clearing and optical evaluation, computer image analysis programme or photomicrographic method by Epiluminescence for measuring the amount of debris, gutta-percha and sealer on the root inner dentin surface. But scanning electron microscope allowed observation of smear layer morphology, the presence of debris inside dentinal tubules and root canal orifices and the morphology of intertubular dentin[63]. Also SEM enhances the inspection of the root canal walls and also allows evaluation of both root halves along their entire length even if the volume of debris cannot be determined precisely. The main advantage of SEM is that it allows evaluation of both halves of the canal wall along their entire length. However, only the surface can be examined and the depth cannot be determined precisely. Preparation of the specimen may also induce artefacts. Moreover,there are practical limitations during evaluation of results. In fact, magnification is a compromise between the need to observe large areas of root internal surface, yet still maintaining the possibility of identifying specific structures[5]. The

resolution of all other possible techniques (including micro-computed tomography) is insufficient. So scanning electron microscope was used to evaluate the cleanliness of dentinal tubules in this study.

The present study evaluated the efficacy of solvents on retreatment and also evaluated the efficacy of passive ultrasonic irrigation after retreatment. The results showed that group without using any solvent and with passive ultrasonic irrigation, left more open tubules among the four groups followed by solvent and passive ultrasonic irrigation. The group with solvent showed less number of open tubules when compared with, without solvent group. More open tubules were found in middle third of all the four groups followed by coronal third and apical third. Regarding the retreatment time for gutta-percha and AH Plus sealer removal from the root canal, the groups without using any solvent performed faster than the groups using Endosolv-R solvent. The retreatment time was significantly shorter for, without solvent group compared with solvent group .

In the present study, endodontic retreatment without using any solvent showed more cleanliness of dentinal tubules when compared with the groups using Endosolv-R solvent. This is due to the reason that when solvents are used, it dissolves gutta-percha and

sealer and a fine layer of softened gutta-percha and sealer is formed. This will adheres to the root canal wall and it is difficult to remove completely from the canal walls[77,49]. According to Wilcox&Juhlin, the use of solvents resulted in the deposition of a thin layer of filling material on the root canal walls that is difficult to remove. This layer attenuates the action of intracanal antibacterial medicaments and might impair the adaptation of the subsequent filling material to the root canal walls.[63]

When considering the cleaning of dentinal tubules in coronal, middle and apical third after retreatment with or without solvent, the middle and coronal third showed more open tubules than the apical third. This is due to the differences between the taper and diameter of the D1,D2 and D3 files and apical diameter of the D3 files(size 20) are designed to reach the working length and it does not permit a complete cleaning action. This result is similar to the study by Guiliani et al where protaper retreatment files showed more debris in the apical portion than in middle and coronal third of the canal[24]. It was also observed that in a retreatment study (Masiero & Barletta Bueno et al) greater amount of filling material remained in the

apical third than in middle and cervical thirds irrespective of the technique used[81].

This present study demonstrated that the greater filling material remained in apical area than in middle and coronal third. This is due to the increased anatomical variability and difficulty of instrumentation in curved and narrow canals. The existence of curvature in many planes of deep grooves and depressions on dentine walls in the apical third, well explains the presence of these less instrumented areas making it impossible to direct protaper files against entire root canal walls (Hulsmann&Bluhm).[23]

Moreover, files placed in curved canals will be deflected from their long axis with resultant inequality of cutting and cleaning effectiveness,depending upon the pressure with which the cutting instrument contacts different walls of the root canal. This instrument deflection produces greater cutting and cleaning efficiency in the direction opposite to the curvature of the instrument [23]. Hence, the middle third of the canal showed more open dentinal tubules than apical third followed by coronal third. Schirrmeister et al on their study on retreatment using protaper system demonstrated that more

debris was found in apical region due to the smaller size of the protaper files which reduces the efficacy in apical region[59].

In the present study endodontic retreatment with protaper retreatment files alone showed less retreatment time than the groups used Endosolv-R solvent. This is because protaper retreatment files remove large amount of gutta-percha in spirals around the instrument than in small encircles which do not adhere to the instruments.[24].when solvents are used for removing gutta-percha and sealer the time required will be more since more time is needed for the solvent to soften the gutta-percha and moreover the fine layer of softened gutta-percha that forms and adheres to the root canal wall and it is difficult to remove it completely from the canal walls.[77,49]. Hence the time taken in removing gutta-percha and AH Plus sealer is more with the use of Endosolv-R solvent and this result is consistent with the previous study by Gu-et al and Takahashi et al where NiTi rotary instruments without using any solvent proved to be faster [77,28.]

Eventhough resin based sealers are considered to have good adhesion property, these material may have caused a weaker bond in the apical third making it more easier to remove[17]. Moreover

Zmener et al decribed that AH Plus sealer seemed to show a fast setting time,which would lead to premature detachment from the root canal walls. Still the sealer has poor adherence to moist dentin. Furthermore, during the material setting time, the polymerization stress could cause blank formation either inside the sealer(cohesive stress), or between the sealer and dentin, or between the sealer and gutta-percha cones(adhesive stress). All these factors would explain why AH Plus could have been removed from canal walls easily, during retreatment process eventhough it is considered to be an adhesive sealer.

However Reis et al evaluated the efficacy of protaper rotary retreatment system and hand files for removing filling materials in palatal roots of maxillary first molars which were obturated with guttapercha and either a zinc oxide eugenol based sealer (Endo fill) or a resin based sealer(AH plus sealer) using thermoplasticized guttapercha technique. No solvent was used for retreatment .Results showed that debris was left in all canal thirds, regardless of the retreatment technique. The greatest difference between technique and sealers were found in the middle third, with less amount of debris in canals obturated with Endofill and reinstrumented with hand files.

Both Protaper universal rotary retreatment files and hand files had similar cleaning efficacy in the apical third, regardless of the sealer. This result is in contrast to the result of our study where middle third of canal is more clean. This is due to the variation of palatal root where canal is almost straight and wide and instrumentation is possible till the apex, unlike the mesiobuccal/ distobuccal canals included in this study have more curvature.

In the present study passive ultrasonic irrigation showed a better results when compared to groups where ultrasonic irrigation is not used. This can be attributed to higher velocity of irrigant flow that are created within the canal during ultrasonic irrigation.

The other reason for better effect of passive ultrasonic irrigation is that, an irrigant in conjunction with ultrasonic vibration ,which generates a continuous movement of the irrigant which is directly associated with the effectiveness of the cleaning of the root canal space. The temperature of irrigant increases when aggitated with ultrasonic unit which increases the NaOCl action both against microbes as well as soft tissue. A temperature increase in any solution inside a root canal is considered desirable in properties

because it enhances chemical reactivity and hence disinfecting potential[91]

In this study, even though passive ultrasonic irrigation reduces the debris from the canal walls better, it could not completely remove the filling material from the canal walls. The results of this study showed more debris were found in the apical third than in middle and coronal third. The reason is that this study is done in curved molar roots were root diameter influences the efficacy of ultrasonic irrigation. In curved canals, the greater force by which a tip contacts the canal walls will reduce its efficiency. A straight instrument placed in a curved canal will have at least three contact points with root canal walls[3].Narrow and curved canals compromise the effectiveness of ultrasonic irrigation and when file rotates in canals ,the file may bind thus restricting their vibratory motion and cleaning efficiency. For the irrigants to be effective they have to be in direct contact with the surface. In small diameter roots, irrigating solution have difficulty in reaching apex and this also influence the efficiency of the passive ultrasonic irrigation. Further more a freely oscillating instrument will cause more ultrasonic effects in the irrigant solution than one that binds to canal walls.[64]

Another explanation could be that it is difficult to standardize the positioning of the ultrasonically activated instrument in the centre of the root canal and to standardize the displacement amplitude as a small constraint in the canal will change the amplitude. This will have a direct effect on the efficacy of passive ultrasonic irrigation.[70]

Moreover, when evaluating irrigation in the apical third, the phenomenon of vapour lock should be considered. Vapour lock are created by the organic decomposition of NaOCl into a bubble of carbon dioxide and ammonium which result in gas entrapment at the apical third. This vapour lock effect prevents the flow of irrigant into the apical region and adequate debridement of the canal system. A study by Schoeffel et al shown that when ultrasonic activated tips leaves the irrigant and enters the apical vapour lock, acoustic streaming and cavitation becomes physically impossible.[25]

The result is in accordance with the study by Al-Jadaa et al where they found in more curved canals, the greater force by which a tip contacts the canal walls might reduce the ultrasonic efficiency[3]. Studies by Burleson et al, Cameron.J.A, Sluis et al ,and Neto et al have shown promising results in removal of debris from root canals

when passive ultrasonic irrigation is used , even though most of the studies were performed in simulated straight canals which are rarely encountered in natural teeth[7,69,57,78]

The results of this study showed that more open tubules were found in the middle third of the canals after passive ultrasonic irrigation. The reason is due to the placement of ultrasonic files 2mm away from the apical end for the free oscillation of the file. The file in an ultrasonic device vibrate in a sinus wave like fashion. A standing wave has areas with maximum displacement (anti nodes) and areas with no displacement(nodes). The tip of the instrument exhibits an anti node. Also acoustic streaming create small intense, circular fluid movements (eddy flow) around the instrument. The eddying occurs closer to the tip than the coronal end of the file[94] .So since the file is placed 2mm away from the apical area and more action of the files remain on file tips than the coronal end of the files, the canals are cleaned more in the middle third than apical third. Moreover when ultrasonic files activate in the canal the flushing action of the file moves the irrigant towards the apex during initial oscillation of files and the irrigant flushes out with the removed debris away from the file tip. During this process there are chances again for the debris to

accumulate in the coronal third. These are the reasons why coronal third is not as clean as that of middle third in this study.

The present study suggests that protaper universal retreatment files without using any solvent is more efficient in removing the gutta-percha and AH Plus sealer in non surgical endodontic retreatment. The use of Endosolv-R led to more gutta-percha and sealer on root canal walls and inside dentinal tubules. The use of solvent in this study even proved to be a time consuming factor in removing gutta-percha and AH Plus sealer. Therefore use of solvents should not be recommended during endodontic retreatment. An additional step of using passive ultrasonic irrigation after gutta-percha and sealer removal in non surgical endodontic retreatment will definitely enhances the cleanliness of dentinal tubules further. However, further investigation should be done to evaluate the effect of other irrigation techniques like Endovac, Navitip, Max I Probe on the cleanliness of dentinal tubules during endodontic retreatment.

SUMMARY

This invitro study was done to evaluate the effect of ultrasonic irrigation on the cleanliness of dentinal tubules during endodontic retreatment with and without the use of solvent.

Thirty six roots (mesiobuccal or distobuccal) of maxillary molars having curvature between 15º to 25º were obturated with gutta-percha and AH Plus sealer by lateral condensation method. After 2weeks of storage at 100% humidity for 2 weeks the samples were divided into four groups of 9 samples each.

In group I retreatment was performed with protaper universal retreatment files with the aid of Endosolv-R solvent. In group II retreatment was performed with protaper universal retreatment without using any solvent. Time was recorded for endodontic retreatment.

In group III retreatment was performed with protaper universal retreatment files with the aid of Endosolv-R solvent followed by passive ultrasonic irrigation with 3%NaoCl .

In group 1V retreatment was performed with protaper universal retreatment without using any solvent followed by passive ultrasonic irrigation with 3%NaoCl .

All 9 samples from each groups were split longitudinally using safe sided flexible diamond discs and the split root halves washed with 0.5ml of saline for removing any cutting debris. The coronal middle and apical thirds of root halves were examined using SEM at a standard magnification of 2000X. The total number of dentinal tubules and the number of dentinal tubules either completely or partially filled with materials were evaluated for the coronal,middle and apical third.

CONCLUSION

Within the limitations of this study it can be inferred that

1. The use of Endosolv-R solvent with protaper NiTi rotary retreatment files during non surgical endodontic retreatment on curved root canals of mesiobuccal and distobuccal roots of maxillary 1st and 2nd molars revealed more gutta-percha /AH Plus sealer remnants on the root canal walls.
2. The use of passive ultrasonic irrigation after retreatment further enhances the removal of remaining debris inside the root canal walls and thereby reveals more number of open dentinal tubules in the SEM study, compared to other experimental groups.
3. In all the experimental groups, more number of open dentinal tubules were observed in the middle third, reduced number in the coronal third and least in apical third.
4. The use of solvent during retreatment is more time consuming in removing the gutta-percha/AH Plus sealer.
5. It was impossible to remove all the traces of gutta-percha/sealer remnants from the root canal walls of curved roots, regardless of the instrumentation and irrigation techniques used.

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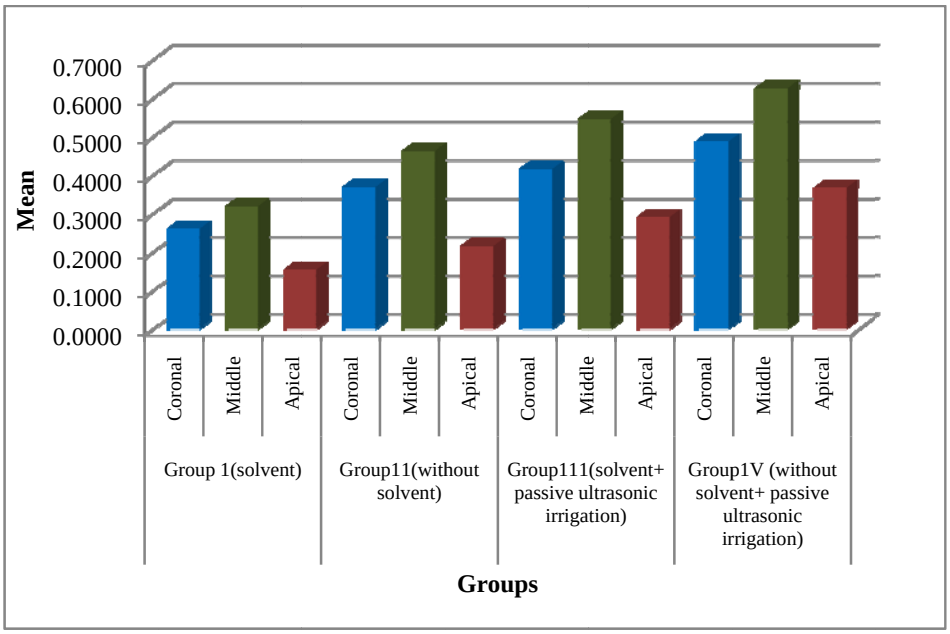
Graph 1: Mean of the ratios evaluated in SEM (number of open tubules/total number of tubules in mm^2) between groups.



Graph 2: Mean time required for removing gutta-percha and AH Plus sealer in minutes