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Original Article

Comparative Evaluation of Sealing Ability of white MTA, Biodentine, Calcium Phosphate Cement, and Glass Ionomer Cement as Furcation Repair Materials: An Ex Vivo Study

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ABSTRACT:

Background: Root perforation is an artificial communication between the root canal system to the supporting tissues of the tooth or to the oral cavity. Despite the favorable properties of MTA that supports its clinical use, it has several clinical drawbacks such as prolonged setting time, difficult handling characteristics, and potential discoloration. Biodentineis a high purity calcium silicate based dental material composed of tricalcium silicate; calcium carbonate, zirconium oxide, and water-based liquid containing calcium chloride as the setting accelerator and water-reducing agent.Hence; we planned the present study to evaluate the sealing ability of white Mineral trioxide aggregate, Biodentine, Calcium phosphate cement, and Glass ionomer cement as furcation repair materials using dye extraction leakage method. **Materials & methods:** Forty-five extracted, intact human mandibular molars with non-fused and well-developed roots were used in this study. Molars were decoronated 3 mm above the cemento-enamel junction and roots were amputated 3 mm below the furcation. Teeth were randomly divided into five groups with 10 samples each for the experimental group and 5 samples in the control group. Group I was repaired with white MTA (Angelus), Group II with Biodentine (Septodont, France), Group III with Glass Ionomer Cement (3M ESPE), Group IV with Calcium Phosphate Cement (GBone surgiwear) and Group V is control group which was left unrepaired (positive control). All the teeth in each group were allowed to set for 24 h. Each specimen was subjected to dye extraction and microleakage evaluation. This was followed by centrifugation and spectrophotometric evaluation. The obtained readings were statistically analyzed using one-way analysis of variance and Tukey multiple comparisons tests. **Results:** There was a significant difference in the mean dye leakage among four groups ($P < 0.001$). There was a statistically significant difference seen between the White MTA and CPC groups, between Biodentine and GIC groups, also between Biodentine and CPC groups. As there are more values of absorbance in GIC, CPC, and control groups compared to White MTA and Biodentine groups. **Conclusion:** Among all four materials used viz. White MTA, Biodentine, Glass ionomer cement, and Calcium phosphate cement, Biodentine showed least dye absorbance and best sealing ability as compared to other materials due to differences in properties like specific surface area, pore volume and pore size.

Key words: Biodentine, Calcium phosphate cement, Glass ionomer cement, Sealing

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INTRODUCTION

Root perforation is an artificial communication between the root canal system to the supporting tissues of the tooth or to the oral cavity. Perforations occur primarily through three possible mechanisms: procedural errors occurring during root canal treatment or post space preparation, resorptive processes and caries. Most perforations result from procedural errors.[1]

An ideal orthograde or retrograde filling material should seal the pathways of communication between the root canal system and its surrounding tissues.Calcium phosphate cement (CPC) is a synthetic bone graft material that was invented in 1986 by L. C. Chow and W. E. Brown, scientists at the American Dental Association.[2,3]

Glass ionomer cements (GICs), also known as glass polyalkenoic cement, has a fundamental role in current Dentistry.The Mineral Trioxide Aggregate forms a colloidal gel upon hydration, which solidifies in approximately four hours. Therefore, when used as a root

repair material, moisture must be provided from the internal aspect of the root (using a moist cotton pellet).[4, 5]
Despite the favorable properties of MTA that supports its clinical use, it has several clinical drawbacks such as prolonged setting time, difficult handling characteristics, and potential discoloration. Biodentine (Septodont, France) is a high purity calcium silicate based dental material composed of tricalcium silicate; calcium carbonate, zirconium oxide, and water-based liquid containing calcium chloride (CaCl2) as the setting accelerator and water-reducing agent.[6- 9]
Hence; we planned the present study to evaluate the sealing ability of white Mineral trioxide aggregate, Biodentine, Calcium phosphate cement, and Glass ionomer cement as furcation repair materials using dye extraction leakage method.

MATERIALS & METHODS

SAMPLE SELECTION:-
Forty-five extracted, intact human mandibular molars with non-fused and well-developed roots were used in this study. The teeth were stored in 3% sodium hypochlorite until further use.

SAMPLE PREPARATION:-
Molars were decoronated 3 mm above the cemento-enamel junction and roots were amputated 3 mm below the furcation. A standardized endodontic access opening was prepared in all 45 samples. Sticky wax was placed over the orifice of each canal. It was then coated with two layers of nail varnish.
To ensure each perforation was centered between the roots, a black marker pen was used to mark the location of the defect. A defect 1 mm in diameter was made from the external surface of the tooth with a number 2 round carbide bur mounted on a high-speed handpiece with air water coolant. The chamber and perforation were flushed with water and dried. The teeth were kept in an incubator at 37°C for 24 h for simulating clinical conditions.

PERFORATION REPAIR:-
Teeth were randomly divided into five groups with 10 samples each for the experimental group and 5 samples in the control group. Group I was repaired with white MTA (Angelus), Group II with Biodentine (Septodont, France), Group III with Glass Ionomer Cement (3M ESPE), Group IV with Calcium Phosphate Cement (GBone surgiwear) and Group V is control group which was left unrepaired (positive control). All the teeth in each group were allowed to set for 24 h.

DYE EXTRACTION MICROLEAKAGE EVALUATION
Each group was placed in separate Petri dishes containing 2% methylene blue such that all teeth were immersed in dye up to the cemento-enamel junction for retrograde dye challenge and dye was added to access chamber of each teeth so that it was filled for orthograde dye challenge (shown in figure 6). All samples were stored similarly for 48 h.
After removal of the dye, teeth were rinsed under tap water for 30 min and varnish removed with a polishing disc. Each tooth was stored in a vial containing 5 ml of concentration nitric acid (69 weight %) for 3 days.

CENTRIFUGATION:-
The solutions thus obtained were centrifuged at 3500 rpm for 5 min.

SPECTROPHOTOMETRY:-
Four milliliters of the supernatant liquid was then analyzed in an ultraviolet (UV) visible spectrophotometer at 550 nm wavelength with concentrated nitric acid as the blank and readings were recorded as absorbance units. The obtained readings were statistically analyzed using one-way analysis of variance and Tukey multiple comparisons tests.

RESULTS
Data was entered in Microsoft excel sheet, cleaned for errors and analysed using EPI-INFO software version 7.0 and SPSS software version 20.0. As our outcome measure was quantitative variable, we used mean, standard deviation, 95% confidence interval for mean for description of data. For overall comparison ANOVA test/ kruskalwallis test was used depending upon the variance was equal or not. The mean absorbance valuesof experimental groups and control group in the current study showed that the positive control samples (Group V) in which perforations were left unrepaired had the highest dye absorbance (0.958 ±0.028) of all groups denoting the accuracy of the technique. This was followed by Calcium phosphate cement (Group IV) and Glass ionomer cement (Group III) which had dye absorbance values (0.875 ± 0.135), and (0.735±0.135) respectively, significantly higher than White MTA (Group I) and Biodentine (Group II) showed least dye absorbance than remaining groups.
There was a significant difference in the mean dye leakage among four groups ($P < 0.001$). Hence, Tukey's HSD Multiple comparison test was done. It was seen that there was no statistically significant difference between White MTA and Biodentine groups. Similarly, there was no significant difference between White MTA and Glass ionomer cement and between Glass ionomer cement and Calcium phosphate cement groups either. However, there was a statistically significant difference seen between the White MTA and CPC groups, between Biodentine and GIC groups, also between Biodentine and CPC groups. As there are more values of absorbance in GIC, CPC, and control groups compared to White MTA and Biodentine groups.

Table 1: Mean value for five different experimental groups

Group	Mean absorbance value	P- value
1	0.56	<0.01
2	0.478	
3	0.735	
4	0.875	
5	0.958	

Table 2: Comparison Between Individual Groups

COMPARISON GROUP	COMPARISON MEAN DIFFERENCE	P VALUE
1 & 2	0.082	0.739
1 & 3	-0.175	0.146
1 & 4	-0.315	0.002
2 & 3	-0.257	0.014
2 & 4	-0.397	<0.001
3 & 4	-0.140	0.314

Table 3: Mean Values For Four Different Experimental Groups

Group	Mean absorbance value	P- value
1	0.56	<0.01
2	0.478	
3	0.735	
4	0.875	

Figure 1: Sample preparation

Figure 2: Samples in test tube before centrifugation

DISCUSSION

Root perforation is defined as an artificial communication between root canal system and the supporting tissues of teeth or the oral cavity. Root perforation is one of the procedural accidents which can occur as a result of a misdirection and misuse of dental burs during access preparation or during preparation of a post space or while trying to locate an elusive root canal. In addition, excessive flaring of the cervical portion of curved roots in molars can also cause lateral root perforations known as strip perforations.[9- 12]In our present study we used extracted human mandibular molars and reason for the perforation is intentional. The goal of endodontic therapy is to maintain the integrity of the natural dentition and its supporting structures to proper form, function, and esthetics. In endodontic practice, procedural accidents are commonly encountered, which affect the prognosis of the root canal treatment. A furcation perforation is one such complication that refers to mid furcation opening into the periodontal ligament (PDL) space and leads to worst possible treatment outcome.[13- 15]

In the present study among all the above ideal requirements of repair material we have evaluated the sealing ability of different materials in furcation repair. This can be checked properly in an ex vivo study. Several materials such as intermediate restorative material, cavit, zinc oxide eugenol, composite resin, amalgam, super ethoxy benzoic acid, resin-modified glass ionomer cement, calcium hydroxide, chloroform, Gutta-percha, calcium phosphate cement, Mineral trioxide aggregate (MTA), Endosequence, and Biodentine etc have been the most commonly used repair materials.[16] As far as their sealing ability and other properties are concerned we used four different materials namely White MTA, Biodentine, Glass ionomer cement, and calcium phosphate cement as furcation repair materials in mandibular molars using a dye extraction leakage method.

First of all, we saw that Calcium phosphate cement i.e. group 4 showed the maximum mean absorbance value (0.875±0.135) among the four materials and 5 groups used in this study. This means dye absorbance is more in the group treated with CPC and subsequently there will be maximum microleakage which will not be a suitable material for perforation repair. The specific surface area (147 m2/g), pore volume (0.19 cm3/g and pore size (5µm-100µm) of CPC may be the reason for its microleakage. Although this property of CPC is advantageous in bone growth because this allows migration and proliferation of osteoblasts and mesenchymal cells, as well as vascularization, but these properties like pore size, pore volume and specific surface area etc of CPC did not meet the requirement in furcal perforation repair. Next comparision is in between GIC i.e. group 3 and rest 4 groups. Despite all the above advantages of glass ionomer cement if we look at the spectrophotometric absorbance values of GIC (0.735±0.135), it is somewhat in between White MTA (0.560±0.135) and CPC (0.875±0.135) and also more than Biodentine (0478±0.220). Under the same scenario in this study conditions like moisture contamination cannot be a factor for its higher mean value in spectrophotometry. It can be explained that surface roughness and cracks seen on the set GIC and also specific surface area of GIC (10m2/g), pore volume (0.035cm3/g is in between White MTA (6.2m2/g) and CPC (147m2/g). Pore size of GIC (7µm-30µm) is more than White MTA (0.25µm- 2.5µm) and Biodentine (0.012µm-0.35µm) and less than CPC (<5µm->100µm). This may be reason for higher dye absorbance in our results. Subsequently inference can be made that it can allow the bio-fliud material to penetrate through surface which cannot meet the requirement of furcal repair material.

Furthermore, in the present study group 1 i.e. White MTA (0.560±0.208) showed better results as compared to Glass ionomer cement i.e. group 3 and Calcium phosphate cement i.e. group 4 with absorbane values 0.735±0.135 and 0.875±0.135 respectively. As we can say the properties like pore volume (0.016cm3/g), pore size (0.25µm-2.5µm) and specific surface area (6.2m2/g) of White MTA make it superior to GIC and CPC.

The results of our study have shown least dye absorbance values with Biodentine (mean 0.478±0.220) than white MTA, GIC,and CPC (mean 0.560±0.208, 0.735±0.135, 0.875±0.135 respectively). This means Biodentine offers better sealing ability as compared to white MTA, GIC,and CPC. In our study Biodentine showed the least dye absorbance values. The reason for this may be because of factors like fast setting time, porosity, and pore volume in set Biodentine is less as compared to MTA and others materials. These porosity related properties of these two materials are namely specific surface area (MTA 6.2m2/g), and Biodentine 4.0 m2/g), pore size (MTA 0.25µm-2.5µm and Biodentine (0.012µm-0.35µm) and pore volume (MTA 0.016 cm3/g and Biodentine 0.0080 cm3/g). The larger surface area is considered to be a more favorable condition to cellular adhesion and further microleakage of microorganisms.

Significant differences of dye absorbance values of four materials used in this study may be due to differences in properties like specific surface area, pore volume and pore size. All these three properties are related to porosity of materials on the basis of which above mentioned four materials were compared. This led to conclusion that Biodentine group showed least mean absorbance value as when compared to other groups.

CONCLUSION

Perforation repair is a frustrating problem to the dentist. So thorough idea regarding its restorability is essential which includes knowledge of site, size, time of perforation and various materials and methods used. Among all four materials used viz. White MTA, Biodentine, Glass ionomer cement, and Calcium phosphate cement, Biodentine showed least dye absorbance and best sealing ability as compared to other materials due to differences in properties like specific surface area, pore volume and pore size.

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