OPEN ACCESS
Saudi Journal of Medicine
Abbreviated Key Title: Saudi J Med
ISSN 2518-3389 (Print) |ISSN 2518-3397 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: http://scholarsmepub.com/sjm/

Original Research Article

Evaluation of Fractured Resistance Using MTA & Biodentin in Apexification v/s Obturation in Simulated Immature Teeth- An In-Vitro Study

Dr. Mohammed Mustafa[1*], Dr. Kahamnuk Jamatia[2], Dr. K. Premnath[3], Dr. Thouseef Ch[4], Dr. Shazia Salim[5], Dr. Alen Pius[6]

[1]Associate Professor, Department of Conservative Dental Sciences, College of Dentistry, Prince Sattam bin Abdulaziz University, AlKharj - 11942, Saudi Arabia
[2]MDS, OMFS, Asst Professor, Dept of dentistry, AGMC & GBP Hospital, Agartala, Tripura, India
[3]Professor, Department of Prosthodontics, KGF College of Dental Sciences, KGF, Karnataka, India
[4]Senior Lecture, Department of Conservative Dentistry & Endodntics, Malabar Dental College & Research Center, Malappuram, Kerala, India
[5]Assistant Professor, Department of Conservative Dentistry and Endodontics, Mahe Institute of Dental Sciences and Hospital, Pondicherry University, Chalakkara, Pallor, 673310
[6]Assistant Professor, Dept. of Conservative Dentistry & Endodontics, PSM Dental College Akkikavu Thrissur Kerala, India

DOI:10.21276/sjm.2019.4.7.3 | **Received:** 03.07.2019 | **Accepted:** 10.07.2019 | **Published:** 20.07.2019

***Corresponding author:** Dr. Mohammed Mustafa

Abstract

Aim and Objectives: The aim of the study is to evaluate the effect of single visit apexification versus complete obturation with Mineral Trioxide Aggregate and Biodentine on the fractured resistance of simulated immature teeth. ***Material and Method:*** Forty five freshly extracted non-carious maxillary central incisors with single canal were selected. The apical 5mm of each tooth was then removed, access cavity preparation followed by preparation using peeso reamers was done to simulate Cvek's stage 3 of root development. Irrigation protocol was carried out followed by randomization of samples and then canals were obturated using different materials. Fracture testing was done under universal testing machine and the ultimate load to fracture was recorded in Newtons. ***Statistical Analysis:*** Statistical analysis was done using SPSS 20.0 Software. One way analysis of variance followed by pair wise comparison of the groups was performed using Tukey's post hoc test. The level of significance was set at 95% ($p < 0.05$). ***Results:*** All the experimental groups had a statistically higher value of fracture resistance than the control groups. Group I (entire canal obturated with MTA) showed highest value of fracture resistance followed by group III (entire canal obturated with biodentine), group II and group IV. ***Conclusion:*** Reinforcing immature teeth with bioactive materials such as MTA and biodentine is advantageous for apexification. ***Clinical Significance:*** Full MTA obturation clinically in patients might produce high success rate of apexification as compared to MTA and Biodentine apical plug and gutta percha obturation.

Keywords: Apexification, Biodentine, Mineral Trioxide Aggregate, Obturation.

INTRODUCTION

Trauma to the anterior dentition during the young age is the most common cause for pulpal necrosis and cessation of root development. The management of such cases is both an endodontic and restorative challenge because of open apices and weak dentinal walls which predispose such teeth to root fractures at the cervical dentin.[1] The ideal treatment strategy recommended is regenerative endodontic protocol as it promotes hard tissue formation and leads to continued root development. But in cases where regenerative procedure is not an indication or possibility, alternative treatment approaches such as apexification should be considered.[2] Apexification with long term calcium hydroxide is known to have a success rate of 79-96%.However, the unpredictable time for apical barrier formation, increased brittleness of the tooth and susceptibility to root fractures are its major disadvantages.[3,4,5] To overcome these disadvantages various bioactive materials with superior properties such as sealing ability, antibacterial and osteogenic potential have been advocated for single visit apexification.[6] MTA has been quite popular as an artificial apical barrier inducer in immature and incompletely developed teeth.[7,8] Researchers have advocated that complete obturation of immature teeth with MTA can enhance their resistance to horizontal as well as vertical root fractures.[9,10]Biodentine a dentin substitute and a relatively new bioactive cement with similar mechanical and physical properties as MTA but

with better handling characteristics can serve as suitable alternative to MTA.[11-13] Although, it is established that apexification can result in the formation of hard tissue apical barrier, but the thin dentinal walls at the cemento-enamel junction may leave the teeth prone to cervical fractures from secondary injuries like mastication or trauma thus leaving them unrestorable.[14-15] The percentage of such cases has been shown to be in the range of 28-77%.[16] Therefore, it could be advantageous to reinforce the roots by using MTA/Biodentine as an obturating material. As there is scarcity of literature on effect of bioactive materials on fracture resistance of immature teeth when used as an obturating material, the aim of present study was to evaluate the fracture resistance and the pattern of fracture (favourable/unfavourable) of simulated immature teeth filled with either a 5mm apical plug or a complete obturation of MTA/biodentine.

MATERIAL AND METHODOLOGY

For this study forty five freshly extracted non-carious maxillary central incisors with single canal were selected. Periapical radiographs were taken with two different angulation and teeth with calcified canals, resorptive defects or an additional canal were excluded. All teeth were examined under magnification for cracks and fractures, before and after instrumentation. The facio-lingual and mesio-distal root diameters were measured below the cementoenamel junction using Boley's gauge and teeth with similar dimensions were selected. For standardization, samples with a length of 20 ±0.5mm were selected and stored in saline until use. The apical 5mm of each tooth was then removed using a low-speed diamond saw. Coronal access cavity was prepared with a size 4 round bur and the pulp was extirpated using a barbed broach. Next, the canals were prepared with peeso reamers (size1-5) until no.5 peeso reamer could easily pass 1 mm beyond the apex to simulate an immature tooth. A no. 6 pesso reamer was then used to prepare the canal 3mm below the cemento-enamel junction such that canal wall thickness of 1.5 mm was obtained to simulate Cvek's stage 3 of root development. 2.5% sodium hypochlorite was used as an irrigant during instrumentation. Final irrigation was performed with 5 ml of 2.5% sodium hypochlorite, 3ml of 17% EDTA and 5 ml normal saline as a final rinse.

The samples were then divided into 4 experimental (n=10) and 1 control group (n=5) as follows using a randomized stratified design:-

Group 1 (n=10):- The entire canal was obturated with MTA.

Group 2 (n=10):- 5 mm apical plug of MTA was formed and rest of the canal was obturated with gutta percha and AH Plus sealer.

Group 3 (n=10) :- The entire canal was obturated with Biodentine.

Group 4 (n=10):- 5 mm apical plug of Biodentine was formed and rest of the canal was obturated with gutta percha and AH Plus sealer.

Control Group (n=5):- The entire canal was obturated with gutta percha and AH Plus sealer using cold lateral compaction.

The quality of obturation and the apical plug was confirmed with radiographs, after which the access cavities were sealed with composite resin. The specimens were stored at 37° C and 100 % humidity for one week.

PDL SIMULATION AND FRACTURE TESTING

PDL simulation was done by covering the specimen roots with polyvinyl siloxane impression material. The roots were embedded in autopolymerising resin blocks such that there was a 2mm gap between the cementoenamel junction and top of the resin to simulate physiologic relationship between the tooth and the bone crest. Fracture testing was done using universal testing machine and load was applied with a 5mm chisel shaped indentor at 130° to the long axis of the tooth at a point 3mm above the cementoenamel junction in a lingual direction at a crosshead speed of 1mm/min until the fracture occurred. The ultimate load to fracture was recorded in Newtons. The pattern of fracture was also evaluated using the following criteria:

a) Favourable or b) Unfavourable fractures

STATISTICAL ANALYSIS

The obtained data was subjected to statistical analysis using SPSS 20.0 Software. One way analysis of variance revealed significant difference among the groups. Pair wise comparison of the groups was performed using Tukey's post hoc test. The level of significance was set at 95% ($p < 0.05$).

RESULTS

The mean value of fracture resistance was recorded in the following order: Group 1 (Full MTA Obturation) > Group 3 (Full Biodentine Obturation) > Group 2 (5mm MTA Apical Plug) > Group 4 (5 mm Biodentine Apical plug) > Control Group (Gutta percha + AH Plus Obturation). Tukey post hoc test for multiple group comparison was done. Group 1 showed higher fracture resistance than group 3 but the difference was not statistically significant (p value >0.05). Group 1 and Group 3 performed significantly better than Group 2 and Group 4, p value < 0.05. No significant difference was found between Group 2 and Group 4. The pattern of the fracture was evaluated according to the position of the fracture. With regard to the fracture pattern, only horizontal fracture at the level of Cementoenamel junction or oblique fractures extending upto the cervical third were observed in all experimental groups without a significant difference between them. The samples in control group showed unfavorable fractures extending beyond the middle third root level.

Table 1: Showing mean and SD

		Mean Difference (I-J)	Std. Error	P-Value SIG.
Full MTA Obturation	5 mm Apical MTA Plug	202.49800*	46.03508	.001
	Full Biodentine (BD) Obt.	15.76400	46.03508	.997
	5mm Apical Plug of BD	227.59300*	46.03508	.000
	A.H. Plus Grp Obt	292.16380*	56.38122	.000
5 mm MTA Apical Plug	Full MTA Obturation	-202.49800*	46.03508	.001
	Full Biodentine (BD) Obt .	-186.73400*	46.03508	.002
	5mm Apical Plug of BD	25.09500	46.03508	.982
	A.H. Plus Grp Obt.	89.66580	56.38122	.512
Full Biodentine (BD) Obturation	Full MTA Obturation	-15.76400	46.03508	.997
	5 mm MTA Apical Plug	186.73400*	46.03508	.002
	5mm Apical Plug of BD	211.82900*	46.03508	.000
	A.h. Plus Grp Obt.	276.39980*	56.38122	.000
5mm Apical Plug of BD	Full MTA Obturation	-227.59300*	46.03508	.000
	5 mm Apical MTA Plug	-25.09500	46.03508	.982
	Full Biodentine (BD) Obt.	-211.82900*	46.03508	.000
	A.H. Plus Grp Obt.	64.57080	56.38122	.782
A.H. Plus Group Obt.	Full MTA Obturation	-292.16380*	56.38122	.000
	Full Biodentine (BD) Obt.	-89.66580	56.38122	.512
	5mm Apical MTA Plug	-276.39980*	56.38122	.000
	5mm Apical Plug of BD	-64.57080	56.38122	.782

DISCUSSION

The high success rate of apexification has been well established, but still the tooth structure remains prone to fracture due to the thin dentinal walls. The tissue loss of the tooth reduces the fracture resistance towards traumatic forces. Thus, reinforcement of fragile radicular dentin in immature teeth is of utmost importance.[9, 11, 13] MTA has shown promising results as an apical barrier in immature teeth when compared to calcium hydroxide.[14] However, studies regarding the ability of MTA to strengthen tooth structure when used as an obturation material has shown controversial results. White et al showed weakening of tooth structure after 5 weeks of exposure to MTA by 33%. They hypothesized that breakdown of the protein structure by the alkalinity of MTA was responsible for this result.[17] Andreasen et al reported that fracture resistance of teeth treated with MTA was higher than those filled with either saline or calcium hydroxide.[18] Biodentine is newer active biosilicate technology based cement known to have improved physical, mechanical and handling properties as compared to MTA.[17] Han & Okiji reported that biodentine may have remarkable bio mineralization capacity than MTA.[20] Literature review indicates that Biodentine apexification can improve the fracture resistance of simulated immature teeth. To our knowledge, very few studies have compared the reinforcement of the cervical dentinal walls in immature teeth when full obturation or an apical plug is given with these bioactive materials. In the present study, maxillary central incisors were selected as they are more susceptible to trauma and external impact owing to their location.[19,20] Cvek's stage 3 of root development was simulated as this stage provides an experimental tooth model with root to canal ratio of 1:1 in the mesio-distal dimension at the CEJ.[9,10] The teeth were embedded in acrylic resin for homogenous stress distribution and PDL stimulation was done with polyvinyl siloxane impression material to approximate the clinical scenario.[11] Fracture testing was performed using universal testing machine at a crosshead speed of 1mm/min. The load was applied at an angle of 130 degree to the long axis of the tooth which mimics the average angle of contact between the maxillary & the mandibular incisors in Class I occlusion.[21,22,23] The results of the present study indicate that all experimental groups had a statistically higher value of fracture resistance than the control groups, indicating that the tested experimental groups considerably enhanced the fracture resistance of immature teeth. Group I (entire canal obturated with MTA) showed highest value of fracture resistance followed by group III (entire canal obturated with biodentine), group II and group IV. The reinforcing effect of full MTA and full biodentine group may be better because of their bioactive nature i.e. their ability to form hydroxyapatite layer between the dentine and the material.[18] Our results are in agreement with the study by Milani et al. who demonstrated that the reinforcing effect of MTA could be due to the similar modulus of elasticity of MTA and dentin. The elastic modulus of MTA is in the range of 15-30 GPa and of biodentine is around 22 GPa approximating that of dentin which is about 14-18.6 GPa.[24] A FEM analysis showed that a material with modulus of elasticity similar to that of dentin can reinforce the weakened root. The lower fracture

resistance of apical plug groups could be because of the inability of gutta percha to reinforce the weakened root in the cervical area, due to its poor cohesive strength and lower elastic modulus.[7] This was further confirmed by the fracture pattern seen in these groups, i.e. oblique fracture, extending till the middle third of the root thus leaving them unrestorable. The mean value of fracture resistance for group I was higher than group III, but the difference was not statistically significant. This finding is in accordance with the results of a study by Elnaghy and Elaska et al.[1] The most probable reason for better performance of Full MTA obturation could be attributed to the hypothesis proposed by Hatibovic - Kofman that tissue inhibitor of MMP was expressed in the MTA treated teeth.[25,26] Bogen G et al also demonstrated that MTA can release bioactive molecules that have been sequestrated in the dentin matrix .It was thought that the change in the dentin matrix as a result of biological interaction between MTA and dentin may inhibit destruction of organic matrix of dentin.[27] The limitations of the study include use of simulated immature teeth and the results could vary in actual clinical scenario. In addition the load was applied at a crosshead speed of 1mm/min, so future studies with higher velocities of 500mm/min that more accurately reflects the forces that cause trauma, needs to be carried out. Furthermore, long term clinical trials are also needed to best evaluate the performance of biodentine and MTA as obturating materials in immature teeth.

CONCLUSION

From the results, it can be concluded that reinforcing immature teeth with bioactive materials such as MTA and biodentine is advantageous. Neither of the two tested materials i.e. biodentine or MTA offer an edge over the other in terms of enhancing the fracture resistance of immature teeth. Thus, biodentine can be recommended as obturating material over MTA due to its short setting time and favorable handling characteristics.

REFERENCES

1. Elnaghy, A. M., & Elsaka, S. E. (2016). Fracture resistance of simulated immature teeth filled with Biodentine and white mineral trioxide aggregate–an in vitro study. *Dental Traumatology*, *32*(2), 116-120.
2. Jeeruphan, T., Jantarat, J., Yanpiset, K., Suwannapan, L., Khewsawai, P., & Hargreaves, K. M. (2012). Mahidol study 1: comparison of radiographic and survival outcomes of immature teeth treated with either regenerative endodontic or apexification methods: a retrospective study. *Journal of endodontics*, *38*(10), 1330-1336.
3. Çiçek, E., Yılmaz, N., Koçak, M. M., Sağlam, B. C., Koçak, S., & Bilgin, B. (2017). Effect of mineral trioxide aggregate apical plug thickness on fracture resistance of immature teeth. *Journal of endodontics*, *43*(10), 1697-1700.
4. Lolayekar, N., Bhat, S., & Hegde, S. (2009). Sealing ability of ProRoot MTA and MTA-Angelus simulating a one-step apical barrier technique-an in vitro study. *Journal of Clinical Pediatric Dentistry*, *33*(4), 305-310.
5. Koçak, M. M., Koçak, S., Aktuna, S., Görücü, J., & Yaman, S. D. (2011). Sealing ability of retrofilling materials following various root-end cavity preparation techniques. *Lasers in medical science*, *26*(4), 427-431.
6. Bortoluzzi, E. A., Souza, E. M., Reis, J. M. D. S. N., Esberard, R. M., & Tanomaru-Filho, M. (2007). Fracture strength of bovine incisors after intra-radicular treatment with MTA in an experimental immature tooth model. *International endodontic journal*, *40*(9), 684-691.
7. Hemalatha, H., Sandeep, M., Kulkarni, S., & Yakub, S. S. (2009). Evaluation of fracture resistance in simulated immature teeth using Resilon and Ribbond as root reinforcements–an in vitro study. *Dental Traumatology*, *25*(4), 433-438.
8. Aksel, A., & Kucukkaya, S. (2019). Surface and vertical dimensional changes of mineral trioxide aggregate and biodentine in different environmental conditions. *Journal of Applied Oral Science*, 27:e20180093:1-8.
9. Ajas, A., Nulekh, B., & Nasil, S. (2018). Comparative evaluation of sealing ability of Biodentine and white MTA- angelus as furcation repair material: A dye extraction study. *International Journal of Oral Care Research*, 6(1):54-57.
10. Pedraza, J. A. Q., Treviño, J. J. F., Fierro, N. C., Meléndez, R. G., Elizondo, J. E., Vargas, L. A. Z., & Moreno, D. A. D. L. R. (2018). Apexification in a mandibular first molar with a middle mesial canal. *Clinical case reports*, *6*(8), 1517-1520.
11. Patel, M. H., Yagnik, K. N., Patel, N. K., & Bhavsar, B. A. (2018). Obturating the pink tooth: An in vitro comparative evaluation of different materials. *Endodontology*, *30*(2), 119-124.
12. Nasseh, H. N., El Noueiri, B., Pilipili, C., & Ayoub, F. (2018). Evaluation of Biodentine Pulpotomies in Deciduous Molars with Physiological Root Resorption (Stage 3). *International journal of clinical pediatric dentistry*, *11*(5), 393-394.
13. Guerrero F, Mendoza A and Aspiaza K et al. Apexification: A systemic review. J Conserve Dent. 2018;21(5):462-465.
14. Mahmoud, S. H., El-Negoly, S. A., El-Din, A. M. Z., El-Zekrid, M. H., Grawish, L. M., Grawish, H. M., & Grawish, M. E. (2018). Biodentine versus mineral trioxide aggregate as a direct pulp capping material for human mature permanent teeth–A systematic review. *Journal of conservative dentistry: JCD*, *21*(5), 466-473.
15. Sarraf, N., Purewal, J., & Raisingani, D. (2018). Management of open apex using new biomaterials. *Journal Oper Dent Endod*, 3(1):43-47.

16. Kumar, Y. R., Tikku, A. P., & Chandra, A. (2018). Single visit apexification using Mineral Trioxide Aggregate in immature permanent tooth with open apex. *International Journal of Science Research*, 7(3):20-22.
17. White, J. D., Lacefield, W. R., Chavers, L. S., & Eleazer, P. D. (2002). The effect of three commonly used endodontic materials on the strength and hardness of root dentin. *Journal of endodontics*, *28*(12), 828-830.
18. Andreasen, J. O., Munksgaard, E. C., & Bakland, L. K. (2006). Comparison of fracture resistance in root canals of immature sheep teeth after filling with calcium hydroxide or MTA. *Dental Traumatology*, *22*(3), 154-156.
19. Malkondu, Ö., Kazandağ, M. K., & Kazazoğlu, E. (2014). A review on biodentine, a contemporary dentine replacement and repair material. *BioMed research international*, *2014*.
20. Han, L., & Okiji, T. (2011). Uptake of calcium and silicon released from calcium silicate–based endodontic materials into root canal dentine. *International endodontic journal*, *44*(12), 1081-1087.
21. Ravn, J. J. (1974). Dental injuries in Copenhagen schoolchildren, school years 1967–1972. *Community dentistry and oral epidemiology*, *2*(4), 231-245.
22. O'Mullane, D. M. (1972). Injured permanent incisor teeth: an epidemiological study. *Journal of the Irish Dental Association*, *18*(4), 160-173.
23. Pene, J. R., Nicholls, J. I., & Harrington, G. W. (2001). Evaluation of fiber-composite laminate in the restoration of immature, nonvital maxillary central incisors. *Journal of Endodontics*, *27*(1), 18-22.
24. Milani, A. S., Rahimi, S., Borna, Z., Jafarabadi, M. A., Bahari, M., & Deljavan, A. S. (2012). Fracture resistance of immature teeth filled with mineral trioxide aggregate or calcium-enriched mixture cement: An ex vivo study. *Dental research journal*, *9*(3), 299-300.
25. Hatibović-Kofman, Š., Raimundo, L., Zheng, L., Chong, L., Friedman, M., & Andreasen, J. O. (2008). Fracture resistance and histological findings of immature teeth treated with mineral trioxide aggregate. *Dental Traumatology*, *24*(3), 272-276.
26. Girish, K., Mandava, J., Chandra, R. R., Ravikumar, K., Anwarullah, A., & Athaluri, M. (2017). Effect of obturating materials on fracture resistance of simulated immature teeth. *Journal of conservative dentistry: JCD*, *20*(2), 115-119.
27. Bogen, G., & Kuttler, S. (2009). Mineral trioxide aggregate obturation: a review and case series. *Journal of endodontics*, *35*(6), 777-790.