An *Ex-Vivo* Stereomicroscopic Evaluation Of The Effectiveness Of Xylene, Endosolv –R And Eucalyptol Along With H-File In Retrieving The Gutta-Percha And Ah Plus Sealer From The Root Canal

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Abstract:

Aim: The aim of this ex-vivo stereomicroscopic study was to compare the dissolution efficacy of Xylene, Endosolv-R and Eucalyptol along with H-file in retrieving Gutta-Percha and AH Plus sealer from the obturated root canal. Materials and Methods: A total of 30 freshly extracted lower permanent mandibular first premolars were obturated and the samples were placed in incubator to maintain 100% humidity at 37℃ for 7 days. After a week, samples were decoronated to standardize the working length (15mm from apices to coronal end). Reservoir of 3-4 mm was created inside each canal and samples were divided equally into three groups with Xylene (group 1=10), Endosolv (group 2=10) and Eucalyptol (group 3=10). 1 ml of each solvent was dispensed in each tested sample and waited for 2 minutes, retrieval was carried out using 25# H-file. After radiographic verification, longitudinal splitting of each sample was done with mandrel and disc. The images were visualized under stereomicroscope at 20x magnification to access the presence and absence of filling materials along the entire sections, photographs were captured using digital camera and images were transferred to Digimizer 4.5 version for evaluation of the area devoid of obturating materials. The collected datas were assembled for further statistical evaluation using ANOVA and Tukey HSD test. Results: On evaluation, all the tested agents, produced certain degree of dissolution. On comparing the mean values between Xylene, Endosolv-R and Eucalyptol in coronal portion, it was found to be 10.763, 7.143 and 5.94, in middle third the mean obtained was 9.526, 5.408 and 5.906 whereas in apical third the values were 9.334, 6.002 and 6.123 respectively. Conclusions: The results of our study showed statistically higher dissolution capacity with Xylene when compared to Endosolv-R and Eucalyptol, whereas, no significant difference was noted between the dissolving capacity of Endosolv-R and Eucalyptol group. The mean obturation loss in coronal, middle and apical third with Xylene was found to be highest when compared with others. On comparison between Endosolv-R and Eucalyptol, the mean area loss with

Endosolv was found to be higher in coronal third, whereas, Eucalyptol was more effective in dissolving the materials in middle and apical third region.
Keywords: Endodontic retreatment, Xylene, Endosolv-R and Eucalyptol

1. INTRODUCTION

Effective cleansing, disinfection and multi-dimensional sealing are the mainstay of endodontic therapy. However, favourable outcome of treatment protocol results only in 86% to 93% cases.[1] Most failed cases are related to persistence of intra-radicular as well as extra-radicular infections.[2] Whenever feasible, endodontic procedure should be repeated in every failure case and considered over other radical interventions, such as peri-radicular surgery or tooth extraction because the nonsurgical procedure is less invasive and provides more successful end-result, displaying higher success rate of 83.0% in comparison with 71.8% for invasive surgery.[3]

With advancement in techniques and improved armamentarium, the non-invasive re-treatment therapy for retrieval of obturating materials has become more predictable. Employing techniques, such as mechanical use of H –files, K-files or barbed broaches, endo-rotary instruments and ultrasonics either solitary or in conjunction with heat or solvents to obtain root canal walls completely free of debris and residual infections.Various combinations are preferred to achieve a safe, effective, and potentially appropriate retrieval of the of obturated materials from the canal.[4]

Presently, Gutta-Percha is generally used and most popular accepted core filling materials in dentistry because it is easy to manipulate, elastic in nature, rarely toxic, radiopaque, dissolves in various solvents like chloroform and halothane, shows change in volume on temperature variation, can be compacted and condensed laterally and vertically to canal walls and is easy to remove from canal with heat or solvents. It can create a fluid tight seal, when combined with various root canal cements such as resin based, calcium hydroxide and eugenol based sealers etc.[5]

AH Plus sealer possess excellent properties, such as decreased solubility, adherence to dentin, slight expansion, and best sealing capacity. It has proven as a "gold standard" amongst the sealants.[7]

Among the various solvents used, chloroform is viewed as the most efficient, for the removal of obturating material. But since its use, has been prohibited by the United States food and drug authority because of its possible carcinogenicity, shrinkage on evaporation and leakage with loss of apical seal leading to harmful effects on the tissues. Therefore, Endosolv E and R, Xylene, Halothane, Turpentine oil, Benzene, Ether, Orange oil and Eucalyptol are other alternatives that have been advocated and used to soften the filling materials.[8] Xylene, Eucalyptol and Endosolv (Septodont) have been reported as an efficient, biologically safe organic solvents for softening of various filling materials.[10]

The combined usage of various mechanical and chemical means, plays a vital role in complete retrieval of obturating materials from the root canal.Therefore, this simple, reproducible and cost effective ex-vivo study is based on the necessity to determine the most effective agent in retrieving the obturating material from the canal, using H-file in non-surgical endodontic retreatment cases using AH Plus sealer.

2. MATERIALS AND METHODS

Permission for this study was granted by Teerthanker Mahaveer ethical Committee**.** Freshly extracted mandibular 1st premolar teeth were collected from patients, between the age group of 18-55 years, from the Department of Oral and Maxillo-facial Surgery, Teerthanker Mahaveer Dental College & Research Center, Moradabad. The collected teeth were cleaned

of all the debris and attached soft tissue, first by placing them under fresh running water, followed by cleaning with ultrasonic scaler. These were then disinfected by placing in kidney tray and steam sterilized in autoclave at a temperature of 121^0 C at15 lbs for 30 minutes.

The collected teeth were inspected both clinically and radiographically. Clinical examination was carried out under endodontic microscope at 4X magnification, while the radiographic examination was carried out using radio-visiography. Out of the examined teeth, 30 were selected on the basis of pre-determined inclusion and exclusion criteria. Teeth with intact crown and root, free of defects and extracted due to periodontal and orthodontic reasons. Teeth with single, straight canal and mature apices were included. Teeth with caries, restoration, root canal treatment, developmental defects, fracture or craze lines, curved or dilacerated root, ankylosis and external and internal resorption were excluded from this study. These selected 30 mandibular premolars, were stored in saline, till the start of the experiment, to simulate the conditions of oral environment.

Conventional access opening in each specimen, was performed using round bur #2 at high speed under water coolant. A smaller size #10 k-file was inserted into the canal of each sample to check patency and extended till it became visible beyond the foramen. The visual working length was determined, which was further verified radiographically, by subtracting 1mm from the total root canal length. Cleaning and shaping of each specimen was carried out, in crown down manner upto the master apical file size #50.Throughout the instrumentation, recapitulation with size 15# k-file along with copious irrigation was carried out using 1ml 5.25%NaOCl, to clean necrotic tissues and debris for 1minute, followed by 17% EDTA, to remove the smear layer and dentinal chips. Rinsing of all the treated samples were carried out with 2ml of sterile water to remove any remaining dentinal chips and debris and later the canal was dried using absorbant paper points. Obturation was performed using lateral compaction technique, employing standardized 50 no. Gutta-Percha master cone and AH Plus sealer (epoxy resin based sealer). Excess Gutta-Percha was removed, at the canal entrance with heated plugger to condense Gutta-Percha at coronal two-third and was restored with temporary filling material (cavit). Finally,a radiograph was taken to verify the obturation in all the samples.

Following Obturation, all the samples were placed in an incubator at 100% humidity at 37℃, to simulate the atmospheric condition inside it for seven days, which allowed the sealer to set completely. After a week, specimens were taken out from the incubator and were allowed to cool down to room temperature. Using round bur #2, temporary filling material was removed from each specimen. Decoronation of each specimen was then carried out, using the mandrel disc, to standardize the length of the root, by keeping 15 mm from apical portion to the coronal end. Further, heated endodontic plugger was used to remove Gutta-Percha, in order to create a reservoir of 3-4 mm inside the canal, for placing the solvent. The samples were then randomly divided, into three groups containing ten samples each, employing Xylene, Endosolv-R and Eucalyptol.(Table 1)

GROUP 1 (n=10)	GROUP 2 (n=10)	GROUP 3 (n=10)
XYLENE	ENDOSOLV-R	EUCALYPTOL

1ml of each solvent was dispensed via 2 ml syringe into the created reservoir in each sample, for a duration of 2 minutes. Mechanical removal of each sample was carried out using No. 25 H-file till the obturating material was eliminated as much as possible.

Canals were rinsed with 75% ethylene alcohol, through a 2 ml syringe, to remove solvents followed by distilled water and each sample was dried using paper points. Each sample was sectioned longitudinally, into two equal halves using mandrel and disc. Each half of the sectioned root samples containing Xylene, Endosolv-R and Eucalyptol were selected in triplicate, together as a single unit and was visualized under Lyser zoom stereomicroscope keeping a constant magnification of 20x. This process was repeated till all the samples were examined, one after the other.

The cleaning effectiveness of the three tested solvents were compared and evaluated, by viewing for presence of residual filling materials along the entire half of the root wall. The images obtained by screening all the samples under microscope were captured using a digital camera (figure1).

All photographs were imported into JPG format and transferred to Digimizer 4.5, installed in a laptop. The images of all samples were resized to achieve a standard magnification of 100%. Digimizer 4.5 calculates the area by allowing manual measurements to determine length, width and area of the canal in nanometer squares filled with and without the obturating materials. The total area of the canal [T_A] (closed path), was determined using the formula : length x width. The variable data thus obtained upto three decimal digits and the mean area of samples were displayed in the statistical measurement window. After area determination, each root sections were divided into apical, middle and coronal third at 5 millimeter apart from each other by selecting the path tool bar button. The obturation loss with Xylene consisting of ten samples each in coronal, middle and apical third was obtained separately by selecting several points on the path tool bar button and the area of each samples were achieved by clicking various plots on area tool bar. Similarly, the mean area obturation loss with Endosolv-R and Xylene samples in all the three segments of the root canal was obtained. All the areas wherever the obturating material was present were calculated singly in each of the thirds and all the obtained datas of area which was displayed in the measurement list window were added manually to obtain presence of obturating material area along the entire canal (PA). This was performed by selecting several points on the area tool button. Finally the difference in total areas of the canal and the areas wherever the GP & sealer was present in all thirds of the canal was calculated to find out an area devoid of obturating materials (ΔRA) using the formula: $\Delta RA = [TA\text{-}PA]\ nm^2$.

The data obtained was collectively assembled and tabulated. The collected data was subjected to statistical evaluation using ANOVA and Tukey HSD tests with the P-value ≤ 0.05 as the significance level.

SAMPLE 1: Xylene SAMPLE 2: Endosolv SAMPLE 3: Eucalyptol

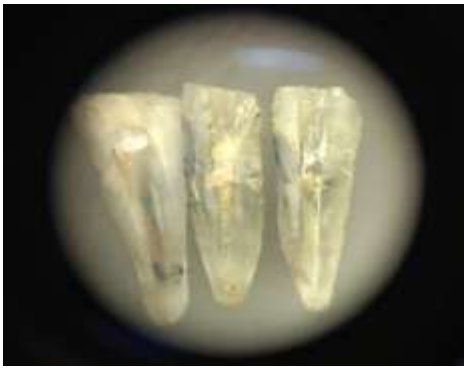


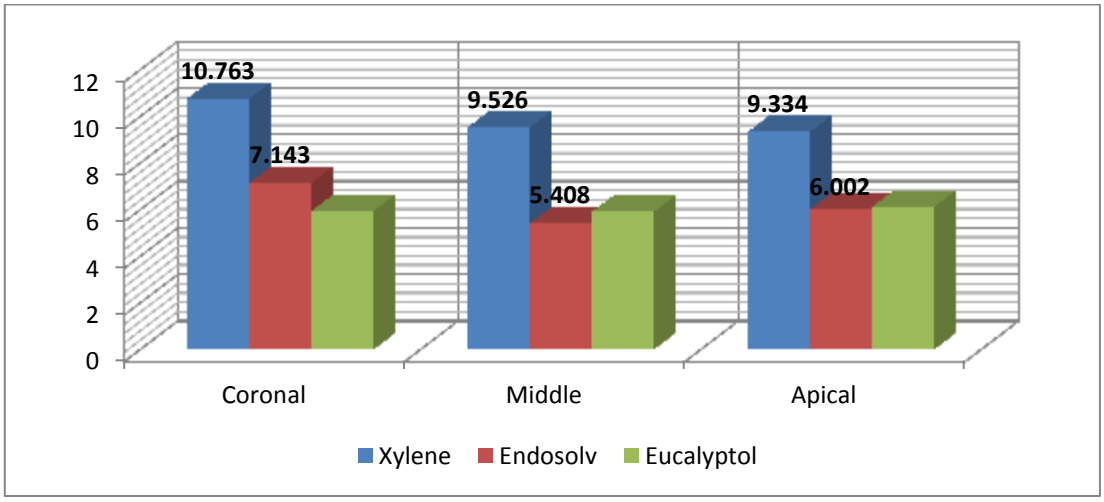
Figure 1: Images of the samples obtained under the stereomicroscope

3. RESULTS

On evaluation of the dissolution potential of different agents on the obturating material along with the use of H-file, it was found that all the tested agents, produced certain degree of dissolution. On comparison between obturation free areas in the coronal, middle and apical third regions, produced by Xylene, Endosolv and Eucalyptol, the mean obturation loss in coronal, middle and apical third with Xylene was found to be highest with a mean value of 10.763, 9.526 and 9.334 when compared with others. On comparison between Endosolv-R and Eucalyptol, the mean area loss with Endosolv was found to be higher in coronal third that is 7.143 whereas, Eucalyptol was more effective in dissolving the materials in middle and apical third region with a mean value of 5.906 and 6.123 respectively.(Table 2, graph 1)

	Groups	**N**	**Mean**	**SD**	**Minimum**	**Maximum**	**ANOVA**	
							p-value	**Sig**
Coronal third (nm^2)	**Xylene**	10	10.763	1.000	9.459	12.700	<0.001*	S
	Endosolv	10	7.143	0.69	6.166	8.208		
	Eucalyptol	10	5.947	0.82	4.989	7.458		
Middle third (nm^2)	**Xylene**	10	9.526	1.006	7.808	10.777	<0.001*	S
	Endosolv	10	5.408	1.055	4.190	7.108		
	Eucalyptol	10	5.906	0.686	4.902	6.853		
Apical third(nm^2)	**Xylene**	10	9.334	0.618	8.624	10.484	<0.001*	S
	Endosolv	10	6.002	0.883	4.900	7.404		
	Eucalyptol	10	6.123	0.884	4.750	8.000		

Table 2



Graph 1

4. DISCUSSION

The endodontic treatment has been found to produce success rate of 86 to 95% but there are cases where probability of endodontic failure occurs.[1] The retreatment is necessary in every failed cases. [11] The process includes regaining canal access via retrieval of original materials from the compacted space followed by cleaning, shaping and disinfecting the canal and re-obturating it with a combination of freshly mixed Gutta-Percha and sealer.[3] This study evaluated the dissolving potential of Xylene, Endosolv R and Eucalyptol on AH Plus sealer and Gutta-Percha with the aid of H-file to comparatively determine the most effective solvent among them to retreat the endodontically treated tooth. None of the previous studies till date have compared the dissolving effectiveness of these three solvents together and there are only few studies that were conducted using Endosolv R solvent in retrieving the materials.

In the current study, samples were longitudinally splitted and the residual Gutta-Percha and cement were measured using Lyser Zoom Stereomicroscope with the image processing camera and the data were collected using Digimizer software. This procedure of measuring the total area of the canal and area devoid of obturating material in coronal, mid and apical third along the entire region were similar to Grabliauskiene et al, in which they used Carl Zeiss Stereomicroscope for sample observation and image were captured using Axio Cam Mrc camera followed by the Axio Vision 4.7 version for data collection.[12]

In another study, Jasim and Gharrawi used Digimizer software to evaluate the amount of retrieval of filling materials in millimeter at five different zones (5 and 7mm from orifice level, starting of the canal curvature, at crest and at the endpoint) after biomechanical preparation on 60 blocks of resin which was similar to our study.[13]

Our findings revealed that all the tested agents to some extent were capable of softening and dissolving the obturating materials. The results of our study showed statistically higher dissolution with Xylene when compared to Endosolv-R and Eucalyptol, whereas, no significant difference was noted between the dissolving capacity of Endosolv-R and Eucalyptol group. On comparison between obturation free areas in the coronal, middle and apical third regions, produced by Xylene, Endosolv and Eucalyptol, the mean obturation loss in coronal, middle and apical third with Xylene was found to be highest when compared with others. On comparison between Endosolv-R and Eucalyptol, the mean area loss with Endosolv was found to be higher in coronal third, whereas, Eucalyptol was more effective in dissolving the materials in middle and apical third region.

The results of the present study was in accordance to the study conducted by Martos et al, who used Xylol, Orange oil and Eucalyptus oil to check their dissolving efficacy on

different sealers.[14] They found all the agents to be effective to some degree in solubilizing the tested sealers, Xylol presented superior solvent effects with a remarkable solubility of all the tested cements followed by Eucalyptol which exhibited lowest dissolving property.

Oliveria et al tested Xylene, Orange oil and Eucalyptol for dissolving efficiency and found best dissolution for Gutta-Percha with Xylene and worst with Eucalyptol.[15] Mushtaq et al also used Tetra-chloroethylene, Xylol and Orange to soften Apexit, AH Plus and Endoflas sealers and reported that Xylene presented the best dissolving capacity. Numan compared the softening efficacy of Eucalyptol, Xylol and Tetra-chloroethylene along with 30# H-file in retrieving filling materials.[17] He reported highest softening with Eucalyptus oil followed by Xylol and Tetrachloroethylene which was contrary to the findings of our present study. Tanomaru - Filho et al in contrast to our study found Eucalyptus and Orange oil to be more efficient in solubilising thermoplastic Gutta-Percha when compared to Xylene.[18]

Xylene (di-methyl benzene) acts slowly, which enables biologically safe and effective removal of softened obturating materials.[16] It is considered as an effective solvent for Gutta-Percha, sealers, resin and resilons (a polycaprolactone) because of action on covalent bonds in between the molecules of the carbon atoms.

In endodontics, the use of Eucalyptus oil as an essential oil is burgeoning because of its confirmed safety, non-carcinogenic behaviour and biocompatibility, which prevents peri-radicular inflammation or irritation.[19] Eucalyptus oil is also the distilled oil known for its Gutta-Percha dissolution property. It is extracted from Eucalyptus Globulus and belongs to the family Myrtaceae which is aboriginal to Australia.[20] It contains 1,8 cineole as its major constituent. It shows pain relief and anti-inflammatory efficiency, nematicidal and antibacterial properties.[21] Upon heating, its dissolving action on Gutta-Percha is faster and if not heated, it displays slower rate of dissolution.[22]

Endosolv-R is commercially a resin based Gutta-Percha softening endodontic agent, manufactured by septodont which has formamide and 2-phenylethanol, as its ingredient.[23] Formamide causes moderate irritation to mucosa and skin. It is beneficial to use clinically at the chair side because of its easy availability, fast action, high solvency capacity, cost effective and minimal risk when used along rotary instruments while de-obturating the canal.[23]

Both Xylene and Endosolv-R work by penetrating deep into the lattice network formed by monomer cross-linking and polymerization process thereby reducing the strength and hardness of obturating material, resulting in softening and dissolution.[24] Endosolv-R requires pre-heating for effective dissolution, which is more time consuming. Only a handful of studies have reported it to be more effective in softening and dissolving Gutta-Percha.[25] Even the studies carried out on its biocampatibilty did not produce satisfactory results. Therefore, Xylene is considered superior than Endosolv-R in dissoluting Gutta-Percha and sealers.[26]

Grabliauskiene et al found least amount of Gutta-Percha in apical portion with 3.71% after retreatment with Eucalyptol followed by middle third root region with 5.08% of filling material and concluded that among the three sections of root canal, Eucalyptol was most effective in dissolving Gutta-Percha in apical third region followed by middle third.[12] According to Limongi et al Eucalyptus oil showed cleaner canal walls in the middle third part of the root canal.[27] Khiyani et al reported that Eucalyptol possess superior solvency property and was most effective in dissolving the Gutta-Percha in comparison to GP solvent, Chloroform and Turpentine.[28]

One of the major reason for the failed endodontic treatment is the persistence of microbial infections within the canal, therefore, Eucalyptol due to its antimicrobial action

against gram negative, gram positive bacteria and fungi, may be beneficial in effectively retrieving and cleaning the deeper portions of the already obturated canal with its good potential of dissolution of Gutta-Percha and sealer.[29] Beside, its restricted solvency effect, it is also helpful in enhancing the penetration of the files within the canal to allow for an efficient removal of the sealers.[26] On the contrary, Gawande et al in a study found that the Endosolv-R was incapable of dissolving the filled root canal portion upto the working and it failed to regain apical patency after retreating the obturated canal with the aid of file system. [30]

5. CONCLUSION

On the basis of the results acquired in this study, it is evident that, the use of an agent along with an instrument is helpful in removal of the previous obturation.Out of the three tested solvents, Xylene tends to dissolve GP along with AH Plus cement, more efficiently than Endosolv-R and Eucalyptol throughout the root canal. In between Endosolv and Eucalyptol, the former is more effective in the coronal third of the root canal, whereas, the latter is more effective in the middle and apical third, although the statistical difference between the dissolution potential of Endosolv-R and Eucalyptol was not found.

Thus, within the limitations of this study, it can be suggested that for retreatment cases, where previous obturation needs to be removed, the use of Xylene along with H-file is an effective method and should be used.

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