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Research Article

Evaluation of the Sealing Ability of Calcium Silicate Based Material as Comparison with Resin-Modified Glass Ionomer Cement as Furcation Repair Material: An *in Vitro* Study

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Abstract

Objective: To compare sealing ability of Resin-Modified Glass ionomer cement (RM- GIC), Mineral trioxide aggregate (MTA) and Biodentine in perforation repair.

Methodology: Forty eight humans mandibular 1st molar was selected after inclusion and exclusion criteria. The teeth were divided randomly into four groups (n = 12) G1(positive control), G2 (RM-GIC was used to repair perforation), G3 (MTA was used to repair perforation) and G4 (Biodentine was used to repair perforation). All samples were coated with nail paint except 1 to 2 mm around the perforation and were immersed in methylene blue dye for 48 hours. Samples were sectioned buccolingually and observed under stereomicroscope at 10x magnification.

Results: Comparison of the four test groups using Kruskal-Wallis test was done and it was found that the difference between the groups were statistically significant (H-value = 30.03, p value = 0.000). No significant difference was seen between MTA with Bio dentine and between RM-GIC and Biodentine. But significant difference was seen when MTA was compared with RM-GIC.

Conclusion: Within the limitations of this study, MTA is the best material for perforation repair. Biodentine also provides a good seal similar to that of MTA. RM-GIC also seal the perforation but not as good as MTA and Biodentine.

Keywords: Perforation; MTA; Biodentine; RM-GIC

Introduction

Perforation is a pathological communication between the root canal system and the surrounding periodontal tissues [1]. It can occur as a result of a misdirected bur during access preparation, search of chamber floor for canal orifices, during preparation of the post space or due to excessive flaring of the cervical portion of the curved roots in molars [2]. It acts as an open channel encouraging bacterial entry either from root canal or periodontal tissues or both eliciting inflammatory response that results in fistulae including bone resorptive processes that may follow.

The ideal repair material should provide an adequate seal, be biocompatible, and possess the ability to induce osteogenesis and cement genesis [3]. The ability of repair materials to seal furcation perforations *in vitro* has been tested using dye, bacteria, radioisotopes, and fluid filtration.

Calcium silicate-based cements (CSC), including mineral trioxide aggregate (MTA), are self-setting hydraulic cements. The powder of CSC is composed mainly of dicalcium and tricalcium silicate. After mixing the powder with water, $Ca(OH)_2$ and calcium silicate hydrate are produced primarily, and the mix forms a sticky colloidal gel (calcium silicate hydrate gel) that eventually solidifies to a hard structure.

Recently, dual cured resin-modified glass-ionomer materials have been developed with the active component a glass ionomer and a photocuring resin system. In an invitro study, a light-cured glass ionomer provided a better deal than Cavity and amalgam when used to repair furcation perforations [4].

MTA is non-resorbable, anti-bacterial, osteoconductive, radio-opaque and biocompatible. Principle components of MTA are tricalcium silicate, tricalcium aluminate, tricalcium oxide, silicate oxide, mineral oxide, bismuth oxide. MTA was considered the ideal material of choice for replacement of dentinal defects with good biocompatibility and marginal sealing ability [5].

A variety of new calcium silicate-based materials have been developed recently aiming to improve MTA shortcomings Biodentine (Septodont, Saint Maur des Fosses, France) [6] is a high-purity calcium silicate-based dental material and is recommended for use as a dentine substitute under resin composite restorations and an endodontic repair material because of its good sealing ability, high compressive strengths, short setting time, biocompatibility, bioactivity, and biomineralization properties [7].

Thus, the purpose of this *in vitro* study was to evaluate the sealing ability of RM-GIC, MTA, and Biodentine to seal the furcal perforation.

Materials and Method

This *in-vitro* study was conducted in postgraduate department of Conservative Dentistry and Endodontics, Institute of Dental Sciences, Bareilly (U.P.), in coordination with Department of Oral pathology and microbiology.

Sample selection

Forty-Eight Human mandibular 1st molars with intact enamel surfaces, not affected by fluorosis, no resorption, no fracture, non-fused and well developed roots, were stored in a sterile solution at room temperature until use.

Study design

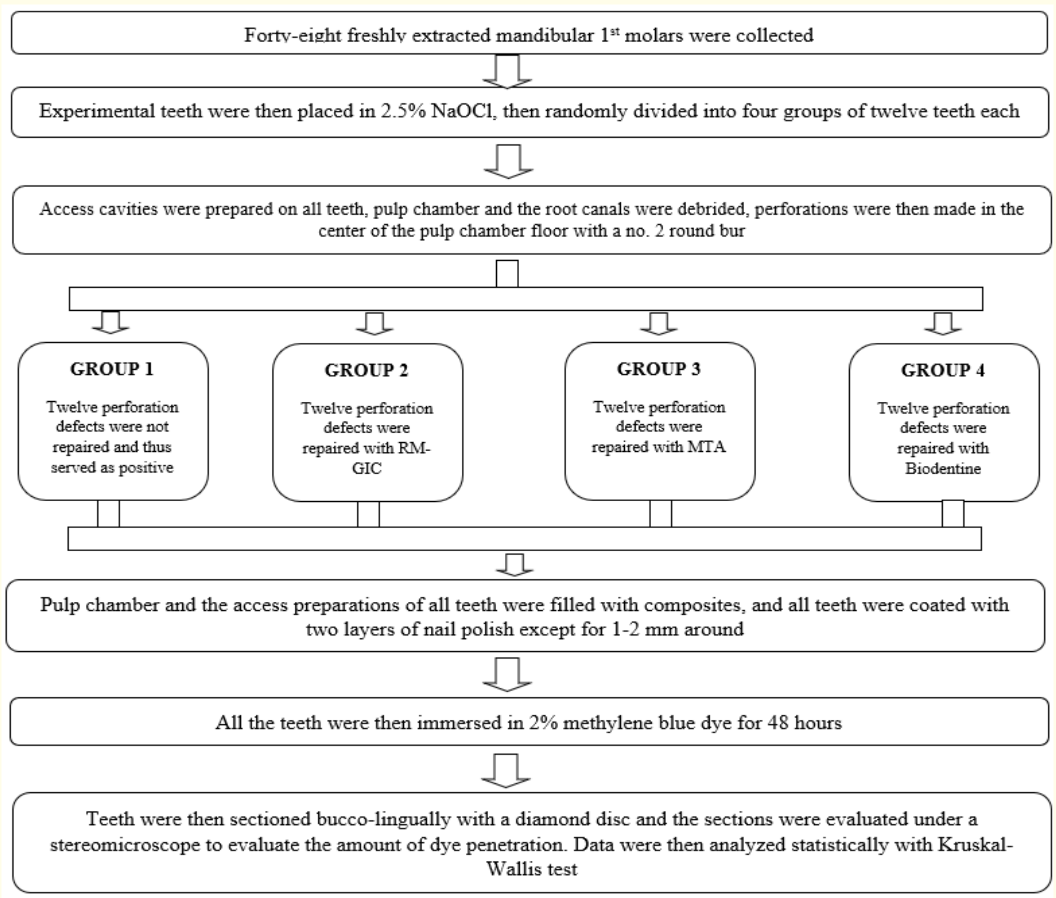


Figure 1

Control group

- **Group I (n = 12):** Access cavities were prepared, and root canals were debrided in all teeth. Perforation defects were not repaired with any material and thus served as positive controls.

Experimental groups

- **Group II (n = 12):** Access cavities were prepared, and root canals were debrided in all teeth. Perforation defects were repaired with RM-GIC.
- **Group III (n = 12):** Access cavities were prepared, and root canals were debrided in all teeth. Perforation defects were repaired with MTA after three days to allow complete setting of MTA.
- **Group IV (n = 12):** Access cavities were prepared, and root canals were debrided in all teeth. Perforation defects were repaired with Biodentine, Complete setting of Biodentine occurs after 5 to 6 minutes.

Post endodontic restoration in all groups (Group I to Group IV):

Acid etching of the access cavities was done with 37% phosphoric acid. Acid etching gel (N-Etch ivoclarviva-dent) was applied using a needle applicator over the prepared cavity and left for 15 seconds. It was thoroughly rinsed for 10 seconds with water and air using the three-way syringe. A single coat of dentin bonding agent (N-Bond) was applied using applicator tip and cured for 20 second using a light curing unit (coltoluxLED) with the curing intensity of 800 mW/cm^2. Post endodontic restoration was done by incremental technique with composite (N-ceram) and cured for 20 second (Figure 2 and 3).

Figure 2: Control showing dye penetration involving perforation and base of the restoration: Designated as score 3.

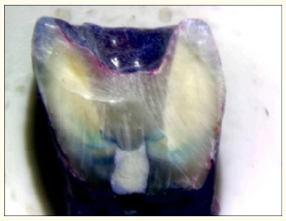


Figure 3: RM-GIC showing dye penetration involving base of the restoration. Designated as score 3.

Dye leakage in all groups (Group I to Group IV) (Figure 4)

All teeth were coated with two layers of nail polish except for 1 - 2 mm around the furcation perforations. The teeth were suspended in 2%methylene blue aqueous dye solutions. Samples were removed from methylene blue dye after 48 hours.

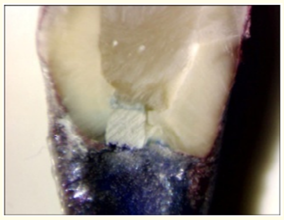


Figure 4: MTA showing no dye penetration: Designated as score 0.

Evaluation of the samples (Group I to Group IV) (Figure 5)

The teeth were split into two half bucco-lingually involving the half of perforation on each side using carborundam disk. Samples were placed in stereo microscope (10X).

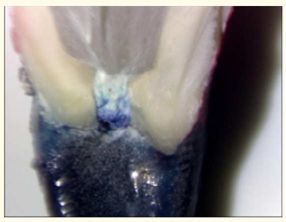
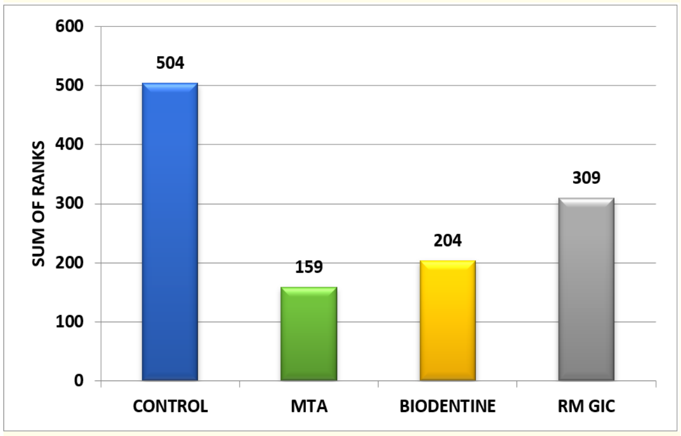


Figure 5: Biodentine showing dye penetration involving less than half of the perforation: Designated as score 1.

Scoring criteria

- **Score 0:** No dye penetration at all.
- **Score 1:** Dye penetration less than half of the perforation length.
- **Score 2:** Dye penetration more than half of the perforation length.
- **Score 3:** Dye penetration involving the base of the restoration.

Stereomicroscope was equipped with camera. Images were captured using Pro 4.6 software. These images were transferred using BMP format. The data obtained by the above-mentioned methodology was tabulated. The results obtained were subjected to statistical analysis. Data were then analyzed statistically with Kruskal-Wallis test and Mann Whitney U test.



Graph: Comparison of the four groups by Kruskal - Wallis Test.

Observations and Results

Several materials have been proposed for use as perforation repair and their biocompatibility and osteogenic potential have been demonstrated. Many such material like RM-GIC, MTA and Biodentine, have been advocated as perforation repair as they permit an adequate seal of the pulp chamber floor and prevent bacterial leakage.

Statistical analysis

Statistical analysis was done using Kruskal–Wallis test and $P < 0.05$ was considered statistically significant and $P < 0.001$was considered statistically highly significant.

There was significant difference in between the groups. Table 1 shows the inter group comparison of the four test groups using Kruskal-Wallis test and it was found that the difference between the groups was statistically significant (H-value= 30.03, p value = 0.000).

Group	Mean Rank	Sum of Ranks	H-value	P-value
Control	42.0	504	30.03	0.0000*
MTA	13.25	159		
Biodentine	17.0	204		
RM GIC	25.75	309		

Table 1: Intergroup comparison among four test groups of perforation repair material.

Results

- Minimum dye penetration was observed in MTA, followed by Biodentine, RM-GIC and control group.
- Complete dye penetration was observed in control group.
- No statistically significant difference was observed when MTA group was compared with Biodentine group.
- Comparison of MTA group with RM-GIC group reveals statistically significant difference.
- Statistically significant difference was observed when Biodentine group was compared with RM-GIC.

Discussion

The success of furcal perforation repair is dependent on an effective seal between the inner and outer tooth environment. Factors affecting the treatment prognosis of perforation repair include the level, location and size of the perforation, the time delay before perforation repair and the material used to seal the perforation [8].

The term "resin-modified" denotes the addition of resin groups (i.e., HEMA) by virtue of the attachment of these molecular groups to the "acidic liquid component". These light-cured, RM-GIC offered many benefits. The speed of light-curing vastly shortened the setting time that had been a significant shortcoming of the original self-cure glass ionomers. RM-GIC release fluoride and bond chemically to tooth structure, as do conventional GI products, yet demonstrate early and increased strength [9].

MTA stimulates cement oblasts to produce matrix force mentum formation and is biocompatible with the peri radicular tissues thus shows a superior sealing ability when used for perforation repair [10]. MTA sets only in contact with moisture. Due to the above mentioned characteristics MTA can be considered the ideal material to seal perforations [11].

Biodentine is a calcium silicate-based bioactive material. It is a powder liquid system, powder composed of Tri-calcium silicate, Dicalcium silicate, Calcium carbonate and oxide, Iron oxide, Zirconium oxide. Liquid consist of Calcium chloride, Hydro soluble polymer. It is easy to handle, has short setting time approximately 12 minutes and has high alkaline pH [12]. Biodentine showed considerable performance as a perforation repair material even after being exposed to various endodontic irritants as compared to MTA.

In the current study, methylene blue dye penetration method was selected to study microleakage because it is inexpensive, easy to manipulate with high degree of staining and a molecular weight even lower than that of bacterial toxins [13].

In this study group 1 is the control group and mean dye penetration observed was 3. It is due as no material was used in perforation repair.

RM-GIC was used for furcation repair in group 2 and mean dye penetration was 1. High microleakage as observed in RM-GIC group may be due to the polymerization contraction of the material. Contamination of thedentinal surface with excessive moisture, solvent or presence of voids could affect bonding, making it unpredictable under clinical conditions. These finding are in agreement with a previous study done by Watts D.C [14]. where significant changes in the properties of similar RM-GIC were reported in aqueous and neutral media.

MTA was used for furcation repair in group 3 and mean dye penetration was 0.25. Studies have reported that MTA provides an excellentapical seal. It has been shown to be very effective in sealing the pathways ofcommunication between the root canal system and the external surface of the tooth.Investigations done by Mitchell., *et al*. [15] have also shown the cell growth of osteoblasts on MTA.

In our study MTA showed minimum leakage compared to RM-GIC and Biodentine. The minimum microleakage as observed in MTA group might be attributed to its superior marginal sealing ability resulting from its hydrophilic properties and formations of an interfacial layer between the material and dentin.

Biodentine was used for furcation repair in group 4 and mean dye penetration was 0.50. Group 4where the perforation was repaired with Biodentine the dye leakage value was between0 to 1 but there were more sample having value 1 as compared to Group 3 (MTA). That means Group 4 leaked more as compared to MTA but these results were not statistically significant. These results were different from a previous study done by Kumar Y., *et al.* [16]. in which least leakage was observed with Biodentine than MTA.

The difference in the results of two studies could be due to a fact that in our study methylene blue dye was used for evaluation while Rhodamine dye was used in their study. Another study done by Georgia et al1 compared MTA and Biodentine in perforation repaired. They observed the least amount of dye penetration in MTA group followed by Biodentine. The result of their study was accordance with our study.

Conclusion

Within the limits of this study it was inferred that:

- MTA is the best of the three materials used for furcation repair.
- Biodentine also provides a good seal almost similar to that of MTA when used as a furcation repair material.
- RM-GIC does not provide a good seal when compared to MTA and Biodentine.

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