EJPMR, 2025, 12(12), 410-413 **Review Article** **Impact Factor 7.065**

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

ISSN (O): 2394-3211
ISSN (P): 3051-2573
Coden USA: EJPMAG

COMPARATIVE EVALUATION OF THREE DIFFERENT PULP CAPPING AGENTS ON CORONAL DISCOLORATION USING SPECTROPHOTOMETRIC ANALYSIS: AN INVITRO STUDY

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How to cite this Article: 1C. Sunil Kumar, 2Reddy Selvi Ramchandra, 3*Shaik. Hakeem, 4Vamsee Krishna Nallagatla, 5S. Sunil Kumar, 6K. S. Chandra Babu. (2025). COMPARATIVE EVALUATION OF THREE DIFFERENT PULP CAPPING AGENTS ON CORONAL DISCOLORATION USING SPECTROPHOTOMETRIC ANALYSIS: AN INVITRO STUDY. European Journal of Biomedical and Pharmaceutical Sciences, 12(12), 410–413.

Article Received on 05/11/2025 **Article Revised on 25/11/2025** **Article Published on 01/12/2025**

ABSTRACT

Introduction: Dental caries is one of the most common human diseases, with a 54.16% prevalence in the Indian population aged 3–75 years. Non-carious cervical lesions (NCCLs) result from attrition, erosion, abrasion, or abfraction and are unrelated to microorganisms. Vital pulp therapy uses pulp-capping materials that may cause tooth discoloration due to leakage into dentinal tubules or residues in the pulp chamber. Calcium hydroxide has long been the gold standard, while MTA—especially Gray MTA—causes discoloration because of metal oxides. Biodentine, a calcium silicate cement, offers improved biocompatibility and reduced discoloration. This in vitro study evaluates coronal discoloration using spectrophotometric analysis. **Materials and Methodology:** Thirty extracted maxillary incisors were prepared, debrided, and randomly assigned to MTA, Bio dentine, or Dycal groups (n=10). Materials were placed in pulp chambers and specimens stored at 37°C. Tooth color (L*, a*, b*) was recorded at baseline and follow-ups, and ΔE values calculated using the CIELAB formula. **Results:** Mean ΔE values for MTA, Bio dentine, and Dycal increased over time. MTA and Bio dentine showed gradual discoloration, with Bio dentine exhibiting lower values. Dycal showed the highest ΔE at 1 month (4.94±1.27) before decreasing at 3 months. Statistical analysis used one-way and repeated-measures ANOVA with Tukey's post hoc test. **Conclusion:** All groups showed progressive coronal discoloration. Delta E changes from 1 week to 3 months were statistically significant among materials. Dycal produced the greatest discoloration, followed by MTA, while Biodentine showed the lowest Delta E values, indicating the least coronal discoloration overall.

INTRODUCTION

Dental caries is reported to be one of the oldest and most common diseases found in humans. it poses a serious threat to healthcare. As per our review and analysis, In the Indian population aged 3 to 75, the overall frequency of dental caries was 54.16%. The primary reason for the etiologic difference between carious and non- carious lesions is that the former are linked to bacteria, whereas the latter are unrelated to microorganisms. The irreversible loss of mineralized tissue unrelated to carious pathology characterizes non-carious cervical lesions, or NCCLs. Attrition, erosion, abfraction, and abrasion are among the causes of NCCLs. The goal of pulp capping treatment is to establish health, function, and esthetics of the dentition. Vital pulp therapy (VPT) is widely used treatment procedure to achieve these goals in young

patients. It involves placement of therapeutic materials in the crown or coronal third of the root canal that might cause discoloration of the tooth.[1]

Materials leaking into dentinal tubules are thought to be the main cause of a gradual discoloration. It has been demonstrated, therefore, that a visible darkening in the crown may not always be related to tubule penetration and instead result from material residues in the pulp chamber that darken with time and spread through the hard tissues.[2]

Since its introduction to the dentistry field in 1921, Calcium Hydroxide has been regarded as the "gold standard" for direct pulp capping materials for a number of years. Ca(OH)2 has been recognized for a number of reasons, including its high pH and strong antibacterial qualities.[3]

Gray MTA (GMTA), the first MTA material designed for use in teeth, was found to discolor teeth due to its dark color. Consequently, white MTA (WMTA), which had therapeutic qualities similar to GMTA but generated more aesthetically acceptable outcomes, was developed. The difference between WMTA and GMTA lies in their respective contents of metal oxides (e.g., iron, aluminum, and magnesium oxides), which are the main cause of discoloration. However, WMTA also causes some tooth discoloration because it still contains various metal oxides, although the content is low, together with bismuth oxide, which was added to improve the radiopacity of the materials.[4]

The number of oxides of magnesium, bismuth, iron, aluminum, and other metals determines how much discoloration happens. Therefore, within a range that does not change the properties of MTA, the content of bismuth oxide could be reduced to minimize any color change.[3] This formulation was thought to be more suitable for use as a pulp capping material in the esthetic region although slight discoloration may still result, necessitating a veneer or crown.[4]

Introduced as a "dentine replacement" or "dentine repair" material, Biodentine (Septodont, Saint Maur des Fosses, France), also known as Biodentine, is a calcium silicate cement that favorably causes cellular differentiation in vitro and mineralization (Laurent et al., 2012; Zanini et al., 2012). It has the potential to overcome some of the discoloration issues associated with MTA after pulp capping.[5]

Compared to other materials, Biodentine offers a number of benefits, such as favorable biocompatibility, good sealing ability, sufficient compressive strength, and quick setting time. Research reveals mixed findings about its discoloration; some cite color stability, while others report discoloration.[6]

Many tools have been developed in dentistry to help with more precise color selection, which enables us to produce more aesthetically pleasing outcomes. Color measuring instruments, which assess the quantity and spectral makeup of light reflected by an object's surface, include colorimeters, spectrophotometers, spectroradiometers, and combinations of these.[7]

Thus, this aim of this invitro study is to evaluate coronal discoloration effect of pulp capping agents by spectrophotometric analysis.

MATERIALS AND METHODOLOGY

SPECIMEN PREPARATION

30 freshly extracted intact permanent human maxillary central incisors were collected. Teeth which were free of cracks, fractures, caries, abrasions and discoloration because of systemic intrinsic causes were selected. Teeth were cleaned mechanically to remove adherent soft tissue, debris & stored in 100% humidity.

All teeth were cross-sectioned in the coronal third of the root complex, 1 mm below the cemento-enamel junction. The apical segments were discarded and the crowns were retained. Apical orifice enlargement done using Gates Glidden Drills No.2 & No.3.Pulp remnants were extirpated with an excavator, and the internal axial walls of the pulp chambers were chemo mechanically debrided using Hedstrom files and k files and 3.5% sodium hypochlorite (10 ml) through the apical access. After the final irrigation, the pulp chambers were washed with sterile saline (5 ml).

Samples (n=30) thus prepared were randomly assigned to three experimental groups (n = 10 each).

GROUPING

Group 1 – MTA
Group 2 – BIODENTIN
Group 3 – DYCAL

MTA and BIODENTIN were mixed according to the manufacturer's instructions and packed into the pulp chambers with MTA carrier. Dycal (Base and Catalyst) was mixed and placed in the pulp chamber with the help of probe through the access. A slight vertical pressure was applied with finger pluggers to fill the pulp chamber with the material, up to the cervical level. Apical access was sealed with thin layer of Glass ionomer cement. After complete setting of Glass Ionomer cement, all crowns were transferred and completely immersed in distilled water and then placed in an incubator at 37 ± 1°C.

MEASUREMENT OF CROWN CHROMATIC ALTERATIONS

Color values were recorded by a single operator using a reflectance spectrophotometer. Measurements were carried out by the same operator prior to material placement day 0 (t0) and at 1 week (t7), 4 week (t30), 3 months (t90) after material placement. Before the

materials were placed but after the teeth were prepared, the baseline value was T0. The L*a*b* value was utilized to determine the color measurement. The L*a*b* value was utilized to measure color.

STATISTICAL ANALYSIS

The mean and standard deviation were calculated and subjected to statistical analysis by One-way ANOVA and repeated measures ANOVA. Data were presented as mean ± SD and statistical significance was set at $p < 0.05$. Tukey's post hoc test was done for multiple comparisons at different time intervals in the same group.

Table 1: ΔE of three different pulp capping agents at different time points.

ΔE	MTA		BIODENTIN		DYCAL	
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
1 week	1.34	0.68	1.16	0.34	1.58	0.21
1 month	2.09	1.11	1.03	0.42	4.94	1.27
3 months	3.21	0.64	2.55	0.74	3.85	1.21

Table 1 depicts the mean change in colour (ΔE) of three different pulp capping agents i.e., MTA, Biodentin, and Dycal, measured at three different time points. For MTA, the mean ΔE increases over time from 1.34±0.68 at 1 week to 3.21±0.64 at 3 months. Biodentin also shows an increase in mean ΔE over time, but at slightly lower values than MTA. Dycal has the lowest mean ΔE at 1 week, but it significantly increases to the highest value of 4.94 ±1.27at 1 month, and then decreased to 3.85 ±1.21 at 3 months. (Figure 1)

DISCUSSION

Aesthetics are crucial in dentistry, and discoloration of even a single tooth can significantly affect a patient's quality of life. Despite advancements in endodontic materials and techniques over the past decade, tooth discoloration after pulp therapy remains a common clinical concern. Tooth discoloration varies in origin, appearance, location, intensity, and staining affinity. During obturation, coronal dentin contacts gutta-percha and sealers, which laboratory studies show can cause moderate to severe discoloration. The extent of staining depends on the chemical composition of the sealers and tends to increase over time (Ioannidis).[8]

Coming to the carious lesion if it is not treated, demineralization can progress and results in a cavitated lesion that will advance through dentine stimulating pulpitis and eventually pulp infection and necrosis; Nonetheless, pulpal recovery happens even in deeply embedded carious lesions with conservative management.[9]

Three different sorts of procedures that are carried out on vital carious exposures are collectively referred to as vital pulp therapy

- Direct pulp capping
- Partial/complete pulpotomy
- Full/partial pulpectomy.

The process of direct pulp capping entails covering the pulp exposure with a medication or wound dressing, most frequently calcium hydroxide. As determined by the preservation of pulpal vitality, the success rate of direct pulp capping techniques employing setting calcium hydroxide was 37% after five years and 13% after ten. The majority of failures developed gradually and asymptomatically over time, with the pulp calcifying or going necrotic. There is debate concerning the use of direct pulp capping with calcium hydroxide in teeth that are cariously exposed due to its poor success rates. With their promise of relatively greater success rates, the development of innovative biocompatible materials like Bio dentine (Septodont; Lancaster, PA, USA, and France) and Mineral Trioxide Aggregate (MTA) has spurred renewed interest.[9]

MTA is a bioactive silicate composed mainly of tricalcium silicate, dicalcium silicate, tricalcium aluminate, tricalcium oxide, bismuth, and iron compounds. Although GMTA and WMTA have similar compositions, GMTA contains higher levels of iron, magnesium, and aluminum oxides, which increases its staining potential. However, studies show that WMTA can also cause discoloration, likely due to its greater solubility, despite having lower concentrations of these oxides.[10]

Bismuth oxide, added to MTA for radiopacity, is a key contributor to its discoloration. It may oxidize and react with carbon dioxide to form bismuth carbonate, a light-sensitive compound that darkens on exposure. Another explanation is that bismuth oxide reacts with collagen, producing a black precipitate.[11]

Biodentine is calcium silicate–based material (Septodont, Saint Maur des Fosses, France), which contains tricalcium silicate, CaCO3, zirconium oxide, a water reducing agent, and a water-based liquid containing calcium chloride as the setting accelerator. The goal of developing and producing biodentine was to combine the strong bioactivity and biocompatibility of calcium silicates with improved qualities like high strength and a short setting time.

Ca(OH) 2 has been the "gold standard" capping material

for a long time. The best-known commercial Ca(OH)2 product is the hard -setting Dycal ® (Dentsply Sirona, Weybridge, UK). Although applying this material directly to the pulp does induce formation of a mineral barrier the barrier is neither uniform or bonded to the dentine wall and a good seal is not produced. The exact mechanism of Ca(OH) 2 remains unclear, biologically it stimulates the production of mineralized tissue, albeit often a porous osteodoentine. Ca (OH) 2 is successful clinically but limitations including solubility, handling and biological response, have led to the development of new materials such as hydraulic calcium silicates.

In the present study the MTA discoloration was more compared to the bio dentin this is due to the present of bismuth oxides in the MTA and biodentin contain tricalcium silicate, CaCO3, zirconium oxide, which shows the color stability over a period of time.

K. Ioannidis et al conducted a study to evaluate the specific alterations in tooth colour with white and grey MTA when used to fill pulp chambers. After one-month, grey MTA produced a clinically noticeable discoloration on the crown, but after three months, the entire color shift brought on by White MTA was more noticeable to the human eye. Teeth that had both grey and white MTA formulations applied showed less brightness as well as less redness and yellowness. The findings of this study are similar to the present study.[12,13]

Limitation

- Our results provide only in vitro observational data on the color stability of study materials (MTA, Biodentin, Dycal) further studies are necessary to elucidate the color stability of the materials in vivo.
- The other limitation was the less sample sizes which may influence the results considerably. Further studies with large sample sizes are required to evaluate for discoloration in the MTA, Biodentin, and Dycal. Also, research is required to determine the discoloration mechanisms responsible for this finding.

CONCLUSION

From this study, it can be concluded that:

- All experimental groups showed coronal discoloration over time, which was consistent among the different groups.
- All three different pulp capping materials shows statistically significant difference in Delta E change from 1week to 3months.
- The agent with the highest mean Delta E is Dycal followed by MTA and least Delta E values with Bio dentin.
- Thus, indicates that Bio dentin exhibited least coronal discoloration compared to Dycal and MTA.

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