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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF APICAL MICROLEAKAGE OF BIODENTINE AND MINERAL TRIOXIDE AGGREGATES (MTA) AS AN APICAL PLUG MATERIAL IN 5mm THICKNESS IN SINGLE ROOTED PERMANENT TEETH-AN IN VITRO STUDY

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ABSTRACT

Introduction: To enhance the success rate of periapical surgery it is of utmost importance to have fluid Seal in apical third of root canal, this study comparative evaluation of apical microleakage of biodentine and mineral trioxide aggregates (MTA) as an apical plug material in single rooted permanent teeth with the help of a UV-VIS spectrophotometer. **Material and Method:** 23 human single-rooted extracted tooth were selected free from cracks and caries and similar anatomical characteristics. The teeth were decoronated using a diamond disk bar in an underwater stream aerator handpiece to create a standardised root length of 16 mm working length of canals of all teeth was adjusted to 15.5 mm. Biomechanical preparation (BMP) was done using rotary pro taper file upto # F4. Apical plug materials were placed as follows---(20 tooth out of 23 tooth) Apical barrier placed 5mm (10 teeth) with Biodentine,and 5mm (10 teeth) with MTA and 3 tooth are control group and remain canal obturation done with G.P point and AH PLUS sealer .Microleakage was tested by using 2% methylene blue dye extraction method with the help of UV-VIS spectrophotometer. **Result:** The apical barrier of 5mm thickness demonstrated less microleakage of Biodentine than MTA. Biodentine has better sealing ability than MTA as an apical plug material in single-rooted teeth in apical thicknesses (5 mm). **Conclusion:** The observation of the present study was the apical barrier of 5mm demonstrated less microleakage of Biodentine than MTA.

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INTRODUCTION

Traumatic injury and dental caries to an immature permanent tooth lead to loss of pulp vitality and arrested root development. Endodontic management of these teeth in young pediatric patients is a great challenge. The divergent dentinal wall and the wide-open apex make it difficult to debridement and obturation of the root canal (1). The apical root closure is a result of apexification or bridge formation. Apexification is a method to induce a calcified barrier in a root with an open apex or continued apical development of an incomplete root in a tooth with a necrotic pulp.(2) Various techniques are used to induce the apexification process. The most commonly used medicament is calcium hydroxide. Kaiser and Frank first introduced it in the year of 1960's(3) The approximate time for calcified apical barrier formation are varies from 6 months to 24 months. Although the technique is efficient with predictable outcomes, it has several disadvantages like prolonged treatment time, chances of reinfection, and risk of cervical fracture. An alternative way to apexification technique with calcium hydroxide is forming an artificial apical barrier using MTA. The MTA is biocompatible with cementogenic properties and has superior sealing ability. It has certain disadvantages like questionable antimicrobial activity, difficulty to handle, and potential for discoloring the tooth.(4) To overcome the disadvantages of MTA, a new calcium silicate-based material, BiodentineTM (Septodont, Saint–Maur– Des-Fosses, France) has been introduced in 2009 and claims to be a revolutionary material capable of offering a bioactive and biocompatible replacement for dentine. The endodontic indications of the novel material are similar to MTA but are reported to provide several advantages including better consistency, improved handling, and a quicker setting time of 12 minutes.(5) An immature permanent tooth is a young/newly erupted permanent tooth. Which root apex is open. After a permanent tooth are emerges in the mouth, it

usually takes time three to more years to complete the root closure Fouad.(6)

MATERIAL AND METHOD

A sample of 23 human single-rooted extracted tooth were selected free from cracks and caries and similar anatomical characteristics. All teeth with caries, and dilaceration root, were excluded. The teeth were stored in 10% neutral formalin. the teeth were autoclaved and kept in 0.5% Sodium hypochlorite for no longer than 7 days. Thereafter, the teeth were decoronated using a diamond disk bar in an underwater stream aerator handpiece to create a standardised root length of 16 mm. Canal Patency was evaluated with # 10 K file and canal orifice enlargement was done with No. #3 and #2 Gates Glidden drill. The working length of canals of all teeth was adjusted to 15.5 mm. Biomechanical preparation (BMP) was done using rotary pro taper file upto # F4 in crown down manner using injectable EDTA as a lubricant. All canals are irrigated with 20 ml. of 5.25% sodium hypochlorite solution after every change of instrument using 30-gauge side vented needle. Root canal was dried with absorbent paper points. There after 3 tooth were obturated with Gutta percha point . Apical plug materials 5mm were placed as follows---(20 tooth out of 23 tooth).

Group	Days	Thickness
MTA	Day 1	81.1 ± 5.41
	Day 2	67.28 ± 3.64
	Day 3	68.54 ± 7.70
Biodentine	Day 1	80.35 ± 8.13
	Day 2	80.3 ± 8.78
	Day 3	82.68 ± 9.16
Control	Day 1	58.3 ± 6.87
	Day 2	54.72 ± 5.42
	Day 3	58.71 ± 7.78

All materials used for apical plug were allowed to set for 24 hours in incubation at 37^0C and 100% humidity. These teeth were obturated up to available working length with protaper GP points #F4, using AH PLUS sealer. The canal orifices of all teeth were sealed with composite resin and cured subsequently. The Coronal and lateral aspects of these teeth were coated with two coats of nail varnish except the area where the apical barrier was placed and allowed to dry. The tooth in control group (3 tooth) were coated with two coats of nail varnish except the area in apical 5mm (3 tooth) and allowed to dry. This uncoated part of each tooth was immersed in the 2% methylene blue dye solution. Specimens were then stored in an incubator at 37°C and 100% humidity for 3 days. Then nail varnish was removed with a BP blade and teeth were washed under running tap water for 30 seconds. Leaked dye was extracted by keeping the specimen at 5ml. of 35% nitric acid for 3 days in an incubator at 37°C and 100% humidity. The resultant solution was filtered and centrifuged at 14,000 rpm for 5 minutes. The supernatant solution subjected to a UV-VIS spectrophotometer using a filter of 670 nm.

According to the Beer-Lambert's Law10

$$A=\log_{10}(I0/I)= e.c.L$$

Where, A is the measured absorbance, 10 is the intensity of the incident light at a given wave-length, I is the intensity of the transmitted light, L the path length through the sample, and c the concentration of the absorbing species. For each species and wavelength, e is a constant known as the molar absorptivity or extinction coefficient. This law states that, the magnitude of absorbance is directly proportional to the concentration of dye in the solution and inversely proportional to % transmission. Thus, values of % transmittance indicate the absorption of light waves in the solution. If the value of % transmittance is less then it indicates that the con-centration of methylene blue in the solution is more and thus more microleakage.

STATISTICAL ANALYSIS

The collected data was tabulated in a spreadsheet using Microsoft Excel 2019 and then statistical analysis was carried out using the GraphPad Prism for Windows, Version 10.1.2 (GraphPad Software, La Jolla California USA). A Shapiro-Wilk's test and a visual inspection of the histograms, standard Q-Q plots, and box plots showed that the collected data were approximately normally distributed for the sample. Descriptive statistics were used to report i) categorical variables in terms of frequencies and percentages & ii) quantitative variables in terms of mean (central tendency) and Standard deviation (measures of dispersion). Parametric tests were carried out for inferential statistics. The two-way analysis of variance(ANOVA) were used to analyze the differences between groups for the various outcome variables. The P value of ≤ 0.05 was considered as the level of significance.

RESULTS

In the MTA group, mean transmittance on Day 1 , 81.1 ± 5.41 at 5mm. By Day 2, transmittance decreased 67.28 ± 3.64 at 5mm. On Day 3, transmittance 68.54 ± 7.70 at 5mm. For the Biodentine group, transmittance on Day 1 80.35 ± 8.13 at 5mm. By Day 2, 80.3 ± 8.78 at 5mm. On Day 3, transmittance 82.68 ± 9.16 at 5mm. In the control group, transmittance on Day 1 58.3 ± 6.87 at 5mm. On Day 2, and 54.72 ± 5.42 at 5mm. By Day 3, transmittance 58.71 ± 7.78 at 5mm.

DISCUSSION

Dental trauma may or may not directly affect the pulp, it may still result in a loss of vitality. If this occurs at a young age when the root development is incomplete, the clinician faces the difficult situation of an immature permanent tooth. with the thin dentine walls and a wide, open apex in need of endodontic treatment. In a traumatized nonvital tooth the canals often become infected (7,8). An infected pulp of a traumatized tooth is particularly dangerous because of the susceptibility to root resorption (9,10). In immature teeth, this process occurs rapidly because of the wide dentinal tubuli, allow the penetration of bacterial irritants (11). Without apical stop or constriction it is difficult to limit the filling process of these teeth within the boundaries of the root canal. Demerit (1948) *et al* advocated extraction for non-vital permanent teeth if the root was not completely formed. This decision was based on the inability to achieve satisfactory root canal therapy in these teeth. Ingle advocated routine endodontic therapy with an overfilling of the canal. Apical surgery was then performed to seal the apex properly. For many years the treatment of choice in these cases has been the apexification technique using calcium hydroxide (12). Calcium hydroxide when mixed with water it attains a high alkaline pH of about 12.5. (13) Also it has the unique potential to induce mineralization even in the tissues, which have not been programmed to mineralize

(Binnie). The high pH may also activate alkaline phosphatase activity, which is postulated to play an important role in the hard tissue formation (Guo and Messer) (14) The high alkaline pH of calcium hydroxide neutralizes the lactic acid secreted by osteoclasts and acidic reaction products of inflammation. This may help to prevent destruction of mineralized tissue. However this conventional apexification procedure may take many months and require multiple visits, making patient compliance a problem. It also further weaken the teeth by the repetition of endodontic procedures during the replacement of the intracanal dressings. To eliminate the disadvantage of the conventional apexification technique by calcium hydroxide many alternative approaches have been suggested aiming mainly at developing a one-step procedure for the completion of endodontic treatment. mineral trioxide aggregate (MTA) has been developed that appears to be a significant improvement over other material. Commercial MTA material is a mixture of Portland cement (75%), gypsum (5%), bismuth oxide (20%). It also contains silicon di oxide Sio2, calcium oxide Cao, magnesium oxide Mgo, potassium sulfate K2SO4, and sodium sulfate Na2SO4. The major component of Portland cement is a mixture of dicalcium silicate, tricalcium silicate, tricalcium aluminate and tricalcium aluminoferrite. The added bismuth oxide provides radiopacity. In recent eras, mineral trioxide aggregate (MTA), which is composed of tricalciumsilicate, tricalcium aluminate, and bismuth oxide, became the material of choice because of its hydrophilic fine particles, excellent biocompatibility, and antibacterial and antifungal properties.(15) MTA was approved by the US Food and Drug Administration in the year 1998 because of its good sealing ability, relative ease of manipulation, and long-term prognosis. The mixing of MTA is very important for its performance as if the mixing is prolonged, it leads to dehydration of the mixture. MTA has a pH of 10.2 immediately after mixing which increases to 12.5 within 3 h of setting. Due to the longer mixing time of MTA, research is now being done on other cement like calcium silicate cement.(16) In 2009, Biodentine was introduced under the name of Septodont, St Maur des Fosses, which is a new tricalcium silicate-based inorganic restorative commercial cement and advertised as a bioactive dentine substitute, claimed to have better physical and biological properties as compared with MTA and other tricalcium silicate cements. The powder is supplied in 0.7 g capsules, while the liquid is packaged in a pipette with a quantity of 0.18 ml. The powder is mixed with liquid in a capsule for 30 seconds in a triturator. The setting time of Biodentine is around 9–12 min because of the presence of calcium chloride as an accelerator and hydro soluble polymer as a water-reducing agent. The low porosity of Biodentine leads to higher mechanical strength which is lower than both decal and MTA, which is due to the use of the hydrosoluble polymer. Its compressive strength continues to improve to reach more than 200 Mpa at 24 h which increases further. Another advantage is resistance to erosion and microleakage more than MTA and glass ionomer cement. A possible disadvantage of Biodentine is that it displays radiopacity as it contains zirconium oxide.(17) The most common material used for multiple-visit apexification is calcium hydroxide. Although this forms a physiological hard tissue barrier, it also has a few shortcomings like increased chances of root fracture, prolonged treatment time, and coronal microleakage. These factors have motivated clinicians to look for other alternatives. The use of various materials like dentinal chips, hydroxyapatite crystals, Portland cement, calcium sulfate, mineral trioxide aggregate, and dentine enables us to overcome the drawbacks of calcium hydroxide.(18) Mineral trioxide aggregate (MTA), being an osteoconductive apical plug, has made one-visit apexification an increasingly popular procedure. Properties like a good sealing ability, setting in the presence of blood, and biocompatibility make MTA the right candidate for an apical plug. Its high success rates reported in the studies have encouraged its use in immature necrotic permanent teeth. However, it also has certain handicaps such as extended setting time, poor handling, and inflated cost. Therefore, surmounting these issues is a new biomaterial named Biodentine (19). Biodentine has prominent clinical features such as improved sealing ability, enhanced compressive strength, reduced porosity, greater density, bioactivity, rapid formation of calcium hydroxide, biomineralization capability, biointeractivity, and color stability compared to mineral trioxide aggregate. The endodontic implications of dentine are similar to MTA. They thus can be used as a root-end filling material. Nevertheless, there are restricted studies on its use for apexification and comparison of its sealing ability with MTA. To achieve a satisfactory outcome after an apexification procedure, the material must have an excellent apical seal. The sealing ability defines the capability of a material to restrict the microleakage throughout its entire thickness. A deficient apical seal leads to microleakage and is one of the major causes of surgical endodontic failure. Various techniques for assessing microleakage include the utilization of dyes, irradiated isotopes, air under pressure, fluid filtration, bacteria, neutron activation analysis, artificial caries, scanning electron microscopy, and other methods. The aim of the study was to evaluate the apical microleakage of Biodentine and MTA orthograde apical plugs The result of the present study suggest that In the MTA group, mean transmittance on Day 1 81.1 ± 5.41 at 5mm. By Day 2, transmittance 67.28 ± 3.64 at 5mm. On Day 3, transmittance remained relatively stable 68.54 ± 7.70 at 5mm. It indicate maximum saturation occur of 2% methylene blue into 5ml of 35% nitric acid solution In the day of 2-3 . . For the Biodentine group, transmittance on Day 1 was80.35 ± 8.13 at 5mm. By Day 2, values were 80.3 ± 8.78 at 5mm. On Day 3, transmittance remained stable at 82.68 ± 9.16 at 5mm. It indicate maximums saturation occur of 2% methylene blue into 5ml of 35% nitric acid solution In the day of 2-3 of Biodentine. In the control group, transmittance on Day 1 was 58.3 ± 6.87 at 5mm. On Day 2, values were 54.72 ± 5.42 at 5mm. By Day 3, transmittance was 58.71± 7.78 at 5mm. . It indicate maximums saturation occur of 2% methylene blue into 5ml of 35% nitric acid solution In the day of 2-3 across all thickness of control group.

Comparison of microleakage of MTA and Biodentine by thickness of 5mm. At 5mm thickness, MTA had significantly lower transmittance than Biodentine (mean difference = -14.20, $P < 0.0001$) and significantly higher transmittance than the control group (mean difference = 9.800, $P = 0.0036$), while Biodentine showed the highest transmittance among all groups (mean difference = 24.00 compared to the control, $P < 0.0001$).). So microleakage is greater in MTA than Biodentine in 5 mm apical plug thickness. A study was conducted by Nepal M, Shubham S,*et al* (2020) Spectrophotometric analysis evaluating apical microleakage in retrograde filling using GIC, MTA and biodentine: an in vitro study compares the apical microleakage of three different root-end filling materials in which the retrograde cavity is prepared by two different burs. The absorbance of the supernatant solution after dye extraction is decreasing in the order of positive control> GIC > MTA >

Biodentine> negative control group. The significant difference was observed between GIC and MTA (p = 0.0001) and GIC and Biodentine (p = 0.0001) with two different burs but statistically non-significant difference was observed between MTA and Biodentine with Carbide bur (p = 0.127) and Diamond bur (p = 0.496) respectively concluded that Biodentine and MTA showed less microleakage as compared to GIC.(20) Bidhya Thapaliya Monika Verma Koul Vinod Kumar Upadhyay Abhishek Khare (2021). They show Apical microleakage of MTA Angelus (Group A) ranged from 1.30 to 3.10 mm with mean (± SE) 2.16 ± 0.10 mm and median 2.05 mm whereas in Biodentine (Group B) it ranged from 0.20 to 1.20 mm with mean (± SE) 0.68 ± 0.06 mm and median 0.60 mm. Sealing ability of Group B (Biodentine) was significantly better They concluded that biodentine was found to excel in its ability to create a secure seal and function effectively as an apical barrier in simulated young permanent teeth. These results underscore its potential as a highly efficient material for dental applications, particularly in scenarios requiring reliable sealing and barrier formation in the root canal system of developing permanent teeth (21). Considering the studies of Matt, *et al* and Al- Kahtani *et al*, in which 5 mm thick apical plugs showed the best results (22).

CONCLUSION

The observation of the present study was the apical barrier of 5mm demonstrated less microleakage of Biodentine than MTA. Biodentine has better sealing ability than MTA as an apical plug material in single-rooted teeth.

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