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Comparative evaluation of apical microleakage of tricalcium silicate, MTA and resin based sealers - An Invitro study

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Abstract

Introduction: The goal of root canal obturation is to obtain a three dimensional seal of the root canal system. An inadequate filling during obturation can results in reentry and re-growth of microorganisms in the root canal system which irritates the periapical tissue and compromises the treatment success. To accomplish this many endodontic obturation materials and sealers are being used.

Aim: To evaluate and compare the apical microleakage of BioRoot RCS, MTA fillapex and Dia-proseal.

Materials and Methodology: Freshly extracted maxillary anterior teeth were taken and decoronated at cemento-enamel junction. Step back preparation of the root canals was performed with k type file to size 45. The samples were randomly divided into 3 groups. Group 1: BioRoot RCS, Group 2: MTA fillapex, Group 3: Dia-proseal. Root

canals were filled with one of the sealers and gutta-percha using lateral compaction technique. After that, the roots were covered with two layers of nail varnish and immersed in Rhodamine dye and stored in an incubator for 72 h at 37°C. The roots were longitudinally split and linear dye penetration was measured from root apex to the most coronal extent under stereomicroscope and microleakage was evaluated.

Results: BioRoot RCS have shown less microleakage followed by MTA fillapex and Dia-proseal.

Conclusion: BioRoot RCS showed superior sealing ability when compared to MTA fillapex and Dia-proseal.

Introduction

It is generally known fact that the quality of root canal filling have an impact on the treatment outcome because of the sealing capability provided by the material against bacteria, microbial byproducts and tissue fluid. Gutta-percha has been used as root canal filling material for almost 150 years, in addition to the use of sealer, essential for obtaining a fluid-tight and air tight, hermetic seal, between the dentinal wall and the gutta-percha. Tricalcium silicate based cements, universally referred to as mineral trioxide aggregate (MTA) cements have revealed interesting biological properties, both in the laboratory and invitro tests, and are more biocompatible than common endodontic sealer. These products are more stable than calcium hydroxide, constantly releases calcium ions and maintains a pH which produces antibacterial effects.[1]

There are many reasons why the canal space in a root canal must be obliterated during obturation. The main reason is that; spaces between the root-canal filling and canal wall may harbour microorganisms, which could lead to irritation of periapical tissue. Increased sealer penetration may eliminate any remaining bacteria and prevent them from repopulating the canal space and causing further peri-radicular disease. In some studies, it has been stated that leakage mostly occurs between the filling material and the root canal walls. The degree of leakage could be reduced by using a material that well adapts to root canal walls. Leakage studies on the sealing properties of endodontic materials, in the present scenario have an important place of research.[2]

Endodontic sealers should meet some requirements, such as biocompatibility, dimensional stability, insolubility in oral fluids, radiopacity, ease of application, antibacterial properties, adaptability to the root canal walls, as well as the ability to produce a hermetic seal. However, none of the sealers currently available have all characteristics of the ideal sealer. Currently in dentistry, there are a wide variety of materials used. Different types of sealers have been introduced, having better physical properties than commonly used materials. Based on the superior biocompatibility and high alkaline activity of mineral trioxide aggregate (MTA), root canal sealers were manufactured.[3] MTA Fillapex (Angelus, Londrina PR, Brasil) is a new MTA-based root canal sealer with a high sealing capacity and it is the only root canal sealer that promotes cementum regeneration according to the manufacturers. However, no data is available regarding the apical microleakage of MTA Fillapex. MTA Fillapex is a sealer presented in a paste/paste system and is composed of MTA, resins, bismuth trioxide, nanoparticulated silica and pigment.[1] Owing to its clinical behaviour related to its biocompatibility, anti-microbial behaviour, sealing abilities, and its inducing tissue healing, its application has been expanded to root-canal filling.[2]

Recently, a new root canal sealer has been introduced to substitute conventional sealers with the guarantee of improved clinical performance (Dia-Proseal, Diadent, Cheongju, Korea) However, little information about Dia-Proseal is available to the dentists.[4] A novel bioactive

tricalcium silicate–based sealer is BioRoot RCS, which contains powder and liquid. Powder comprises of tricalcium silicate, povidone and zirconium dioxide where as the liquid is an aqueous solution of calcium chloride with polycarboxylate.[5]

Various methods have been used to investigate the apical seal of root canal sealers. However, due to the high sensitivity and consistency, the most common method used to evaluate the apical seal is the method of evaluating the dye penetration. The depth of penetration shows the distance between the filling material and the canal walls.[6]

As the sealing ability is one of the ideal apical sealer requirements, this study aimed to compare the apical microleakage of three widely used sealers.

Materials and methodology

Thirty caries-free maxillary anterior teeth, extracted for various purposes, were collected and used for the study. Teeth with previous restorations, visible cracks, decay, fracture, abrasion, or structural deformities are excluded from the study. Teeth were cleaned with ultrasonic scaler to remove debris and calculus and then stored in distilled water until used for the study.

All teeth were analyzed using the Vista Scan digital radiographic system to confirm the presence of single, straight root canals and non-complicated root canal anatomy. The crowns were decoronated at cemento-enamel junction using a water cooled diamond fissure bur in a high speed hand piece.

Instrumentation and obturation

Endodontic access cavities are refined, and pulpal tissue was removed using a barbed broach. The working length is determined by passing an ISO 15 K file into the root canal until the tip of the file was visible at the apical foramen, then 1 mm was subtracted from that length. Biomechanical preparation was carried out using step back technique upto 45 K file. Irrigation was done between successive files using 3% sodium hypochlorite. Recapitulation was done to avoid ledging during biomechanical preparation. Final irrigation was done using Saline. Canals were dried using paper points.

The teeth were randomly divided into three groups of 10 specimens each and obturation was done as follows:

Group 1: BioRoot Rcs (n=10)

Group 2: MTA Fillapex (n=10)

Group 3: Dia proseal (n=10)

The tested materials were handled according to manufacturer's instructions. The sealer was applied over the entire working length of the canal using lentulo spirals. The selected gutta-percha cone was lightly coated with sealer and placed slowly in the canal to full working length. Obturation was carried out using lateral compaction technique. Excess gutta-percha cone was seared off from the canal orifice using a heated instrument. After canal obturation, the teeth were radiographed to make sure the canals were fully obturated and post endodontic restoration was carried out using composite resin. The teeth were then stored at 37°C with 100% humidity for one week to allow the sealers to get fully set.

Sample preparation for microscopy

All the root surfaces, except the apical 2mm were covered with two layers of nail varnish and allowed to dry. Teeth were immersed in Rhodamine dye and then were stored in an incubator for 72 h at 37°C. The roots were rinsed in running water and dried with paper towels and the nail varnish was removed.

Two opposing longitudinal grooves were made into dentin on root surfaces using diamond disc, and the roots were split with a chisel. The linear dye penetration was measured from root apex to the most coronal extent under Stereomicroscope and microleakage was evaluated.

Results

All the analysis was done using SPSS version 18. A p-value of <0.05 was considered statistically significant.

Mean, S.D and ANOVA between various groups (mm)

	N	Mean	Std. Deviation	f-value	df	p value
Group 1 (BioRoot RCS)	10	0.786	0.259	25.02335	2	<0.001*
Group 2 (MTA Fillapex)	10	0.928	0.209			
Group 3 (Dia proseal)	10	1.786	0.489			

Above table shows mean comparison of apical microleakage of different experimental groups, analysed with ANOVA test. As the p-value is <0.001* the results obtained are statistically significant. The mean microleakage of Diaproseal was highest (1.786 ± 0.489 mm), followed by MTA Fillapex (0.928 ± 0.209 mm) , and Bio root RCS (0.786 ± 0.259 mm) respectively.

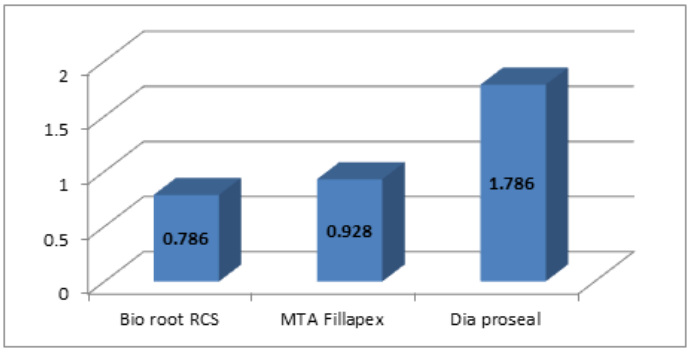
Results of pair wise Comparision between groups

Above table shows intergroup comparison of different experimental groups with Post-Hoc Tukey HSD.

Bio Root RCS showed higher resistance to leakage than MTA Fillapex, which was not statistically significant. Bio Root RCS showed higher resistance to leakage than Dia proseal, which was statistically significant ($p < 0.001$). MTA Fillapex showed higher resistance to leakage than Dia proseal, which was statistically significant ($p < 0.001$).

Multiple comparisons				
POST HOC Tukey HSD				
(I) GROUPS	(J) GROUPS	Mean difference (I-J)	Std. Error	Sig.
Group 1 (BioRoot RCS)	Group 2 (MTA Fillapex)	-0.142	0.108157	0.1946
	Group 3 (Dia proseal)	-1(*)	0.108157	0.0000
Group 2 (MTA Fillapex)	Group 1 (BioRoot RCS)	0.142	0.108157	0.1946
	Group 3 (Dia proseal)	-0.858(*)	0.108157	0.0000
Group 3 (Dia proseal)	Group 1 (BioRoot RCS)	1(*)	0.108157	0.0000
	Group 2 (MTA Fillapex)	0.858(*)	0.108157	0.0000
*The mean difference is significant at the .05 level.				

Graph 1: Mean difference between groups



Above bar graph shows mean apical microleakage of different sealers.

Dia proseal > MTA Fillapex > BioRoot RCS.

Discussion

The main goal of endodontic therapy is to achieve a complete hermetic seal and prevention of coronal and apical microleakage. Thus, this study aimed to evaluate the apical microleakage of a recently introduced tricalcium based root canal sealer BioRoot RCS with MTA fillapex and Diaproseal using dye penetration technique under stereomicroscope.

The application of sealer fills the irregularities at the interface of filling material and walls of the root canal. According to Cohen et al., inadequate apical seal is responsible for up to 60% of treatment failures.

The microleakage occurs through the distance between the gutta-percha and the sealer, the porosity in the sealer, or through the distance between the sealer and the dentin. Therefore, microleakage of sealers has a great effect on the sealing of the canal and the success of the treatment. The level of microleakage is measured in laboratory conditions to assess the sealing ability of materials. Several methods have been designed and used, including: bacterial penetration, dye penetration, gas chromatography, fluid filtration and penetration of radioisotopes. Some of these methods, such as dye penetration, are simple and some other, such as bacterial penetration, are more complex. Among the available

methods, the most commonly used method is dye penetration, which does not require sophisticated and advanced facilities.[6]

BioRoot RCS showed the lowest leakage (0.786 mm), followed by MTA Fillapex (0.928 mm), and Diaproseal (1.786 mm), which was statistically significant ($p < 0.001$).

The BioRoot RCS has a minimum working time of 10 min and a maximum setting time of 4 h. This silicate-based root canal sealer has less toxic effects on human periodontal ligament cells than zinc oxide-eugenol sealer and induces a higher secretion of angiogenic and osteogenic growth factors than ZOE. BioRoot RCS compared to contemporary root canal sealers (AHPlus, Acroseal, EndoRez, RealSeal SE, Hybrid Root SEAL, RootSP, and MTA Fillapex) has the lower cytotoxicity and genotoxicity.[7]

In this study, it was shown that Bio root RCS samples possessed greater sealing ability followed by MTA Fillapex and Diaproseal.

This might be due to the amount of Ca2+ ions released by BioRoot RCS was higher. The high Ca/P values of BioRoot RCS were likely related to the enormous Ca of tricalcium silicate composition and the contribution of calcium carbonates. ZrO2 present allows a greater and longer release of calcium ions and to make the tricalcium silicate cement, more biocompatible.[5] These calcium ions on contact with the physiological fluids form a calcium phosphate phase forming a mineral infiltration zone between the sealer and the root canal dentin. This zone helps in the biomineralization activity of the sealer. This apatite (Ap)-forming ability with gutta-percha may improve sealing ability. Thus this sealer exhibits its higher sealing property.[8]

More pronounced release of calcium ions is seen with BioRoot RCS when compared to MTA Fillapex.

Diaproseal is a newly introduced sealer and it has several characteristics such as fast-setting time, volume stability, good sealing of complex root canal system, long-term storage ability, and dual syringe system allowing easy mixture.[4]

A study conducted by Siboni et al, stated that some apatite deposits were found on resin-based sealer in spite of the absence of calcium release and alkalizing activity. The amount of calcium released by resin based sealer was absent or negligible.[5]

In our study, compared to the resin based sealer, the tricalcium silicate based sealer (BioRoot) showed higher resistance to leakage which was statistically significant. This is in agreement with a study conducted by Ashwini et al using Fluorescent Microscope on tricalcium silicate based sealer, zinc oxide eugenol based sealer, calcium hydroxide based sealer and resin based sealer.[9]

The first commercial tricalcium silicate-based sealer was MTA Fillapex. It is a paste-catalyst material. Paste A is composed of salicylate resin (methyl salicylate, butylene glycol, and colophony), bismuth oxide, and silica. Paste B includes silicon dioxide, titanium dioxide, and base resin (pentaerythritol, rosinate, and toluene sulphonamide), and 13.2% set MTA particles as filler. The working time is 23 min, with a complete set time of approximately 2 h.[7] MTA contains calcium oxide, which might react with water or tissue fluids to form calcium hydroxide which can dissociate into calcium and hydroxyl ions. The calcium ions react with the carbon dioxide in the tissues and form calcium carbonate granulations presenting as calcite crystals. This phenomenon could reduce marginal gaps, porosities and increase the retention of the cement. The MTA hydration forms a sticky calcium silicate hydrate gel that improves the sealing ability of MTA cement overtime.[1]

A probable explanation is that the MTA sealer could reduce the leakage to the root canal wall over time by the continuous formation of hydration products which react with dentinal calcium and phosphate ions and lead to the formation of calcium phosphate precipitate.[1] MTA Fillapex showed a better sealing ability than Dia proseal. MTA Fillapex contains a high ratio salicylate resin, and which causes the long chemical reaction time.[3]

The prolonged release of calcium ions has been demonstrated to be a key factor to promote endodontic and periodontal tissue regeneration enhancing the bioactivity and biocompatibility of the material. In fact, modern endodontic protocols require the use of materials able not only to perform a good and stable seal and prevent recurrent infections, but also to promote periapical tissue regeneration and contribute to the recruitment of osteo-odontogenic stem cells within the apical environment.[5]

Limitations of the study

As it is an in vitro study the findings cannot be correlated with the in vivo conditions. The microleakage values can be evaluated at different time intervals for better evaluation.

Conclusion

With in the limitations of the study BioRoot RCS showed less apical micro leakage than MTA fillapex and Diaproseal.

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