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THE PENETRATION ABILITY OF CALCIUM SILICATE ROOT CANAL SEALERS INTO DENTINAL TUBULES COMPARED WITH RESIN-BASED SEALER: A CONFOCAL LASER SCANNING MICROSCOPY STUDY

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ABSTRACT

Aim: The objective of this study was to compare the penetration ability of calcium silicate root canal sealers and conventional resin-based sealer using confocal laser scanning microscopy (CLSM). **Materials and Methods:** 30 extracted single rooted premolars were selected. Root canals were prepared using ProTaper Gold rotary instruments upto apical size F3. The canals were irrigated with 2ml of 5.25% NaOCl, 2ml of 17% EDTA and 5ml of saline. The specimens were divided into 3 groups of 10 samples each. Group 1 was obturated with Meta AdSeal RCS, group 2 with BioRoot RCS, group 3 with MTA Fillapex respectively using single cone technique. The cross- sectional cutting was carried out at 3mm and 5mm from the apex. The penetration abilities of all samples were evaluated using Confocal laser scanning microscopy. Data were subjected to statistical analysis using Kruskal–Wallis analysis and Mann–Whitney U post hoc tests. **Results:** The MTA FillApex group showed higher sealer penetration at the apical third compared with BioRoot RCS and Meta Adseal group, whereas BioRoot RCS showed higher sealer penetration in the middle third, similar to MTA FillApex. **Conclusion:** Within the limitations of the study, calcium silicate-based sealers showed better sealing ability when compared with the conventional resin-based sealer.

KEYWORDS: Sealing ability, BioRoot RCS, MetaAdseal RCS, MTA FillApex, Confocal Microscopy.

INTRODUCTION

Root canal therapy is indicated for the complete elimination of microorganisms from the radicular space and providing a three-dimensional hermetic seal inside the complex canal systems. This impermeable seal will reduce the microbial contamination, prevents apical as well as coronal leakage and entombs the remaining irritants in the canal space.[1-2]

Endodontic microbes will persist in areas such as lateral canals and accessory canals because these areas are protected from the disinfection action of the various intracanal medicaments and irrigants. Various types of obturating materials have been developed for achieving the fluid tight seal of the canal space. Root canal sealers plays an important role in providing this seal by filling the gap between the root detin wall and the core obturating material. The sealers should fill the irregularities of the radicular space and should penetrate to the dentinal tubules to completely form an impervious seal.[3]

Epoxy resin-based sealers have an established record in the field of endodontics by providing less solubility and high bond strength to the radicular detin. The biocompatibility of these types of sealers is less when compared to the calcium silicate-based sealers. The initial toxicity of the resin-based sealers is very high compared to the final set.[4] Meta Adseal is an epoxy resin-based sealer with tight apical sealing and penetration to the dentinal tubules.

BioRoot RCS (Septodont, St. Maur-des-Fossés, France) is composed mainly of tricalcium silicate and zirconium oxide powder that must be mixed with a liquid containing calcium chloride. In recent studies comparing epoxy resin-based and calcium silicate sealers, BioRoot RCS showed excellent biocompatibility in both the initial and final set states.[5-6]

MTA FillApex (Angelus, Londrina, PR, Brazil) is also a bio ceramic sealer with high alkaline pH ad subsequent antibacterial activity. According to the manufacturer, after the mixing, the composition of the material is essentially MTA, salicylate resin natural resin, bismuth oxide ad silica nanoparticles.[7-8]

Thus, the changes in the physical and chemical properties of root canal sealers influence the depth of penetration.[9] Therefore, it is important to compare the penetrability of various sealers that are used in routine clinical practice. The aim of this study was to evaluate and compare the penetration ability of calcium silicate root canal sealers and conventional resin- based sealer using confocal laser scanning microscopy (CLSM).

MATERIALS AD METHODS

Thirty mandibular single rooted premolars stored in normal saline solution were used in this study. The teeth were decoronated at the cementoenamel junction (CEJ) by a safe-sided diamond disc and the root canal length standardized at 14 mm. Radiographs were exposed from facial ad proximal views to ensure the presence of a single canal. A size 10-K file was introduced into each canal until it could be seen through the apical foramen ad the length measured. Working length was established by subtracting 1mm from that length. Then the teeth were instrumented by using the ProTaper technique (Dentsply Maillefer, Ballaigues, Switzerland) to a size of the F3 instrument at the working length. The canals were then irrigated with 2 mL of 3% sodium hypochlorite (NaOCl) solution using a 27-gauge slotted, side-vented needle during the instrumentation procedure. After the preparation, the root canals were rinsed with 2 mL of 17% ethylenediaminetetraacetic acid (EDTA) solution for 1 min to remove the residual smear layer. As a final irrigation, 10 mL of distilled water was used.

Specimen Grouping and Root Canal Obturation

After drying all canals, the specimens were divided, according to the obturation technique and materials, into three experimental groups of 10 samples each, and the roots of all specimens were coated with two layers of nail varnish.

Group 1 (n=10): GP/Meta Adseal RCS with a single-cone technique. Group 2 (n = 10): GP/BioRoot RCS with a single-cone technique.

Group 3 (n = 10): GP/ MTA-FILLAPEX with a single-cone technique.

All three sealers were manipulated according to the manufacturer's instructions on a mixing pad with the help of a spatula until a homogenous consistency was obtained. Each sealer was labelled with 0.1% rhodamine B dye (Sigma-Aldrich, St. Louis, MO, USA) during the mixing procedure to allow visualization under a confocal laser scanning microscope. In all groups, each sealer was applied to the root canal with a lentulospiral (Dentsply Maillefer) to the working length, and a size 30/0.06 GP cone was inserted into the canal. Light pumping motions were applied to place the GP cone at the full working length. The GP at the upper surface was removed using a heated plugger by 3mm. The coronal access of all groups was sealed with a temporary filling material (Cavit G; 3M ESPE). Finally, all experimental samples were stored for 7 days in wet conditions at 37◦C for complete setting.

Each experimental sample was sectioned perpendicular to its long axis using a low-speed diamond saw, which was set at 500 rpm with continuous water cooling. The horizontal sectioning was done at 3 and 5mm from the apex, and an approximately 1.0 ± 0.1mm-thick sections were collected.

Sample Evaluation by Using A Confocal Microscope

All samples were examined with Leica confocal laser scanning microscope TCS SP5 (Leica, Mannheim, Germany). The images were analysed by Leica Microsystems software (LAS-AF). The measurements were recorded by using the digital measuring ruler, a feature present in the CLSM image recorder software. The canal wall served as the starting point, and sealer penetration was measured to the outer limit of the visual field in the microscope. The data were averaged to obtain a single value for each section. A single operator analysed all the specimens to rule out any discrepancy.

STATISTICAL ANALYSIS

The data were analysed statistically using SPSS software and Kruskal–Wallis analysis was performed for overall comparisons. A series of Mann–Whitney U post hoc tests were used to compare the experimental sealers within the same root levels.

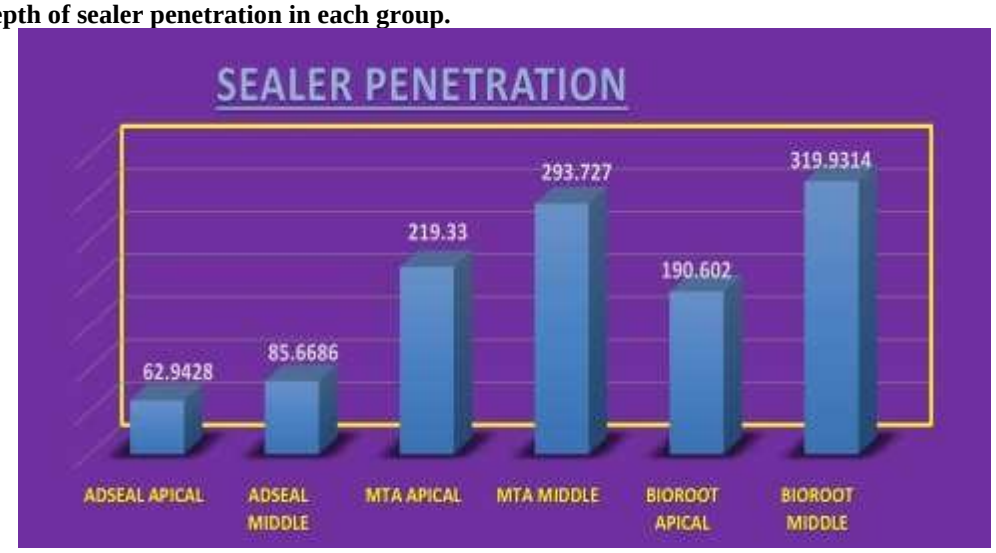
RESULTS

Table I shows the statistical data describing the distance of sealer penetration in the middle and apical sections. The MTA FillApex group showed higher sealer penetration at the apical third compared with BioRoot RCS and Meta Adseal group ($p < 0.017$), whereas BioRoot RCS showed higher sealer penetration in the middle thirds, similar to MTA FillApex ($p > 0.017$). Representative photos of the sealer penetration of each experimental group are shown in Figure 3. Maximum depth of penetration was observed at the middle third, which was significantly higher than the depth of penetration observed at the apical thirds for all 3 root canal sealers tested ($P < .001$).

Table I: Mean and standard deviation of sealer penetration in each group.

SEALER PENETRATION(µm)					
	N	Mean	Std. Deviation	Minimum	Maximum
ADSEAL APICAL	10	62.9428	6.23497	52.69	69.55
ADSEAL MIDDLE	10	85.6686	9.79226	71.24	97.70
MTA APICAL	10	219.3300	46.19699	171.76	297.53
MTA MIDDLE	10	293.7270	61.17593	215.01	375.02
BIOROOT APICAL	10	190.6020	56.31638	104.49	275.04
BIOROOT MIDDLE	10	319.9314	54.22317	264.22	412.15

Table II: Depth of sealer penetration in each group.



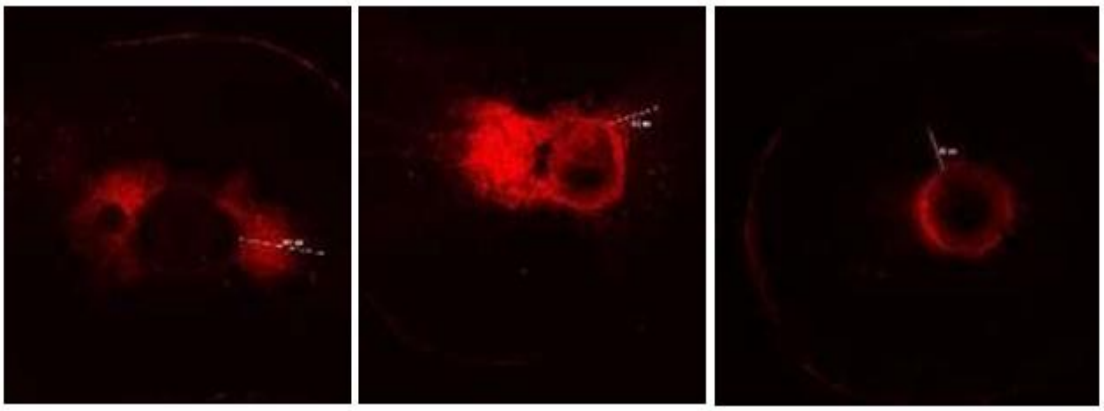


Figure III: Confocal images of BioRootrcs, MTA Fillapex, Meta adseal RCS in apical third.

DISCUSSION

The purpose of this study was to compare the penetration ability of calcium silicate root canal sealers and conventional resin-based sealer using CLSM. The maximum sealer penetration distance was higher at the apical third in the MTA FillApex group compared with BioRoot RCS and MetaAdseal, and at the middle third BioRoot RCS shows the better penetration.

BioRoot RCS has gained in popularity among bioactive sealers, as it shows fewer toxic effects on human periodontal ligament cells and induces osteogenic growth factor secretion[5] additionally, cells in the BioRoot RCS extract spread better than those in the AH Plus extract[10], and its particles create mineral plugs through interactions with dentinal fluids.[11,12] In our study, BioRoot RCS showed higher dentinal tubule penetration ability than the resin-based sealer in the middle third. This represents an advantage of this sealer, as vertical condensation pressure is not necessary for obturation.

In a previous study, BioRoot RCS showed higher calcium ion release than other sealers over a prolonged duration.[12] The prolonged mineralizing ion release triggers the nucleation of calcium phosphate, which may improve the sealing ability of obturation materials. BioRoot RCS provided higher dentinal tubule penetration than resin-based sealer, in accordance with the study conducted by Ozyurek et.al using single GP cone. MTA FillApex, a resin-based sealer with less than 20% MTA particles, had significantly greater tubule penetration in the apical third.

In this study, the CLSM method was used to assess sealer penetration into dentinal tubules, as done in previous studies.[13] CLSM offers several advantages over other techniques, as it does not require any special sample preparation and retains the integrity of the sealer. CLSM also provides the means to visualize the full extent of sealer penetration, as well as the sealer penetration depth.[14]

CONCLUSION

Within the limitations of the study, calcium silicate-based sealers showed better sealing ability when compared with the conventional resin-based sealer while using single cone obturation technique.

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