The effect of blood contamination on compressive strength of two materials used in treatment of furcation perforation (A comparative study)

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ABSTRACT

Background: blood contamination of the materials used for treatment of furcation perforation can affect on their physical properties (such as compressive strength). The aim of this study was to compare the effect of blood contamination on compressive strength for Mineral Trioxide Aggregate MTA and Resin Modified Glass Ionomer Cement RMGIC during furcation perforation management.

Materials and methods: Forty plastic molds (4 mm diameter and 2mm thickness) were constructed to form samples. Ten samples were made for each group: MTA-without blood contamination GI, MTA- with blood contamination GII, RMGI- without blood contamination GIII and RMGI- with blood contamination GIV, and kept in plastic tubes with moist cotton pellet at 37 °C for 4 days then all samples were subjected to compressive strength test by Instron testing machine. Data were subjected to statistical analysis using descriptive analysis, ANOVA and t- test.

Results: statistical analysis of the results showed that there was a highly significant differences in compressive strength between GI and GII (P< 0.01)and significant differences between GIII and GIV, GIII and GI, GIV and GII (P < 0.05), With lowest mean of compressive strength value was recorded to MTA- with blood contamination GII (31.32 ± 0.022 Mpa) and highest mean for RMGI- without blood contamination GIII (168.725± 0.063Mpa).

Conclusion: compressive strength value for both MTA and RMGI cement reduced when exposed to blood during treatment of furcation perforation, RMGI cement has higher value of compressive strength than MTA and it could be suitable choice in treatment of Furcal perforation in presence of bleeding and placing of coronal restoration after 4 days.

Keywords: compressive strength, MTA, blood contamination. (J Bagh Coll Dentistry 2012; 24(4):25-28).

INTRODUCTION

Perforation in the furcation region has been considered one of the major complications leading to failure of endodontic treatment and they might result from the use of a misdirected drill while gaining access to the root canals [1], during its treatment blood comes into contact with and often becomes incorporated into the materials and this contamination might have a detrimental effect on their physical properties which are important in the application of coronal restorations such as amalgam so an ideal root repair and root end filling material should not be affected by the contamination of physiological solutions such as blood and / or saliva [2].

Perforations might be sealed either intracoronally or with external surgical access, the non-surgical intracoronal intervention usually precedes the surgical repair. Immediate repair of a perforation with a biocompatible material is recommended for achieving the optimum outcome [2], a wide variety of materials have been suggested to seal perforations including zinc oxide eugenol cements (IRM and Super EBA), amalgam, gutta-percha, composite resin, glass ionomer and mineral trioxide aggregate (MTA)[3].

An ideal repair material should be antibacterial, be capable of close adaptation to root canal walls, be radiopaque and non resorbable [3-6].

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MTA was developed at Loma Linda University in the 1990s as a root end filling material; the principle component of MTA is Portland cement [7] which consists of tricalcium silicate, dicalcium silicate, tricalcium aluminate, tricalciumaluminoferrite and calcium sulphate. In addition to these principle components, MTA also contains bismuth oxide to make it radiopaque [8]. Portland cement, and its dental derivative, MTA, are hydraulic cements, which are able to set and harden under water [9].

MTA can be differentiated from other root repair materials by its additional ability to conduct cementum and bone formation over its surface. It can also set in a wet environment. These properties are also desirable for a root-end filling material, for pulp capping materials used during vital pulp therapies, for apexification of immature teeth with necrotic pulps, for the nonsurgical repair of invasive cervical root resorption and for the repair of horizontal root fractures [10-16].

MTA have some disadvantages include difficult handling properties and temperamental setting characteristics, which could be because of low environmental pH [17, 18] and/or insufficient hydration [6].

Resin modified glass ionomer cements RMGIC, were developed in 1998 to improve the sensitivity to humidity and the early weak mechanical strength of glass ionomer cement GIC [19, 20].GIC are formed by the acid–base reaction of an aqueous polymeric acid and an ion leachable

glass. The replacement of the polyacid with a modified polyacid grafted with unsaturated groups, and the incorporation of polymerizable hydrophilic resins are recent modifications of these materials that led to the resin-modified GIC. The hydrophilic resin, such as HEMA, is added as a co-solvent. It also polymerizes or copolymerizes with the modified polyacidone of their advantages over other restorative materials is that they can be placed into tooth cavities without an additional bonding agent [19]. They also possess a fluoride-releasing property and are relatively biocompatible with the pulp [20].

The aim of this study was to compare the effect of blood contamination on compressive strength for MTA and RMGI during furcation perforation management.

MATERIALS AND METHODS

The materials investigated were tooth colored MTA (ProRoot MTA) and Resin Modified Glass Ionomer cement RMGI (Riva luting, SDI). Forty plastic moulds of 4 mm in diameter and 2mm thickness were made and divided into 4 groups:

Groups I–MTA samples without any contamination.

Groups II–MTA samples exposed to blood contamination.

Groups III–RMGI samples without any contamination.

Group IV-RMGI samples exposed to blood contamination.

Mixing of both materials were standardized by manufacturer instructions by mixing 1 g from each material with their appropriate liquid medium, for MTA samples the measured distilled water was added to the powder and mixed. It was then placed with minimal pressure [21] as higher compressive strength of the MTA occurred with lower condensation pressure using the tip of a dental spatula into the moulds which were placed between two glass plates. For RMGI after mixing powder and liquid the moulds were slightly overfilled and gently compressing them between two glass plates a transparent celluloid strip was applied on the surface, then specimens were polymerized by quartz-tungsten-halogen QTH light cure unit with light intensity 400-450 MW/cm^2 for 40 sec. exposure time to top surfaces [21]. The distance between the light and the specimen will be standardized by the use of 1mm glass slide centered over the mold [22].Specimens cured under the glass slide had a mirror smooth surface that didn't require further finishing. The MTA samples were then removed by cutting vertically through the wall of the moulds using a disposable surgical scalpel blade No.15, whilst taking care not to damage the MTA samples (Fig. 1) This novel method minimized the forces on MTA samples prior to compression testing that might otherwise introduce confounding variables [15], following removal from the moulds, all samples were inspected visually to ensure they had no voids or flaws.

Figure 1: Method used in the removal of MTA from the mould

In group II and IV before placement of the material moulds were filled with fresh human blood which then removed by aspirating with a syringe to leave a coating of blood on the inner wall of the moulds to expose the lower surface of the specimens [14].Whole, fresh human blood was collected from a healthy consented volunteer by a trained individual in accordance with Helsinki ethical principles for medical research involving human subjects (2001), fresh human blood was chosen to contaminate samples rather than substitutes to closely replicate the human clinical situation.

Then all samples were placed in sealed 1.5-ml plastic tubes, in GII and GIV a cotton pellet was soaked with blood and placed at the bottom of the tube and a moist cotton pellet was then placed above the moulds but not in contact with the samples surface to produce a fully saturated humid atmosphere. For GI and GIII there was no cotton pellet soaked with blood in the tube, all samples were then incubated at 37^{o}C for 4 days[14] before being subjected to the compressive strength test.

Compressive strength test

To test for compressive strength, samples were placed vertically on the steel plate of a universal testing machine (LIoyd, model 1361110, England) towards which a calibrated steel cross head plate moved at a speed of 0.5 mm min). When both planes were in contact with the samples, the compressive load was recorded until a loading failure point was reached. This loading failure was used to calculate the compressive strength of the MTA samples using the following equation:

$$CS = 4P\backslash \pi d^2$$

where CS is compressive strength, P(N) is loading failure and d (mm) is the diameter of the cylindrical

The mean compressive strengths, confidence intervals and standard deviation values were calculated for each group and analyzed using one-way ANOVA and t-test as the data was normally distributed.

RESULTS

The results of the present study showed that there was significant decreased in compressive strength for the tested materials after contamination with blood. Table (1) and figure (2) showed the descriptive statistics (mean and standard deviation) of the compressive strength values for all tested specimens.

Table 1: Descriptive statistical analysis for the experimental groups

Statistical analysis	GI	GII	GIII	GIV
Mean	72.42	31.32	168.725	122.127
SD±	0.043	0.022	0.063	0.011

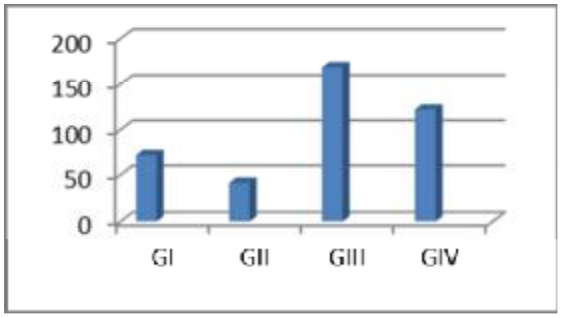

Figure 2: shows the differences in mean of compressive strength values among groups represented in bar chart graph.

Table 2: ANOVA test shows the differences in mean of compressive strength values among groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	53424.625	3	17808.208	5.936	.000
Within Groups	.000	16	.000		
Total	53424.625	19			

ANOVA test revealed that there was statistically high significant difference (P<0.0001) in compressive strength among tested groups as shown in Table 2.

Table 3: t-test

	t-test	P-value	Sig
GI & GII	1.052	0.009	HS
GIII & GIV	1.332	0.011	S
GI & GIII	5.616	0.04	S
GII & GIV	4.125	0.03	S

P< 0.05 Significant
P<0.01 High significant

Statistical analysis of variance using t-test revealed that there was a high significant difference between GI and GII in their compressive strength values, there was a significant difference between GIII and GIV, GI and GIII, GII and GIV as show in Table (3).

A summary of the results of the compressive strength tests revealed that the compressive strengths of the experimental groups, which were in contact with blood, were significantly less than that of the control groups ($P < 0.05$)

DISCUSSION

The results of this study showed significant reduction in compressive strength for MTA and RMGI when contaminated with blood.

There was statistically high significant reduction in compressive strength value between MTA GI and GII these findings can be explained by the air entrainment properties of blood proteins that affected the porous microstructure of cements [17] and the resultant increased porosity most likely explain the results of this study. These findings are in accordance with Al-Hezaimi et al. [3] and Shokouhinejad et al. [4]. Also Portland cement was created by a dense meshwork of acicular crystal formation that radiate from the cement particles and the interlinking crystal phase was composed of tricalcium aluminate and/or tetracalcium aluminoferrite, the lower compressive strength values of the groups contaminated with blood is most likely explained by the lack of interlinking acicular crystals, these changes inacicular crystal microstructure upon blood contamination might be the cause of one of the most important disadvantages of MTA, in that in some instances MTA slurries might remain unset and, ideally, should be replaced (Manufacturer's instruction manual A0405).

There was statistically significant reduction in RMGI GIII and GIV these finding can be explained because this kind of materials set by various competing reactions, resulting in a complex structure. The polymeric network will contain both ionic and covalent crosslink and these products have a tendency to undergo phase separation and may contain domains of different hydrophobic and hydrophilic phases, It is hence

expected that the water taken up will migrate preferentially to the hydrophilic sites and will probably provoke the dissolution and leakage of ionic species, which may result in a decrease of the physical properties of these materials.

Moreover, because of the nature of the monomers used in this kind of material, which are mainly HEMA or modified HEMA monomers, the organic structure left after the setting reactions will contain a higher proportion of hydrophilic functional groups. This structure is similar to the structure of hydrogels. Thus, in an aqueous environment, RMGI take up great amounts of water; they swell, became plastic and are mechanically less resistant. These findings are in accordance with Andre et al. [21] and Bonifacio et al. [20].

There was also high significant differences between MTA GI,GII and RMGI GIII,GIV in their compressive strength values which can be related to their different composition and setting reaction.

As conclusion, RMGI had greater values of compressive strength than MTA and the compressive strength of both materials decreased when there is blood contamination. It is recommended that hemorrhage be controlled at perforation site and blood be removed from the perforation walls before placement of the material. During the placement of the final restoration care should be taken to prevent excessive forces from being directed against the material and it is preferable to place coronal restoration such as amalgam after a week from the treatment.

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