ORIGINAL ARTICLE

An In Vitro Study of Sealing Ability of Commercially Available Root Canal Sealers

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ABSTRACT

Objective: The current study aimed to explore the sealing ability of commercially available root canal sealers after obturation by using stereomicroscope.

Study Design: Experimental laboratory-based study.

Place and Duration of Study: The study was conducted at Zoology Department, National Centre of Excellence in Geology and Department of Pathology at College from 10th January 2021 to 31st March 2022.

Materials and Methods: Teeth used in this study were divided randomly into four experimental (four commercially available sealers) and one control group (only gutta percha without using sealer) (n=10) denoted by EG1, EG2, EG3, EG4 and CG5 respectively. After obturation, specimens were coated with varnish except for 1-2mm of apical area and immersed in 2% methylene blue for 1 week. Specimens were analyzed using Stereomicroscopy, Scanning electron microscopy and Energy Dispersive X-ray Analysis (SEM, EDX). Kruskal Wallis and Mann-Whitney U-tests were employed to measure statistical significance.

Results: Fifty percent samples of Endomethasone sealer had a score of 2 and the rest score 3. Sixty percent of Sealapex sealer had score of 2 and Forty (40) percent had score of 3. Fifty percent of Adseal sealer had score of 2 and remaining fifty (50) percent of Adseal sealer had score of 3. Fifty percent of AH Plus sealer had score of 2. Forty (40) percent had a score of 1 and remaining ten percent had score of 3 (Table. I).

Conclusion: AH Plus proves to have better sealing ability with minimal dye penetration when compared to other endodontic sealers.

Key Words: *Apical Microleakage, Dye Penetration, Gutta Percha, Root Canal Sealer.*

Introduction

The endodontic treatment comprises of eradication of bacterial load in the root canal and filling of the entire root canal system three dimensionally.[1] The anticipated outcomes of endodontic treatment rest on mechanical instrumentation, root canal disinfection, eradication of pathogens, absolute debridement of pulp remnants as well as filling the entire root canal. Root canal filling should adequately seal the root canal and hinder the oozing of fluid into the root canal. Thus, it stimulates the resolution of pathologies in the periapical area and ensures the cementum deposition to achieve the biological seal.[1]

Ideally root canal sealer should provide satisfactory adhesion between itself, root canal walls and the core filling materials. It should be radiopaque, act as lubricant, possess antibacterial properties, able to flow easily into surface irregularities.[2,1] An endodontic sealer is applied in conjunction with core filling material (GP), because the root canal system cannot be obturated completely by gutta-percha itself and avoid the infection of root canal by providing seal both apically and laterally.[1] Sealers enhance the possibility of achieving an impermeable seal and aids to act as fillers for canal irregularities.[4] The leakage through a filled root canal occurs between the sealer and dentine interface, or the sealer and the gutta percha interface or through voids within the sealer.[5] Although hermetic seal is not always possible with today's sealers, a fluid-tight seal is at the very least preferable.[1]

The sealers used in root canal treatment are usually divided into groups depending on their constituents, for example sealers based on zinc oxide, sealers based on calcium hydroxide, glass ionomer cement sealers, formaldehyde containing sealers as well as resin-based sealers.[8] Despite the tremendous progress, until today no material meets all requirements and desirable properties to

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hermetically seal the root canal system. Apical leakage is still a common experience in root-filled teeth, which raises concern about the quality of obturation obtained with the presently available root canal filling materials.[7]

Literature search showed that many studies have been conducted in the past to determine the sealing ability of various commercially available sealers by using different techniques due to established concept that improper obturation can lead to reinfection, but the comparison of the efficacy of the sealing ability of various root canal sealers currently available in the local market was not carried out in the past therefore the aim of the present study was to evaluate the ability of different commercially available endodontic sealers to seal the root canal.

Materials and Methods

This was an in-vitro, study conducted from 10th January 2021 to 31st March 2022, in Department of Dental Materials Peshawar Dental College, after approval by the Institutional Review Board (Prime/IRB/2021-359). The materials used in the study are given in (Table. I). Sample size was determined based on ISO standard (# 11405). A total of fifty (50) intact non-carious human permanent mandibular premolar teeth were selected. Teeth were divided randomly into four experimental and one control group (n=10) denoted by EG1, EG2, EG3, EG4 and CG5 respectively (Table I). Mandibular premolar intact non-carious human extracted permanent teeth were included while carious, fractured teeth, teeth with open apices, root resorptions and teeth with bifurcating canals were excluded from the study.

All the teeth were placed in 5.25% sodium hypochlorite solution[6] for 48 hours to clean the surface of teeth. Coronectomy of all selected teeth was done by fissure bur (1.59 – 1.6mm shank diameter) at the cemento-enamel junction in Ultra Push Type high-speed hand piece. ProTaper universal rotary system (Foshan, Guangdong, China, ISO Specification CEO197) was used to prepare root canals 1mm short of the length, until reaching to a size F2 (master apical file). Barbed broaches were used to extirpate the pulp tissue from. Sodium hypochlorite (5.25%) and 5ml of EDTA was used to irrigate the canals, prior to final irrigation by 5ml distilled water. Canals were dried with paper points.

Each of the sealer was manipulated according to manufacturer's directions and was introduced into the canal using the lentulo-spiral fitted. Hand spreader was used, and entire canal was obturated. Then the teeth in all the groups were placed in an incubator (Intelligent Laboratory Incubator, China) at 37 °C and 100% relative humidity for one week.

Two to three layers of clear nail varnish was applied on the root surface. Apical area (1-2mm) covered with sticky wax was left uncoated. Roots were completely immersed into the 2% methylene blue aqueous solution for 1 week. Then sticky wax and coating was removed from the surface while rinsing under a tap water. The roots were vertically sectioned by using teeth cutting saw. Stereomicroscope was used to determine apical dye leakage. The specimens were scored as follows[1]. 1: (1-3 mm); 2: (3-5 mm); and 3: (>5 mm).

The bond between the sealer and the dentin was examined using scanning electron microscopy. Using a diamond disc on teeth cutting saw machine, the roots were sectioned perpendicular to the longitudinal axis to get 2mm thick samples. The samples were polished with sand discs and washed with distilled water. Then, the samples were dried and fixed on aluminium stubs. Sputter coating of the samples was performed with a gold–palladium alloy before being scanned with SEM (JAPAN, JSM-IT 100).

Statistical analysis was done by using software version 23 of SPSS. Mean and standard deviation values were determined. Kruskal Wallis and Mann Whitney test was applied to determine significant values. P value less than 0.05 was considered as significant.

Results

The mean and standard deviation values for Endomethasone, Sealapex, Adseal, AH Plus, and control are 4.48±0.99, 5.06±0.98, 5.02±0.89, 3.75±1.21, 6.54±0.47 mm respectively (Table I), while the Table II shows the distribution of samples for dye leakage based on scoring criteria. Kruskal Wallis test specified statistically significant difference among the various experimental groups *(p=0.039).* Dye penetration was highest (5.06mm) in Sealapex (EG2) and lowest (3.75mm) in AH Plus (EG4). Adseal (EG3) showed less dye penetration than Sealapex (EG2) *(p=0.970)*. AH-Plus (EG4) showed lower amount of dye penetration when

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compared to Endomethasone (EG1), Sealapex and Adseal (EG3*) (p<0.05)*. When Endomethasone sealer was compared with Sealapex, Adseal and AH Plus, no statistically significant difference was found *(p>0.05).* Similarly, comparing Sealapex (EG2) to Adseal (EG3), no statistically significant difference was observed *(p > 0.05)*. While comparing Sealapex sealer with AH Plus sealer, statistically significant difference *(p < 0.05)* was found. Similarly, when Adseal (EG3) was compared with AH Plus (EG4), a statistically significant difference *(p < 0.05)* was noted.

In SEM analysis, Endomethasone showed no gap (good adaptation) between the sealer and dentin at the interface. Sealapex, showed gap (poor adaptation) between the dentin and sealer. Epoxy resin based endodontic sealer (Adseal) displayed no gap (reasonable adaptation) between dentin and sealer. Also, AH- Plus displayed no gap (good adaptation) between the sealer and the dentin.

Table I: Descriptive Analysis of Experimental Groups Showing Mean, Standard Deviation, Minimum and Maximum Values

Sealer	Mean(mm)	Std. Deviation	Minimum	Maximum
Endomethasone	4.48	±0.99	3.16	5.93
Sealapex	5.06	±0.98	3.16	6.47
Adseal	5.02	±0.89	3.12	6.12
AH Plus	3.75	±1.21	1.83	5.66
Control Group	6.54	±0.47	5.75	7.00

Table II: Distribution of Samples as per the Dye Leakage Scoring Criteria

Groups	Score 1	Score 2	Score 3
Endomethasone Sealer	0	5	5
Sealapex Sealer	0	6	4
Adseal Sealer	0	5	5
AH Plus Sealer	4	5	1

Discussion

In experimental groups, mean dye penetration values for each group revealed that dye penetration was highest in Sealapex sealer (60% of Sealapex sealer had score of 2 and 40% percent had score of 3) and lowest in AH Plus. Afterwards, Adseal sealer showed dye penetration less than Sealapex (50% of Adseal sealer had score of 2 and remaining 50% of Adseal sealer had score of 3). AH Plus shows lowest amount of dye penetration (50% of AH Plus sealer had score of 2, 40% had a score of 1 and remaining 10% had score of 3) as compared to Endomethasone

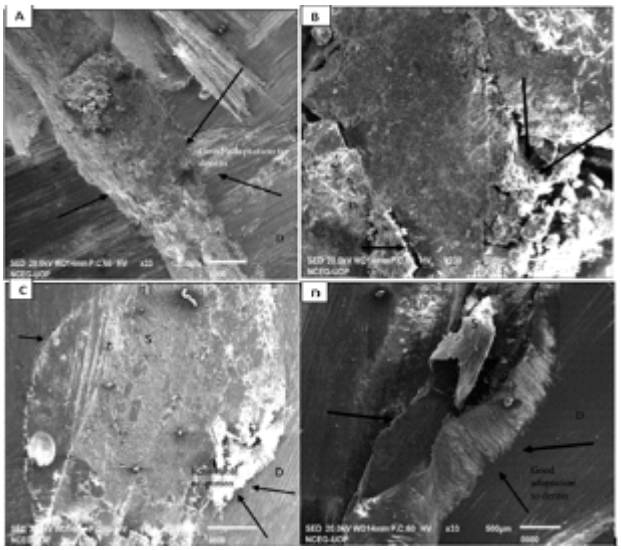

Figure 1: (A). Endomethasone, SEM with 33X magnification. 'Arrow' indicates no gap (good adaptation) between the dentin and sealer at the interfaces. (B) Sealapex, SEM with 230X magnification. 'Arrow' indicates gap (poor adaptation) between the dentin and sealer (C) Adseal, SEM with 43X magnification. 'Arrow' indicates no gap (reasonable adaptation) between the dentin and sealer. (D) AH Plus, SEM with 33X magnification. 'Arrow' indicates no gap (good adaptation) between the dentin and sealer. S: Sealer D: Dentine

sealer (50% had a score of 2 and the rest scored 3).

The results of this study demonstrated that leakage was present in the apical area, between root canal walls and the sealers, between the sealer and gutta percha, and through the sealer. The dye penetration inside the sealers also indicated leakage in the sealer's body, opening up another avenue for leaking. The results of this study were also supported by previous studies that all root canal fillings leak.[15,16]

The results of apical micro leakage are influenced by numerous factors. Besides the sealing ability and properties of root-end materials, the technique of assessment, root canal morphology and the diameter of the root canal may influence the results of sealing ability.[17] Several approaches of microleakage assessment have been employed, such as fluid filtration, dye penetration, bacterial leakage, radioactive isotopes and others. It is essential to highlight that no standard method of microleakage assessments exists, and there is a lack of technical standardization even when the same methodology is employed. The lack of standardization is possibly the

main reason why there are so many different methods to investigate the same phenomenon.[17]

In this study, Sealapex demonstrated significantly higher leakage than AH Plus sealer. Sealer's porous nature allows for significant water intrusion, promoting the powder-binder reaction to continue. Other study reported insignificant difference between the Sealapex and AH Plus in apical leakage.[1] Because of water sorption due to the presence of calcium oxide, Sealapex expands in volume during the setting process. This property may increase the solubility of the substance, increasing the danger of leaking over time.[19]

ZOE-based sealer (Endomethasone) displayed the highest dye penetration when compared to sealer based on epoxy resin (AH Plus), which is in agreement with the previous findings.[1,20] Earlier studies have reported that sealers based on ZOE have not good dentin adhesion and sealing qualities and is highly permeable.[21,22]

The findings of the current study demonstrated that AH Plus had a better sealing ability than the other types of sealers. These results are similar with the findings of the Patni et al[6] which revealed that AH-Plus has a superior capability to seal than traditional zinc oxide eugenol and calcium hydroxide-based sealers. Superior adaptation of AH Plus is due to its ability to bond to root dentine chemically by reacting with exposed amino groups in collagen.[10]

Resin-based endodontic sealers (Adseal) did not provide a superior seal than ZOE-based sealers in the current study. This is since the specimens were kept at temperature and humidity level similar to the human body[23]. In the current study, AH Plus was found to give low dye absorption values, implying less dye leakage, and impacting sealer's strategic advantage over the other sealers. Finally, dye was seen in all sealers, regardless of kind, implying that a full airtight seal is impossible to achieve with contemporary sealers.

Linear dye penetration measurement is the most frequent, simple, and quick approach for determining sealant microleakage.[1,18] For obturation, lateral compaction technique was utilized in this work as it has been used as standard for comparison[10]. Methylene blue (MB) is a commonly used dye with concentrations of 0.25, 1 and 2%. We selected 2% MB in our study, because it was the most prevalent concentration and a reliable method.[13] It was reported that MB penetrates more deeply along the root canal filling and exhibits greater penetration than India ink due to low molecular.[12,14]

The SEM of the Endomethasone sealer demonstrated uneven surface and a uniform distribution of components (Fig. 1). The surface was entirely covered by huge granules. SEM image of Adseal sealer display rough surface and a homogenous distribution of components. It contains particles of variable morphology as shown in (Fig. 1). Cakici and his coworkers[24] stated, that for an epoxy resin sealer (Adseal & AH Plus), the apical area exhibits the highest bond strength when compared to other areas. AH Plus, an epoxy resin-based sealer, displayed smooth surface and a consistent distribution of elements, with particles having spherical shape and similar size. Balaguerie et al[25] reported deeper flow of AH Plus sealer in tubules on SEM examination. In this study, humidity and heat factor were not investigated; however, they are known to alter sealer flow and penetration. Because of their creep capability and extended polymerization duration, epoxy-based sealers penetrate easier into micro irregularities.

One of the limitations of this study was that it used the traditional dye-penetration approach. Dye penetration approach is an invasive approach since the specimens were split vertically and during the splitting, there was a possibility that core material would be extruded from the specimens, influencing the outcome of this study. Also, the linear dye penetration technique does not provide information about the volumetric data of the tracer penetrating the interface between the root filling and the root canal wall. Additionally, due to lack of a simulated periodontal ligament and other clinical characteristics, data obtained in in-vitro studies may not be applicable and instantly extrapolated to clinical conditions.

Furthermore, there is still a need for future work to compare different canal preparation methods, sealers and obturation skills since all of these factors may influence the seal of the root canal. It is also essential not to overlook the biocompatibility and cytotoxicity. Other causes of leakage in this study might be linked to the presence of entrapped air or atypical anatomy which was not investigated in our

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work and may be topic of research in future studies.

Conclusion

Within the limitation of this study, it can be concluded that among all the commercially available root canal sealers tested, epoxy resin-based sealer (AH Plus) proves to have better sealing ability and good adaptation between the dentin and sealer at the interfaces with least amount of dye infiltration, implying minimal dye penetration and microleakage.

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CONFLICT OF INTEREST

Authors declared no conflicts of Interest.

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DATA SHARING STATMENT

The data that support the findings of this study are available from the corresponding author upon request.

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