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COMPARATIVE EVALUATION OF SEALING ABILITY OF MINERAL TRIOXIDE AGGREGATE, RESIN MODIFIED GLASS IONOMER CEMENT AND CALCIUM PHOSPHATE CEMENT IN FURCATION PERFORATION REPAIR: AN IN-VITRO STUDY

Dental Science

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ABSTRACT

A perforation is an undesirable communication between the root canal system and the supporting tissues or both. In endodontics, root perforations are referred as the second greatest cause of treatment failure next to improper obturation. Many materials and techniques have been tried to repair the furcation perforation. The purpose of this study was to evaluate the sealing ability of mineral trioxide aggregate, resin modified glass ionomer cement and calcium phosphate cement to repair the furcation perforation. The results of the study demonstrated that the microleakage was least when perforation was repaired with mineral trioxide aggregate and it was maximum when perforation was repaired with calcium phosphate cement.

KEYWORDS

Furcation Perforation, Mineral Trioxide Aggregate, Resin Modified Glass Ionomer Cement, Calcium Phosphate Cement, Sealing Ability

INTRODUCTION

An endodontic perforation can be defined as "an opening in the crown or the root of the tooth, resulting in a communication between the pulp chamber of the root canal of the tooth and the periodontal attachment apparatus (Fuss & Trope1996)." Undesirable communications between the pulp space and the periodontal attachment apparatus may occur at any level; in the chamber or along the length of the root canal. They may occur during preparation of the access cavity, root canal space, or the post space (Frank 2002).

Perforations, especially in the furcation during the endodontic treatment, have a notably detrimental effect on prognosis (Ford et al 1995). Therefore the prognosis of perforation repair include: location of the perforation, time elapsed prior to perforation repair, previous contamination by micro-organisms and the biological and physical characteristics of the restorative material (Ibarrola et al 2008).

The rationale for non-surgical treatment of the perforation is to prevent periradicular inflammation. This can be achieved by immediate sealing of the perforation with a non-irritating material that will provide an adequate seal to prevent microbial penetration. A variety of materials have been reported for use in non-surgical intracoronal repair of furcation perforation including: amalgam, gutta-percha, dentin chips, calcium hydroxide, Cavit, tricalcium phosphate, hydroxyapatite, glass ionomer cement and Super EBA and more recently, mineral trioxide aggregate (MTA) (De-Deus 2006).

None of these materials however fulfill all of the criteria of an ideal repair material: osteogenesis and cementogenesis induction, biocompatibility, nontoxicity, noncariogenecity, ease of procurement, convenience and economy. In addition, an ideal repair material should serve as both matrix or barrier against which a root canal filling or a restorative material can be placed (Hartwell & England 1993).

In 1987, Brown and Chow described self-setting calcium phosphate cement (CPC) containing tetra calcium phosphate (TTCP) and either dicalcium phosphate anhydrous (DCPA) or dicalcium phosphate dihydrate which when mixed with water hardened into cement with a chemical composition and crystal structures similar to tooth and bone (Shetty & Kundabala 2013). Positive biological results achieved with calcium phosphate cement are encouraging its use as an endodontic restorative material with low cost.

Hence, the purpose of this in vitro study was to compare the sealing ability of mineral trioxide aggregate, resin modified glass ionomer cement and calcium phosphate cement in the repair of furcal perforations.

MATERIALS AND METHODS

50 freshly extracted and intact human permanent molars were collected and cleaned of calculus, soft tissue and debris using surgical scalpel and stored in normal saline until used. Access opening for all the teeth used in the study was prepared by high speed handpiece using access preaparation kit (Dentsply Maillefer, Ballaigues – Suisse). Perforations were then made in the center of pulpal floor using number 12 round bur (ISO 001/012 FG, Dia-burs, Mani, INC. Japan) in a high speed handpiece for all the teeth. The width of perforation was standardized to the diameter of bur. The depth of the perforation depended on the dentin cementum thickness from the pulpal floor to the furcation area. All perforations were rinsed with water and air dried.

The teeth were then randomly divided into four groups. Group A, B, C were the experimental groups and comprised of fifteen teeth each. Group D was used as control group consisting of five teeth.

All the teeth in experimental groups were repaired with different materials as follows:

GROUP A: Comprised of 15 teeth repaired with Mineral Trioxide Aggregate (MTA-Angelus,Londrina, Brazil). MTA was mixed according to manufacturer's instructions and placed into perforation using MTA carrier and was condensed with endodontic hand plugger.

GROUP B: Comprised of 15 teeth repaired with Resin Modified Glass Ionomer Cement (GC Gold Label, Tokyo, Japan). The material was manipulated according to manufacturer's instructions. A small amount of material was carried into pulp chamber with the plastic filling instrument and allowed to flow apically into perforation. The glass ionomer cement was then light cured for 30 seconds with a compact visible light curing unit. Incremental layers were applied until the perforation was completely filled.

GROUP C: Comprised of 15 teeth repaired with Calcium Phosphate Cement (BIOGRAFT-CPC, IFGL Refractories Ltd., India). The material was manipulated according to manufacturer's instructions and was placed into perforation using plastic filling instruments and was condensed with endodontic hand pluggers (GDC® RCP 5/7).

All experimental perforation defects were filled with repair materials to the level of the pulpal floor.

GROUP D: Comprised of 5 teeth used as control group and they did not receive any repair material.

A moistened cotton pellet which did not act as a matrix for the repair material was placed between the roots to simulate the clinical situation during the repair. No attempt was made to prevent overextension of the repair material. After completion of the repair, the pulp chamber and the access preparation of all teeth were restored with light cured composite resin (FILTEK Z350, 3M ESPE).

Preparation For Microleakage Test

All experimental teeth and control group teeth were covered with two layers of nail varnish except for 1 to 2 mm around the perforation. The apical foramina were sealed with modeling wax. Samples were then stored in saline at 37° C and 100 % humidity for 48 hours.

The specimens were then immersed in methylene blue dye (Thermo Fisher Scientific India Pvt. Ltd., Mumbai) for 48 hours. After removal from the dye the teeth were rinsed with distilled water and air dried. Teeth were sectioned along buccolingual direction using Carborundum discs. The sections were polished and analyzed under the stereomicroscope (Magnus, MSZ BI SWH10X) at 20 x magnification.

The extent of dye leakage was measured as the most coronal linear extent of dye penetration from the most apical extent of the perforation. The extent of dye leakage was then calculated as a percentage of perforation depth. The leakage of dye to the level of pulpal floor represented 100% leakage (Figure.1:A,B,C,D).

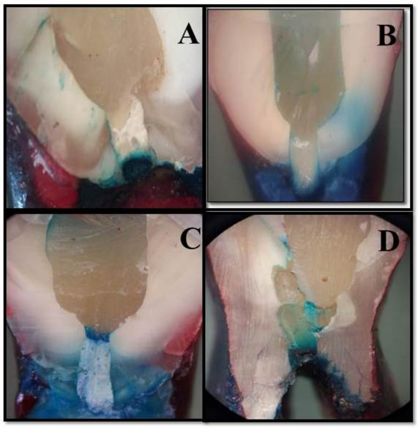


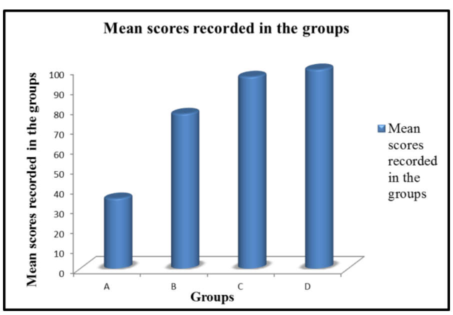
Figure 1A: Maximum Microleakage Observed In Group A
Figure 1B: Maximum Microleakage Observed In Group B
Figure 1C: Maximum Microleakage Observed In Group B
Figure 1D: 100 % Microleakage Observed In Group D

STATISTICALANALYSIS

All the samples were analysed using One way ANOVA (Analysis Of Variance) and post-hoc Tukey's HSD (Honest Significant Difference) test to find out among which pair of groups there exist a significant difference. Statistical significance were preset at $\alpha = 0.05$ for all analyses.

RESULTS

The mean score was found to be higher in Group D followed by Group C followed by Group B and Group A. The p-value corresponding to the F-statistic of one-way ANOVA was lower than 0.05, suggesting that the one or more treatments are significantly different (Table 1), (Graph 1).



Graph 1: Mean microleakage scores recorded in the study groups

Group	Mean	Standard Deviation	ANOVA: Between Subject Factor	p-Value
A	35.18	19.10	54.9631	P=0.0003 (p<0.05*)
B	77.74	16.21		
C	96.36	6.50		
D	100	0		

denotes significant difference

Table 1: Distribution of Mean, Standard Deviation, ANOVA Between Subject Factor and p-Value of microleakage between all the study groups

A significant difference was observed between Group A and Group B ($p<0.01$), Group A and Group C ($p<0.01$), Group A and Group D ($p<0.01$), Group B and Group C ($p<0.01$), Group B and Group D ($p<0.01$). Group C exhibited less dye leakage (%) than Group D. But there was no significant difference between Group C and Group D ($p>0.05$) (Table 2).

GROUPS COMPARED	Tukey HSD p-value	Tukey HSD Q-value	Tukey HSD Interference
[GROUP A]vs[GROUP B]	0.0010053	11.5439	p<0.01**
[GROUP A]vs[GROUP C]	0.0010053	16.5936	p<0.01**
[GROUP A]vs[GROUP D]	0.0010053	12.4325	p<0.01**
[GROUP B]vs[GROUP C]	0.0045504	5.0496	p<0.01**
[GROUP B]vs[GROUP D]	0.0207703	4.2697	p<0.05*
[GROUP C]vs[GROUP D]	0.8999947	0.6990	p>0.05

[*=p<0.05 **=p<0.01]

Table 2: Pair-wise comparison of microleakage using Tukey's HSD test between the study groups

DISCUSSION

The principle goal of an endodontic therapy is to remove microbes and seal the root canal system effectively. Inadvertent perforation interferes with this goal because of damage to the periodontal attachment apparatus and subsequent bacterial proliferation (EIDeeb 1982). Surgical repair for furcation perforations is not recommended since the area is usually surgically inaccessible.

The present study was conducted to compare the sealing ability of mineral trioxide aggregate, resin modified glass ionomer cement and calcium phosphate cement when used to repair perforations in the furcation area.

Mineral trioxide aggregate (MTA) has evolved as a material of choice for perforation repair due to its biocompatibility, good sealing ability, ability to promote dental pulp and periradicular tissue regeneration and it can harden in the presence of moisture (Torabinejad et al 1995). It also possesses ideal properties including antimicrobial effect, radiopacity and dimensional stability (Torabinejad & Chivian 1999). However, MTA is known to exhibit certain shortcomings including long setting time, the potential to discolour teeth, technique sensitivity and high cost (Chng 2005).

Resin modified glass ionomer cement is a dentin adhesive material that is tissue compatible, has good sealing ability and acceptable strength (Alhadainy et al 1998). The ability to command set, to bond to the dentin and to avoid pretreating dentin are the advantages which prompted investigation of this material as a potential material to repair furcation perforation (Chong et al 1991). During setting, calcium ions of the dental hard tissue form a chemical bridge between tooth structure and the glass ionomer. In addition, light cured glass ionomer cement has a flow property that helped it to seal the apical end of the perforation (Alhadainy & Himel 1993).

Calcium Phosphate Cements (CPC) are two-component cementing compositions having a powder part containing dry calcium salts and an aqueous based wetting liquid, which produce a self-setting putty or paste. Excellent biocompatibility and osteotransductivity are additional advantages. CPCs are well adaptable to dentin surface when filled in endodontic defects or root canals and the set cement has excellent dimensional and mechanical stability. A cement formulation with viscous and cohesive properties has been developed in India by Sree Chitra Thirunal Institute for Medical Sciences and Technology, Trivandrum, Kerala, India. The setting time was found to be approximately 20 minutes. The compressive strength was observed to be 11.12 Mpa, which is in the range of trabecular bone (Komath & Varma 2003).

In the present study the width of the perforation was standardized as the diameter of number 12 round bur. The depth of the perforation was dependent on the dentin cementum thickness from the pulpal floor to the furcation. To overcome this uncontrolled variable, percentage of linear dye penetration was taken.

All the experimental groups demonstrated dye leakage. Group A showed mean dye leakage percentage of 35.18±19.10 with minimum leakage of 0 % and maximum dye leakage of 62.95%. MTA showed lowest dye leakage % in all the experimental groups. These results are in agreement with the studies conducted on MTA in sealing furcation perforations.(Ford et al 1995, Shetty et al 2013, Torabinejad et al 1999).

The probable reason for this could be the ability of the MTA to expand while setting which adapts it more efficiently to the dentinal walls (Torabinejad et al 1995). MTA being water based cement has ability to set in the presence of moisture (Torabinejad et al 1995). A moist cotton pellet kept in between the roots of teeth during perforation repair with MTA provided the wet environment needed by the MTA for adaptation to occur.

The teeth in which the perforations were repaired with resin modified glass ionomer cement (GROUP B) showed a mean dye leakage % of 77.74±20.75 with minimum of 55.40 % and maximum leakage of 100 %. Group B exhibited significantly more leakage than Group A. In the present study extrusion of glass ionomer cement beyond the furcation perforation was not observed. The mix of the cement used may be more viscous, which reduced the incidence of extrusion. The probable cause for significant leakage in Group B specimens as compared to Group A specimens could be the viscosity of the material and moisture contamination during the setting of the material. Decreased flow in combination with the potential for air bubble formation that can result in voids in the repair material might not have filled the defect completely. The presence of moisture from the cotton pellet, which was kept in between the roots to simulate clinical conditions, would have adversely affected the sealing ability of RMGIC.

Group C showed mean dye leakage % of 96.36±6.50 with minimum leakage of 83.12 % and maximum dye leakage of 100 %. The injectable calcium phosphate cement which was used in this study was inefficient to repair furcation perforation and the tracer dye had entered massively into the perforation defect. This is in accordance with the study by Chordiya et al (Chordiya et al 2010) and Tsatsas et al (Tsatsas et al 2005) where similar results were obtained with Chitra-CPC and tricalcium phosphate respectively. The probable cause for significantly more leakage in group C specimens as compared to group A and group B specimens could be the partial washing away of the unset cement as a result of the moisture from the moist cotton pellet placed in the furcation area. The resorbable nature of the cement (helps in remodeling of the defects) might have resulted in loss of the cement from the perforation site (Fernandez et al 2006).

The results of present study show that the positive control group D had 100% dye penetration in the perforation defect. This showed that the perforation did not hamper dye leakage. The entry of the leakage marker, from all other portals were blocked well by nail varnish coats. Hence, a decreased penetration of the dye in the teeth of experimental groups may be attributed to the sealing ability of the repair material used.

CONCLUSION

Within the limitations of the present study it can be concluded that MTA showed superior sealing ability in furcation perforation repair as compared to RMGIC and CPC. Thus, MTA proves itself as a perforation repair material due to its better sealing ability and at the same time ability to stimulate tissue repair. MTA with its added properties like biocompatibility and ability to allow regeneration of hard tissues may improve the prognosis of furcation perforation defect. The self-setting injectable calcium phosphate cement with its properties of biocompatibility and osteoconduction may be used as a barrier material and not a repair material for furcation perforations.

Additional in vivo and in vitro tests and clinical trials are desirable in order to elucidate the effectiveness of the newer perforation repair materials.

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