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Effect of Time of Interradilarcular Preparation on Apical Microleakage of Endodontically Treated Teeth

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ABSTRACT

Purpose: This study was conducted to evaluate apical leakage of post space preparation when performed at different time intervals immediately after root canal obturation (after setting of the sealer used) or delayed after two weeks. **Materials and methods:** Forty-five extracted human anterior single rooted teeth were selected and placed in sterile physiologic saline solutions. Teeth were decoronated perpendicular to their long axis and 2mm above the cemento-enamel junction (CEJ). The canals were filed to mater apical file size #40 using step-back tech. The root canals were enlarged and flared to size #55. The specimens were divided randomly into 3 equal groups(15 samples each) , according to type of sealer that used during root canal treatment group (1) Eugenol-based sealer, group(2) Calcium hydroxide-based sealer and group (3) Resin –based sealer, After root canal obturation, the specimens were further subdivided into three subgroups (5 samples each): subgroup (A) without post space preparation as control, Subgroup (B) with immediate post space preparation and Subgroup (C) with delayed post space preparation**. Results:** Calcium hydroxide based sealer group recorded the highest mean value of apical leakage followed by Zinc oxide eugenol-based sealer and AD SEAL resin based sealer which recorded the lowest mean value with no statistical significant difference (P>0.05). Regarding the effect of time interval control sub group recorded the statistically significant lowest mean value followed by immediate subgroup, while delayed subgroup recorded the statistically significant highest mean value (P <0.05). **Conclusions:** The type of sealer had major effect on the apical seal of endodontically treated teeth. Post-space preparation affects the apical seal of endodontically treated teeth. The effect of immediate preparation on apical seal was significantly lesser than delayed post space preparation.

KEYWORDS

Apical seal, Apical leakage, post space preparation, post hole preparation, endodontic sealer.

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INTRODUCTION

The objectives of endodontic therapy are to clean and shape the root canal system and to seal this system with a permanent three dimensional (3D) filling that does not allow leakage [1]. Various materials have been used to obturate the root canal in an attempt to achieve which are most often applied involve the use of gutta-percha cones and an endodontic sealer [2].Endodontically treated teeth often lack sufficient support for a permanent restoration. An additional retention can be necessary gained from the root canal. Thus, these teeth often may require the use of an intra-canal post for retention of the core and to disperse the forces along the root. In order to create space for a post, part of the root canal filling material must be re-moved [3,4].

Many techniques are used to remove gutta-percha, chemical using a solvent such as chloroform, thermal using hot endodontic pluggers, and mechanical, using a rotary instrument such as a Gates Glidden or a peso- reamer [4]. Recently, a nick-el titanium (NiTi) drill with a non cutting tip and non cutting lateral surface has been proposed for removing gutta-percha and preparing the post space without enlarging the canal diameter like the other drills that might remove an excessive amount of root canal dentin and then reducing the strength of the root [5]. During preparation of the post space the residual filling material may be dislodged, twisted or vibrated which creates a pathway for bacterial invasion and re-infection of the root canal system. Several factors can affect the integrity of the apical seal while post space is prepared such as length of remaining gutta-percha, time of removal of the filling material and method of gutta-percha removal[6,7].

Studies investigated the effect of post space preparation on the integrity of the apical seal of the teeth obturated initially by different material and obturation technique [3,5]. There is no consensus on the time interval between the endodontic treatment and the post preparation with some authors proposing an immediate preparation and others recommending different time intervals [8].

Root canal sealers are considered a medium that play the role of lubricant, close the interface between obturation material and root canal. Sealers also fill voids and irregularities in the root canal, lateral and accessory canals, and spaces between gutta-percha points used in lateral compaction. Microleakage can result in failure of endodontic treatment. An important characteristic of endodontic sealer is their sealing ability. The sealer is very important for long term seal of the root canal filling because it adheres gutta-percha to the root canal dentin and fills irregularities and spaces among gutta-percha cones and between the root canal walls and fillings [9].

Zinc oxide eugenol (ZOE)-based sealers were introduced by Grossman in 1936, to be used in conjunction with the gutta-percha or silver cones. Endofill is a commonly used ZOE-based sealer, available in a powder-liquid form. Root canal sealers based on epoxy-resin are employed because of their good physicochemical properties and adhesion.

Adseal is resin-based sealer that contains bismuth phosphate and zinc-oxide mixed with vinyl polymer available in two paste containing tubes. It has advantages like more radiopacity, less solubility, slight or no shrinkage on setting, excellent adhesion property and tissue compatibility. In case of calcium hydroxide based sealer, Calcium hydroxide ($Ca(OH)_2$) is added to ZOE sealer to reduce the irritating effect of eugenol and also to get its additional disinfecting, antibacterial and osteogenic effect. The bacterial growth is inhibited due to alkaline effect of $Ca(OH)_2$ [10].Final restoration of root canal treated teeth mostly involves removal of considerable amount of root canal filling material in order to insert a post. Many research found that post space preparation affects the sealing ability of the root canal filling and this effect differs according to the type of sealer and time of post hole preparation immediate or delayed [9,11,12].

MATERIALS AND METHODS

Forty-five extracted human anterior single rooted teeth free from caries, fractures were used. These teeth were placed in sterile physiologic saline solution. The teeth were decoronated perpendicular to their long axis and above the cement-enamel junction (CEJ) using diamond disc. The samples were stored in saline during all the time of the experiment. The working length was established by using a size #15k file inserted into each root canal until the tip of the file was visible at the apical foramen, then the length was shorter by 1mm.

The canals were filed to master file size #40 by using step-back tech. The root canals were enlarged and flared to size #55 and irrigated with 10ml 5.25%(by volume) sodium hypochlorite (NaOCl). Upon completion of these procedure the specimens were divided randomly into 3 equql groups of 15 samples each, according to type of dental sealers that used during root canal treatment of these teeth. Group (1) Eugenol –based sealer [Endofil] was used. Group (2) Calcium hydroxide based sealer [Apixit Plus] was used. Group (3) Resin based sealer [ADSEAL] was used. After root canal treatment, the teeth was further subdivided into three subgroups (5 samples each): Subgroup (A) without post space preparation, Subgroup (B)with immediate post space preparation. Subgroup (C) with delayed post space preparation.

The gutta-percha points in all specimens were laterally condensed and auxillary cones were applied. A heated instrument was used to remove the excess gutta-percha and vertical force was applied with pluggers (0.8 mm. diameter) to compact gutta-percha in the coronal portion of the canal. Post space preparation was done while the root block former was fixed inside acrylic resin block and fixed to parallometer table to sure that post hole is parallel to the long axis of the root and root block and facilitate uniform load application during post cementation.

Vertical holding device was used to ensure placement of the root in a vertical position. Gutta-percha were removed from the root canal using number 2&3 Gates Glidden drills with rubber stopper to control the depth of post hole preparation (8.5mm. length) to ensure that 5 mm. length root canal filling was to maintain the apical seal and to provide information regarding the effect of post space preparation on the seal of a root canal filling. Next, post space preparation was completed for fiber post using size matched (8.5mm. length) drill supplied with it.

The specimens of subgroup (B) in all groups were prepared immediately after complete setting of the each sealer according to manufacturer instructions. In case of Apexit Plus approximately 3 hours, in case of ADSEAL the setting time is 45 minutes, and in cases of Endofil the setting time is 2hours and 15min. The teeth of subgroup (C) of all groups were prepared after two weeks from obturation, during this period the teeth were stored in saline. No post space preparation was performed for subgroup (A) of all groups (as control group).

A special designed pressure jig with 5kg weight was machined from stainless steel, in order to aid in load application upon the samples during cementation procedure. After post space preparation fiber posts of 1.20 mm. diameter and 10 mm length were cemented into the canal using Glass ionomer cement. The cement was mixed using plastic spatula and inserted into the canal with 50 K-file. The post was inserted into the canal with light pressure and stabilized for 2 min under static load using the cementing device. Then, the excess material was removed.

After removal of the acrylic resin block, the root samples were covered with two layers of nail polish (except for 2 mm around the root apex) then vertically downward immersed in a solution of 2% methylene blue dye for 24 hours at 37°C temperature incubator. Subsequently, samples were taken out of the dye solution, washed with water, and the samples were mounted onto special holding device for sectioning. Samples were sectioned with

a low speed diamond saw under water spray. The specimens were rinsed in running water and then dried with tissue paper. The dye penetration along the canal wall was assessed with USB Digital microscope at 25× magnification in which the image was captured and transferred to a computer equipped with the image analysis software program (Image J 1.43U, National Institute of Health, USA) Within the Image J software, all limits, sizes, frames and measured parameters are expressed in pixels.

RESULTS

Data analysis was performed using two factorial analysis of variance ANOVA test of significance comparing variables affecting mean values (sealer and time of post space preparation)

Descriptive statistics of apical leakage results

Descriptive statistics of apical leakage results (Mean ±SD) determined by dye penetration method measured in for all sealer groups as function of time of post space preparation are summarized in Table (1).

Effect of sealer on apical leakage

Regardless to time of post space preparation, totally it was found that Ca(OH) based sealergroup recorded statistically non-significant (p>0.05) highest mean value (1.074±0.58 mm) followed by ZOE based sealer group (1.0004±0.29 mm) while AD SEAL resin based sealer recorded statistically non-significant (p>0.05) lowest mean value (0.8878±0.15 mm) as indicated by two-factorial ANOVA followed by pair-wise SNK post-hoc test, Figure 1.

Table (1) *Descriptive statistics of apical leakage results (Mean ±SD) for all sealer groups as function of time of post space preparation*

Variables		*Time of post space preparation*			*Statistics*
		Control	*Immediate*	*Delayed*	*P value*
Sealer	*AD SEAL*	$0.7465^{A}c\pm0.11$	$0.7964^{B}a\pm0.28$	$1.1203^{B}a\pm0.06$	0.0277*
	CaOH	$0.4713^{C}b\pm0.047$	$0.8104^{B}a\pm0.05$	$1.9403^{A}a\pm0.32$	<0.0001*
	ZOE	$0.7672^{B}a\pm0.18$	$0.7927^{B}a\pm0.26$	$01.4414^{A}b\pm0.13$	0.002*
Statistics	*P value*	0.0017*	0.9943 ns	0.0223*	

*Different superscript letter in same row indicating significance between time (p<0.05) ns; non-significant (p>0.05) *; significant (p≤0.05)*

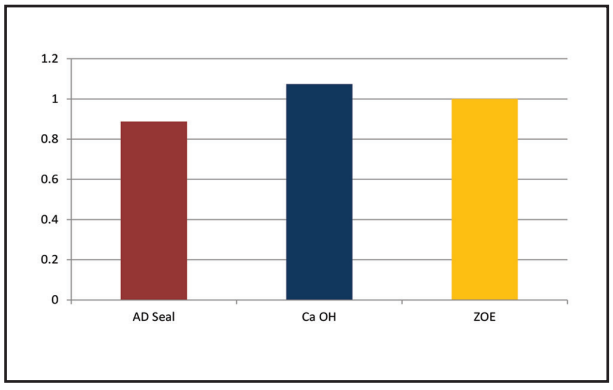

Fig. (1) A column chart of total apical leakage mean values as function of sealer

Effect of time of post space preparation on apical leakage

Irrespective of sealer type, totally it was found that Control subgroup recorded statistically significant (p<0.05) highest mean value (1.5007±0.29 mm) followed by Immediate subgroup (0.7998±0.007 mm) while Delayed subgroup recorded statistically significant (p<0.05) lowest mean value (0.6618±0.13 mm) as indicated by two-factorial ANOVA test. Pair-wise SNK post-hoc test showed non-significant (p>0.05) difference between immediate and delayed subgroups, figure 2.

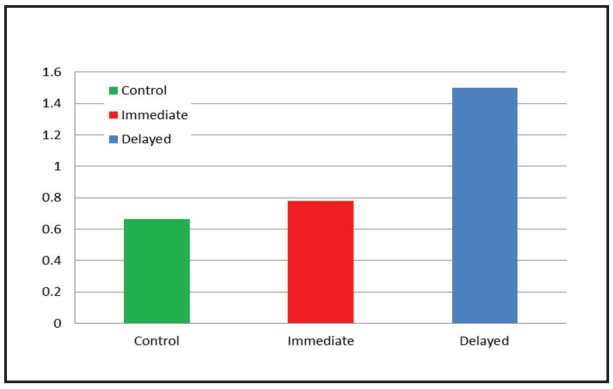

Fig. (2) A column chart of total apical leakage mean values as function of time of post space preparation

DISCUSSION

Several studies have shown that the integrity of the reaming obturation after removal of root canal filling materials may depend on a number of factors, and some of these factors are techniques and instruments used for removal [13-19] the length of the remaining materials [20-22], endodontic obturation technique [14, 23-25], used cements and time of their setting [8, 18, 26-28]and time of removal of root filling[8,13,14,17,18,27,29-31]

According to previous work [30], in the restoration of endodontically treated teeth, space for any posts required should be gained with rotary instruments at a subsequent visit after the complete setting of the sealer, and that the apical segment of the root filling can be condensed after the coronal gutta-percha has been removed.

Following obturation of the root canal, immediate preparation for post placement has a number of additional advantages. The operator has greater familiarity with the root canal morphology and its working length, and there is less risk of coronal tooth tissue fracturing, so losing the reference point from where the working length was determined. This leads to the appropriate amount of gutta-percha removal and less risk of post perforation [27, 32].

Another author found more apical leakage after delayed post preparation compared with immediate preparation and removal of laterally compacted gutta-percha with either AH26 or Pulp Canal sealer. In a similar dye leakage study, immediate preparation of canals obturated with gutta-percha and a zinc oxide–eugenol based sealer also resulted in less apical leakage [27]. This has been attributed to less 'pulling' effect that mechanical removal of gutta-percha may have on setting sealer compared to set sealer.

This study was designed to compare apical sealing ability endodontically treated single rooted teeth at different time immediate and delayed post space preparation intervals using three different root canal sealers.

Predictable clinical results have been reported with the use of gutta-percha points and epoxy resin-based root canal sealers[33]. There is an increasing interest in the use of methacrylate resin-based sealers (containing urethane dimethacrylate – UDMA)[2], because these materials can be used with dentin adhesives for bonding to intraradicular dentin. Moreover, hydrophilic methacrylate resin monomers may be incorporated into root canal sealers to improve resin penetration into dentinal tubules after removal of the endodontic smear layer [34]. This fact may explain the low microleakege results of EndoREZ, which is a UDMA resin-based root canal sealer.

These results could be attributed to the difference in adhesion and solubility properties of these types of cements stated before [35]. Also the results of early and delayed preparation of all sealer groups shown that early preparation subgroups had less leakage compared with the delayed preparation subgroups. Epoxy resin-based root canal sealers have also shown good physicochemical properties as well as excellent apical sealing. Studies have demonstrated that resin endodontic sealers, such as AH Plus, have lasting dimensional stability and satisfactory apical sealing ability [36].

Calcium hydroxide ($Ca(OH)_2$) is added to ZOE sealer to reduce the irritating effect of eugenol and

also to get its additional disinfecting, antibacterial and osteogenic effect. The bacterial growth is inhibited due to alkaline effect of Ca $(OH)_2$. These sealers may stimulate sterile biological closure of the apical seal. They have very long setting time, low solubility, shrinkage, and are radiopaque, biocompatible [1].In this study, single rooted teeth with single root canal and approximate sizes were used to minimize anatomical variation and allow standardization of results.

Glass ionomer based cement was used to avoid the inhibiting effect of eugenol present in the sealer on the setting of the used cement. To standardize the process of post-hole preparation and post cementation the teeth were fixed inside an acrylic resin block. The time of post-hole preparation in the immediate group was the setting time determined by the manufacturer of each cement and the delayed preparation was performed two weeks. During the waiting period the samples were stored in saline solution to prevent drying of the samples. Longitudinal sectioning of roots and linear measurement of dye penetration were used in this study to measure apical leakage. Methylen blue dye was used as the leakage tracer due to its advantages as easily preparation and technique of usage.

The results of this study showed that the resin based sealer showed the least leakage, followed by zinc oxide and eugenoal based and the highest leakage was seen in the group used calcium hydroxide sealer. Many authors showed significantly less leakage when the post space was prepared at the time of obturation than when it was prepared at one week after obturation, since the sealer is still within its working time when the gutta-percha is removed and defects can be remedied. When post space preparation is delayed, the sealer sets completely, such that removal of the filling mass later on causes movement that disrupts the bond sealer interface [31].

CONCLUSIONS

Within the limitations of this in vitro study the following conclusions were evident:

1. The type of sealer had major effect on the apical seal of endodontically treated teeth.
2. Post-hole preparation affects the apical seal of endodontically treated teeth
3. The effect of immediate preparation on apical seal was significantly lesser than delayed post space preparation.

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