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Radiological evaluation of Indirect pulp capping by Biodentine and Mineral Trioxide aggregate (MTA)

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Abstract:
Background*: Keeping the pulp's vitality must be the dentist's first priority. An important precedence in the treatment of deep carious is to preserve pulp vitality.Calcium hydroxide is the gold standard for the pulp capping materials. However in long term clinical studies of pulp capping with calcium hydroxide base materials, failure rates increase after a period of time.As an alternate to calcium hydroxide, Mineral Trioxide aggregate (MTA) has been developed on the basis of calcium silicate water chemistry which contain a mixture of tri-calcium silicate, di-calcium silicate, tri-calcium aluminate, tetra-calcium alluminoferite, calcium sulphate dehydrate and bismuth oxide for radio-opacity.Newly developed Biodentine^{TM}has a number of advantages over calcium hydroxide and MTA. This bioactive tricalcium silicate is diverse from the usual dental calcium silicate “Portland Cement” materials. The setting reaction is a hydration of tricalcium silicate which produces a calcium silicate gel and a calcium hydroxide. In contact with phosphate ions, it creates precipitates that resemble hydroxyapatite. These precipitates from MTA and tricalcium silicate can be incorporated into dentin. A comparison of the calcium and silica uptake with MTA versus tricalcium silicate demonstrated a greater uptake achieved with tri-calcium silicate. There was an increase in the carbonate content of interfacial dentin, which suggested that inter tubular diffusion and mineral tags of Biodentine^{TM} hydration products creating a hybrid zone.Biodentine^{TM} has the good handling properties, short setting time, resistance to acid solubility and improved mechanical properties such as high flexural and bond strength as well as ability to reduce micro leakage. Furthermore, its radio opacity is equivalent to 3.5 mm of aluminum which allow identification on radiographs. It is therefore considered that Biodentine^{TM} can be a comparable replacement for calcium hydroxide and MTA. This practice-based, randomized clinical trial was to evaluate and compare the success of direct pulp capping by the radio graphical the examination of permanent teeth using the MTA (mineral trioxide aggregate) or CaOH (calcium hydroxide) as an indirect pulp capping agent in permanent teeth.*
Materials and Methods*: The Randomized clinical trial was conducted in the Department of Conservative Dentistry and Endodontics, Faculty of Dentistry, BSMMU over period of 12 months from November 2015 to October 2016. Ethical clearance was achieved from the institutional IRB.60 permanent teeth from forty five individuals (age 18 - 40 years) were selected for the study from Department of Conservative Dentistry and Endodontics, BSMMU. The Randomized clinical trial was over a period of 12 months from November 2015 to October 2016. Indirect pulp capping was done randomly by using the Biodentine and MTA respectively in two groups to minimize the allocation bias. Reparative dentin formations were assessed by the post-operative radiographs at a regular interval and comparison were done.*
Results*: At the baseline, none of Biodentineand MTA treated teeth revealed any sign of reparative dentin formation. However, at 3 months observation period, hard tissue-like structure (reparative dentin) was recognized beneath the restoration in 24(80.0%) Biodentine and 21(70.0%) MTA treated teeth. At 6 and 12 months observation period, except in 1(3.3%) Biodentine and 2(6.7%) MTA treated teeth, all cases showed evident of reparative dentin formation. The differences between two groups were not statistically significant ($p>0.05$). Pain assessment was performed according to VAS (Visual Analogue Scale) system. Pulp vitality was assessed by vitality test. Thermal test, both cold and heat test were done. The response was recorded in data collection sheet. The data were presented in the form of tables and statistical analysis of the results was done by using computer based statistical software, SPSS 20.00 version (SPSS Inc. USA). Significant of difference Chi-*

square test was done to compare between two groups and 95% confidence interval (p value<0.05) was followed for testing level of significance.
Conclusion: *The capability of reparative dentin formation by Biodentine™ is similar to that of MTA*
Key Words: *Dental caries, Pulp vitality, Reparative dentin, Bio dentin, MTA, Pulp capping, Radio opacity*

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I. Introduction

Dental caries that cause progressive damage of the tooth structures is the principle threat to the health of the dental pulp. The damage can convert the reversible pulp to irreversible state. Concepts and treatment principles of deep carious lesions are an area of debate and constant change.[1]The conventional concept of entire caries removal in very deep preparation has been challenged.[2] Absolute carious dentin removal may not be a prerequisite to seize caries progression. It is well recognized that bacteria in the dentinal tubules cause pulpal inflammation. This inflammation process may promote the pulp regeneration.[3]

Keeping the pulp's vitality must be the dentist's first priority. An important precedence in the treatment of deep carious is to preserve pulp vitality.[4] Conservative pulp management is potentiality to reduce a more invasive endodontic treatment.[5,6,7] The repair capacity of pulp tissue after removal of carious lesion without pulp exposure is expected to occur. However after pulp exposure, such conservative treatment is questionable and unpredictable.

The search for the ideal vital pulp therapy material has led researchers to investigate many different materials. These include calcium hydroxide compound, zinc oxide, calcium phosphate, zinc phosphate and polycarboxylate cements, calcium tetracycline chelate, antibiotic and growth factor combination, calcium phosphate ceramics, Emdogain, Bioglass, cyanoacrylate, hydrophilic resins, hydroxyapatite, resin-modified glass ionomer, MTA and Biodentine.[8,9,10] But unfortunately so far no material has been developed that can fulfill all the requirements of a suitable pulp capping agent.[11]

Calcium hydroxide is the gold standard for the pulp capping materials. It allows for the formation of reparative dentin bridge through cellular differentiation, extracellular matrix formation and subsequent mineralization.[12, 13]It protects the pulp against thermo electrical stimuli and has an antimicrobial action.[14] However in long term clinical studies of pulp capping with calcium hydroxide base materials, failure rates increase after a period of
time.[15-19]

As an alternate to calcium hydroxide, Mineral Trioxide aggregate (MTA) has been developed on the basis of calcium silicate water chemistry which contain a mixture of tri-calcium silicate, di-calcium silicate, tri-calcium aluminate, tetra-calcium alluminoferite, calcium sulphate dehydrate and bismuth oxide for radio-opacity.[20-22]

Many studies have been revealed that MTA shows markedly lower to no cytotoxic effects, protection against microleakage by synthesis mineralized dentin interface similar to that of biological hydroxy appetite, induce secretion of reparative dentin formation and pulp healing, sealing ability, alkaline pH when set that is the potent inhibitor of bacterial endotoxin and slowly release of calcium ions and these also clinically better results than other chemical material.[23, 24, 25] It is also radio-opaque,[26] remains intact even in acidic environment[27] and is able to activate cementoblast and cementum.[26] Furthermore, MTA has no reaction with other dental materials[28] and is very friendly with periradicular tissue. Despite the many advantages of MTA, it has some drawbacks such as a long setting time (around 3 hours), less compressive and flexure strength, non-bonding to enamel and dentin and causes discoloration of teeth.

Newly developed Biodentine™has a number of advantages over calcium hydroxide and MTA. This bioactive tricalcium silicate is diverse from the usual dental calcium silicate “Portland Cement” materials. The setting reaction is a hydration of tricalcium silicate which produces a calcium silicate gel and a calcium hydroxide. In contact with phosphate ions, it creates precipitates that resemble hydroxyapatite. These precipitates from MTA and tricalcium silicate can be incorporated into dentin. A comparison of the calcium and silica uptake with MTA versus tricalcium silicate demonstrated a greater uptake achieved with tri-calcium silicate. Furthermore, there was an increase in the carbonate content of interfacial dentin, which suggested that inter tubular diffusion and mineral tags of Biodentine™ hydration products creating a hybrid zone. Burgess and coworkers characterized this hybrid zone as being microleakage free.[29,30]

Biodentine™ has the good handling properties, short setting time, resistance to acid solubility and improved mechanical properties such as high flexural and bond strength as well as ability to reduce microleakage. Furthermore, its radiopacity is equivalent to 3.5 mm of aluminum which allow identification on radiographs. It is therefore considered that Biodentine^{TM} can be a comparable replacement for calcium hydroxide and MTA.

This practice-based, randomized clinical trial was to evaluate and compare the success of direct pulp capping by the radio graphical the examination of permanent teeth using the MTA (mineral trioxide aggregate) or CaOH (calcium hydroxide) as an indirect pulp capping agent in permanent teeth.

II. Materials and Methods

This study was conducted in the Department of Conservative Dentistry and Endodontics, Faculty of Dentistry, BSMMU over period of 12 months from November 2015 to October 2016. The anticipated study was presented in front of the Ethical Review Committee, BSMMU and ethical clearance was achieved. Informed signed written consent were taken from the patients prior to the commencement of the study.

Study design: Randomized clinical trial.

Sample size: For the study sixty (60) permanent teeth from forty five individuals (age 18 - 40 years) were selected for the study from Department of Conservative Dentistry and Endodontics, BSMMU.

Inclusion criteria: For the study the patients were selected that met the inclusion criteria such as

1. Permanent teeth having deep carious lesion which is closer to but not involving the pulp.
2. Teeth having reversible pulp status based on clinical sign, symptom.
3. The radiographs should be restorable.

Procedure methodology: The 60 teeth were randomly allocated into two groups. In Group A& B, indirect pulp capping was done randomly by Biodentine and MTA, respectively to minimize the allocation bias. A written informed consent was taken from every patient. Verbal data was collected. The pulp vitality test, palpation and percussion tests were performed in standard procedure and radiograph was examined to assess the pulpal health for each patient. Symptoms, clinical signs of the patients and a detailed medical and dental history were recorded in a prefixed data collection sheet and radiograph was taken for each case. The radiographs were examined by the same evaluator and recorded in the data collection sheet. Proper counseling was done by informing the patients about the treatment procedure, its benefit and cost.

At first mouth preparation was performed by removal of plaque and calculus.Biodentine^{TM} (Septodont, Saint-Maur-des-Fossés, France) was mixed according to the manufacturer's instruction as follows: the liquid from single ampule was poured in the capsule and the capsule was triturated for 30 sec. The freshly mixed Biodentine^{TM} had a putty-like consistency and carried to the operative site with help of amalgam carrier and adapted to the underlying dentine up to 3 – 5 mm thickness with buck nun plugger or cotton pellet followed by Fuji-IX glass ionomer and composite resin restoration (Giomer) to replace the enamel. Occlusion was checked for any high spots. Then post-operative radiograph was taken as base line radiograph.

MTA (Proroot, Dentsply, Tulsa Dental, Tulsa, OK, USA) powder was mixed with sterile water in a 3:1 ratio, according to the manufacture recommendation and placed on the operative site with amalgam carrier up to 2-3 millimeter thickness and applied by light pressure with moist cotton pellets. A damp cotton pellet was placed over MTA and then sealed with a temporary cement to allow for final set of the MTA. The patient was recalled at 2nd visit within 12 to 48 hours and following removal of the temporary cement and cotton, MTA was examined to ensure that it set hard and the tooth was restored with composite restoration (Giomer) to replace enamel. Occlusion was checked for any high spot. Then post-operative radiograph was taken as base line radiograph. Patients were advised to maintain oral hygiene instructions and avoid taking any analgesics in case of mild pain during follow up period. The patient was recalled for clinical and radiological evaluation at 3, 6 and 12 months interval.

Pain assessment was performed according to VAS (Visual Analogue Scale) system. Pulp vitality was assessed by vitality test. Thermal test, both cold and heat test were done. The response was recorded in data collection sheet. The data were presented in the form of tables and statistical analysis of the results was done by using computer based statistical software, SPSS 20.00 version (SPSS Inc. USA). Significant of difference Chi-square test was done to compare between two groups and 95% confidence interval (p value<0.05) was followed for testing level of significance.

III. Results

The results of assessment of conduction of reparative dentin were assessed. It was found that at the baseline, none of Biodentineand MTA treated teeth revealed any sign of reparative dentin formation. However, at 3 months observation period, hard tissue-like structure (reparative dentin) was recognized beneath the restoration in 24(80.0%) Biodentine and 21(70.0%) MTA treated teeth. At 6 and 12 months observation period, except in 1(3.3%) Biodentine and 2(6.7%) MTA treated teeth, all cases showed evident of reparative dentin formation. The differences between two groups were not statistically significant ($p>0.05$).

IV. Discussion

In this study, reparative dentin by Biodentine and MTA as indirect pulp capping agents were verified in vivo. Thirty permanent molar teeth were treated by Biodentine (Group-A) and the remaining 30 permanent molar teeth were subjected to MTA (Group-B) therapy. All teeth in both groups evaluated clinically and radiographically at 3, 6 and 12 months interval.

Biodentine reduces pain is due to its high alkalinity, biocompatibility, early mineralization.[31] It can full fill all the requirements of perfect pulp capping material such as to adhere or bond to tooth tissue, be dimensionally stable, unaffected by moisture in either the set or unset state, be well tolerated by pulpal tissues with no inflammatory reactions, stimulate the formation of reparative dentin and be nontoxic both systemically and locally.[32] In a study Biodentine showed substantial performance as a pulp capping material even after being exposed to various endodontic irrigants as compared to MTA.[33] On the other hand, previous studies have reported that MTA can reduce pain due to its high p^H as well as antibacterial activity[34], outstanding biocompatibility and encourage mineralization.

The results of the study revealed that at 3 months, 24 (80%) Biodentine and 21 (70%) MTA treated teeth showed the reparative dentin formation radiologically (IOPA). The remaining 6 (20%) Biodentine and 9 (30%) MTA did not clearly evident the reparative dentin formation.[35-38] The reason might be due to have the radiographic beam not always absolutely perpendicular to the axis of the tooth and the exposure site at the same time that was also reported in NajatFersi et al.[39] The conduction of reparative dentin can early and easily identify in histological studies which was not performed in the present study.

Reparative dentin formation at 6 and 12 months observation period it was found that 29 (96.7%) Biodentine and 28 (93.3%) MTA treated teeth showed reparative dentin formation. It can be considered that good clinical success rate related to the thickness of the newly formed dentin. As the thickness of newly formed dentin was not evaluated in the present study, but in a study Stanly et al.[40] showed that the thickness of the dentin bridge reached up to 0.5 mm after 6 months. Furthermore,Benoist et al. indicated that the mean initial residual dentin was 0.23 mm, and increased by 0.12 mm with MTA at 3 months. At 6 months, there was an increase of 0.23 mm with MTA group. Previous study indicated that both MTA and Biodentine have good sealing ability when used for pulp capping.[41] On the other hand, Biodentine showed a markedly higher release of free calcium ions, higher alkalinizing capability, and the formation of smaller calcium phosphate deposits. Moreover, Biodentine demonstrated lower apparent porosity, volume of open porosity, and water absorption. The ability to release calcium is a key factor for successful pulp capping therapies because of the action of calcium on mineralizing cells (osteoblasts, cementoblast, pulp cells, and odontoblasts) differentiation and hard tissue mineralization.[42]

However,Moretton, T. R. et. al. [43] also suggested that MTA is osteoconductive in indirect pulp capping therapy that stimulates the production of mineralized tissue in areas where this tissue is normally present, indirectly as a part of stereotypic wound healing mechanism. The formation of dentin adjacent to the MTA occurs due to its sealing ability, which prevents microleakage, to its biocompability, alkalinity or due to other properties such as the capacity to stimulate cytokine release by the hard tissue forming cells. On the other hand Biodentine is known as bioactive materials that are able to bond to the living bone tissue by inducing an osteogenic response through the stimulation and activation of osteoblasts. These studies showed that pulp capping by Biodentine or MTA were successful both in clinical and radiological examinations.

V. Conclusion

It can be concluded that capability of reparative dentin formation by Biodentine™ is similar to that of MTA.

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VI. Table & Figures

Comparison of reparative dentin formation between two groups (n=60 teeth in each group).

Reparative dentin formation status evaluation period	Group A (n=30 teeth)		Group B (n=30 teeth)		p value
	No	%	No	%	
Baseline					
Present	0	0.0	0	0.0	ns
Absent	30	100.0	30	100.0	

After 3 months					
Present	24	80.0	21	70.0	0371^{ns}
Absent	6	20.0	9	30.0	
After 6 months					
Present	29	96.7	28	93.3	0.553^{ns}
Absent	1	3.3	2	6.7	
After 12 months					
Present	29	96.7	28	93.3	0.553^{ns}
Absent	1	3.3	2	6.7	

P value is determined by Chi-square test, ns=Not significant, n = Number of samples.
Group A = Biodentine, Group B = MTA

List of the Figuresof Post treatment radiographs

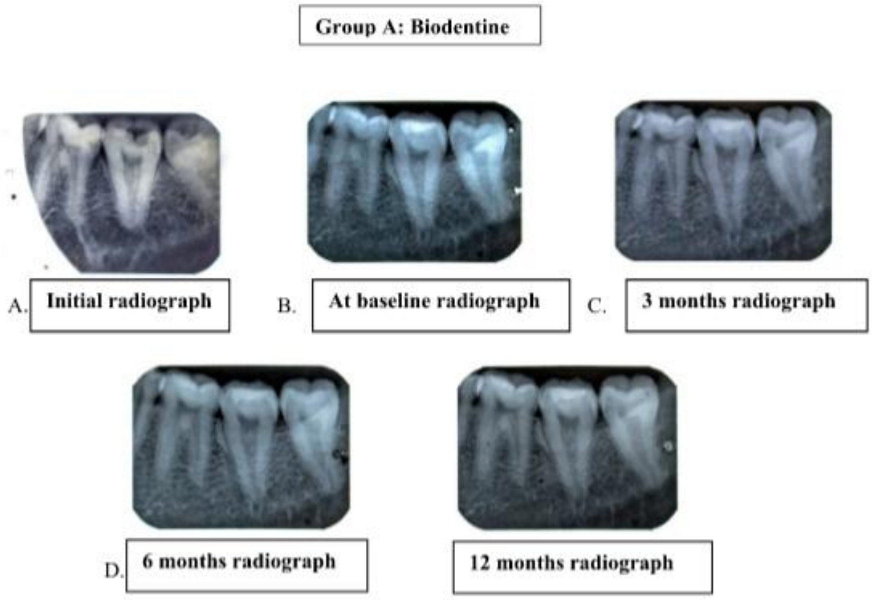

Fig-1: Radiographs showing conduction of reparative dentin by Biodentine.

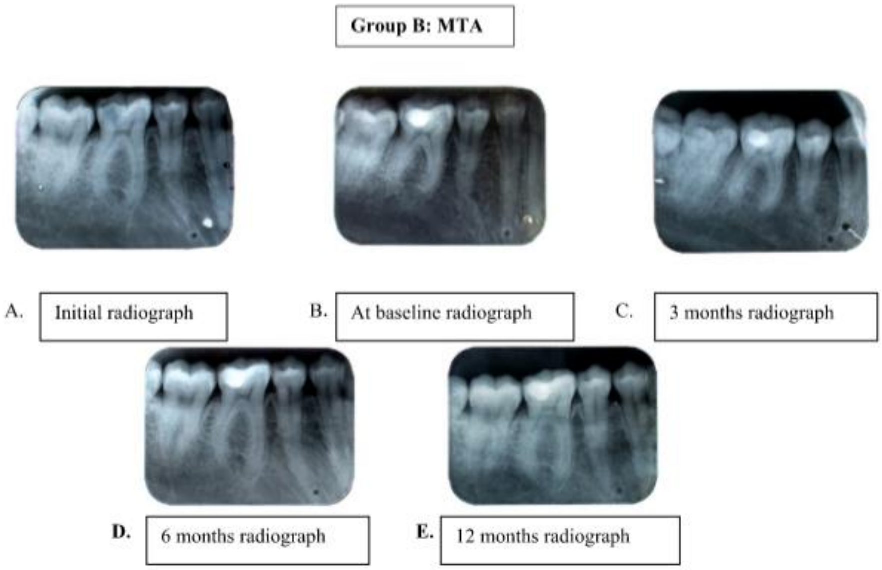

Fig-2: Radiographs showing conduction of reparative dentin by MTA

List of the Figures of the materials used for the treatment purpose

Group A: Biodentine

Fig 1.a: Biodentine, France (Septodent)

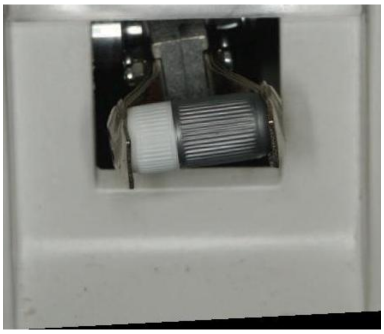

Fig 1.b: Mixing device

Group B: MTA

Fig 2.a: MTA

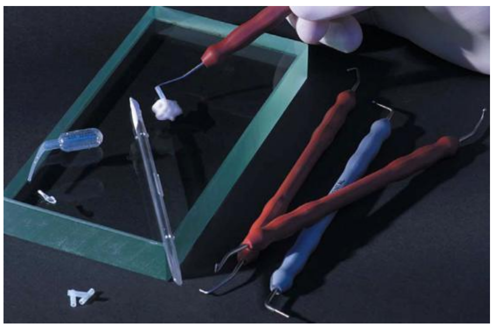

Fig 2.b: Mixing of MTA (Powder: Water-2:1

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