

## Evaluation of the Sealing Ability of Mineral Trioxide Aggregate, Biodentine, Bone Cement used in the Retro Cavities Prepared with two types of Ultrasonic Retro Tips - A Comparative In Vitro Study

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### Abstract

### Original Research Article

The aim of this study is to compare the sealing ability of three retro filling materials; Mineral Trioxide Aggregate, Biodentine and Bone Cement and to compare the effect of two different ultrasonic retro tips; stainless steel and diamond coated on the sealing ability of these materials. Sixty human mandibular premolars were decoronated and root canal treatment was performed. 3 mm of root apex was resected at 90° to the long axis of root were randomly divided into two groups of 30 specimens each. Retro cavity was prepared with stainless steel retro tips in group I and in group II using diamond coated tip. Subgroups IA and IIA were filled with Mineral trioxide aggregate (n = 10), Subgroups IIA and IIB were filled with Biodentine (n=10) and subgroups IC and IIC were filled with Bone Cement (n=10). The teeth were sectioned longitudinally through the centre after immersion in Rhodamine B solution. The sections were visualised under confocal laser scanning microscope for depth of dye penetration. **Results:** Biodentine showed least dye penetration followed by MTA and Bone Cement. Diamond coated retro tips performed better than stainless steel retro tips. **Conclusion:** Biodentine group showed excellent sealing ability than MTA and Bone Cement. Diamond coated retro tip groups showed least leakage than stainless steel retro tip groups.

**Keywords:** MTA, Biodentine, Bone Cement, retro tip, retro cavity, Rhodamine B dye, Confocal laser scanning microscope.

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## INTRODUCTION

Endodontic microsurgery has enabled surgeons to assess pathological lesions more precisely and remove them with far greater precision with the help of dental operating microscope [1]. One of the most significant advances in the microsurgery was the introduction of ultrasonic microsurgical tips. There are several advantages of using microsurgical tips; like, the tip will stay centred in the root decreasing the possibility of root perforations, conservation of greater thickness of the remaining root canal walls, smaller osteotomy required to accommodate the retro tips, deeper root end preparation, lesser dentinal tubules exposure, therefore decreasing the chances of leakage around the root end filling materials [2,3].

Various types of ultrasonic retro tips have been introduced like smooth stainless steel, diamond coated, and zirconium nitrite coated tips. Zuolo *et al.* [4] found

that the walls of preparation were smoother, contained less debris and smear layer. Diamond tips cut faster than the noncoated tips but also create a large preparation because of diamond coating. It is reported that ultrasonic tips produce microcracks in the resected root surface [2].

One of the prerequisites for the success of surgical endodontics relies on selection of an ideal root end filling material.

One of the recently introduced material, PMMA bone cement is polymethyl methacrylate material which has been widely used in the orthopaedic surgery, mainly used for the fixation of the prosthesis and also for the stabilizing compressive vertebral fractures or filling bone defects.

Therefore the aim of this study was to compare the sealing ability of three retro filling materials; Mineral

Trioxide Aggregate, Biodentine and Bone Cement and to compare the effect of two different ultrasonic retro tips; stainless steel and diamond coated on the sealing ability of these materials.

## METHODOLOGY

Sixty human extracted single rooted mandibular premolars with completely formed apices were cleaned and any remnants of periodontal ligament were removed using a scaler. Teeth were then decoronated at the cemento-enamel junction using a diamond disc (Horico, Germany) under water coolant. The root canal orifices were enlarged with No.2 and No.3 Gates Glidden drills (Mani, Japan). Working length was determined by inserting #10 K-file (Mani, Japan) into the root canal until the tip of the file was visible at the apex. 1mm was subtracted from the obtained length which was considered as working length for biomechanical preparation.

Root canals were prepared by hand K-files (Mani, Japan) using step back technique to a final apical size of 40. The canals were irrigated with 2ml of 3% sodium hypochlorite (Vishal Chemicals) between each instrument change. Obturation was done with lateral compaction technique using AH Plus sealer (Dentsply, Germany). Hot instrument was used for searing off excess gutta percha at the orifice. After obturation the canal orifices were sealed with Cavit (3M ESPE). The samples were stored for 1 week to allow for the complete setting of the sealer.

Root resection was done at a distance of 3mm from the root apex at 90° to the long axis of the root using a straight fissure bur (Horico, Germany) under water coolant. Roots were randomly divided into 2 groups of 30 specimens each. In group I – Retro cavity prepared with stainless steel retro tip (n=30) and in group II – Retro cavity prepared with diamond coated retro tip (n=30).

The retro cavities were prepared with ultrasonic retro tip (Woodpecker) connected to the ultrasonic hand piece (EMS, Piezon) at the power setting of 2 with light intermittent pressure. Each group was subdivided into three subgroups based on the retro filling material used as mentioned below:

Group I- Subgroup IA (Mineral Trioxide Aggregate, n=10)

Subgroup IB (Biodentine, n=10)

Subgroup IC (Bone Cement, n=10)

Group II- Subgroup IIA (Mineral Trioxide Aggregate, n=10)

Subgroup IIB (Biodentine, n=10)

Subgroup IIC (Bone Cement, n= 10)

All the materials were mixed according to the manufacturer's instructions and condensed into the retro cavities. After the retro filling of the roots they were stored at 37° C in 100% relative humidity for 48 hours

and were then coated with two coats of nail varnish except at the root end and were allowed to dry. 2% solution of Rhodamine B dye was prepared by dissolving 2gms of dye in 100 ml of distilled water.

The roots were then immersed in 2% aqueous solution of Rhodamine B dye for 24 h following which the roots were washed under running tap water to remove the excess dye. The roots were then sectioned longitudinally through the centre of the root canal using a diamond disc (Horico, Germany) under water coolant. One half of the root section was retained for the examination under confocal laser scanning microscope.

Root end filling material of these sections were observed for the extent of dye penetration along the interface of the root end filling material and the cavity wall under confocal laser scanning microscope (Olympus LEXT 4000, Japan) at 5X magnification and the data was analysed using two-way ANOVA test followed by Bonferroni's post hoc analysis. The wall with maximum dye penetration was taken into consideration and the scoring was done according to the following scoring criteria:

0 – No dye leakage

1 – Leakage up to one-third of the cavity wall

2- Leakage up to two-third of the cavity wall

3- Leakage along the cavity wall and floor.

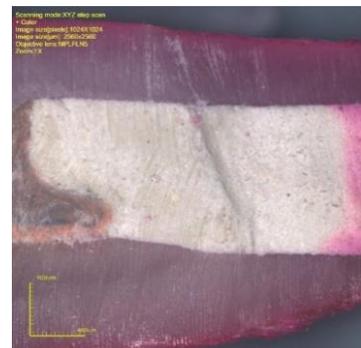


Fig-1: Confocal laser microscopic view of sample filled with Biodentine prepared with stainless steel retro tip

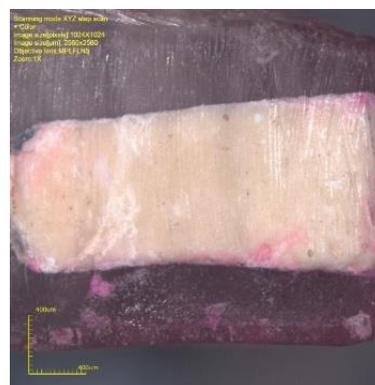


Fig-2: Confocal laser microscopic view of sample filled with MTA prepared with stainless steel retro tip

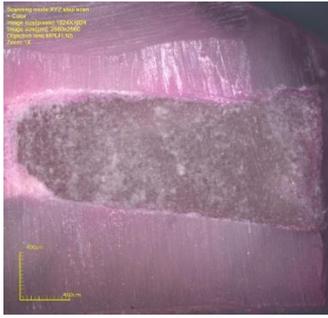


Fig-3: Confocal laser microscopic view of sample filled with Bone Cement prepared with stainless steel retro tip

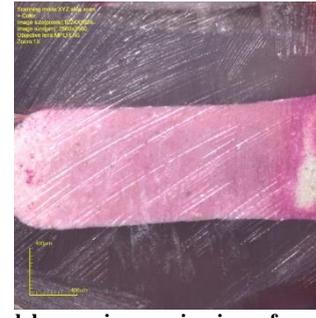


Fig-5: Confocal laser microscopic view of sample filled with MTA prepared with diamond coated retro tip



Fig-4: Confocal laser microscopic view of sample filled with Biodentine prepared with diamond coated retro tip

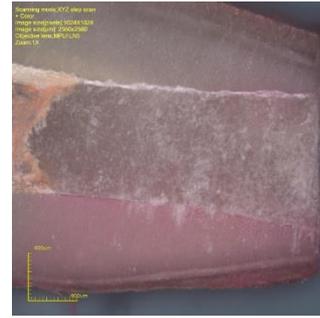


Fig-6: Confocal laser microscopic view of sample filled with Bone Cement prepared with diamond coated retro tip

**RESULT**

The mean dye penetration score of MTA, Biodentine and Bone Cement was 2.10, 1.50 and 2.45 respectively. The retro cavities filled with Biodentine showed lesser dye penetration values as compared to the retro cavities that were filled with MTA and Bone Cement. The

results were statistically significant. MTA showed lesser dye penetration scores when compared to Bone Cement but the results were not statistically significant. Therefore, among all the retro filling materials used, Biodentine showed least dye penetration followed by MTA and Bone Cement.

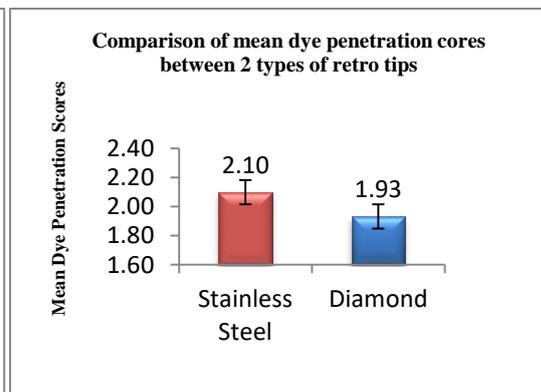
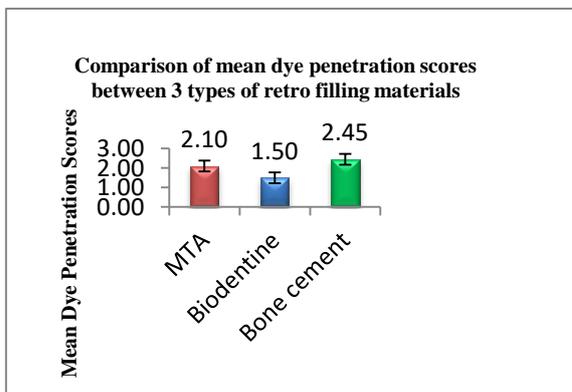
**Table-1: Estimated marginal mean dye penetration scores between the retro filling materials**

Materials	N	Mean	SD	95% CI for Mean		P-Value
				Lower	Upper	
MTA	20	2.10	0.79	0.18	1.73	<0.001*
Biodentine	20	1.50	0.51	0.12	1.26	
Bone Cement	20	2.45	0.51	0.11	2.21	

\*statistically significant

The mean dye penetration score of cavities prepared with stainless steel retro tips was 2.10 and for cavities prepared with diamond coated retro tip was 1.93. The comparison of dye penetration score between the retro tips used, revealed that the cavities that were prepared with diamond coated retro tips showed lesser dye

penetration values than the cavities that were prepared with stainless steel retro tips but the results were not statistically significant. Therefore, the sealing ability of the three retro filling materials was not effected irrespective of the type of retro tips used to prepare the cavities.



## DISCUSSION

Endodontic surgery comprises of thorough debridement of pathological periradicular tissue, root end resection followed by a Class I retrograde cavity preparation and insertion of an appropriate root end filling material into the prepared cavity in order to completely seal the root end against microleakage [2].

The resection of the apical 3mm of the root apex will eliminate 98% of apical ramifications and 93% of the lateral canals that would contribute to periradicular disease [5,6].

Ingle *et al.* [7] recommended using a #702 tapered fissure bur or a #3 or #8 round bur in slow speed hand piece for this procedure. Therefore, in this study a straight fissure bur was used in high speed hand piece under water coolant for the root end resection [8].

Bevelling of the root end results in opening of the dentinal tubules on the resected root surface that can communicate with the root canal space and result in apical leakage, even when root end filling has been placed. 90° angulation along the long axis of the root and bevel of 0-10° has therefore proved to be acceptable [2, 9]. Therefore in this study the angle of resection of the apical 3mm of the root was kept at 90° to the long axis of the root.

Various types of ultrasonic tips have been introduced like smooth stainless steel, diamond coated, zirconium nitrite coated tips. The walls of preparation were smoother, contained less debris and smear layer when retro cavities were prepared with smooth ultrasonic retro tip versus diamond coated tip [2]. Diamond tips cut faster than the non-coated tips but also create large preparation because of the diamond coating.

The retro cavities were prepared with light intermittent pressure with in and out motion to reach the depth of 3mm from the resected surface under water coolant and then ultrasonic tip was moved circumferentially to obtain a dimension of 2mm diameter [10]. The objective of a root end filling materials is to establish a seal between the root canal space and the periradicular tissues. Hence selection of an appropriate root end filling material plays an important role in the success of surgical endodontics.

One of the new materials that might have potential properties of a root end filling material is polymethylmethacrylate bone cement. In 1936, the Kulzer company patented a heat curable dough made by mixing polymethylmethacrylate powder and liquid methylmethacrylate and a heat sensitive initiator. In 1943 the first cold curing cement was developed by the companies Degussa and Kulzer [11]. It was widely used in orthopaedic surgery for over 40 years, mainly for the fixation of the prosthesis, stabilizing compressive vertebral fractures or filling bone defects.

The material is packaged as a powder which contains polymethylmethacrylate polymer or methylmethacrylate copolymers, dibenzoyl peroxide (BPO) as initiator, radiopacifiers which are either zirconium dioxide or barium sulfate. Optionally an antibiotic or a dye may be present. The powder and liquid are mixed in the ratio of 1:1, the initiator BPO from the powder and the activator DMpT from the liquid interact to produce free radicals in so called initiation reaction. These radicals are able to start the polymerization of MMA by adding to the polymerizable double bond of the monomer molecule. This results in the growing polymer chain [11].

Bone cement has characteristics that makes it well suited as a retrofilling material. The cement exhibits low cytotoxicity, has short setting time of 15 minutes, and moist environment or blood contamination has no effect on its properties.

In present study the specimens were immersed in a 0.5% aqueous solution of rhodamine B dye for 24 hours after sectioning of the specimens longitudinally through the midline of the root end filling material [12].

One of recent method of assessment of leakage is confocal laser scanning microscopy. Illumination is achieved by scanning one or more focused beam of lights, usually from a laser or arc-discharge source, across the specimen. This point of illumination is brought to focus in the specimen by the objective lens and laterally scanned using a scanning device under computer control [13].

Results of the present study showed that cavities filled with Biodentine and prepared with diamond coated retro tip showed the least dye penetration value when compared with the other experimental groups. The probable reasons could be:

- When Biodentine comes in contact with dentine it leads to the formation of tag like structures alongside an interfacial layer called the “mineral infiltration zone”, were the alkaline caustic effect of calcium silicate cement hydration products degrades the collagen component of interfacial dentine [13].
- The sealing ability of Biodentine is mostly through the formation of tags. Han and Okiji showed that the calcium and silicone uptake into the dentine leading to the formation of tag-like structures in Biodentine was higher than MTA [14].
- Better seal with Biodentine can also be attributed to its modified powder composition i.e, the addition of setting accelerators and softeners, a new pre-dosed capsule formulation for the use in mixing device largely improves the physical properties including sealing ability of the material.

- Biodentine has an advantage of shorter setting time thereby sealing the interface earlier to avoid further leakage to take place so there is a low risk of bacterial contamination.
- Due to its better handling properties, adaptation to the cavity walls is better which can be responsible for improved sealing of Biodentine.
- Smaller particle size of Biodentine adapts well to cavity surface, sealing the interface.
- Porosity or pore volume in set Biodentine material is also less than MTA that could be a reason for better sealing ability) [15].

The results of this study also showed less dye leakage of MTA as compared to Bone Cement. Good adaptation of MTA to cavity wall margins might be intrinsically linked to the nature of the material. MTA powder consists of fine hydrophilic particles that absorb water during hydration. Therefore, the material expands during solidification [16]. This might have played a role in its superior adaptation to cavity margins.

The results of Bone Cement were also comparable to MTA. The good adaptation of bone cement to the dentine wall in spite of the well known polymerization shrinkage of acrylics might be explained by the results of a study by Charnley [17], who used a fluid displacement model and observed that the volume of the cement increases to a maximum during polymerization before shrinking slightly, although not to its initial volume. According to Amany Al Badr [18], there was a satisfactory marginal seal obtained by the use of bone cement. The volume of bone cement used in root end cavities is very less which would produce a smaller exothermic reaction and much reduced amount of free monomer. Therefore it appears as bone cement might be considered as a promising material for use as a root end filling.

According to the results of the present study, cavities that were prepared with diamond coated retro tips showed lesser dye penetration values than the cavities prepared with stainless steel retro tips. The reasons could be that the diamond coated retro tip owing to its abrasive property take lesser time for the cavity preparation [19], and the number of microcracks produced by the diamond coated tips are also lesser as compared to the stainless steel tips [20].

## CONCLUSIONS

Within the limitations of this in vitro study it can be concluded that,

1. Biodentine showed the least dye penetration as compared to MTA and Bone Cement and the results were statistically significant.
2. MTA showed less dye penetration as compared to Bone Cement but results were not statistically significant.

3. The samples prepared with diamond coated retro tips showed lesser dye penetration than the samples that were prepared with stainless steel retro tip but results were not statistically significant.
4. The type of the retro tips did not influence the dye penetration of the test materials

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