Comparing Apical Microleakage Around Separated Rotary Instrument Sealed with Two Bioceramic Obturating Materials - An Invitro Study

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Abstract

Aims and Objective: The purpose of this study is to compare apical microleakage in root canal containing separated rotary instrument obturated with two materials i.e. ProRoot MTA and Biodentine.

Introduction: An optimal apical seal plays an important role in success of endodontic treatment and health of periapical tissues and can increase the success of endodontic treatment by up to 97%. Absence of apical seal has been reported as the most common cause of endodontic treatment failure. Instrument separation is an unfortunate sequela of endodontic instrumentation. Regarding the location of the separated fragment, a higher rate of separation is observed in the apical third (41% - 82.7%). The most common separation site is 2mm from the tip of the instrument.

Studies have shown that the separated instrument itself does not play a large role in the sealing ability as the obturation material and success of the root canal therapy. Root canal therapy was dependent on the coronal seal and absence of any residual irritant beyond the level of the separated instrument. In such type of cases, a good quality obturation is required so that the

sealer or the obturating material may seal the spaces between the flutes of the broken file resulting in an adequate apical seal.

Mineral trioxide aggregate (MTA) has been suggested as a root canal filling material due to its optimal sealing ability. Successful use of MTA for apical seal, apical plug and root perforation repair has been reported in many previous studies.

Another calcium silicate-based material named Biodentine which claims to have beneficial properties such as excellent sealing ability, biocompatibility, good dimensional stability with the added advantage of short setting time, improved mechanical strength easy manipulation.

Material and Method: A total sample size of 30 single rooted extracted premolars were divided into 3 groups **Group 1:** Biodentine, **Group 2:** ProRoot MTA and **Group 3:** Positive control. After breaking size 30 rotary file in the apical third, rest of the canal was obturated with Biodentine, ProRoot MTA and left empty in positive control group. Apical microleakage was measured using dye penetration under stereomicroscope at 40X.

Results: There was statistically significant (p value < 0.05) less microleakage in tooth obturated with Biodentine as compared to ProRootMTA and Positive control.

Conclusion: The result had found that microleakage in root canal containing separated instrument **Biodentine < Pro root MTA < Positive Control Group**

INTRODUCTION

Non-surgical endodontic treatment has a high success rate given that adequate cleaning and shaping and efficient obturation of root canals are performed1. Efficient obturation must provide a hermetic seal to prevent the reentry of microorganisms[2]. The absence of an apical seal has been reported as the most common cause of endodontic treatment failure[3]

Instrument separation is an unfortunate sequela of endodontic instrumentation. The fracture of the endodontic instrument has a multifactorial etiology, being influenced by diverse elements such as characteristics of the access cavity, the geometry of root canals, cross-sectional features of the root canals, which are influenced by the endodontic pathology, and age of the patient, design features of rotary instruments, metallurgical properties of various nickel-titanium rotary instruments, imperfections or manufacturing defects of the instrument, Instrumentation technique, Instrument dynamics in the root canal, number of sterilization cycles to which the instrumentation has been subjected and its number of uses, clinician's experience.[4]

When separation occurs, the clinician has the choice of leaving the instrument in the canal or attempting to remove it either surgically or non-surgically. The choice of retaining or removing the separated instrument depends upon various factors like the Initial condition of the pulp and periapical tissue, the location of separation, and the stage of the root canal treatment at which the separation occurred.

Canals followed by the precise endodontic obturation to achieve a fluid-tight seal using separated fragments as a part of obturation. The separated fragment is incorporated into the obturation, which makes it imperative that clinicians be offered more definitive, evidence-based information for predicting the potential consequences of this procedural complication.

Mineral trioxide aggregate (MTA) has been suggested as a root canal-filling material due to its optimal sealing ability. Successful use of MTA for apical seal, apical plug, and root perforation repair has been reported in many previous studies [5,6]. It is biocompatible and non-toxic and has bactericidal properties[7]. Long setting time, difficult handling, high cost, and difficult removal in case of requiring post-space preparation or retreatment are among its drawbacks[8]. Calcium-enriched mixture (CEM) cement is another root-filling material with hydrophilic and antimicrobial properties. It can provide an optimal apical and coronal seal as well[9]

A new active calcium silicate-based material named Biodentin claims to have beneficial properties such as excellent sealing ability, biocompatibility, good dimensional stability with the added advantage of short setting time, improved mechanical strength easy manipulation, and quite economical.

Given the existing concerns about managing root canals with a broken instrument, this study aimed to compare apical microleakage in root canals with broken instruments filled with two bioceramic materials.

MATERIALS AND METHODOLOGY

Preparation of the specimen:

The teeth were selected using random sampling; therefore, 10 teeth were included in each group. A total of 30 samples were included in the study.

Inclusion criteria

1. Only mandibular premolars with a single root canal are included in the study.
2. Teeth extracted for periodontal or orthodontic reasons.

Exclusion criteria

1. Extracted Incisor, Canine, and Molar tooth.
2. Premolar tooth having more than one canal
3. Teeth extracted due to caries.

Randomization: Simple random sampling was used for dividing the tooth between the groups.

Blinding: Single-blind technique (Statistician) was used in the study.

The study was conducted in the Department of Conservative Dentistry and Endodontics, RUHS College of dental Sciences, Jaipur. The teeth fulfilling the inclusion & exclusion criteria were included in the study. After collection, the teeth will be cleaned and disinfected by immersion in 5.25% sodium hypochlorite for one hour. They will then be stored in 0.9% saline at room temperature until the experiment.

The crowns were cut using a diamond bur and high-speed handpiece under water irrigation, and the roots were divided into three groups based on root canal filling.

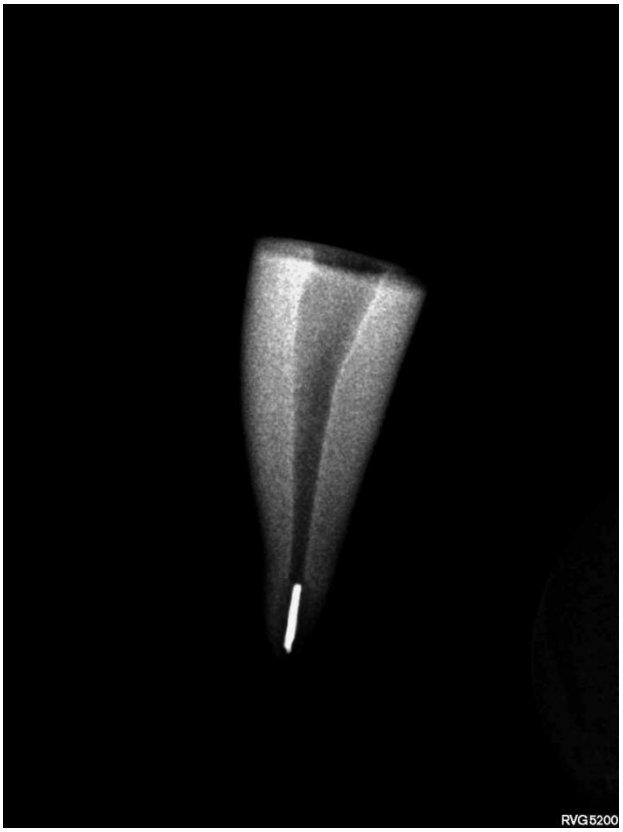
Group 1: Biodentine

Group 2: ProRoot MTA

Group 3: Positive control

First, roots were radiographed in a buccolingual direction after mounting them in acrylic blocks. Next, the working length was determined, and the root canals were instrumented with hand K-files followed by Neoflex files fixed taper rotary files up to size 25/0.06 to the working length and 30/0.06 to 1.5 mm short of the working length. Next, recapitulation was performed between files, and root canals were irrigated with 5.25% sodium hypochlorite. A final rinse with 1.25% sodium hypochlorite was also performed, followed by 17% EDTA and 5 mL of saline.

A #30 rotary file was scratched at 3 mm from its tip by a high-speed handpiece and was intentionally broken in the canal in the apical region. The middle and coronal sections of the canals were filled with the root mentioned above canal filling materials/techniques. The roots were radiographed after file fracture and after filling. The roots were coated to 2 mm around the root apex with nail varnish. The coronal orifice was sealed with glass ionomer cement.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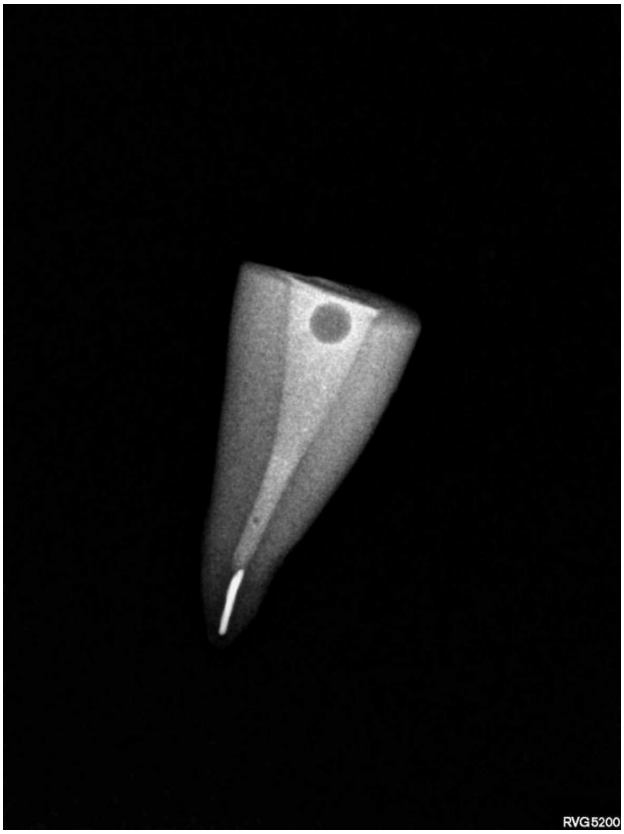
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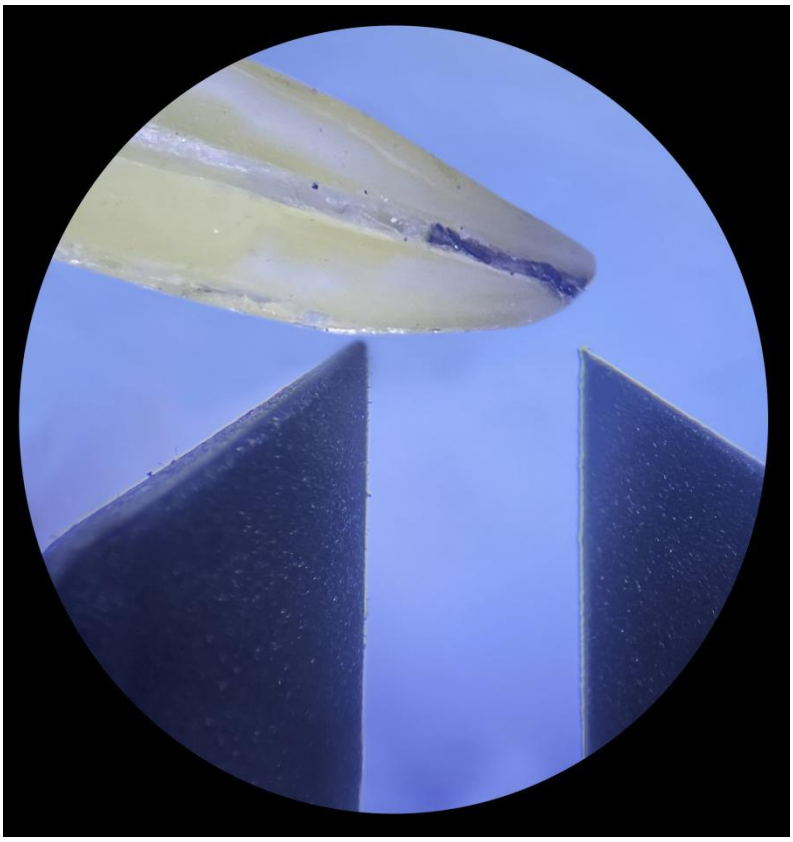

RESULTS

The mean depth of dye penetration in Biodentine was 3.31±0.61 mm, in Pro root MTA was 5.15±0.89 mm, and in the positive control group was 9.13±1.05 mm. One-way ANOVA test showed a significant difference between the groups with an F value of 115.39 and a p-value of 0.001.

The result was further evaluated by Post hoc Tukey test and unpaired student t-test to determine the difference between each pair of groups. The Post hoc Tukey test was performed to determine the difference between each pair of groups. The groups showed a significant difference between groups.

The mean depth of dye penetration in Biodentine was 3.31±0.61 mm, and in Pro root MTA was 5.15±0.89 mm. Student t-tests showed a significant difference between groups with a t-value of 3.90 and a p-value of 0.001. (Table 3)

The amount of Microleakage in Biodentine < Proroot MTA

The mean depth of dye penetration in Biodentine was 3.31±0.61 mm and in the positive control group was 9.13±1.05 mm. Student t-tests showed a significant difference between groups with a t-value of 18.31 and a p-value of 0.001. (Table 4)

The amount of Microleakage in Biodentine < Positive control group

The mean depth of dye penetration in Pro root MTA was 5.15±0.89 mm and in the positive control group was 9.13±1.05 mm. Student t-tests showed a significant difference between groups, with a t-value of 11.73 and a p-value of 0.001. (Table 5)

The amount of Microleakage in Pro root MTA < Positive control group

Inference

The result found that microleakage in the root canal containing separated instrument

Biodentine < Pro root MTA < Positive Control group.

Table 1: Comparison of Apical Microleakage in Root Canal Containing Separated Canals Using Different Filling Material Group

Group	N	Mean	Std. Deviation	Minimum	Maximum	F value	P value
Biodentine	10	3.31	**0.27**	3.00	3.8	115.391	.001**
Proroot MTA	10	5.15	**0.41**	4.5	5.80		
Positive Control	10	9.13	**0.66**	8.00	10.00		
Total	30	9.13	1.34	3.00	10.00		

Table 2: Comparison of Apical Microleakage in Root Canal Containing Separated Canals Using Biodentine and Proroot MTA Filling Material Group

Group	N	Mean	Std. Deviation	T value	P value
Biodentine	10	3.31	0.27	5.59	0.001**
Proroot MTA	10	5.15	0.41		

Biodentin has shown statistically lesser microleakage around separated instruments than ProRoot MTA

Table 4: Comparison of Apical Microleakage in Root Canal Containing Separated Instrument Using Biodentine Filling Material and Positive Control Group

Group	N	Mean	Std. Deviation	T value	P value
Biodentine	10	3.31	0.27	18.31	0.001**
Positive Control	10	9.13	0.66		

Biodentin has shown statistically lesser microleakage around separated instruments than in the control group.

Table 5: Comparison of Apical Microleakage in Root Canal Containing Separated Instrument Using Proroot MTA Filling Material and Positive Control Group

Group	N	Mean	Std. Deviation	T value	P value
Proroot MTA	10	5.15	0.41	11.73	0.001**
Positive Control	10	9.13	0.66		

ProRoot MTA showed lesser microleakage around separated instruments than the control group ($p < 0.05$)

DISCUSSION

Root canal treatment is one of the procedures to treat the infected pulp of a tooth, aiming to eliminate the infection and seal the canal from future microbial invasion apically and coronally.

The success in endodontics is the triad of root canal preparation, disinfection, and complete canal obturation.

Endodontic mishaps can happen at any of the steps mentioned above: the most troublesome endodontic iatrogeny is instrument separation during root canal preparation.

The outcome of the separated instrument depends on the following like success rates were reduced if the tooth had necrotic pulp at the beginning of the treatment, as a separated instrument hampers the ability to disinfect the canal, location of the fragment if it is located in the apical third beyond a severely curved root canal, stage at which the separation occurs, i.e., at the end stages of root canal preparation when the root apex has been cleaned and shaped.

Unfortunately, there has yet to be a consensus on management approaches in current practice..

Following are the different approaches for managing a separated instrument:

Retrieval of the fractured instrument, bypassing the separated fragment and managing the canal, retaining the separated instrument in the canal followed by management of the remaining portion, or retrieving by periapical surgery followed by its management.[10]

The approaches mentioned above to manage separated instruments have their disadvantages and should be performed considering the risks involved; ledge formation while attempting to retrieve the instrument will further worsen the prognosis, as they are potential areas of stress concentrations that may contribute to vertical root fractures, Secondary fractures; Ni-Ti instruments may fracture while attempting to remove via ultrasonics, perforations and vertical root fractures can occur because of the staging platform made for instrument removal, extrusion of the fragment apically or even beyond the root apex is a complication that usually results from excessive pressure applied on instruments used for removal or from the vibration of ultrasonic instruments.[10]

Standard endodontic procedures must be performed when the separated fragment is decided to be left in the canal. If the separated fragments cannot be retrieved, then the separated fragment may be left over in the canal. If the fractured segment binds snugly in the apical third, this method of treating the canal can be considered. Removal or bypassing the separated fragment is considered if the file binds in the coronal or middle third. Retaining the instrument in the canal may be especially applicable if the separation occurs toward the final stages of root canal preparation or the fragment is located in the apical third beyond a severely curved root canal.[10]

Fracture of the file in the canal occurs most commonly during endodontic treatment. Evidence shows that a broken instrument remaining in the root canal does not significantly affect the quality of the root canal seal by filling materials, and the success of endodontic treatment mainly depends on the coronal seal and cleaning of the middle and coronal thirds.

Microleakage in the root canal is the movement of periradicular tissue fluids, microorganisms, and their associated toxins along the interface of the dentinal walls and the root-filling material.

For many years, gutta-percha has been the most commonly used natural material for filling root canals and has been marked as a gold standard. It has several advantages, but these only satisfy the secondary requirements of an ideal obturating material. The primary requirements of being an antimicrobial material and sealing all the portals of exit in the root canal system are not satisfied by gutta-percha.Several alternative materials have been tried to overcome the drawbacks of GP, like plastics (Resilon), cement, and pastes (Calcium Phosphate, Gutta Flow, Hydron). However, many of these materials must meet the complete requirements for the obturation of root canal systems. Only calcium silicate-based materials like MTA and related bioactive cement have shown promising results.[11]

Mineral trioxide aggregate (MTA) has been suggested as a root canal-filling material due to its optimal sealing ability. Many previous studies have reported the successful use of MTA for apical seal, apical plug, and root perforation repair.[12-14] It is biocompatible and non-toxic and has bactericidal properties.[15] However, long setting time, complex handling, high cost, and difficult removal in case of requiring post-space preparation or retreatment are among its drawbacks.[16]

Another Calcium silicate-based material, Biodentine introduced in 2010, is composed of Tricalcium silicate (3CaO.SiO2) as the primary core material, dicalcium silicate (2CaO.SiO2) as the second core material, Calcium carbonate (CaCO2) as filler, Zirconium Oxide (ZrO2) as radio opacifier & Iron oxide as a coloring agent. Considering its physical properties (increased compressive strength, push-out bond strength, density, and porosity), biological properties (immediate formation of calcium hydroxide, higher release, and depth of incorporation of calcium ions), and handling properties (faster setting time), Biodentine has been advocated as an efficient alternative to mineral trioxide aggregate to be used in a variety of indicators.

In this study, the dye penetration technique was performed using Indian ink as a tracer to measure microleakage, as it is the most frequently used technique for assessing the sealing quality of root canal sealers.

The present study was conducted to compare and evaluate apical microleakage in root canals containing separated rotary instruments obturated with three different root canal filling materials, i.e., ProRoot MTA and Biodentine.

Godiny et al. 2017 [21] showed MTA and CEM cement to have better apical sealing ability around separated rotary instruments than laterally compacted gutta-percha and injected gutta-percha. Mashalkar et al. 2019 [22] showed Portland cement to have superior sealing ability than CLC gutta percha with AH Plus sealer around a stainless steel hand K file at the apical third.

Another study by Banga KS et al. 2021 [23] compared a 4mm plug of MTA and Biodentine coronal to the separated instrument with the rest of the canals obturated with gutta-percha using the CLC technique and thermoplasticized technique; their results showed no statistically significant difference between all the groups.

The present study compared apical sealing ability in separated instrument teeth of two bioceramic materials, i.e., Biodentin, ProRoot MTA filling the entire root canal and revealed that Biodentine

provided a better apical seal around the separated instrument and showed the least microleakage.

The microleakage showed by Biodentine was significantly ($p>0.05$) less. Both materials showed statistically significantly less leakage than the control group ($p>0.05$).

These bioceramic materials have been compared as root-end filling, pulp capping, and perforation repair. The results of the present study showing lesser microleakage in the case of Biodentine are consistent with many other studies. Khandelwal et al. 2015 [24], in their study, compared GIC, MTA, and Biodentine as root-end filling material & reported Biodentine to have a better marginal adaptation than MTA. Pathak et al. 2015 [25] also reported MTA to have a higher microleakage as a root-end filling material than Biodentine, which they owed to its higher setting time Nepal M et al. 2020 [26] et al also compared apical microleakage in MTA and Biodentine. They showed similar results as the present study, i.e., Biodentine showed less apical microleakage than MTA as a root-end filling material. Refaei et al. 2020 [27] also compared the ProRoot MTA with Biodentine and showed that Biodentine showed significantly less microleakage than MTA; these results are similar to the results

However, a study by Soundappan et al. [28] and Mandava P et al. [29] proved MTA to have surpassed Biodentine, with MTA having better marginal adaptation due to the expansion of the cement on the setting.

Naik et al. 2015[31] in their study, showed Biodentine to have tricalcium silicate and zirconium particles of finer particle size, thus a higher value for specific surface area. Furthermore, due to its optimized particle size distribution, the tricalcium silicate's reaction rate was higher for Biodentine than MTA. . Thus, the biomineralization ability of Biodentine, most likely through the formation of tags, more excellent calcium and silicon uptake from adjacent root canal dentine, and least microleakage compared with other retrograde filling materials are the probable reasons for its least dye absorbance.

Even if apical surgery is still indicated, only the apical part containing the broken instrument can be ressected following root canal filling with this endodontic cement, and there would be no need for a retrograde filling. Surgical procedure is greatly enhanced, and more predictable results may be obtained.

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