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In Vivo Evaluation of Various Restorative Materials as an Alternate to Crown Coverage of Endodontic Treated Teeth.

Ruchi Gupta[1], Anil K Tomer[2], Sushma Kumari[3]
1 Professor, Dept of Conservative Dentistry and Endodontics, Divya Jyoti College of Dental Sciences and Research, Modinagar, Ghaziabad
2 Professor and Head, Dept of Conservative Dentistry and Endodontics, Divya Jyoti College of Dental Sciences and Research, Modinagar, Ghaziabad
3 PG Student, Dept of Conservative Dentistry and Endodontics, Divya Jyoti College of Dental Sciences and Research, Modinagar, Ghaziabad
Corresponding Author: *Dr Ruchi Gupta*
Professor, Dept of Conservative Dentistry and Endodontics, Divya Jyoti College of Dental Sciences and Research, Modinagar, Ghaziabad

Abstract
To evaluate various restorative materials as an alternate to crown coverage of an endodontically treated teeth. The specimens were randomly divided into four groups and restored with different post operative restorative materials.Group I Biodentine, Group II MTA Angelus, Group III MTA White & Group IV MTA Plus after endodontic treatment. The characteristics of the restoration, including anatomic form of the restoration, marginal adaptation, marginal discoloration, surface roughness, secondary decay and postoperative pain were analysed. It was concluded that biodentine is the best material of choice for core build material.

Key words: *Root canal treatment, Biodentine, Mineral trioxide, Crown, Post obturation, Restoration.*
Clinical significance - Biodentine is the best material of choice for core build material

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I. Introduction

The restoration of endodontically treated teeth remains a challenge. Diverse opinions remain about clinical procedure and materials to be used to restore these teeth, once fracture occur. The success of the final restoration depends mostly on the structure of the remaining tooth structure. Although the materials and procedures available today result in successful restoration of root-filled teeth via direct techniques, one should first consider the amount of the coronal tooth structure remaining as well as the functional requirements. Endodontically treated teeth have reduced coronal and radicular tissue as a result of dental caries, operative procedures, intra-radicular procedures, previous restorations and restorative procedures that require extensive reduction of the tooth lead to further tissue loss.[1] Cavity preparations lead to dental tissue loss, reducing the fracture strength of the remaining dental structure. Preserving a sound tooth structure should be the dentist's main goal and a conservative approach should be taken to protect the remaining tissue. Restoration using direct composite resin is a good treatment option, but polymerization shrinkage is one of the major limitations of this material. The application of various base materials under the composite resin is an effective method.[2] Covering the cusps with the restorative material is another option to save the remaining tooth structure; however, some materials may be unsuitable in stress-bearing areas. Materials applied to the orifice of a root canal also have a major effect on tooth biomechanics.

In an effort to simplify clinical procedures, simplified dental adhesives, bulk-fill flowable base materials and bulk-fill resin restorative materials have been developed. Based on the results of randomized controlled studies, these low and high viscosity (sculptable) materials have proved successful; however, information regarding their performance in restoring root-filled teeth is lacking. One of these products, namely stress-decreasing material (SureFil SDR Flow; Dentsply, York, PA), was developed in an attempt to modify the dynamics of the polymerization reaction by slowing the polymerization rate.[3]

Intra-coronal barriers generally are used if immediate restoration of the tooth is not possible. Intra-orifice barriers strengthen the fracture resistance of endodontically treated teeth compared with root-filled teeth.[4] GICs, fissure sealants, conventional and flowable composite and mineral trioxide aggregate(MTA) may be used for this purpose. The techniques used for creating monoblock units in the endodontics has been already reviewed.[5] Although the creation of these monoblocks in endodontically treated teeth seems practically difficult, several researchers reported the positive effects of monoblock units in terms of stress distribution and

fracture strength resistance. The elastic modulus of MTA is reported to be similar to that of dentin.[6] Therefore, replacing the missing dentin structure with MTA appears to be an effective way to create successful post endodontic restorations.

MTA is basically a mechanical mixture of three powder ingredients: portland cement (75%), bismuth oxide (20%) and gypsum (5%) . According to MTA patent, it consist of calcium oxide (50-75 wt %) and silicon oxide (15-20 wt %), which together constitute 70-95% of the cement. Upon blending of these raw materials; tricalcium silicate, dicalcium silicate, tricalcium aluminate, tetracalcium aluminoferrite are produced . There are two commercial types of MTA: grey and white and the difference lies due to the presence of iron in the former which further forms the tetracalciumalumino-ferrite phase. On the contrary, there is absence of oxide of iron in white.now a days other types of MTA ia also available such as MTA PLUS and MTA Angelius . In 2001, MTA Angelus (MTA-A) was introduced as an alternative to ProRoot MTA and used in certain regions with its lower price. The chemical difference between ProRoot MTA and MTA-A is that MTA-A lacks calcium sulfate dehydrate as one of its main compounds, resulting in that MTA-A has shorter setting time than ProRoot MTA (165 minutes for ProRoot MTA, while 10 minutes for MTA-A).MTA-A is less radiopaque than ProRoot MTA due to the lower content of bismuth oxide in its composition.[7] A novel MTA material called MTA-Plus (MTA-P), which is claimed to have a finer particle size than the currently available MTA products that has been introduced on the market.

A new calcium-silicate restorative material was produced under the trademark Biodentine (Septodent, Lancaster, PA). The manufacturer introduced this product not only as an endodontic repair material but also as a replacement for coronal dentin. Its adhesion to the dentin surface was found to be superior to that of both GICs and MTA. Biodentine performed similarly to GICs.[8] Although this material was found to be weak in its early phases, Biodentine seems promising as a coronal restorative material. Its good sealing properties, high compressive strengths and a short setting time are suggestive of its potential as a restorative material.[9] Biodentine is available in the form of a capsule containing the ideal ratio of its powder and liquid. The composition of powder is given in while the liquid contains calcium chloride which act as an acclerator, hydrosoluble polymer function as water reducing agent and water.[10]

Restoration of endodontically treated teeth is a common procedure. Although crown restoration has been suggested as a mean to strengthen a tooth after endodontic treatment, tooth fracture have been unavoidable despite the crown placement.[11] Hence, an in vivo study was carried out to determine whether advanced restorative materials would be an alternate to crown coverage. The present study evaluated various materials as an alternate to crown coverage of an endodontically treated teeth.

II. Methodology

Forty patients with intact non-carious mandibular molars were selected for this invivo study. To achieve standardization and to minimize the influence of variations in size and shape on the results, the teeth were selected based on their mesidistal dimensions.All the teeth were subjected to access cavity preparation. The canals of all the experimental teeth were prepared to a size F1 proTaper Rotary file system (Dentsply,Mumbai,India) and was obturated with the respective Protaper gutta percha(Dentsply,Mumbai,India) with AH Plus(DeTrey,Switzerland) sealer. The specimens were randomly divided into four groups (n = 10) and restored with different post operative restorative materials.

Group I Biodentine (Septodent, PA, USA)
Group II MTA Angelus (Angelus ,Londrina ,Brazil)
Group III MTA White (Angelus ,Londrina,Brazil)
Group IV MTA Plus (Avalon Biomed inc.Bradenton,FL,USA)

All four different materials are used as an alternate to crown . Biodentine is a high purity Ca3SiO5-based dental material(Laboratoires Septodont, Saint-Maur, France) composed of a solid part containing tricalcium silicate (3CaO·SiO2),calcium carbonate (CaCO3) and zirconium oxide (ZrO2) and a liquid part containing calcium chloride (CaCl2·2H2O), and a water reducing agent.Both parts were provided in single-dose units. Five drops of liquid were added to the powder single unit. After mixing 30 s at 4,000–4,200 rpm, Biodentine was applied as such without requiring any surface treatment. Same way other materials like MTA Angelius MTA White and MTA Plus are mixed according to manufacturer instructions. A control radiograph was taken after the procedure. Follow-up visits were scheduled and included a clinical evaluation and a radiographic examination.

Furthermore the characteristics of the restoration, including anatomic form of the restoration, marginal adaptation, marginal discoloration, surface roughness, secondary decay and postoperative pain were analysed. The criteria was selected from the USPHS. The following scoring scales were used for these evaluations:

– Consistency, working time, adhesion to instruments, ease of handling (0 to 3): 00 very satisfying; 10 satisfying;2 0 unsatisfying, 30 very unsatisfying.

– Anatomic form (0 to 3): 00 restoration is continuous with existing form; 10 restoration is discontinuous,without exposure of the dentine or base; 20 part of restoration missing, enough to expose the dentine; 30 partial or total restoration loss, fracture, traumatic occlusion, pain in tooth or surrounding tissue. A score above 1 was considered clinically unacceptable.
– Marginal adaption (0 to 4): 00 complete adaptation of the restoration to the tooth, no visible marginal defects;10 significant defects, but no dentine exposure; 20 significant marginal defects with dentine exposure; 30 fractured and mobile restoration, insufficient material;40 restoration mobile, fractured or lost. A score above 2 was considered clinically unacceptable.
– Marginal discoloration (0 to 3): 00 no discoloration; 10 slight discoloration; removed with polishing; 20 obvious discoloration; not removable with polishing; 30 considerable discoloration. A score above 2 was considered clinically unacceptable.
– Surface roughness (0 to 3): 00 smooth surface; 10 slightly rough; 20 rough; no new finish allowed; 30 deep pitted surfaces, irregular fissures. A score above 1 was considered clinically unacceptable.
– Secondary caries (0 to 1): 00 no evidence of marginal caries; 10 visible marginal caries. A score of 1 was considered clinically unacceptable.
– Post-operative pain (0 to 2): 00 no pain; 10 acceptable pain; 20 unacceptable pain. A score of 2 was considered clinically unacceptable.
The results of the study were evaluated statistically.

III. Result

After placement of the restorations, all products received good scores for material handling between 0 and 1, i.e., very satisfactory and satisfactory (Table 1 & Table 2). The consistency score was statistically superior for Biodentine compared to MTA Angelius, MTA white, MTA plus. The characteristics of the restoration in place, including anatomical form, marginal adaptation and postoperative pain were rated as very satisfying by the mean scores near 0.

During the follow-up period, product performance was evaluated at each visit. The anatomic form score remained very satisfactory for the majority of patients with biodentine restorations throughout the study. In MTA Angelius group, the product achieved acceptable scores up to 6 months after the restoration for the anatomic form, the marginal adaptation while MTA white and MTA Plus show only upto 3 months. The difference at 3.6 months and at 1 year between all the four groups was statistically significant .

At the time of the analysis, biodentine demonstrated better scores for anatomic form, marginal adaptation and proximal contact than mta white and mta plus at the 6-month visit. This situation was con-firmed at 1-year visit. During the follow-up of the first three cases, it appeared that surface was abraded and required an additional restoration . At the interim evaluation, results showed that 5 cases underwent an additional restoration. Twenty-five percent of cases occurred before the 3-month visit, 40% between 3 months and 6 month and 66% after 1 year.The evaluation of anatomic form, marginal adaptation, the resistance to marginal discoloration, surface roughness, the absence of secondary caries, and post-operative pain yielded very satisfactory scores throughout the study in case of biodentine. Marginal discoloration and surface-roughness scores remained very satisfactory in both biodentine , MTA Angelius through-out the study while in case of MTA white and MTA plus it was more . There was one case of secondary caries reported at M6 in the mta white due to the restoration loss 2 months prior to the visit.

	Biodentine	MTA Angelius	MTA White	MTA plus
Consistency	**0**	**0**	**1**	**0**
Working time	**0**	**1**	**1**	**0**
Non adhesion to instrument	**0**	**1**	**2**	**0**
Ease of handling	**0**	**1**	**1**	**1**

Table 1:Material performance of the restoration

	BIODENTINE	MTA ANGELIUS	MTA WHITE	MTA PLUS
Anatomic form	**0**	**0**	**1**	**0**
Marginal adaptation	**0**	**1**	**2**	**1**
Interproximal contact	**1**	**1**	**2**	**1**
Marginal discolouration	**0**	**0**	**2**	**1**
Surface Roughness	**0**	**1**	**2**	**0**
Secondary caries	**0**	**0**	**1**	**0**
Postoperative pain	**0**	**0**	**1**	**0**

Table 2 : Clinical evaluation of the restoration

MTA White showed stastically significant difference in consistency ,working time and easy of handling while MTA Angelius, MTA White showed stastically significant difference in non - adhesion to instrument .In marginal adaptation score upto 3months MTA White showed stastically significant difference while MTA Angelius and MTA Plus showed stastically significant difference upto 6 months .In marginal discolouration score upto 3 month MTA White showed unacceptable score with stastically significant difference while MTA Plus and MTA Angelius showed stastically significant difference upto 6 to 12months . In surface roughness and anatomic form score stastically significant difference was there in MTA White upto 3 months while 6 to 12 months MTA –A ,MTA-W, MTA-P showed stastically significant difference. In secondary caries and postopervative pain score upto 3 to 6 months there was stastically non significant difference in all the four groups while after 12 months there was stastically significant difference.

IV. Discussion

The decrease in fracture resistance of all occlusal cavity preparations in proportion to the width of the preparation has been established in restorative dentistry. Similar concept was later suggested to endodontics, stating that the cuspal deflection was proportionally greater with the increase in cavity size and was greatest in the presence of an endodontic cavity. The remaining coronal tooth structure and functional requirement are crucial in deciding the type of restorative material and the technique to restore endodontically treated teeth.

The structural integrity of teeth in nonvital and root canal treated teeth is lost, which may contribute to tooth fracture.[12] The largest reduction in the tooth stiffness results from additional preparation, especially the loss of marginal ridges.

In recent years, a modified endodontic cavity concept with minimal tooth structure removal intended to improve fracture resistance of root- filled teeth has arrived. The remaining dentin thickness offers a sound base required for tooth restoration. Its structural strength depends on the quality and integrity of its anatomic form, hence the key problem is the decreased quantity of sound dentin remaining to retain and support the restoration. Therefore, selecting an appropriate restorative material and technique to compensate for the loss of coronal tooth structure is fundamental to restorative success.[13]

The present study was designed to evaluate whether an alternate to crown coverage can be considered in strengthening an endodontically treated tooth mimicking an extensive loss of crown structure due to caries. Considering the functionary requirement and placement of the tooth in the arch, mandibular molars were selected for this study.

Biodentine was one of postendodontic restorative material chosen as it is considered a dentine substitute. It sets within 12 min, which facilitates its use in immediate crown restoration. Its properties such as elastic modulus, compressive strength and micro hardness is very similar to that of natural dentin. It exhibits good bacterial tight seal with the margins of the tooth structure.[14]

The reaction of the powder with the liquid leads to the setting and hardening of the cement. Just after mixing, the calcium silicate particles of Biodentine react with water to from a high pH solution containing Ca2+, OH- and silicate ions. The hydration of the tricalcium silicate leads to the formation of a hydrated calcium silicate gel on the cement particles and calcium hydroxide nucleates[6]. With the passage of time, calcium silicate hydrated gel polymerizes to form a solid network and the alkalinity of the surrounding medium increases due to the release of calcium hydroxide ions. Further the hydrated calcium silicate gel surrounds the unreacted tricalcium silicate particles and due to its relatively impermeable nature to water, it helps in slow down the effects of further reactions .

The presence of setting accelerator in Biodentine results in faster setting thereby improving its handling properties and strength. This is an advantage over MTA, since a delayed setting time studied by Torabinejad M et al, leads to an increased risk of partial material loss and alteration of the interface during the finishing phase of the procedure . Therefore, Biodentine has a great improvement compared to MTA in terms of setting time .

The hydration reaction during setting occurs between tricalcium silicate and dicalcium silicate to form a calcium hydroxide and calcium silicate hydrate gel, producing an alkaline pH. A further reaction between tricalcium aluminate and calcium phosphate forms a high-sulphate calcium sulphoaluminate. The calcium ions leach through the dentinal tubules, and the concentration increases with time as the material cures.

A finite element analysis study was conducted by Zelic *et al*. to determine weakening of the tooth regarding extent of access cavity preparation. They concluded that access cavity preparation had the greatest influence on tooth strength while canal enlargement did not contribute to this process significantly. Furthermore, in a study by Koubi *et al*. Biodentine was used as a posterior restoration and revealed satisfactory surface properties such as good marginal adaptation until 6 months and later covered by a surface layer of composite and concluded that Biodentine can be used as a dentine substitute under composite for posterior restorations.. The statistical results of the study demonstrated lower fracture resistance than the control and experimental groups, but the mean value was at par with the bite force values as demonstrated by Regalo *et al*. Franquin J-C et al., claimed that Biodentine have compressive strength value of 316.3 MPa after 28 days.

There are some studies which are against this also S.Dayalan concluded that biodentine is bioactive materials can enhance healing, when placed near biological tissues.We found that it is not an able substitute for core build-up materials in terms of physical properties. Jang Y-E et al., studied the physical properties of Biodentine and affirms that the compressive strength to be 61.35±5.09 N which is much inferior to what Franquin J-C et al., claimed in his study. Study conducted by Lucas CD et al., also exhibited inferior mechanical properties for Biodentine

In the present trial, Biodentine received good rates for material handling and performance after restoration placement. Two evaluation criteria with excellent ratings for all materials were absence of post-operative pain and secondary decay.In our study almost all patients analysed were free of post-operative pain. Only one case of secondary caries was reported in the MTA White group after a 1-year follow-up. This case was due to the loss of the material. No other adverse events were observed after Biodentine application. Another common problem observed in posterior composite restorations is marginal discoloration .We found that Biodentine had significantly better scores for this characteristic compared to MTA White ,MTA Plus,MTA Angelius.

This was the clinical trial evaluating the performance and safety of Biodentine, a new dentine substitute composed mainly of tricalcium silicate, MTA Angelius, MTA White ,MTA Plus. The biocompatibility of these material was recently proven in vitro and in vivo studies . Importantly, the material did not affect human pulp fibroblast specific functions such as mineralization, as well as expression of collagen I, dentine sialoprotein and Nestin . Biodentine may enhance the repair and pulp healing in case of partial impairment of the odontoblastic layer[6]. Given the mechanical properties of Biodentine, we expected it to be a posterior restorative material in clinical situations where the evaluation of pulp healing is required before a definitive restoration.

One of the main limitation of biodentine is that its not available in shades like composite so satisfying esthetically patient is very difficult; .to overcome this limitation we can add thin layer of composite over biodentine.

At this interim analysis, BIODENTNE had better scores for anatomic form, marginal adaptation and surface discolouration than MTA Angelius ,MTA White and MTA PLUS at the 6-month recall. This situation was confirmed at the 1-year recall. Moreover, during the follow-up of the first cases, it appeared that some abrasion process occurred on Biodentine restorations for 25% before 6 months and 30% between 6 months and 1 year. Although the deficiencies of marginal adaptation required a new restoration, no marginal discoloration occurred. Regarding handling properties and behavior in stress bearing conditions of posterior teeth, Biodentine can be successfully used as a posterior restoration material for up to 12 months. At this time, abrasion is the main degradation process without any marginal discoloration. Thus, the clinical relevance of this study is the ability to use Biodentine as a dentine substitute under a composite for posterior restoration

V. Conclusion

Under the limitation of this invivo study it was concluded that biodentine MTAangelius is the best material and showed superior property than MTA plus but because of dentine substitute property, less setting time, maximum compressive strength biodentine is the best material of choice for core build material in cavities with 1.5cm circumference.

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