Research Article

EFFICACY OF BARRIER MATERIALS IN WALKING BLEACH TECHNIQUE – A PH DIFFUSION STUDY

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ARTICLE INFO

Introduction:- Common causes of discoloration in teeth are trauma, medications, genetic defects, diseases, caries and aging. To overcome these discolorations, bleaching can be performed in pulpless teeth to achieve an esthetic smile. Aim:- To evaluate the efficacy of Biodentine, Glass Ionomer cement and MTA when used as intracoronal barriers in internal bleaching. Materials & Method:- 49 single rooted maxillary anterior teeth were obtained. Specimens were divided in 3 groups with Biodentine, XtraCem–LC & MTA respectively used as barrier material beneath walking bleach compound in the access chamber. Leakage was measured using a pH diffusion method using digital pH meter. A mixture containing sodium perborate & 35% hydrogen peroxide was placed and pH checked immediately after placement, at 24 hrs and 72 hr interval. One way ANOVA followed by Post hoc test for inter group analysis. Results:- Group III (MTA) showed significantly better results compared to Group I (Biodentine) at p<0.01 whereas Group II (Light cure GIC) showed the least favorable results (p<0.01). MTA showed minimal variations in pH at the end of 24 and 72 hours. Conclusion:- MTA showed better sealing ability when used as barrier in non vital bleaching when compared to Biodentine and light cured GIC.

Key terms:
External cervical root resorption, MTA, Biodentine, Sodium perborate, light cured Glass Ionomer Cement, Hydrogen peroxide.

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INTRODUCTION:
The success or failure of a pleasant smile depends on the colour of single or multiple teeth. Common causes of discoloration in teeth are trauma, medications, genetic defects, diseases, caries or normal aging processes. Trauma is one of the most common causes leading to loss of vitality of teeth. It is often seen in the anterior teeth with incidence of complicated fractures with pulp involvement ranging from 0.9-13%. Discoloration of the teeth is an undesirable sequela. In 1976, Nutting and Poe introduced the ‘walking bleach’ intraradicular bleaching technique and for obtaining the natural color of the tooth. The basic reaction involves release of nascent oxygen which is obtained by combining sodium perborate and hydrogen peroxide (H₂O₂ concentrations of 30-35%) that is inserted into the pulp chamber. The most common complication using hydrogen peroxide as the oxidizing agent is the development of external cervical root resorption at the cervix of the tooth in the area of the gingival attachment extending apically to the crest of alveolar bone. Different studies have shown that a protective cement layer as a barrier placed over the root canal obturation prior to bleaching helps to prevent the seepage of H₂O₂ to the extraradicular tissues. Materials used as barriers are glass ionomer cement, zinc oxide eugenol and zinc phosphate cement.

Mineral Trioxide Aggregate (MTA) powder is composed of 20% bismuth oxide, 5% gypsum and trace amounts of silica oxide(SiO₂), calcium oxide(CaO), magnesium oxide(MgO), potassium sulphate(K₂SO₄), sodium sulphate(Na₂SO₄). MTA contains fine hydrophilic particles that set in the presence of moisture. Important properties of MTA are its superior ability to resist leakage due to its marginal adaptation, biocompatibility and prevention of tooth resorption. Biodentine has been claimed to be a bioactive dentin substitute. Its powder consists of Tri-calcium silicate, Di-calcium silicate, Calcium carbonate & oxide, Iron oxide and Zirconium oxide. The liquid consists of Calcium chloride hydroxosoluble polymer. A modified powder composition, the addition of setting accelerators and softeners, and a new capsule formulation for use in a mixing device has largely improved the physical properties of this material with a shorter setting time. The advantages of hybrid material or light activated or resin modified glass ionomer over conventional glass ionomer cements are controlled working time, less sensitivity to moisture, higher fracture resistance and fatigue resistance, lower solubility and better esthetic properties. Various studies have been carried out checking the efficacy of MTA and light cure GIC as barriers.

The aim of this study is to evaluate the efficacy of Biodentine, Glass ionomer cement and MTA when used as intracoronal barriers. Leakage will be evaluated by a pH diffusion method.

MATERIALS AND METHOD:
Preparation of the specimen
49 intact, freshly extracted single rooted maxillary anterior teeth were obtained. The soft tissues covering the root surface were removed with ultra sonic scalers. Standard access cavities were prepared using high speed diamond abrasives (Mani, Japan). A size 15 K-file (Mani, Japan) was introduced into each canal until its tip was visible at the apical foramen. The working length was established by subtracting 1 mm from this length. The root canals were then instrumented using hand Protaper files (Dentsply Maillefer, Ballaigues, Switzerland). 2.5% sodium hypochlorite solution (Prime Dental Products, Mumbai, India) was used as an irrigant. The canals were then obturated with gutta-percha (Dentsply India, Manesar, India) and zinc oxide eugenol sealer (RC Fill, Prime Dental, Mumbai, India) by means of cold lateral condensation. Satisfactory obturation was confirmed with radiographs.

The coronal-third of the gutta-percha was removed 3 mm apical to the cementoenamel junction (CEJ) with hot pluggers. Remnants of gutta-percha and sealer were removed from the access cavity with a cotton pledget soaked in 90% alcohol. The pulp chamber was rinsed thoroughly with distilled water. The external root surface including the apical foramen was covered with sticky wax to seal potential superficial defects. To simulate standardized breaks in the cemental covering, both wax and cementum were removed at the CEJ with a round bur No.2 (Mani, Japan) at low speed, in four sites; i.e., mesially, distally, buccally and lingually. The smear layer of these hemispherical defects (diameter 1.0 mm, depth 0.5 mm) was removed with 17% EDTA (Dent Wash, Prime Dental Products, Mumbai, India). The exposed dentin surface was rinsed with distilled water. All the remaining root surfaces were covered with two layers of nail varnish. The teeth were randomly assigned to three groups of 15 teeth each.

**Group 1** (n=15)
Biodentine (Septodont, Lancaster PA, USA) was mixed in a triturator according to manufacturers’ instructions. 0.5mm thick barrier of Biodentine was packed 1 mm apical to the CEJ level with a plugger and was allowed to set for 15 mins. A dry cotton pellet placed in the pulp chamber and access cavity sealed with temporary filling (Prime Dental Products, Mumbai, India).

**Group 2** (n=15)
XtraCem–LC (Medicept Ltd, Middlesex, UK) was mixed according to manufacturer’s instructions. 0.5mm thick barrier of light cure GIC was placed 1 mm
apical to the CEJ level with a plastic filling instrument. Curing was done using an LED light source (Apoza, Taiwan). The access cavity was sealed with a dry cotton pellet placed in the pulp chamber and access cavity sealed with temporary filling.

**Group 3** (n=15)
MTA (Angelus, Londrina-PR, Brazil) was mixed according to manufacturer’s instructions. 0.5mm thick barrier of MTA was placed 1 mm apical to the CEJ level with a plugger and allowed to set. A wet cotton pellet was placed on the MTA and the access cavity sealed with temporary filling.

The teeth were stored at 100% humidity for 48 hours. Following this, each tooth was suspended through a plastic lid and placed in a vial containing distilled water (Figure 1). The roots were submerged in the solution till the CEJ. The teeth were incubated for 24 hours at 37°C. The pH values in the vials were determined (baseline values) with a digital pH-meter (pHep Hanna instruments, Bedfordshire UK). After the baseline readings were taken, the coronal seal in all the specimens was removed, pulp chambers rinsed with distilled water and dried with cotton pellets. A paste of sodium perborate (Ventron Laboratories, Mumbai, India) and 30% Hydrogen Peroxide (Merck Specialities Private Limited, Mumbai, India) was placed inside the cavity. A dry cotton pellet was placed and the cavity was sealed with hard setting cement Zinc phosphate (Cem–Zinc, D–Tech Technologies, Pune, India). Teeth were then suspended in vials of distilled water. The pH measurements were recorded at 1 and 3 days after renewal of the surrounding medium (Graph 2a, b, c).

**Graph 2(a): Comparison of the Baseline pH values of Bio-dentine, light cure GIC and MTA using one way ANOVA**

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
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</thead>
<tbody>
<tr>
<td>Bio-dentine</td>
<td>7.45</td>
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<tr>
<td>Light cure GIC</td>
<td>8.1</td>
</tr>
<tr>
<td>MTA</td>
<td>7.28</td>
</tr>
</tbody>
</table>

**Graph 2(b): Comparison of the pH values of Bio-dentine, light cure GIC and MTA at 24hour interval using one way ANOVA**

<table>
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<th>Mean (SD)</th>
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<td>Bio-dentine</td>
<td>7.35</td>
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<tr>
<td>Light cure GIC</td>
<td>7.11</td>
</tr>
<tr>
<td>MTA</td>
<td>6.86</td>
</tr>
</tbody>
</table>
Graph 2(c): Comparison of the pH values of Bio-dentine, light cure GIC and MTA at 72 hour interval using one way ANOVA

The results were subjected to one way ANOVA and Tukey’s post hoc test for Inter group analysis using IBM SPSS version 20. Confidence limit was set as 95% (Table 1-3).

Figure 1 - pH meter with the arrangement

Figure 2 - Comparison of the pH values of Bio-dentine, light cure GIC and MTA at similar time interval using one way ANOVA (p < 0.05 - Significant*, p < 0.001 - Highly significant**)

(A) Baseline P- Value = <0.001**
RESULTS
The pH values were significantly different between Groups I, II, III (p<0.001). MTA showed significantly better results at the end of 24 hours and 72 hours when compared to Biodentine and light cure GIC. Biodentine showed better sealing ability when compared with light cured GIC, but the difference was not statistically significant.

DISCUSSION
Factors leading to external cervical resorption are dental trauma, orthodontic treatment, intracoronal bleaching, periodontal therapy or of idiopathic etiology. Internal bleaching of endodontically treated teeth can be performed in two different ways – the Thermocatalytic Bleaching technique and the ‘Walking Bleach’ technique.

The primary difference between the two methods is the process by which nascent oxygen is released from the chemicals. In the Thermocatalytic Bleaching technique, 30% H₂O₂ solution is activated by various forms of heat to speed up the release of oxygen, whereas, in the Walking Bleach technique, the release of oxygen is the result of a chemical reaction. Sodium perborate contains about 95% perborate and 9.9% available oxygen. When sodium perborate reacts with H₂O₂, sodium perborate undergoes decomposition to form metabolates.
The resultant products bring about oxidative and reductive reactions, which give H$_2$O$_2$ its bleaching properties.

\[
2\text{Na}^+ [(\text{H}_2\text{O})_2 \text{B}(-\text{O}-\text{O})_2 \text{B(OH)}_2]^2- + 2\text{H}_2\text{O} \\
\text{Sodium peroxoborate}
\]

\[
2\text{Na}^+ 2 \{\text{H}_2\text{BO}_3\}^+ + 2\text{H}_2\text{O}_2 \\
\text{Sodium Hydrogenborate}
\]

H, O, OH, HO$^2$. (radicals) 
OH$^-$. OOH$^-$. (Ions)

The resultant products bring about oxidative and reductive reactions, which give H$_2$O$_2$ its bleaching properties.

- pH value
- light influence
- existence of metallic reaction partners
- Different radicals or ions from the released hydrogen peroxide
- temperature
- crack unsaturated double bonds of colored molecules
- reduce the colored metallic oxides like Ferric oxide Fe$_2$O$_3$, (Fe$^{3+}$) 
  colorless Ferrous oxide FeO, (Fe$^{2+}$)
30% \( \text{H}_2\text{O}_2 \) has pH value around 4.0 (acidic) and decomposes into water and nascent oxygen when in contact with the dentin\(^{14} \). The larger colored organic molecules responsible for the stains are reduced to smaller molecules by the oxidation process. \( \text{H}_2\text{O}_2 \) acts both as an oxygenator as well as oxidant\(^{17,18} \). Another theory is that \( \text{H}_2\text{O}_2 \) penetrates into enamel and dentine and oxidizes tooth discolorations. The passage of nascent oxygen into the tooth structure occurs first in enamel and then in dentine \(^{18} \). When used with sodium perborate, \( \text{H}_2\text{O}_2 \) showed lower pH values at 14 days. According to Rostein and Friedman\(^{19} \), sodium perborate is alkaline, whereas 30% \( \text{H}_2\text{O}_2 \) is acidic. Later, the pH of the materials when mixed together changes from acidic to alkaline in extraradicular environment\(^{20} \). Low pH of \( \text{H}_2\text{O}_2 \) causes acidic environment resulting in different complications such as inflammatory reactions with osteoclastic activity leading to bone and external cervical root resorptions. pH changes due to the release of \( \text{H}_2\text{O}_2 \) is maximum in the initial period i.e. the first three days after application. The low pH may produce an acid-etch effect on dentin, dissolving the smear layer and increasing diffusion of \( \text{H}_2\text{O}_2 \) through dentinal tubules\(^{20} \).

Several clinical studies and case reports have been carried out to establish the association between bleaching using \( \text{H}_2\text{O}_2 \) with Sodium perborate and cervical root resorption\(^{11} \). Dentinal tubules travel in an incisal direction from the root canal to the enamel surface\(^{11} \). In almost 10% of the cases, the enamel and cementum do not meet at the CEJ, thus leaving exposed dentinal tubules\(^{21} \). Bleaching agents tend to penetrate the patent dentinal tubules and denatured dentin exposed at the cervical line. This denatured dentin induces a foreign body reaction. The penetration of \( \text{H}_2\text{O}_2 \) into the cervical region can be facilitated by cervical defects at the cementoenamel junction\(^{20} \). In this study, simulated defects were created in the cementum to provide a scenario for the leakage of \( \text{H}_2\text{O}_2 \). Many methods are used to detect leakage like dye penetration, bacterial leakage, air pressure method, fluid filtration method. The method used in this study was through the pH diffusion test. The advantage of this test is that it is simple, reproducible and accurate\(^{22} \). MTA when used as a barrier material provides an effective seal against penetration of dyes and bacteria and their metabolites such as endotoxins\(^{7} \). Its main advantage is that it sets in presence of moisture. Biodentine is a calcium silicate based material having high mechanical properties & excellent biocompatibility. It has the advantages of high elastic modulus, compressive strength and microhardness. Due to such improved mechanical properties, it is used in perforation repair, resorptions, apexification, root-end fillings and pulpotomies\(^{21} \). The disadvantage of conventional GIC is lesser early initial set and strength. Light cured GIC has the potential to form a chelative bonding to the tooth structure and therefore, can be successfully used as a protective base prior to bleaching\(^{12} \). In the present study, MTA (Group III) showed significantly better results compared to Biodentine (Group I) whereas Light cure GIC (Group II) showed the least favorable result. MTA showed minimal variations in pH at the end of 24 and 72 hours. The possible reason could be the presence of calcium oxide in the formulation which results in the release of calcium hydroxide during its hydration\(^{24} \). Calcium hydroxide has been shown to arrest or prevent tooth resorption\(^{25} \). Bleaching agents lower the pH on the root surface, which has been suggested as a mechanism for cervical resorption\(^{11} \). Therefore, in such cases, higher pH of the MTA and released calcium hydroxide may counter the effects of low pH created by \( \text{H}_2\text{O}_2 \) and further protect the root and prevent cervical resorption. Light cured GIC showed maximum rise in pH at 24 and 72 hours respectively compared to baseline reading. Biodentine when used as barrier showed better results compared to light cure GIC. The reason for this could be the marginal sealing ability of calcium silicate–based materials. It has an ability to produce surface apatite crystals and crystalline precipitates formed when in contact with the phosphates available in tissue fluids\(^{23} \).

**CONCLUSION**

Within the scope of this study, use of MTA as a barrier material shows significantly better action in preventing leakage of walking bleach material when compared to Biodentine and light cure GIC. MTA can be recommended as a barrier material for use in the clinical scenario in cases where Walking Bleaching is used.

**ACKNOWLEDGEMENTS**

The authors have no conflict of interest related to this study.

**REFERENCES**


