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RESEARCH ARTICLE

PUSH-OUT BOND STRENGTH OF THERACAL LC, MTA AND GIC USED AS FURCAL PERFORATION REPAIR MATERIALS AND THE TIME DEPENDENT CHANGE IN IT: AN IN-VITRO STUDY

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ABSTRACT

The present study was conducted to compare and evaluate the push-out bond strength and its time-dependent change, of various materials when used for furcal perforations i.e. change in strength after 24 hours and 7 days to determine which material had the maximum push-out bond strength measurement so as to bear the forces of compaction of the coronal restoration. The study was carried out by preparing standard endodontic access cavities and decoronating 30 molars 5mm above the pulpal floor. After which, perforations were made in the furcal area of the pulpal floor. The size of the perforations was measured with a Stereomicroscope and ImageJ analysis. The remaining dentin thickness was measured with digital calipers. In each sample, a saline-soaked sponge was placed apical to the furcal perforation. For stabilisation, the roots were embedded in Silicon putty impression material to simulate the periodontal ligament, the apical third being embedded in cold-cure acrylic. The perforations were repaired with three different materials, Group I ProRoot White MTA, Group II Glass Ionomer Cement and Group III Theracal LC. Out of 10 samples, 5 samples in each group were subjected to push-out bond strength measurement after 24 hours & the remaining 5 after 7 days. Universal Instron testing machine with 1-mm-thick cylindrical stylus was used for push-out bond strength measurement at a crosshead speed of 0.5 mm/min. The results thus obtained were tabulated and were statistically analysed by using Anova and Tukey's test. At both 24 hours and 7 days, the push-out bond strength of MTA>Theracal LC>GIC.

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INTRODUCTION

Furcal perforation is usually an undesired complication that can occur iatrogenically during opening of endodontic access cavities or exploring canal orifice of multirooted tooth. They may also manifest as a result of caries or resorption (Tsesis and Fuss, 2006). They affect the prognosis of the endodontic treatment, occurring most frequently on the floor of the pulp chamber because of presence of accessory canals and less remaining dentin thickness. It is advisable to repair the perforation as soon as it is identified, since any delay will allow bacterial ingress leading to complicated endodontic-periodontal lesion (Aggarwal *et al.*, 2013). The main goal of furcal perforation repair is to quickly seal the perforation site and provide optimal conditions for periodontal reattachment at the area (Saberi *et al.*, 2013). Adequate pushout strength is needed so as to bear the condensation force to which the repair material will be subjected to, during placement of an intracoronal restoration (Aggarwal *et al.*, 2013). Therefore, this study was conducted to compare various materials for repair of furcal perforations.

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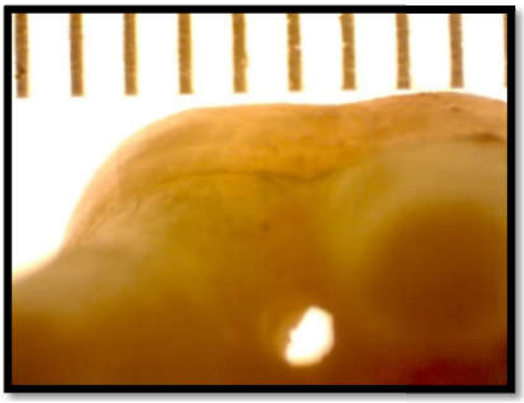
MATERIALS AND METHODS

Thirty intact human permanent maxillary and mandibular molars were collected. Teeth with cracks, open apices, root caries, or fused roots were excluded from the study. An EndoAccess bur was used for preparation of endodontic access cavity. The teeth were decoronated 5mm from the pulpal floor with a water cooled diamond sectioning disk. In each sample, a furcal perforation was prepared with a high-speed long shank round bur. Since there could be a discrepancy in the coronal and apical diameters of the furcal perforations within the same sample and as compared with other samples, each perforation was photographed coronally and apically by a Stereomicroscope (Abdel Rahman Hashem *et al.*, 2012) (Figure 1) for the purpose of measuring the coronal and apical diameter (d_1 and d_2 respectively) of each perforation in all the samples. From the diameter, the coronal and apical radius (r_1 and r_2 respectively) was deduced by dividing the diameter by 2.



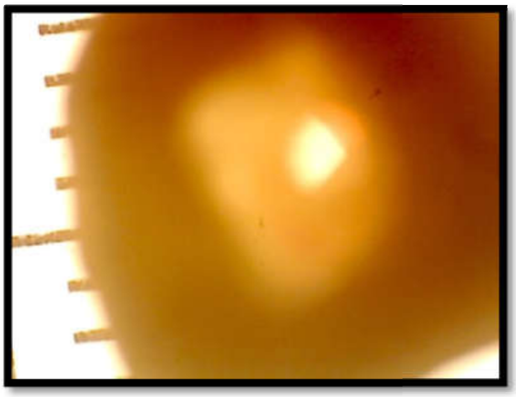


Figure 1. Stereomicroscopic images of furcal perforation as viewed top: apically, bottom: coronally

Inclusively, the length from the decoronated surface of the crown to the furcal area of the roots was measured with micrometer digital callipers (H). The remaining dentin thickness (h) from the pulpal floor to the furcal area of the roots was calculated by reducing 5 mm from the length measured by the micrometer digital callipers as the crown of each tooth had been decoronated at a length of 5 mm from the pulpal floor. Before repairing each sample, as per the measurements of the stereomicroscope, the furcal perforation had been considered as truncated cone (Figure 2). The push-out bond strength of the repair material depends directly upon the force applied and inversely upon the lateral surface area of the perforation (Abdel Rahman Hashem *et al.*, 2012; Patierno *et al.*, 1996).

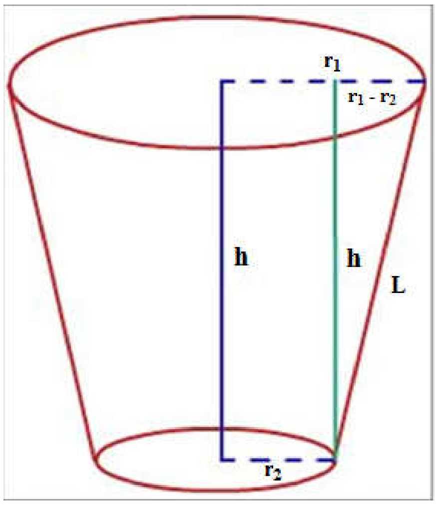


Figure 2. Truncated cone

The Lateral surface area or Adhesion area of each perforation was calculated as follows (Patierno *et al.*, 1996; Muvdi *et al.*, 1997):

$$\pi \mathbf{L}(\mathbf{r_1} + \mathbf{r_2})$$

where
π is the constant 3.14,
$\mathbf{r_1}$ **(=** $\mathbf{d_1 / 2}$ **)** is the coronal larger radius,
$\mathbf{r_2}$**(=** $\mathbf{d_2 / 2}$ **)** is the apical smaller radius
and**L** is calculated as follows (Muvdi *et al.*, 1997):

$$\mathbf{L} = \sqrt{(\mathbf{r_1} - \mathbf{r_2})^2 + \mathbf{h}^2}$$

Where **h** is the thickness of the repair material

In each sample, a saline-soaked sponge was placed directly in contact with the apical aspect of the furcal perforation. Then the apical third of the roots were covered with C-Silicon heavy body/putty impression material. Lastly, the apical third of the roots were embedded in cold-cure acrylic to stabilise the roots. (Marchionatti *et al.*, 2014)

Following the simulation of the periodontium, the samples were randomly divided into three major experimental groups of twenty samples each, based on the repair material used, which were:

- GROUP I: Furcal perforations repaired using Pro-Root White MTA
- GROUP II: Furcal perforations repaired using Universal GIC
- GROUP III: Furcal perforations repaired using Theracal LC.

Each group has been further divided into 2 subgroups A and B, tested after 24 hours and 7 days respectively. All the samples were stored in 100% humidity before being mounted in loading fixtures using rapid repair acrylic resin and iron molds. 1 mm thick cylindrical stylus was placed coronally on the repaired perforation in each sample and a force was applied by the Universal Instron Testing Machine (UTM), at a crosshead speed of 0.5 mm/min in a coronal-apical direction. The tip of the stylus was positioned so that it only contacted the repair material (Abdel Rahman Hashem *et al.*, 2012).

Figure 3. A sample being tested with 1mm thick cylindrical stylus under Universal Testing Machine

Push-out bond strength (In MegaPascals) = Force at which the perforation repair material failed (In Newtons) ÷ Lateral surface area of the furcal perforation (in mm^2)

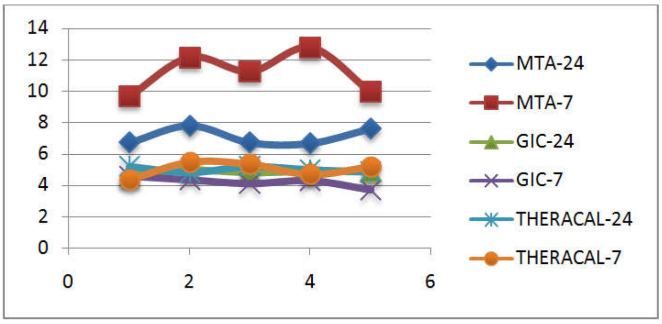


Figure 4. Scatter diagram representing push-out bond strength value of each sample in MPa

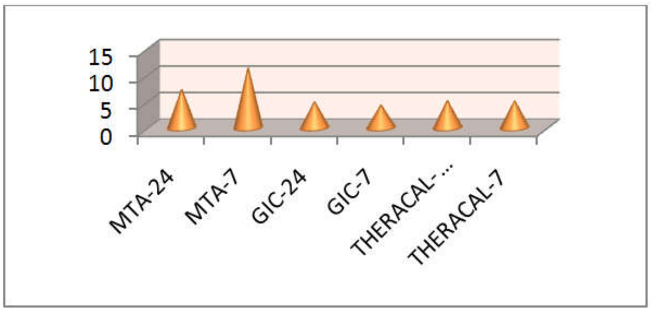


Figure 5. Comparison of Means of all the groups

RESULTS

The results of the present study showed that the mean push-out bond strength from the highest to the lowest in the order of: ProRoot White MTA after 7 days (11.162MPa) >ProRoot White MTA after 24 hours (7.116 MPa)>Theracal LC after 24 hours (5.026MPa) >Theracal LC after 7 days (5.008 MPa)>Conventional Glass ionomer cement after 24 hours (4.818 MPa) > Conventional Glass Ionomer cement after 7 days (4.22 MPa). After the data was analysed using One-way Anova and Tukey's test, the difference between the subgroups of ProRoot MTA with other materials was statistically significant. But, the difference between GIC and Theracal at 24 hours and 7 days respectively was not significant.

DISCUSSION

Furcal perforations are significant iatrogenic complications of endodontic treatment and could lead to endodontic failure (da Silva *et al* (2012). Their origin could be attributed to iatrogenic mishaps, caries or resorption (Regan *et al*., 2005). They are relatively common due to the presence of accessory canals and less remaining dentin thickness (Gluskin *et al*., 2013). Haznedaroğlu *et al* (2003) had reported a 21% incidence of patent accessory canals in molars in a Turkish population. Hashem and Wanees Amin (2012) reported a push-out bond strength of 8.49 ± 1.75 MPa when MTA was allowed to set for 4 days in contact with phosphate-buffered saline. Saghiri *et al* (2010) demonstrated that pH has an effect on the push-out bond strength of MTA in the lumen of root slices, and reported a mean push-out bond strength of 9.46 ± 0.63 MPa when the samples were stored at a pH of 8.4 for 3 days. The ability of MTA to seal root perforations effectively and its setting properties in the presence of moisture and even blood are important characteristics that may result in greater success rates when used for treating root perforations (Mente *et al*., 2010). Exceptionally, the samples restored with Glass ionomer cement had shown dislodgement resistance less than the average force recorded by Lussi *et al* during amalgam condensation (3.7 ± 1.3 MPa) (Aggarwal *et al*., 2013).Contamination with saline during the formation of the cross-linked matrix could have caused dissolution of the matrix forming cations and anions to the surrounding areas (Shen, 2007). Even more so, Yao*et al* (1990) have also reported a detrimental effect on GICs due to moisture contamination. Theracal LC, a recently introduced Light-curable resin-modified Calcium silicate material, has an advantage of a controllable working time especially when compared to MTA. Theracal LC requires a clean surface according to the manufacturer's recommendations although it does require moisture for its hydration. It has a curing depth of 1.5-1.7mm (Qureshi *et al*., 2014). In samples used in the present study, the length of the furcal perforation was 3.02 – 4.97 mm resulting in variability of curing of the resin component of Theracal LC affected by saline contamination. Further studies with larger sample size are required to come to a definite conclusion.

Conclusion

Mineral Trioxide aggregate has the highest push-out bond strength but Theracal LC has the advantage of its setting being operator controlled, contrary to both MTA and GIC.

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