Repair of root canal perforation by different materials

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ABSTRACT

Background: The aim of this in vitro study was to compare sealing ability of Mineral Trioxide Aggregate (MTA), Glass ionomer cement (GIC) and Epiphany obturation system in repairing the iatrogenic lateral root canal perforation.

Materials and Methods: Thirty freshly extracted human teeth with single and straight canals were used in this study. These teeth were cleaned and their crowns were removed at the cemento-enamel junction. The roots were instrumented using the step-back technique. A perforation was created on the mesial root surface at about 45-degree angle to the long axis of each root apico-coronally at the middle third by small round bur #1/2 with copious irrigation of 2.5% NaOCl and 17% buffered solution of EDTA was used as the final rinse to remove the smear layer and to prevent the blockage of perforation. The 30 roots were divided randomly in to three groups (10 roots for each group):- Group A: The root canal perforation was repaired by MTA then obturated by lateral condensation technique with gutta-percha and zinc oxide eugenol sealer. Group B: The root canal perforation was repaired by GIC then obturated by lateral condensation technique with gutta-percha and zinc oxide eugenol sealer. Group C: the roots were obturated with Epiphany obturation system by lateral condensation technique. The external surfaces of all roots were coated by two layers of sticky wax except the perforation site then immersed in 2% methylene blue dye for 48 hrs in incubator at 37C°. After that all roots were longitudinally sectioned for linear measurement of dye penetration through the perforation using a stereomicroscope at X40 magnification with calibrated scale ocular grid.

Results: The result showed that group A showed the lowest mean of dye leakage (0.77mm) while group C showed the highest mean of dye leakage (4.45mm).

Conclusion: Significantly less dye leakage in roots which perforations repaired by MTA than those repaired by GIC and highly significant less dye leakage than those repaired by Epiphany obturation system.

Keywords: Lateral root canal perforation, MTA, GIC, Epiphany obturation system. (J Bagh Coll Dentistry 2011; 23(sp. issue):30-35).

INTRODUCTION

Root perforation is an artificial communication between the root canal system to the supporting tissues of tooth or to the oral cavity (1). Perforations occur primarily through three possible mechanisms: procedural errors occurring during root canal treatment or post-space preparation, reparative processes and caries. Most perforations result from procedural errors. Errors leading to these defects include bur perforation during access opening or during the search for canal orifices, excessive removal of dentine in the danger zone, either with hand or rotary instruments, misdirected files during canal negotiation, unsuccessful attempts at bypassing separated instruments and misaligned instruments during post-space preparation (2). The prognosis of a root perforation depends on its size and location, the length of time the defect has been open to the environment before sealing and the amount of periodontal irritation. The shorter the time lapse, the smaller the size and the more apical the perforation, the greater is the chance for successful treatment (3). Sealing perforations of iatrogenic, resorptive, or carious origin poses a challenge even for dentists with endodontic experience.

The rationale of treatment of such cases should be immediate sealing with a biocompatible material that is insoluble in the presence of tissue fluids and allows regeneration of surrounding tissues. The following materials have been recommended for sealing root perforations: Cavit, silver amalgam, super EBA cement, calcium hydroxide, hydroxyapatite, calcium phosphate cement, glass ionomer, and decalcified freeze-dried bone. None of these perforation sealing materials is adequately biocompatible to ensure a good treatment outcome when it comes into direct contact with bone tissue. Therefore, the prognosis for teeth with root perforations was considered very uncertain before the introduction of mineral trioxide aggregate (MTA) (4).

MTA was developed at Loma Linda University in the 1990s as a root-end–filling material. The material consisted of fine hydrophilic particles, and the main components were tricalcium silicate, tricalcium aluminate, tricalcium oxide, and silica oxide. Bismuth oxide acted as a radioopacifier (5).

A new material, Resilon™ (Epiphany™, Pentron Clinical Technologies, USA), has been developed to replace gutta-percha and traditional sealers for root canal obturation. It is a thermoplastic synthetic polymer-based root-canal filling material. In addition, Epiphany is a dual curable dental resin composite. According to the manufacturer, Resilon™ sealer bonds to root canal filling material and to dentin (6). Successful prognosis from conservative treatment of root
canal perforation without surgical treatment would be of great benefit for patients. The purpose of this study was to compare the sealing ability of MTA, Glass ionomer cement and Resilon in repairing the iatrogenic lateral root canal perforation.

MATERIALS AND METHODS
Thirty extracted lower premolars obtained from orthodontic department with mature apices and straight canals were used for this study. Using a diamond disc bur with straight handpiece and water coolant the crowns of teeth were sectioned perpendicular to the long axis of the root at the cemento-enamel junction to facilitate straight line access for canal instrumentation and filling procedure and to get flat reference point for measurement. The length of roots ranged between (15- 16) mm. The pulpal tissue was removed by using barbed broaches, the patency of each canal was established by passing size #15 K-file through the apical foramen and the working length was determined by subtracting 1 mm from the length at which the tip of size #15 K-file just appeared at the apical foramen. The size of first file that bound to the working length was 20. A step back preparation technique was used to prepare the root canals using K-files with circumferential filing action. The canals were instrumented to the size #35 master apical file, flaring began after completion of apical preparation by stepping back to three sizes after the master apical file till size #50 with a 1 mm reduction in the working length with each larger file and copious irrigation of 2.5 % NaOCl between each larger size. Then all around the canal walls were smoothed with vertical push-pull strokes using Hedstroem files #35(7).

A perforation was created on the mesial root surface at about 45-degree angle to the long axis of each root apico-coronally at the middle third by small round bur #1/2 as in figure (1) and the roots were rinsed with NaOCl solution to prevent the blockage of perforation by dentinal chips (8). A total of 10 ml of 2.5% NaOCl was used for irrigation during instrumentation then 5ml of 17% EDTA rinses were used after instrumentation for 1 minute to remove smear layer and to prevent the blockage of perforation by dentinal chips followed by 5 ml of deionized water(7). The roots were wrapped by lead foil to prevent the extrusion of the repair material from the perforation.

The 30 roots were divided randomly in to three groups (10 roots for each group):

- **Group A**: The root canal perforation was repaired by MTA (Angelus, USA) as shown in figure (2). The canal was dried with paper point #35, small cotton pellet was inserted in the canal by endodontic plugger just apical to perforation to prevent the blockage of the canal by the repair material (9). MTA powder was mixed with distilled water in to thick paste and carried with mess root canal gun in to perforation site as in figure (3), then condensed with small finger plugger then by the butt end of paper point moistened with distilled water because moisture is essential for the material to set (10). According to the manufacturer, the initial setting time is 10 minutes and the final is 15 minutes so no necessary to wait for the final set to continue treatment procedures. The cotton pellet was retrieved by hedstroem file and the MAF was placed in the canal to ensure that the canal was not blocked by the repair material then the canal was obturated by lateral condensation technique with gutta-percha and Zinc oxide eugenol sealer (Zical, India).
Group B: The root canal perforation was repaired by glass ionomer cement (Medifil, Germany). A similar procedure of Group A was used in this Group. Glass ionomer cement powder and liquid were mixed to thick paste which applied in to perforation site by messing gun and condensed by small finger plugger, and then root canal obturation was completed by lateral condensation technique by gutta-percha and Zinc-oxide eugenol sealer (Zical, India).

Group C: The 10 roots were obturated with Epiphany obturation system (Pentron Clinical Technologies, USA) which shown in figure (4) by lateral condensation technique. The root canal spaces were filled with Epiphany primer using a pipette provided by the manufacturer. Then dry paper points # 35 were used to pick up the excess primer from the canal, followed by placement of Epiphany sealer. The dual syringe (with mixing tip) was used to express the sealer onto the mixing pad then the Epiphany sealer was carried to the canal in small amounts on a master apical file #35 then complete root canal obturation using Resilon master cone #35 and accessory cones by lateral condensation technique.

The coronal 2-3 mm of each root in the three experimental groups was sealed with glass ionomer cement as a temporary restoration. Each root was radiographed to evaluate the density of the filling materials then wrapped in saline moistened gauze for one week for complete setting of repair material and sealer in incubator at 37\degree C. Each root was coated by 2 layers of sticky wax completely except the perforation site as in figure (5), and then immersed in 2% methylene blue dye for 48 hrs in incubator at 37\degree C.

Then the sticky wax was scrapped from the root surface. Using diamond disk with straight handpiece, two grooves were made longitudinally on the opposite side of root without penetrating in to pulp space including the perforation site & separation was done by placing the edge of chisel in the groove with gentle pressure as in figure (6). The repair materials from the perforation site and the obturating material from the root canal were removed & the sample examined for the degree of dye penetration using stereomicroscope at X40 magnification with calibrated scale ocular grid to establish the degree of dye penetration in millimeters (7).

The linear dye penetration was measured by summing the dye penetration in the perforation site (length of perforation through canal wall was 2.5-3 mm) and the dye penetration through the root canal space. The deepest score of dye penetration from both split halves of each root was obtained and the average of the two measurements of each root was considered for statistical analysis as shown in figures (7, 8, 9).
RESULTS
Descriptive statistical analyses was carried out on the collected data to establish the values of the standard deviation (SD), minimum (Min), maximum (Max) and mean in millimeters for each experimental group used in the study, as shown in the table (1).

Table 1: Descriptive of groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>0.20</td>
<td>1.40</td>
<td>0.770</td>
<td>0.437</td>
</tr>
<tr>
<td>Group B</td>
<td>0.90</td>
<td>4.90</td>
<td>2.170</td>
<td>1.579</td>
</tr>
<tr>
<td>Group C</td>
<td>2.40</td>
<td>6.20</td>
<td>4.450</td>
<td>1.394</td>
</tr>
</tbody>
</table>

Table 2: t-test between groups

<table>
<thead>
<tr>
<th>Comparison Groups</th>
<th>t-test</th>
<th>p-value</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A &amp; Group B</td>
<td>1.657</td>
<td>0.026</td>
<td>S</td>
</tr>
<tr>
<td>Group A &amp; Group C</td>
<td>1.465</td>
<td>0.000</td>
<td>HS</td>
</tr>
<tr>
<td>Group B &amp; Group C</td>
<td>1.667</td>
<td>0.002</td>
<td>S</td>
</tr>
</tbody>
</table>

*P<0.05 significant  **P<0.001 High significant  ***P>0.05 Non significant

Student t-test was used to evaluate the significance of difference between each two groups. The results of student t-test are listed in table (2)

DISCUSSION
Many different methods were used for leakage assessment, dye penetration method was most commonly used because it is easy to perform and cheap. The leakage marker used in this study was methylene blue because it is inexpensive, easy to manipulate, has a high degree of staining, and has a molecular weight lower than that of bacterial toxins, highly soluble in water and penetrated more deeply along root canal filling.[14]

As shown in tables (1, 2), group A (perforation repaired by MTA) showed lowest dye leakage than group B (perforation repaired by Glass ionomer cement) and group C (perforation repaired by Epiphany obturation system) and the difference between group A & group B was statistically significant while the difference between group A & group C was statistically high significant.

According to the results of the present study, MTA showed the best sealing of lateral root canal perforation. This result coincided with Jong Lee et al in 1993 who tested Amalgam, IRM, and MTA for repair of experimentally created root perforations. A perforation was created on the mesial root surface at about a 45-degree angle to the long axis of each tooth. After placing the repair materials into the perforations, the teeth were kept for 4 wk in the Oasis model. The perforation sites were then stained with methylene blue for 48 h, sectioned, and examined under a dissecting microscope. The results showed that the MTA had significantly less leakage than IRM or amalgam[8].

This study in line with Adiga et al who presented two cases of strip perforation that are successfully repaired nonsurgically using MTA with 2-year follow up. Cases suggested that MTA can be used as an alternative root canal obturation material for the treatment of strip perforation.[12]

These good outcomes of MTA were obtained because the MTA is the only material that is not affected by moisture or blood contamination. MTA sets only in contact with moisture. Due to the abovementioned characteristics and primarily because it is hydrophilic, MTA can be considered the ideal material to seal perforations.[13]

The mechanism of action of MTA was the MTA powder contains calcium oxide that forms calcium hydroxide when mixed with water. The reaction of the calcium hydroxide and the carbon dioxide from the pulp tissue produces calcite crystals which act as an initiating step in the formation of a hard tissue barrier.[14]

MTA has been applied with good outcomes in rootend surgery, direct pulpal coverage, apexification, radicular resorption, and repair of lateral radicular and furcal perforation. Its suitability for managing all of these problems can be attributed to its biocompatibility, its low induction of inflammation, its solubility, its capacity for creating a seal between the pulpal...
chamber and periodontal tissues and its repair capacity. The last of these features can in turn be attributed to the antimicrobial properties and high pH (12.5) of MTA, which promote growth of the cementum and formation of bone, which in turn allow regeneration of the periodontal ligament around the site of injury (15).

Glass-ionomer cements were developed by Wilson and McLean in 1965. The bonding mechanism of the conventional glass-ionomer is very complex, but consists initially of the wetting of the tooth surface by free polyacrylic acid, followed by ionic bonding between the carboxyl group in the cement liquid and calcium ions in the tooth structure (16).

Glass ionomer cements have certain characteristics that are attractive to the dentist. They bond adhesively to enamel and dentin, release fluoride ions over a prolonged period of time, are biocompatible and have approximately the same coefficient of thermal expansion as that of tooth structure. In spite of these advantages, conventional glass ionomers suffer from the disadvantages such as short working times and rather long setting times, brittleness, low fracture toughness, poor resistance to wear, susceptible to moisture contamination or dehydration during the early stages of the setting reaction (17).

Ashofteh-Yazdi et al in 2006 compared histologic tissue responses of experimentally induced pulp chamber perforations in dogs’ teeth repaired with amalgam, light-cured glass ionomer and MTA. They found MTA and GI are more suitable materials for perforation repair as compared to amalgam (18).

Saini et al in 2008 compared the microleakage of three root end filling materials: MTA, Glass ionomer cement (GIC) and Silver GIC (Miracle Mix) using dye penetration technique under stereomicroscope. They found that MTA and GI are more suitable materials for perforation repair as compared to amalgam (19).

The mechanism of action of epiphany obturation system was the formation of (monoblock). Epiphany primer will enable bonding of the Epiphany Sealer to the walls of the canal space. The catalyst contained in the sealer will polymerize the primer and bond the sealer to the walls. The sealer will in turn bond to the resin in the Epiphany cones creating a monoblock (a material which is contiguous from its resin tags in cleared dentinal tubules through sealer to the core material) (20).

Many studies reported the sealing ability of Resilon better than that of Gutta-percha like the studies of Shipper et al in 2004 (21), 2005 (22) and Bodrumlu & Tunga in 2006 (23), 2007 (24).

Maltezos et al in 2006 compared the root-end sealing of the Resilon / Epiphany system (RES) to Pro Root MTA and Super-EBA using a bacterial leakage system. They found that RES and MTA leaked significantly less than Super-EBA & There was no statistical difference between RES and MTA (25).

Also Mohammadi Z & Khademi A evaluated the sealing ability of gray-colored MTA, white colored MTA and Resilon as root filling materials. They found that the sealing ability of gray-colored MTA, white colored MTA was similar to Resilon as orthograde root filling materials (6).

These good results of epiphany obturation system were obtained due to the formation of (monoblock), but in this study the monoblock was not created because only the epiphany primer and sealer entered the perforation site without the Resilon cone leading to more dye penetration.

REFERENCES