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Comparative Evaluation of Peroxide Release during Non-Vital Bleaching Using RMGIC, MTA and Biodentine as Intracoronal Barriers: An in Vitro Study

[1]Dr. Sial Shruti, MDS, Reader, Department of Conservative Dentistry and Endodontics, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001

[2]Dr. K K Saraf, MDS, Reader, Department of Conservative Dentistry and Endodontics, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001

[3]Dr. Shandilya Ashutosh, MDS, Lecturer, Department of Conservative Dentistry and Endodontics, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001

[4]Dr. Agrawal Muskan, Post Graduate Student, Department of Conservative Dentistry and Endodontics, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001

[5]Dr. Sandhiya Rajendran, Post Graduate Student, Department of Conservative Dentistry and Endodontics, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001

[6]Dr. Lija Tharakan James, Post Graduate Student, Department of Conservative Dentistry and Endodontics, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001

[7]Dr.Sanjeev Kunhappan, MDS, Professor, Department of Conservative Dentistry and Endodontics, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001

Corresponding Author: Dr.Sanjeev Kunhappan, MDS, Professor, Department of Conservative Dentistry and Endodontics, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001

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Abstract

Background: Bleaching agents may lead to external cervical root resorption if peroxide leaks into periodontal space. To shield surrounding tissues and inhibit such leaking, an intra-coronal barrier is placed beneath bleaching agents.

Aim: To evaluate and compare peroxide release during non-vital bleaching on Day 1 and 3 using Resin-Modified Glass Ionomer Cement (RMGIC), Mineral

Trioxide Aggregate (MTA) and Biodentine as intra-coronal barriers.

Materials and Methods: Fifty-one maxillary central incisors were collected and root canal treatment was done. 3-millimeter section of gutta-percha from coronal end were removed and samples were allocated into three groups (n=17): Group A (RMGIC), Group B (MTA) and Group C (Biodentine). Intra-coronal barrier was placed beneath the orifice. Non-vital bleaching was carried out with 35% Hydrogen Peroxide gel and peroxide release was measured on Day 1 and 3 using UV spectrophotometer. Paired t-test and One-way ANOVA followed by Tukey's Post Hoc test was used for statistical analysis.

Results: Biodentine and MTA showed significant difference out performing RMGIC on both days. No significant difference was observed between Biodentine and MTA.

Conclusion: Biodentine and MTA are effective intra-coronal barriers for nonvital bleaching, showing significant improvements over time and superior performance compared to RMGIC. Biodentine and MTA demonstrated comparable efficacy.

Keywords: Biodentine; Mineral Trioxide Aggregate; Non-vital Bleaching; Peroxide Release; UV spectrophotometer.

Introduction

Tooth colour results from a combination of optical properties and the interaction of light. Both internal and external variables are the main determinants of it. Extrinsic colour is influenced by surface deposits on the enamel, while intrinsic colour is determined by the optical characteristics of the enamel and dentin and how they interact with light.[1]

There are differences in tooth discoloration's origin, appearance, location, intensity, and degree of adhesion to the tooth structure. It can be classified as intrinsic, extrinsic, or a combination of the two depending on its cause and location. [2]

Non-vital tooth discoloration, caused by factors like trauma, pulp remnants, restorative or endodontic materials, is a common aesthetic concern, especially in anterior teeth. When it comes to enhance the appearance of discolored endodontically treated teeth, intra-coronal bleaching is a safer, more effective and more conservative option than crowns, veneers or composite restorations.[3] Sodium perborate combined with 30% H_2O_2, 30% hydrogen peroxide (H_2O_2) and sodium perborate combined with distilled water are among the bleaching agents that are employed.[4]

External cervical root resorption is the most frequent side effect of non-vital bleaching. This happens when extremely concentrated oxidizing agents permeate into the pericemental region. The bleaching agents' acidic pH causes cementum breakdown, inflammation, and osteoclast buildup. An intra-coronal cervical barrier is advised to reduce this risk by inhibiting peroxide from penetrating into the region of the periodontal ligament. [5,6]

To prevent peroxide leakage during non-vital bleaching, a number of materials have been suggested as protective barriers. These consists of Mineral Trioxide Aggregate, Cavit™, IRM®, Amalgam, Super-EBA™, Composite Resin, Calcium Enriched Mixture Cement, Glass Ionomer Cement (GIC), Resin-Modified Glass Ionomer Cement and Biodentine™.[6,7]

Resin-modified formulations were developed towards the end of 1980's as a result of the incorporation of polymerizable hydrophilic resins into conventional glass ionomer cements. Free radical polymerization along with an acid-base reaction are the two mechanisms by which these materials set. Compared to conventional glass ionomers, resin-modified glass ionomer cements demonstrated improved mechanical properties such as prolonged working time, improved translucency and faster setting. Due to their high flexural strength, dentin-like elastic modulus, chemical bond with tooth structure, along with resistance to bleaching agent-induced disintegration, they are employed as coronal barrier materials. [8,9]

In endodontics, calcium silicate-based cements have gained popularity recently due to their superior marginal flexibility, sealing ability and biocompatibility with the oral environment.[10] Furthermore, they are advised for a number of procedures, including coronal barrier materials, root-end fillings, vital pulp therapy, regenerative endodontic treatments, perforation repairs, and apexification. [11]

MTA's high calcium hydroxide concentration, superior marginal adaptation, and resistance to microleakage make it an effective intra-coronal barrier that prevents root resorption in the cervical area. High initial solubility, a longer setting time, handling challenges, and tooth discoloration are some of its drawbacks. [12,13]

Biodentine™, a calcium silicate-based cement introduced in 2009, is specifically developed as a ‘dentin replacement’ material. [4] Because of its non-toxicity, short setting time, ease of handling, dentin remineralizing qualities, and similar mechanical characteristics to dentin, biodentine is utilized as an intra-coronal barrier material. Biodentine's clinical characteristics and indications are comparable to those of MTA cement, but it has better physical qualities and is easier to handle.[3,14]

This article aims to assess the amount of peroxide leakage using RMGIC, MTA and Biodentine as intra-coronal cervical barriers during non-vital bleaching.

Materials and Methods

After informing the patients about the study and taking consent from them, fifty-one freshly extracted maxillary central incisors were used as sample in the study. The teeth were stored in distilled water with a 0.1% thymol solution after being cleaned with an ultrasonic scaler. The study excluded teeth that had undergone endodontic treatment, had cracks, fractures or root caries or had cervical abrasions.

A No. 2 round bur (Mani, India) was used to prepare the access cavities in each tooth (Figure 1-a, 1-b).Determination of working length was done with #10 K-file (Mani, India) and adjusted by subtracting 0.5 mm. Wal-flex anterior rotary files (Waldent Innovations India Pvt. Ltd., India) were used for shaping and cleaning up to size 60/2%.

For irrigation, 3% sodium hypochlorite and 17% EDTA were used for one minute, followed by saline. The canals were coated with AH Plus sealant (Dentsply, De Trey GmBH, Konstanz, Germany) after being dried with paper points. The cold lateral compaction technique was used to obturate the canal with gutta-percha (Dentsply, Maillefer, Switzerland) (Figure 1-c).The teeth were incubated at 37°C for seven days after access cavities were filled with temporary filling material (Cavit G, 3M Deutschland GmbH, Germany).

Using the labial cement-enamel junction (CEJ) as the reference point, 3 mm of gutta-percha was removed after 7 days using heated pluggers (Figure 1-d, 1-e). Based on the intra-coronal barrier, the samples were divided into three groups: Group A- Fuji II LC (GC Corporation, Tokyo, Japan); Group B - MTA (Angelus, Londrina, Brazil); Group C - Biodentine® (Septodont, Saint-Maur-des-Fosses, France) with 17 samples in each group. The manufacturer's recommendations were followed while creating intra-coronal barriers (Figure 2-a, 2-b, 2-c).The barrier in the MTA group was covered with cotton soaked in saline and the cavity was filled for a whole day using temporary restorative material. Radiographs were taken to verify the barrier placement (Figure 1-f) and all surfaces except cervical 3 mm below the CEJ were painted with nail polish (Figure 2-e). Following a 24-hour period, access cavities were opened again and in accordance with the manufacturer's directions, non-vital bleaching was carried out using Opalescence Endo (Ultradent, South Jordan, UT, USA) (Figure 2-d).Glass ionomer cement (GC Corporation, Tokyo, Japan) was used to reseal the cavities. Samples were then immersed in Eppendorf tubes filled with two millilitres of distilled water and incubated for three days at 37°C. (Fig. 2-f).

On the first and third days, the samples' peroxide release in distilled water was evaluated using UV spectro-photometry and potassium iodide (KI) solution. The absorbance of 2 mL of the sample solution was measured at 390 nm using a UV-1900i Double Beam UV-VIS Spectrophotometer (Shimadzu, Japan) after adding 200 microliters of KI solution. The absorbance of the samples on the first and third days was compared in order to determine the peroxide concentration in the samples.

Statistical Analysis

The data was statistically analyzed using the Paired t-test for intra-group comparison and the one-way ANOVA followed by Tukey's Post Hoc test for intergroup comparison. The mean and standard deviation were calculated for each group. SPSS 11.5 software for Windows (SPSS Inc., Chicago, IL, USA) was used to conduct analyses at the 5% significance level, and a P-value of less than 0.05 was considered statistically significant.

Results

The research assessed the relative effectiveness of different intra-coronal barriers - RMGIC, MTA and Biodentine used in non-vital bleaching technique. The intra-group analysis (Table no. 1) showed that both MTA and Biodentine exhibited significant changes from 1stto 3rdDay (P=0.005andP=0.004, respectively), while no statistically significant difference (P=0.057) was shown by RMGIC group. The lowest peroxide release was observed in the Biodentine group, followed by MTA and then RMGIC on both days. The inter-group comparison (Table no. 2) revealed significant differences between the materials, with Biodentine and MTA showing significantly better performance than RMGIC on both days. Nevertheless, no significant difference was observed between MTA and Biodentine on either day.

Discussion

The main problem with nonvital bleaching is the resorption of external cervical roots surface. This occurs as a consequence of the bleaching agent's peroxide leaking from the tooth into the periodontal space, which damages the cementum and causes inflammation. [4] One of the main causes of cervical root resorption is the drop in pH on the tooth's surface that occurs after intra-coronal whitening. The dentinal tubules, which join the pulp to the root surface, should be sealed with a filler material to avoid this. However, because neither the filling material nor the sealer can completely prevent chemicals from escaping into the canal, a filled root canal is still susceptible to microleakage. [10]

The bleaching agent utilized in this study was 35% H2O2 gel and the maximum amount of peroxide released 24 hours after bleaching and gradually diminished over time, aligning with the result of study done by Roy et al. and Zoya et al. [4,15]

In a bacterial leakage study, Khanna et al found that the seal of RMGIC as orifice barrier was inferior compared to MTA. [16]In the current study, the RMGIC group released the greatest amount of peroxide on the first day. This might have occurred because of microleakage through RMGIC that can be possibly because of shrinkage during polymerization, poor condensation or improper manipulation that produced a non-homogenous mix.[10,17] According to Torabinejad et al[18]., MTA has greater marginal adaptability, which contributes to its leakage resistance. This sealing ability is ascribed to its hydrophilic properties and its expansion when set in a damp condition. Additionally, MTA results in lesser porosity because it is a condensable material. The development of hydroxyapatite crystals at the material-dentine interface may be the cause of the lower peroxide release in the biodentine and MTA groups. [3,19]

In the current study, the likely reasons for Biodentine outperforming MTA could be:

- Biodentine forms tag-like structures and an interfacial layer known as the "mineral infiltration zone" on coming in contact with dentin. The collagen components of the interfacial dentin are broken down by the alkaline-caustic action of the calcium silicate cement's hydration products, which improves Biodentine's capacity to seal by encouraging the production of these tags. [20]
- Biodentine's smaller particle size enables it to conform well to the cavity surface, providing a robust seal at the interface. [21]
- One of the benefits of Biodentine is its rapid setting time (12 minutes), which enables earlier sealing of the interface and consequently lowers the risk of leakage. [22]
- Set Biodentine exhibits lower porosity and pore volume compared to MTA. [23]
- Also, Biodentine is mixed in amalgamator which results in better consistency of mix compared to MTA which is mixed manually.

Its prolonged setting time may potentially be the cause of the relatively large leakage of MTA seen during the first 24 hours, which is consistent with the findings of Nabeel et al. [24]

In comparison to the first day, peroxide emission had dramatically dropped by the third day in both the MTA and Biodentine groups. However, it was also shown that there was no statistically significant difference between the Biodentine and MTA groups on intergroup comparison, suggesting that these two materials were equally effective. This could be because MTA's structural integrity increased over time. Furthermore, the release of calcium hydroxide and the increased alkalinity of MTA help shield the root surface from resorption.

The in vitro approach and the small sample size of this investigation restricted the evaluation of clinically significant parameters. Peroxide release from bleaching chemicals requires further study in a setting that is more clinically relevant.

Conclusion

Within the confines of the investigation, MTA and Biodentine both demonstrated a considerable decrease in peroxide release over time. RMGIC, however, did not exhibit any statistically significant alteration. Inter-group comparisons also showed that Biodentine and MTA performed noticeably better than RMGIC. Nonetheless, MTA and Biodentine showed equivalent results, with no discernible difference, suggesting that these two materials are equally effective. The results of this study indicate that MTA and Biodentine are better intra-coronal barriers than RMGIC, which makes them better options for clinical application in the nonvital bleaching process.

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Legend Tables and Figures:

Table 1: Mean peroxide release (Intra-group comparison)

Paired Samples Statistics						
		Mean concentration (%)	N	Std. Deviation	Mean Difference	P value
Rmgic (Group A)	1st Day	0.2194	17	0.04790	0.056	0.057
	3rd Day	0.1628	17	0.03435		
MTA (Group B)	1st Day	0.1726	17	0.03729	0.059	0.005
	3rd Day	0.1128	17	0.03195		
Biodentine (Group C)	1st Day	0.1536	17	0.02550	0.055	0.004
	3rd Day	0.0978	17	0.01800		

Table 2: Multiple Group Comparison (Inter-group comparison)

(TUKEY HSD)							
Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
DAY 1	Rmgic	MTA	0.0468	0.0203	0.081	0.0050	0.0987
		Biodentine	0.0657*	0.0203	0.012	0.0139	0.1176
	MTA	Rmgic	-0.0468	0.0203	0.081	-0.0987	0.0050

		Biodentine	0.0189	0.0203	0.627	-0.0329	0.0708
	Biodentine	Rmgic	-0.0657*	0.0203	0.012	-0.1176	-0.0139
		MTA	-0.0189	0.0203	0.627	-0.0708	0.0329
DAY 3	Rmgic	MTA	0.0499*	0.0155	0.013	0.0103	0.0895
		Biodentine	0.0649*	0.0155	0.002	0.0254	0.1045
	MTA	Rmgic	-0.0499*	0.0155	0.013	-0.0895	-0.0103
		Biodentine	0.0150	0.0155	0.605	-0.0245	0.0546
	Biodentine	Rmgic	-0.0649*	0.0155	0.002	-0.1045	-0.0254
		MTA	-0.0150	0.0155	0.605	-0.0546	0.0245

Figure 1: Preparation of samples

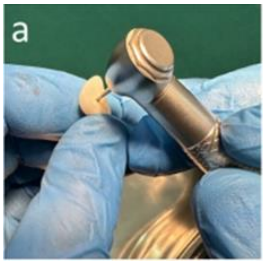

Figure 1a: Access cavity preparation

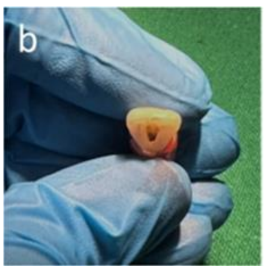

Figure 1b: Access cavity

Figure 1c: Obturation

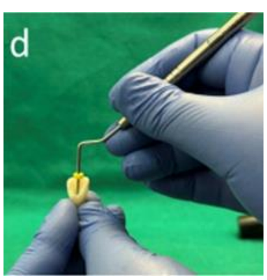

Figure 1d: GP removal 3 mm below CEJ

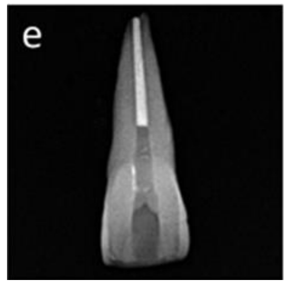

Figure 1e: Radiograph showing 3 mm gp removed

Figure 1f: Intra-coronal barrier

Figure 2:Intra-coronal barrier and peroxide release

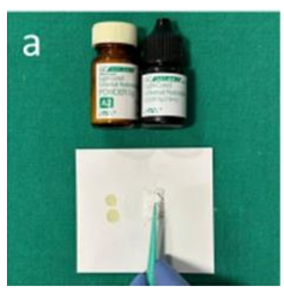

Figure 2a: Mixing of RMGIC

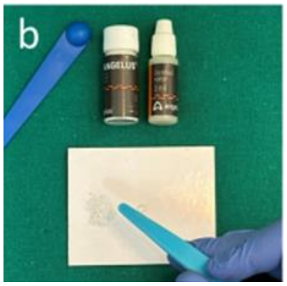

Figure 2b: Mixing of MTA

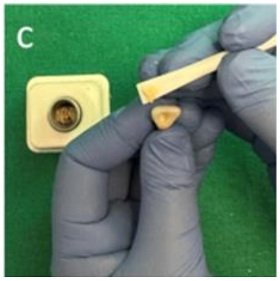

Figure 2c: Placement of intra-coronal barrier

Figure 2d: Bleaching agent placement\

Figure 2e: Coating with nail varnish

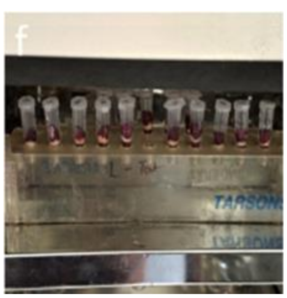

Figure 2f: Samples in incubator