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The Effect of Irrigating Solution on Apical Sealing Ability of AH Plus, MTA Fillapex and Endomethasone N Root Canal Sealers: An In - Vitro Study

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ABSTRACT

Background: To assess the effect of two different root canal irrigating solutions (5.25% Sodium hypochlorite with 17% EDTA and 2% Chlorhexidine) on the apical sealing ability of three different root canal sealers, i.e. AH Plus, MTA Fillapex, and Endomethasone N under a light microscope. One of the major reasons for the failure of root canal treatment is apical microleakage. Maximum sealing ability and adhesion of sealer to dentin can be achieved by effective removal of smear layer. There are various types of root canal sealers being used in endodontics with varying rate of clinical success.

Materials and method: Sixty-six freshly extracted single-rooted human mandibular premolar teeth, were selected for the study. Root canals were prepared in a step-back manner up to the working length to a master apical file size of # 45. Sixty-six samples were randomly divided into six experimental groups of ten samples each. Three samples were kept as positive, and three samples as a negative control group. Samples in Group 1,2 and 3 were irrigated using 5.25% Sodium hypochlorite followed by 17% EDTA and samples in Group 4,5 and 6 were irrigated using 2% CHX. Both control groups were irrigated using sterile saline. A lateral condensation technique was used to obturate all teeth. In Group 1 and 4 AH Plus sealer was used, and in Group 2 and 5 MTA Fillapex sealer was used whereas in Group 3 and 6 Endomethasone N sealer was used. The positive control group, i.e. Group 7, was obturated with gutta-percha without sealer and negative control group, i.e. Group 8 was not obturated. The 2 % methylene blue dye penetration method was used to measure leakage from the apical to the coronal extent, and raw data were statistically analysed.

Results: Intergroup comparison showed that Group 1(1.56±0.34) exhibited the best sealing ability as compared to other sealer used in the study. Group 6 (3.65±0.37) showed the maximum amount of apical leakage.

Conclusion: Within the limitation of the study, no sealer used in this study perfectly seal root apex. 5.25 % NaOCl followed by 17% EDTA and AH Plus sealer showed the best apical seal.

Keywords: Cleaning and shaping, microleakage, root canal irrigants, root canal sealers.

INTRODUCTION

The major goal of endodontic treatment is complete obturation and hermetic seal of the root canal system. The predictable success of endodontic treatment requires accurate diagnosis, proper cleaning and shaping and perfect obturation of root canal system. Microleakage of endodontically

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treated teeth is major cause of treatment failure. Apical leakage is influenced by many variables such as different obturation technique, presence or absence of smear layer and the properties of root canal sealers [1].

While the instrumentation is important in the removal of the infected dentin from the main canal, irrigants play an indispensable role in areas inaccessible to instruments, such as lateral and accessory canals as well as fins and webs throughout the canal[2]. Irrigating solutions are used during instrumentation to increase cutting efficiency and to flush away debris. The ultimate aim of these chemomechanical procedures is a clean, debris-free canal that is necessary both for bacteriological reasons and for optimal sealing of the canal.

Studies have shown that mechanical instrumentation of the root canals leaves a smear layer covering the dentinal walls. This layer contains inorganic and organic materials. Despite the controversy over keeping or modifying the smear layer, it has been demonstrated that the smear layer itself may be infected and may protect the bacteria within the dentinal tubules. The smear layer has also been shown to hinder the penetration of intracanal disinfectants and sealers into dentinal tubules and has the potential of compromising the seal of the root canal filling[3].

For effective removal of both organic and inorganic components of the smear layer, the combined application of NaOCl and a chelating agent, such as EDTA, is recommended. It has been reported that the smear layer was completely removed by 5.25% NaOCl followed by17% EDTA for 1 minute.[5,6] EDTA alone does not completely remove the smear layer, and the best result is obtained with EDTA combined with NaOCl.[7] Sodium hypochlorite is the most used endodontic irrigant. It has many desirable properties such as the ability to dissolve necrotic tissues, antibacterial properties against most microorganism and ability to dissolve biofilms. But it has a cytotoxic effect when injected periapically, unpleasant taste and tendency to bleach cloth. Chlorhexidine (CHX) has been recommended as an irrigating solution or intracanal dressing in endodontic therapy[8]. It is an effective oral antimicrobial agent and routinely used in periodontal surgery. It has broad-spectrum anti-microbial action, substantivity and the relative absence of toxicity but does not possess tissue dissolving capabilities. Irrigation with 2% CHX has been shown to prevent microbial activity with residual effects for 48 hrs. It is an excellent root canal irritants for those allergic to sodium hypochlorite.[9]

Ingle and Taintor reported that the majority of endodontic failures had been caused by incomplete sealing of the root canal. Thus it is necessary to use materials which will be able to create a hermetic seal between the root canal system and the periapical tissues. The sealer act as a binding agent to the dentin and to the core material. An ideal sealer should be low viscous, good wetting, biocompatible, antibacterial, non-toxic, radiopaque and dimensionally stable, should have good adhesion to dentin and core material.[10]

There are numerous brand and types of sealer used in endodontic therapy. They are generally classified as Zinc Oxide Eugenol based, calcium hydroxide based, resin-based glass ionomer based. Recently calcium silicate MTA based root canal sealer MTA Fillapex(Angelus, Londrina, Brazil) has been proposed as an endodontic sealer. It is mineral tri oxide-based, salicylated resin containing 13% MTA, bismuth oxide and silica. MTA has excellent property of biocompatibility, bioactivity, osteoconductivity. Manufacturers claim good radiopacity, flow, alkali PH, great working time, low solubility and easy handling.[11]

The most commonly used sealer is AH Plus (Detrey Densply Konstanz, Germany), which is epoxy resin-based sealer having excellent sealing properties. It is a two-component paste sealer with excellent physicochemical properties and good adhesion.[12] Endomethasone N (Septodont, Saint Maur, France) is zinc oxide eugenol based sealer that does not contain paraformaldehyde in its composition. It is supplied as powder and liquid.

Root canal sealer has crucial importance with regards to the long term results of the root canal fillings because sealing material is required to adhere guttapercha to the root canal dentin and fill irregularities[13]. The most common technique of obturation is cold lateral compaction of gutta-percha along with sealer clinically proven among all obturation technique.[14,15]

There are several methods for evaluating the apical leakage such as bacterial penetration, fluid transport, clarification, penetration of radioisotopes, electrochemical methods and gas chromatography etc. But the most widely used technique to measure linear leakage is Dye penetration method because of its sensitivity, ease of use and convenience. The depth of dye penetration represents the gap between the root filling and the canal walls. The assessment of linear dye penetration apically or coronally is the most common in vitro method.[16]

Till date, there has been very limited literature to assess and compare the effect of irrigating solution on apical sealing ability of calcium silicate MTA based root canal sealers, epoxy resin-based root canal sealers and zinc oxide eugenol based root canal sealer.

Therefore, the present study is being undertaken to assess the effect of two different root canal irrigants i.e. 5.25% NaOCl in combination with 17% EDTA and 2% Chlorhexidine on the apical sealing ability of three different root canal sealers, i.e. Endomethasone N, AH plus, MTA Fillapex.

MATERIALS AND METHOD

Sixty-six freshly extracted single-rooted human mandibular premolar teeth were selected for the study and stored in saline. They were confirmed by digital radiograph from every aspect buccal, lingual and proximal views to ensure the presence of a single canal.

The teeth were cleaned and disinfected with Sodium hypochlorite solution and the crowns sectioned at the cement-enamel junction with the help of diamond disc.

The canal lengths were established by placing a size 15 K file into each root canal until the tip of the file was visible at the apex, and the stopper was placed at the coronal reference point, i.e. the cement-enamel junction. The working length was determined by subtracting 1 mm from the previously measured root canal length. The canals were prepared in a step-back manner using K files, and BMP of each root canal was completed with the master apical file size of # 45 K File. The coronal and middle portion of the root canal was flared to a gradual taper using #3 and #4 Gates Glidden drills. Three millilitres of irrigant was used after every change of Gates Glidden drill or endodontic file in all groups sample.

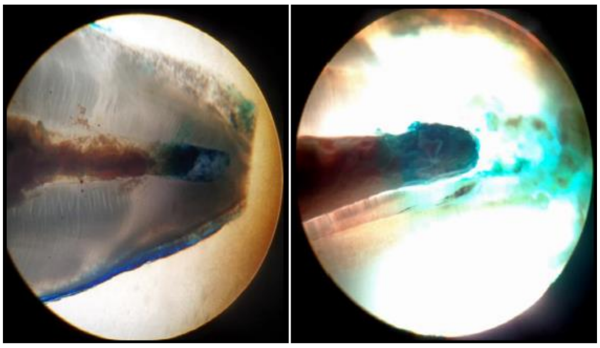

Fig 1: Light microscopic view of Group 1 and Group 4.

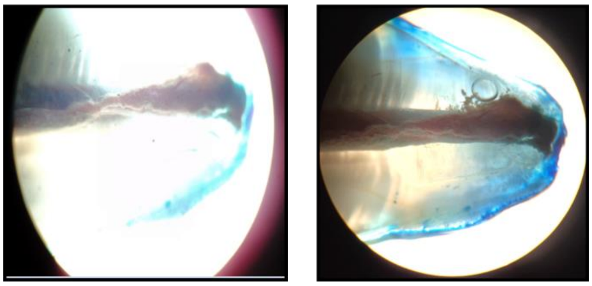

Fig 2: Light microscopic view of Group 2 and Group 5.

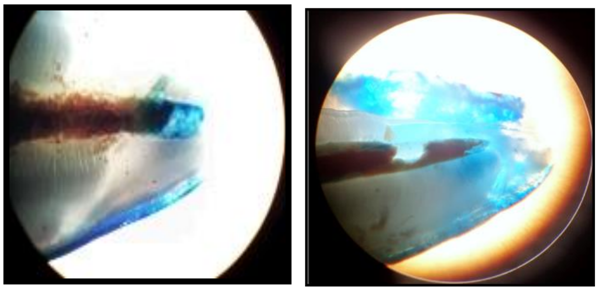

Fig 3: Light microscopic view of Group 3 and Group 6.

Sample size distribution

Based on the irrigating solutions used in this experiments total 66 samples were divided into two experimental groups of 30 samples each and one control group of 6 samples. In one experimental group, 30 samples were irrigated with 5.25% of NaOCl followed by 17% EDTA solution and in other experimental group, 30 samples were irrigated with 2% CHX solution. In control group 6 samples were irrigated with only sterile normal saline solution.

After completion of BMP of each sample and according to different root canal sealers were used in this study, total 60 samples of experimental groups were further divided into 6 experimental groups i.e. Group 1, Group 2, Group 3 , Group 4, Group 5, Group 6 of 10 samples each. Control group was further divided into two groups i.e. Group 7 (positive control) and Group 8 (negative control) of 3 samples each.

The samples were grouped as follows:

Group 1: Ten samples were irrigated with 5.25 %Sodium hypochlorite followed by 17% EDTA and obturated with Gutta-percha in conjunction with AH Plus sealer using lateral condensation technique.

Group 2: Ten samples were irrigated with 5.25% Sodium hypochlorite followed by 17% EDTA and obturated with Gutta-percha in conjunction with MTA Fillapex sealer using lateral condensation technique.

Group3: Ten samples were irrigated with 5.25% Sodium hypochlorite followed by 17% EDTA and obturated with Gutta-percha in conjunction with Endomethasone N sealer using lateral condensation technique.

Group4: Ten samples were irrigated with 2% CHX and obturated with Gutta-percha in conjunction with AH Plus sealer using lateral condensation technique.

Group 5: Ten samples were irrigated with 2% CHX and obturated with Gutta-percha in conjunction with MTA Fillapex sealer using lateral condensation technique.

Group 6: Ten samples were irrigated with 2% CHX and obturated with Gutta-percha in conjunction with Endomethasone N sealer using the lateral condensation technique.

Group 7 (Positive Control): Three samples irrigated with sterile normal saline and obturated with Gutta-percha without any sealer using the lateral condensation technique.

Group 8 (Negative Control): Three samples irrigated with sterile normal saline and not obturated that has remained empty.

Sample in group 1, 2 and 3 was irrigated using 5.25% Sodium hypochlorite followed by 17% EDTA and teeth in group 4, 5 and 6 were irrigated using 2% CHX. Both control groups were irrigated using sterile normal saline solution. In all experimental groups, the root canals were finally flushed with 2ml of saline solution. The apical patency was checked again by passing a #10 K file through the apical foramen.

Later the root canals were dried with absorbent paper points. Standardized gutta-percha points that fit with tug back at the working length were selected as master gutta-percha points. A lateral condensation technique was used to obturate all teeth.

In groups 1 and 4 AH Plus sealer was used, and in Group 2 and 5 MTA Fillapex sealer was used whereas in groups 3 and 6 Endomethasone N sealer was used. The positive control group i.e. Group 7 was obturated with gutta-percha without sealer and negative control group, i.e. Group 8 was not obturated.

After obturation, the coronal access cavity was sealed with glass ionomer cement, and radiographs of the roots were taken in both labiolingual and mesiodistal directions to check the density of filling. It was considered adequate if homogenous gutta-percha without voids could be observed. The procedure for preparation and obturation was standardized for all groups and performed by a single operator.

All samples were stored in an incubator at 37 ^{0}C and 100 % humidity for 2 days to accomplish a complete setting of the sealer.

After 2 days, all the study samples were thoroughly dried. The roots of all experimental groups and the positive control group were coated with two coats of clear nail varnish except for the apical 2 mm. The entire root and apical foramen of the negative control was totally covered with two coats of the nail varnish.

All samples were placed in 2% methylene blue dye solution and centrifuged at 5000 rpm for 5 min. Afterwards, teeth were rinsed under tap water to remove the dye on the external tooth surface. The roots were then longitudinally grooved with a diamond disc and split with a chisel, ensuring that the root canal filling was not penetrated and then split into two halves by levering with a plaster knife. The dye penetration was measured from the apical to the coronal part of the root canal.

The dye penetration was examined under a light microscope (Olympus CH20i) of × 40 magnification. Images were captured by the Sony HD camera. Thereafter captured image was transferred to a computer, and the length of linear dye penetration was measured using Image J software.

Statistical Analysis

SPSS 22 was used for analyzing the results. ANOVA test was used to compare the mean apical dye penetration in eight groups. A P value < 0.05 was considered to be significant. Pairwise comparisons of dye penetration in all eight groups were carried out by Mann- Whitney U Test.

RESULTS

Apical Dye microleakage was observed in all the eight groups. Maximum dye penetration was seen in the positive control group, and the negative control group showed the least dye penetration. Table 1 shows the means and standard deviations of eight groups and comparison of eight groups by Anova Test. Among experimental groups, Group 1 showed the least amount of apical leakage(1.56±0.34) and Group 6 showed maximum apical microleakage (3.65±0.37). Sample irrigated with 5.25% NaOCl and 17% EDTA and obturated with AH Plus root canal sealer showed the least amount of leakage. And samples irrigated with 2 % CHX irrigant and obturated with Endomethasone N sealer showed maximum leakage. This resulted that sealing ability of AH Plus is best in comparison to MTA Fillapex and Endomethasone N. Pairwise comparison of each group was made by Mann Whitney U test which showed that there is statistically insignificant difference between Group 1 and Group 2, which means samples obturated with MTA Fillapex sealer sealing ability is also very good in comparison to Endomethasone N, but little lesser than AH plus sealers sealing ability. Also, there was a statistically significant difference between the mean value of dye penetration of Groups(Group 1, Group2, Group 3) irrigated with 5.25% followed by 17% EDTA and Groups (Group 4, Group5, Group 6) irrigated with 2% CHX. The apical sealing ability of sealers was affected by the irrigation solutions. Figure 1,2,3 shows dye penetration in various experimental groups

Table 1. Comparison of microleakage values (mm) of eight groups by ANOVA

Groups	Mean	SD	Median	H value	P-value
Group 1	1.56	0.34	1.55	52.66	0.001*
Group 2	1.74	0.40	1.735		
Group 3	2.68	0.33	2.675		
Group 4	2.69	0.69	2.63		
Group 5	2.80	0.55	2.85		
Group 6	3.65	0.37	3.71		
Group 7	4.32	0.07	4.34		
Group 8	0.38	0.07	0.38		

*P< 0.05 indicates significant differences between the groups.

DISCUSSION

For successful endodontic therapy, the root canal filling must hermetically seal to prevent the ingress of microorganism or their endotoxin into the canal space. This is validated that the most common reason for endodontic therapy failures is apical microleakage[17]. There are two potential interfaces of leakage, i.e. between gutta-percha and sealer or between sealer and dentinal walls[18].

Hoveland and Dumsha(1985) demonstrated that mostly leakage occurs between sealer and dentinal wall. So three-dimensional obturation and the complete coronal and apical seal is important. The tight apical seal is desired to prevent bacteria, and they are by-products from invading apex.

In this regard, the smear layer is one of the most important factors that can affect coronal or apical microleakage that might lead to failure of endodontic therapy. The presence of the smear layer on dentin is known to modify sealer properties and their sealing abilities. The smear layer resulting from root canal instrumentation acts as a physical barrier which might contribute to microleakage. So, in this study 17% EDTA is used along with 5.25 % of NaOCl solution as an irrigant to completely dissolve organic as well as an inorganic portion of the smear layer. NaOCl does not affect an inorganic portion of smear layer so EDTA compliments the response of sodium hypochlorite by chelating calcium ions in dentin and making instrumentation of the root canal easier. [19]

NaOCl is the best solution to date and most commonly employed root canal irrigants. Its concentration ranges from 0.5% to 5.25 %. Its antimicrobial activity is in proportion to its concentration. 5.25% NaOCl kills microorganism in seconds, agreeing with the finding of Senia *et al.,*(1975). CHX has been recommended as an alternative to NaOCl, especially in cases of the immature tooth with wide apex, perforation, or difficult isolation cases **[20]**. The substantive antimicrobial effect of CHX is related to its cationic molecule binding to negatively charged bacterial cell walls, thereby altering the osmotic equilibrium of bacteria. The antibacterial property of 2% CHX is similar to 5.25 % of NaOCl.[20] However, CHX is less toxic and malodorous agent than NaOCl. A disadvantage of CHX is that it does not dissolve organic tissues. Thus it lacks the ability to dissolve necrotic pulp tissue.

White et al.[19] studied the effects of various irrigants on smear layer removal and concluded that the removal of smear layer requires both organic and inorganic solvents. Thus in this present study, we aimed to compare 5.25% NaOCl plus 17% EDTA irrigating solutions to 2% CHX irrigating solutions regarding the removal of smear layers and cleanliness of root canal.

Several techniques have been developed to improve the seal of the prepared root canal. Currently, the most common technique is the cold lateral compaction of gutta-percha in combination with an insoluble root canal sealer **[20]**. In this study, three different sealers were used AH Plus, MTA Fillapex and zinc oxide eugenol based Endomethasone N, which is paraformaldehyde free. AH, Plus is considered the gold standard when compared with all new sealers(Brackett et al.). Zinc Oxide Eugenol based sealers are used in endodontics since several decades were also known as Grossman's sealer because of its satisfactory physicochemical properties.

MTA Fillapex is a newly introduced therapeutic and biocompatible sealer. The manufacturer claims that MTA Fillapex provides good seal due to expansion during setting, high biologic regeneration. It is mainly composed of combination of resins, silica and MTA. The strong interest in developing mineral trioxide aggregate (MTA)-based endodontic materials is because of the excellent biocompatibility, bioactivity and osteoconductivity of MTA.

Therefore in the present study, we aimed to compare MTA Fillapex new sealer with AH Plus most widely used sealer to Endomethasone N the oldest of all sealer. Dye penetration is the most common method in microleakage studies [21]. The advantages of this method are low cost, low toxicity, availability, easy handling and high accuracy. The disadvantage of using this method is the roots of the specimen is destroyed, and so repeated observation cannot be done. The efficacy of dye penetration method is proved [22] therefore we used this method to measure apical microleakage of root canals

According to Torabinejad if a root filling materials prevents the penetration of dye molecules, it is possible that it can prevent the bacterial microleakage too. Methylene blue is used as the leakage marker is readily detectable under visible light, which allows for rapid, artefact-free direct measurements. The advantages included were its water solubility, diffusibility, and hard tissue non-reactivity. The depth of dye penetration apically or coronally represents the gap between the filling material and the canal wall. Kersten et al. **[23]** suggested that apical microleakage was enhanced by pressure. Therefore in this present study, the centrifuge was used to force the solution through any defects in the root canal filling rather than waiting for passive penetration.

Scanning electron microscope (SEM) has been used in the literature for the assessment of cleanness of the canals[24]. However, in SEM images, edges and ridges of the specimen emit secondary electrons, which result in a brighter image than reality; this may affect evaluation. A root canal is apparently an uneven surface; thus, this effect is always present with SEM but does not exist with the light microscope.

The main drawback of the SEM is that when magnification increases, the field of depth decreases. So the result might vary if present study samples would have been observed under SEM. So in this present study light microscope was used for observation of dye penetration in root samples.

An ideal endodontic sealer should, in part, adhere firmly both to dentin and to gutta-percha. Differences in the adhesive properties of endodontic sealers may be expected because their interaction with either dentin or gutta-percha may vary with their chemical composition.

According to the result of the present study, AH Plus showed least microleakage and Endomethasone N with maximum leakage. MTA Fillapex sealing capability was inferior to AH Plus but superior to Endomethosone N. There were significant differences in respect to apical dye leakage present among all the experimental groups.

The sealer penetration depth in the dentinal tubules depends on factors like smear layer removal, dentinal permeability, root canal dimensions and Physico-chemical properties of the sealers. An acceptable flow within the working time is important for any root canal sealer in order to reach and seal the apical foramen and lateral dentinal wall irregularities.

The better sealing ability of AH Plus can be explained by the fact that epoxy resin sealer is considered contraction free setting reactions which are responsible for its appropriate interfacial adaptation. Due to its creep capacity and long setting time, AH Plus has better penetration into the micro-irregularities, and this increases mechanical interlocking of root dentin and sealer.

Studies by Sonmez *et al.* (2012) and Ferreira *et al.* (2013) showed that MTA Fillapex resulted in more microleakage than AH Plus and Topseal respectively, when irrigating canals with NaOCl and EDTA. Phukan *et al.* (2017)[25] concluded that AH Plus showed better adhesion compared to MTA Fillapex and Apexit Plus with a root canal.

De Almeida[26] evaluated the sealing ability of three endodontic sealers ZOE based, Glass Ionomer based and AH Plus. The leakage between ZOE and Glass ionomer sealers was not significantly different, but AH Plus showed much better result. Singh *et al.* 2016[27] demonstrated that Adseal epoxy-based resin sealer showed less microleakage in compare to MTA Fillapex. Marciano *et al.* (2011) showed AH Plus, Adseal and Acroseal presented similar root canal adaptation and similar physicochemical properties. The result of the present study was found consistent with these study result.

MTA Fillapex provides a good seal due to the expansion during setting over a certain period of time. On the other hand, limited studies reported comparable results about the sealing and penetrating ability of MTA Fillapex when compared to commonly used resin-based sealers.[28]

Ferraria *et al.* (2013) showed MTA Fillapex reduces leakage to the root canal walls over time which can be attributed to volumetric change after decomposition of components. Kuçi *et al.* (2014) evaluated the effect of the smear layer on MTA Fillapex sealer's penetration ability and their results showed that smear layer removal was a critical factor for increasing the penetration ability of MTA Fillapex. Gad *et al.* (2016)[29] showed that MTA Fillapex sealer showed superior sealing ability compared to resin-based AH Plus sealer using the fluid filtration method. This finding may be attributed to the presence of MTA component suggesting the possibility of setting expansion, which might have favoured the sealability. This study result is in conflict to present study result, which may be due to different experimental method and time factor.

The presence or absence of moisture in root canal during obturation and type of sealer used also plays a major role in apical microleakage and sealing ability[30]. Ehsani *et al* (2014) showed resin based sealer resulted in least microleakage under dry condition while ZOE had the highest microleakage under moist conditions. MTA Fillapex provided acceptable apical seal regardless of moisture present.So complete dryness of root canal before obturation is critical factor for apical microleakage and sealing ability of root canal sealers.

These results might explain the highest linear tracer dye penetration in Endomethasone N group in this present study. This may be due to flow value of Endomethasone N was lower than those considered acceptable for the ISO specification.

The thickness of the endodontic sealer film ranges from 4 to 180µm[31]. Since all experimental sealers shows micro leakage to certain extent, this implies the necessity to limit its presence to a thin film and increasing the mass of gutta percha, because the sealer might shrink during setting and dissolve overtime period producing apical leakage.

The result of the present study also showed that all materials exhibited apical microleakage, but there was insignificantly less microleakage in AH plus when 5.25 % NaOCl and 17 % EDTA was used as an irrigant. At the same time, maximum leakage was seen in Endomethasone N when 2% CHX is used as root canal irrigant.

The outcome might be attributed to the fact that 2% CHX solutions cannot dissolve organic tissues in the root canal system. Hence remnants of these organic components might interfere with the bonding of the sealers to the root canal wall when CHX is used as root canal irrigants. Whereas 5.25 % of NaOCl used along with 17% EDTA as an irrigant, completely dissolves organic as well as an inorganic portion of the smear layer. EDTA chelates with calcium and removes the mineralized portion of the smear layer and NaOCl acts as a proteolytic agent to remove organic component[89] resulting complete removal of smear layer and improve bonding of sealers to the dentinal wall and ultimately reduces apical microleakage for groups irrigated with 5.25% NaOCl with 17% EDTA as irrigating solution.

To determine the accuracy of experiment control groups were included in this study. As expected, negative control groups exhibited negligible apical microleakage indicating using two layers of varnish is effective to prevent dye penetration. Absence of dye penetration in negative environments indicated the efficacy of nail varnish. However, all positive control groups showed that in the absence of root canal sealer, there is no proper seal and exhibit maximum apical microleakage in the root canal system. Since this study was short term study, further long term studies with the more precise and advanced method are required for the evaluation of the effect of 2% CHX and 17% EDTA plus 5.25 % NaOCl irrigating solutions on the apical sealing ability of AH Plus, MTA Fillapex and Endomethasone N root canal sealers.

CONCLUSION

In the confine of this study and according to the methodology, observation and result it may be concluded that AH Plus showed better apical sealing ability than MTA Fillapex and Endomethasone N root canal sealer irrespective of irrigating solutions used in this study.

AH Plus> MTA Fillapex>Endomethasone N root canal sealer

More apical microleakage seen in experimental group irrigated with 2% CHX then irrigated with 17 % EDTA along with 5.25% NaOCl solution.

2% CHX>17% EDTA with 5.25% NaOCl irrigating solution.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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