An In-vitro study comparing the apical sealing ability of three bioceramic sealers

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ABSTRACT

Introduction: The conventional root canal sealers have shown inadequate biological activity and have proven to be cytotoxic in cultures especially when they are freshly prepared. The hydrophobic nature of the conventional sealers also serve as a major drawback. Hence the uses of MTA based sealers which are bioceramic in nature are a novel technology in endodontics.

Materials & Method: This was a single blind in vitro study conducted to assess the microleakage of three MTA based endodontic sealers, Endoseal MTA, BioRoot RCS, ProRoot MTA mixed with Propylene Glycol. Thirty young permanent single rooted teeth extracted for therapeutic purposes were chosen for the study. Apical Dye Penetration test was performed on the samples after they were decoronated and sectioned at CEJ horizontally to obtain a standard root length of 12mm.

Results: mean depth of dye penetration was 1.2mm in Group A (Endoseal MTA), 2mm in Group B (BioRoot RCS) and 3.2 mm in Group C (ProRotMTA).The Standard Deviation being 0.42, 0.67 and 0.79 respectively. maximum dye penetration took place in Group C (Pro Root MTA), followed by Group B (BioRoot RCS) and least penetration was seen in Group A (Endoseal MTA)

Discussion & Conclusion: Endoseal MTA showed the least apical microleakage followed by BioRoot RCS and ProRoot MTA. This study hence concluded that there is still a need of research in the field of bioceramic sealers. Further studies are required to clarify the clinical outcomes associated with the use of these sealers.

Keyword: apical sealing, Bioceramic, Sealer, Single root, Tooth section

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INTRODUCTION

The key to endodontic procedures in teeth is achieving a hermetic seal at the root end. [1] The success of the endodontic treatment greatly relies on the ability of the filling material to prevent the infection of the periapical space both from the coronal as well as the apical region. Sealing the root canal system thereby prevents the egress of microorganisms or their by-products into the periradicular tissues.[2]

Therefore various materials and methods employed for root canal obturation are considered utmost crucial. Over the decades many materials and techniques have been advocated to establish a three dimensional fluid tight seal.[3]

Obturation is routinely accomplished with the use of a semi solid material known as gutta percha in conjunction with a sealer.[4]Hence an endodontic sealer should possess the prerequisites of filling all the voids and gaps between the root canal filling material and dentin by adhering to both the dentin and gutta percha. Obturation can be performed in different methods .The widely accepted ones being cold lateral condensation and warm vertical compaction. In both of these methods sealer is pushed into the non-instrumented spaces where residual bacteria may persist.[5]

Aforementioned techniques are highly reliable but excessively time consuming and highly operator dependent .Thus the single cone technique serves as a rescue for all practitioners and helps in surpassing this milestone of tedious obturations in quite a simpler way. Due to the non-circular shape of the coronal and middle thirds of the canal space the gutta percha cone does not perfectly fit into the ovoid canal. Thus the remaining space should be filled with the sealer. This concept basically originates from Grossman's concept of maximum interface of the sealer with the gutta percha acting as a support.[6,7]

Root canal sealers have been classified based on their composition like zinc oxide eugenol, calcium hydroxide, resin , glass ionomer and recently developed MTA based sealers.[8]

The conventional root canal sealers have shown inadequate biological activity and have proven to be cytotoxic in cultures especially when they are freshly prepared. The hydrophobic nature of the conventional sealers also serve as a major drawback.[9]

Hence the uses of MTA based sealers which are bioceramic in nature are a novel technology in endodontics .These MTA based sealers have major advantages like[10]

1.They are biocompatible in nature and are not rejected by surrounding tissues.

2.They contain Ca silicate which improves the setting property as it is crystalline in nature and similar to bone and dentin apatite crystals leading to improved sealer to dentin bonding.

3.They possess inherent antimicrobial property that will be helpful in reducing the remaining bacteria or eradicating them completely.

The MTA based sealers used in this study are BioRoot RCS (Septodont), Endoseal MTA (Maruchi, Wonju) and ProRoot MTA (Dentsply, Tulsa) mixed with Propylene Glycol.

Endoseal MTA provides a biological endodontic seal by means of biomineralization rather than a physical seal. It is a premixed ready to use MTA based sealer that is stored in an airtight syringe which makes its application easier. It uses a patented pozollan based setting mechanism which quickens the setting time.[11]

BioRoot RCS is hydrophilic in nature and sets even in the presence of moisture. It is resin free and also monomer free ensuring zero shrinkage. It is dispensed in the powder and liquid form which can be manipulated by mixing powder component with the liquid component in a simple manual spatulationtechnique without the need of a mixing machine. The sealer is bioactive due to properties like biocompatibility, hydroxyapatite crystals formation and alkaline pH.[12]

ProRoot MTA introduced in 1998 is a cement which comprises of powder and liquid component. It was widely used as a reparative material.ProRoot MTA mixed with propylene glycol is used as asealer.Propylene glycol (1,2- propanediol) is adihydric alcohol with adequate consistency that results in improving the handling properties of MTA.Hence this mixture can eventually be used as a sealer eliminating the drawbacks of certain MTA sealers with relatively high concentration of MTA in their composition and resin free composition.[13]

METHODOLOGY

This was a single blind in vitro study conducted to assess the microleakage of three MTA based endodontic sealers

a) Endoseal MTA (Maruchi, Wonju, Korea)
b) BioRoot RCS (Septodont, USA)

c) ProRoot MTA (Dentsply, Tulsa Dental) mixed with Propylene Glycol (Isochem Laboratories)

Dye Penetration Test was carried out for thirty extracted teeth that were obturated with MTA based sealers. These stained longitudinal sections of extracted teeth were then examined under the stereomicroscope to compare the apical sealing ability of the sealers

A. SAMPLE PREPARATION

Young permanent single rooted teeth extracted for therapeutic purposes were chosen for the study. The teeth were decoronated and sectioned at CEJ horizontally to obtain a standard root length of 12mm using a diamond bur under a coolant. Working length was then determined by using 15 ISO K files (MANI).Biomechanical preparation was performed as per standard protocol using rotary instruments. Canals were irrigated in between the filing procedure with 1ml of 5% Sodium hypochlorite solution and Normal Saline. The canals were then dried using sterile paper points.

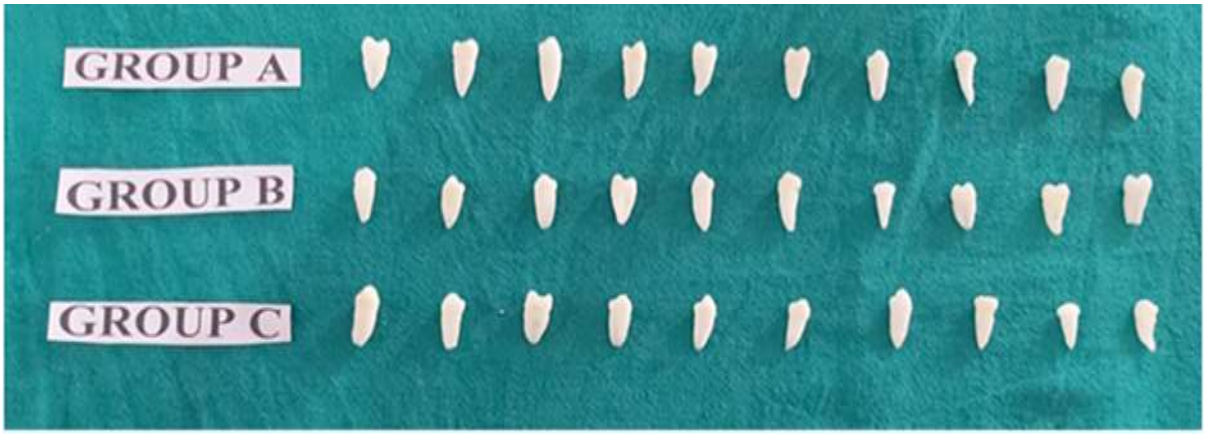


Fig 1: Thirty young permanent single rooted extracted teeth collected as sample and divided into three groups randomly

B. OBTURATION PROCEDURE

The specimens were then randomly divided into three groups.

Group A -10 extracted teeth obturated with Gutta percha and Endoseal MTA as the sealer.

- The first step is to replace the 24 gauge metallic tip provided in the package.
- Insert the tip in the root canal not deeper than the apical third
- Inject the sealer into the root canal until it is seen at the canal orifice
- Insert the master cone softly to the apical stop.
- The setting time of the sealer is no longer than 13 minutes. (ISO 6876)

Group B- 10 extracted teeth obturated withGutta percha and BioRoot RCS as the sealer.

- The sealer was mixed extemporaneously on a mixing pad.
- The root canal sealer was progressively prepared by adding powder to the liquid. It was mixed thoroughly toobtain a smooth paste (about 60 seconds**).**
- BioRoot RCS has a minimum working time of 10 minutes and a maximum setting time of 4 hours.
- Coating of the sealer was applied on the walls of the root canal with the help of either a paper point or a gutta percha cone

- Complete the obturation by inserting the gutta-percha master cone previously coated with BioRoot RCS

Group C - 10 extracted teeth obturated with Gutta percha and ProRoot MTA mixed with propylene glycol and used as a sealer.

- After drying the canal with paper point ProRoot MTA was mixed with 50% Propylene glycol and the distilled water that was provided with the powder content itself.
- The mixture was placed into the canal using a size 40# lentulo spiral.
- The Gutta percha cone was then coated with the mixture and single cone obturation was performed

The quality of obturations was then assessed by radiographs and the acess cavities were restored with Type II GIC. The specimens were then be stored at 37ºC for 24hrs in the humid environment (incubator).

C. LONGITUDINAL SECTIONING

After being kept in the incubator the surfaces of the samples were dried and two layers of coloured nail varnish was applied on surface 1mm short of the apex. The varnish applied roots were then immersed in 1% methylene blue dye for 48 hours. After 48hours the roots were rinsed for three minutes under running tap water to sweep off the varnish and the samples were air dried. Specimens were then split longitudinally parallel to the long axis with a diamond disc under a coolant.

D. STEREOMICROSCOPE EVALUATION

The depth of dye penetration was examined under the stereomicroscope at 40X magnification using a millimeter scale with a resolution of 0.5mm. Photographic records were obtained and the depth of dye penetration was scored. The following scoring criteria was used to assess the microleakage.

E. SCORING CRITERIA[14]

Grading /scoring	Penetration of methylene blue dye
0	Penetration of dye Nil
1	Penetration of dye starting from apical foramen extending coronally between 0.1mm to 1.00mm
2	Penetration of dye starting from apical foramen extending coronally between> 1.1mm to 2.0mm
3	Penetration of dye starting from apical foramen extending coronally>2.1mm to 3.0mm
4	Penetration of dye starting from apical foramen extending coronally>3.1mm to 4.0mm
5	Penetration of dye starting from apical foramen extending coronally>4.1mm to 5.0mm
6	Penetration of dye starting from apical foramen extending coronally>5.1mm to 6.0mm
7	Penetration of dye starting from apical foramen extending coronally>6.1mm to 7.0mm

STATISTICAL ANALYSIS

- The data obtained from the study was compiled, tabulated in Microsoft excel and analysed with SPSS software Version 24 (Armonk,NY: IBM Corp).
- The variables are presented with mean and standard deviation.

- Analysis of Variance (ANOVA) test andTukey post hoc test was performed to compare the groups
- The p value ≤0.05 is considered as statistically significant

RESULT

Traditionally dental materials used in dentistry were passive and non-biomimetic in nature.With the advancement in endodontic treatment and techniques; the importance and use of appropriate sealers have become significant and noteworthy.

Bioceramic sealers have become popular recently because they are biocompatible and non-metallic, induce osteogenesis and are bioinductive in nature.[15]

The present in vitro study was conducted to evaluate the apical sealing ability of three bioceramic sealers ; Endoseal MTA, BioRoot RCS, ProRoot MTA

- Sealing ability was analysed by dye penetration test using methylene blue dye under a stereomicroscope.

Table 2. Comparison of apical sealing scores between the groups using one way ANOVA

Groups	Minimum	Maximum	Mean	SD	P value
Group A	**1.00**	**2.00**	**1.20**	**0.42**	**<0.001***
Group B	**1.00**	**3.00**	**2.00**	**0.67**	
Group C	**2.00**	**4.00**	**3.20**	**0.79**	

Table 2 and graph 1 shows that the mean depth of dye penetration was 1.2mm in Group A (Endoseal MTA), 2mm in Group B (BioRoot RCS) and 3.2 mm in Group C (ProRotMTA).The Standard Deviation being 0.42, 0.67 and 0.79 respectively.

The p value was <0.01indicating that that the difference in three groups was statistically significant

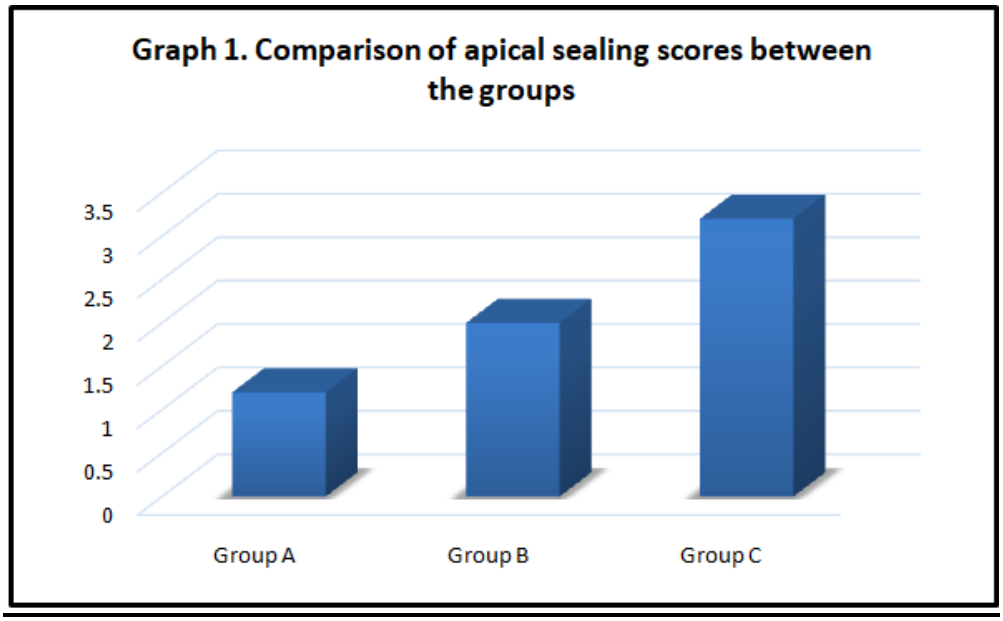
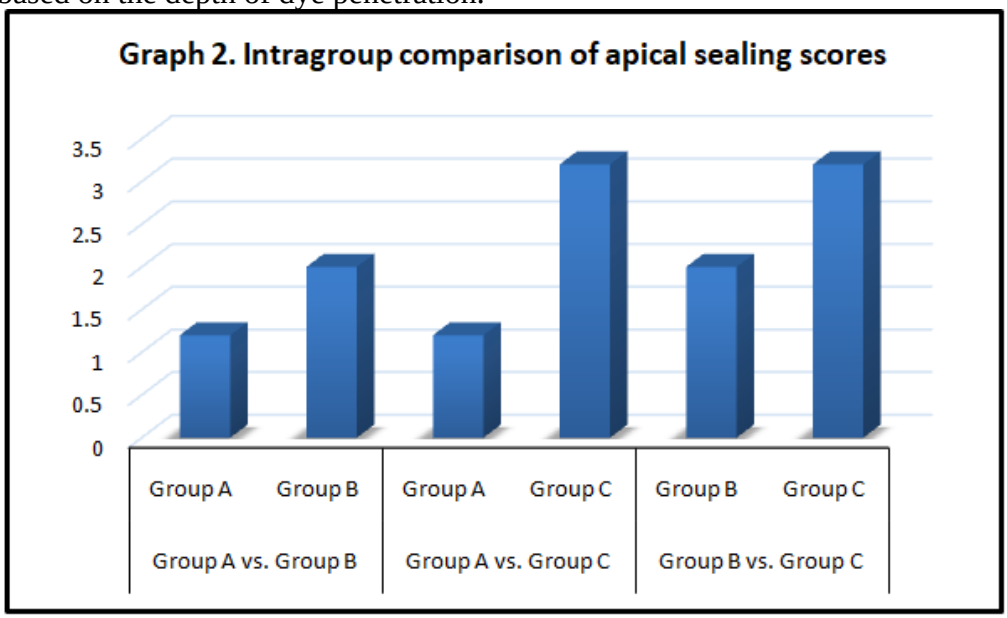


Table 3. Intragroup comparison of apical sealing scores using Tukey post hoc test

Groups		Mean	SD	P value
Group A vs. Group B	**Group A**	**1.20**	**0.42**	**0.026***
	Group B	**2.00**	**0.67**	
Group A vs. Group C	**Group A**	**1.20**	**0.42**	**<0.001***
	Group C	**3.20**	**0.79**	
Group B vs. Group C	**Group B**	**2.00**	**0.67**	**0.001***

	Group C	**3.20**	**0.79**	

Table 3 and graph 2 shows the intragroup comparison of apical sealing ability of the three groups based on the depth of dye penetration.



On comparing Group A (Endoseal MTA) and Group B (BioRoot RCS) the mean depth of dye penetration in Group A (Endoseal MTA) was 1.2mm and Group B (BioRoot RCS) was 2mm. The difference of which was statistically significant.

On comparing Group A (Endoseal MTA) and Group C (Pro Root MTA) the mean depth of dye penetration in Group C (Pro Root MTA) was 3.2mm.The difference of which was statistically significant .

On comparing Group B (BioRoot RCS) and Group C (Pro Root MTA). The difference of which was stasticallysignificant .

Hence indicating that maximum dye penetration took place in Group C (Pro Root MTA), followed by Group B (BioRoot RCS) and least penetration was seen in Group A (Endoseal MTA).

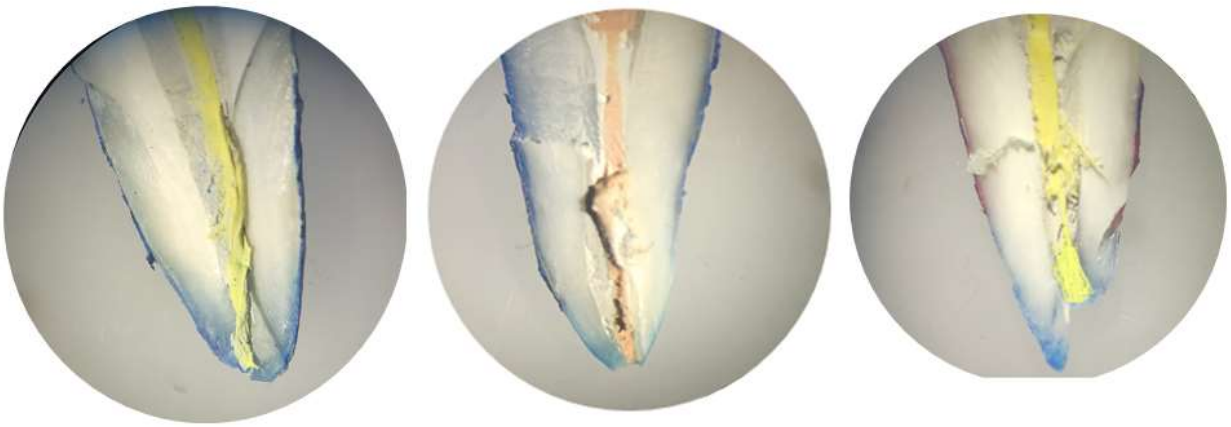


Fig 2: Microscopic view showing dye penetration in samples obturated with Endoseal MTA

Fig 3: Microscopic view showing dye penetration in samples obturated with BioRoot RCS

Fig 4: Microscopic view showing dye penetration in samples obturated with ProRoot MTA and Propylene Glycol

DISCUSSION

Even after meticuluous mechanical preparation as well as chemomechanical debridement, bacteria, residual pulpal tissue and dentinal debris may still persist in the canal due to irregularities of the root canal system. Peters et al (2001) utilized micro CT scans before and after mechanical instrumentation and found that regardless of the instrumentation technique, 35% or more of the root canal surfaces (including canal fins, isthmi and cul-de-sacs) remained uninstrumented.[16]

Major causes underlying the failure of endodontically treated teeth was described by Vire DE et al (1991) where it was concluded that the main factors were initiation of infection from outside, traumatization of remaining tissue and use of irritating drugs. High risk of root canal therapy failure is due to the absence of an apical fluid tight seal or a proper coronal seal. The lack of apical seal enables the microorganisms to derive nutrition from the periapical blood vessels whereas loss of coronal seal allows the entry of new microorganisms into the tooth.[17]

The onset of bioceramic endodontic sealers in the clinical field of endodontics is highly therapeutic.Sealing the interface of the root canal dentin is facilitated by the presence of the calcium phosphate content in the bioceramic sealers which thereby enables it to form a crystalline structure, similar to thatof hard biological tisssues, when fully cured.[18]Thus the concept has progressed from a physical endodontic seal of inactive materials to a biological active endodontic seal with biomineralization of dentin possible due to bioceramic sealers.[19]

In a study conducted by C Delong et al it was seen that the push-out bond strength of the bioceramic sealers when used with single cone technique gave more favourable results when compared to the thermoplastic techniques. The simplicity of this technique also decreases the practitioner's fatigue thereby permitting optimal treatment to the patient in a shorter time span.[20]

There are different methods used to evaluate the apical sealing ability of root canal sealers. Linear measurement of dye penetration is one of the most common method employed which is relatively easy and fast. The different dyes that are used for this test are Methylene Blue (MB), India ink, eosin, Procion, brilliant blue, 50% silver nitrate and pelican ink. Out of the prevailing options Methylene Blue dye is widely used and the concentrations of MB used are 0.25, 1 and 2%. In our study, we used 1% MB as it was most commonly used concentration.[21]

In this study it was seen in Table 2 / graph 1 that the mean depth of dye penetration was 1.2mm in Group A (Endoseal MTA),2mm in Group B (BioRoot RCS) and 3.2 mm in Group C (ProRotMTA). Hence indicating that maximum dye penetration took place in Group C (Pro Root MTA), followed by Group B (BioRoot RCS) and least penetration was seen in Group A (Endoseal MTA).Thereby concluding that Endoseal MTA displayed the least microleakage followed by BioRoot RCS and then ProRoot MTA.

Similar results were seen in the study conducted by Dastorani M et al where microleakage was evaluated for a period of 35 days.The results of their study showed that teeth sealed with Endoseal MTA showed very less bacterial microleakage compared to the teeth sealed with Pro-Root MTA showed bacterial microleakage.[22]

Ammar EID conducted a study to evaluate and compare the filling ability of BioRoot RCS and AH Plus sealer in preventing the dye penetration apically. It was seen in their study that the microleakage shown in samples obturated with bioceramic sealer BioRoot RCS was much lower in comparison to those obturated with AH Plus sealer. This result was opposite to that of the result derived by Viapina et al where they had seen no difference in apical dye leakage when they compared the same materials BioRoot RCS and AH Plus sealer . This

variance in the result was probably due to the method of obturation applied that was lateral condensation for their case whereas Ammar EID et al used single cone technique.[23]
The small particle size of Endoseal MTA enables stable precursor formation for guiding effective diffusion of ions. Such stable precursors induce the propagation of crystallization along the dentinal tubules by secondary nucleation of the individual nanoparticles which further provide densified biomineralization into deeper dentinal tubules.[24]
The constraint of this study lies in the fact that there is a chance of gutta percha being withdrawn from the samples during longitudinal sectioning and thereby altering the results of this study.[25]
The limitation of in vitro dye infiltration done was that it was not an accurate indicator of clinical endodontic success or failure although the length of penetration was closely related to the treatment outcome which allowed comparisons.[26]

CONCLUSION

Under the present conditions and within the limitations of the study it can be concluded thatbioceramic materials show promising results as root canal sealers.It was also seen that the bioceramic sealers when used in single cone obturation technique provided a better apical and marginal seal.It was concluded that Endoseal MTA showed the least apical microleakage followed by BioRoot RCS and ProRoot MTA.This study hence concluded that there is still a need of research in the field of bioceramic sealers. Further studies are required to clarify the clinical outcomes associated with the use of these sealers.

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