ORIGINAL ARTICLE

Comparative evaluation of mineral trioxide aggregate and bioaggregate as apical barrier material in traumatized nonvital, immature teeth: A clinical pilot study

N Tuloglu, S Bayrak

Department of Pediatric Dentistry, Faculty of Dentistry, Eskisehir Osmangazi University, Eskisehir, Turkey

Abstract

Background: Clinical research examining the use of mineral trioxide aggregate (MTA) as an apical barrier material are limited, and no studies have so far examined the clinical performance of BioAggregate as apical barrier material in nonvital immature teeth.

Aim: This study was aimed to provide a comparative evaluation of the clinical and radiographic success of MTA and BioAggregate as an apical barrier material in children with traumatized nonvital, immature permanent maxillary incisors.

Subjects and Methods: A total of 26 maxillary incisor teeth in 20 children aged 7–11 were chosen for this study. Teeth were randomly divided into two groups according to the material to be applied, and the apical barrier was performed. Following treatment, for 24-month, teeth were clinically and radiographically evaluated once every 3- and 6-month, respectively.

Results: All teeth treated with MTA and BioAggregate were clinically and radiographically successful throughout the 24-month follow-up period.

Conclusions: Similar success was achieved in the apical barrier that using BioAggregate and MTA. BioAggregate would be considered suitable materials for apical barrier technique and can be used as an alternative to MTA.

Key words: Apical barrier, BioAggregate, mineral trioxide aggregate

Date of Acceptance: 31-May-2015

Introduction

Completion of root development and apex closure occurs from 1 to 4 years after the emergence of the tooth in the oral cavity.[1] In teeth with an open apex, proper root filling cannot be achieved if endodontic treatment is needed as a result of dental trauma or caries.[1-3] Thus, the clinician is faced with the challenge of creating an apical stop or constriction in order to achieve a hermetically sealed root-canal filling.[4]

Various treatment options exist to manage nonvital immature teeth which include apexification, apical barrier technique, and regenerative endodontic procedures.[2-5] Up to now, mineral trioxide aggregate (MTA) has been popularly employed as a suitable material in apical barrier technique,[2-11] as it combines good tissue biocompatibility, low solubility, ability to induce mineralized tissue formation, and bacteriostatic action with favorable sealing ability.[2,5,12] Despite these excellent properties, MTA also possesses several undesirable characteristics such as long setting time,[12] difficulties in manipulation and insertion,[13] high costs,[14] and potential of discoloration.[7,8] In order to overcome these limitations, various alternative formulations have been developed.

Address for correspondence:
Dr. N Tuloglu,
Department of Pediatric Dentistry, Faculty of Dentistry,
Eskisehir Osmangazi University, 26480, Eskisehir, Turkey.
E-mail: nuraytuloglu@yahoo.com

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/1119-3077.164332

PMID: 26755219

Recently, a modified version of MTA, the calcium silicate-based nanoparticles sized bioceramic BioAggregate (DiaRoot BioAggregate, Innovative BioCeramix Inc., Vancouver, BC, Canada) has emerged on the dental market.[15] Unlike MTA, BioAggregate does not contain aluminum oxide and bismuth oxide.[15,16] Recent studies reported that BioAggregate is more biocompatible,[17-19] better-sealing ability,[20,21] higher fracture,[22] and acidic resistance[23] than MTA.

In light of the information presented above, BioAggregate represents a reasonable alternative to MTA for apical barrier material in nonvital immature teeth. However, to our knowledge, no published study has investigated the clinical performance of BioAggregate as an apical barrier material in nonvital immature teeth. Therefore, the aim of this study was to evaluate and compare the clinical and radiographical success of MTA and BioAggregate as an apical barrier material in children with traumatized nonvital, immature permanent maxillary incisors.

Subjects and Methods

Subject selection

The study population consisted of good general healthy (having no history of systemic diseases or hospitalization) and cooperative children applying for treatment at the Department of Pediatric Dentistry, Faculty of Dentistry, Ondokuz Mayıs University, Samsun, Turkey from November 2009 to December 2010. This clinical pilot study was approved by the Clinical Research Ethics Council (2009/3), and informed consent was obtained from the parents of all study participants.

Medical and dental histories were obtained during the initial evaluation of each patient, and clinical and radiographic examinations were performed to assess tooth vitality. The following clinical signs and symptoms were recorded: Acute pain, need for analgesics for pain control, tenderness to percussion, tenderness to palpation, sinus tract, a bad taste in the mouth, discoloration, luxation injury, and crown fracture. Clinical examinations also included electric pulp testing (Digitest, Parkell Electronics Division, Farmingdale, USA) and cold stimulation testing (Chloraethyl, Wehr, Baden, Germany). Radiographic examinations were conducted using an anterior film holder and periapical radiolucencies, periodontal ligament thickness and root resorption were recorded.

A total of 62 teeth were assessed for eligibility from November 2009 to December 2010, 36 teeth were excluded for not meeting inclusion criteria ($n = 32$) and declined to participate ($n = 4$). Following clinical and radiographic examinations, 26 immature incisor teeth with evidence of pulp necrosis as a result of previous dental trauma in 20 children aged 7–11 were selected for inclusion in this study. Inclusion and exclusion criteria are given in Table 1.

Treatment procedures

All treatment procedures were performed by the same pediatric dentist (NT) using the same protocol. In the first appointment, local anesthesia (Ultracaine DS-Fort Ampul, Sanofi Aventis Ilaclari Ltd. Sti., Istanbul, Turkey) was administered, and teeth were isolated with a rubber dam (Ash Rubber Dam Kit, Dentsply International Inc., Milford, USA). A round diamond burr (801H016, Hager and Meisinger GmBH, Heisinger, Germany) was used to prepare an appropriate access cavity to allow removal of all necrotic tissue. The necrotic pulp was extirpated and working length was determined from a radiograph taken with a film holder. Canals were prepared to 2 mm short of the radiographic apex with K-files (Diadent Group International Inc., Canada) using a gentle, circumferential motion, and copious irrigation with 2.5% sodium hypochlorite to maximize cleansing and minimize dentin removal. After biomechanical preparation, canals were irrigated using a sterile saline solution and dried with sterile paper points (Spident, SPI Dental Mfg. Inc., Korea). Calcium hydroxide [$Ca(OH)_2$] paste (Kalsin, Aktu Tic., Izmir, Turkey) was placed in the canal using a lentulo spiral (Mani Inc., Tochigi, Japan), and a radiograph was exposed to determine the degree of the $Ca(OH)_2$ filling. If found to be adequate, the endodontic access cavity was sealed with cotton pellets and reinforced with zinc oxide eugenol cement (IRM, Dentsply International Inc., Milford, USA).

Patients were recalled for a second appointment after 7 days, at which time the root-canal was re-accessed, the $Ca(OH)_2$ dressing was removed with reamers and the canal was irrigated with ethylenediaminetetraacetic acid followed by 2.5% sodium hypochlorite. After minor instrumentation, canals were irrigated with sterile saline solution and dried with sterile paper points. Teeth were then randomly divided into treatment groups ($n = 13$) for apical barrier with MTA or BioAggregate (randomization was achieved by coin throwing). Patients were blinded to the type of materials used. Materials were mixed in line with the manufacturers' instructions, inserted into the apical third of the root-canal using a carrier, and gently condensed using pluggers premeasured to 4 mm short of the working length. A conventional periapical radiograph was taken to confirm the appropriate placement of the material, a cotton pellet moistened with sterile water was placed over the apical plug, followed by a dry cotton pellet, and the endodontic access cavity was sealed with IRM.

After 4 days, patients were recalled for a third appointment. The cotton pellets were removed, and a reamer was used to check the apical plug for set and hardness. Canals were then obturated with Gutta-percha (Spident, SPI Dental

Mfg. Inc., Korea) and a resin-based root-canal sealer (AH plus, Dentsply, Konstanz, Germany) using the lateral condensation technique. If the apical plug hardness was unsatisfactory, procedures were repeated, and the final obturation was delayed to a later visit. Once obturation was completed, a periapical radiograph taken was used to evaluate the root filling. After the root-canal filling was determined to be adequate, teeth were restored with glass-ionomer liner material (Fuji IX, GC Corporation, Tokyo, Japan) and composite resin (Grandio, Voco, Cuxhaven, Germany).

Clinical and radiographic examinations

All preoperative, immediate postoperative, and recall radiographs were taken with a beam guiding device using the paralleling technique. All radiographic films were exposed and processed conventionally under similar conditions and analyzed under standardized conditions (darkened room, magnification).

Clinical and radiographic evaluations were performed by two different investigators (NT and SB). Kappa-Cohen test used for examiner calibration showed complete agreement between the two investigators.

Following treatment, study participants were recalled at 3-month intervals for the 24-month follow-up period. The following clinical parameters were assessed:

- Pain or discomfort at any time following root-canal obturation
- Use of any analgesics for pain relief
- Tenderness to palpation or obvious signs of abscess formation (sinus tract, etc.)
- Tenderness to percussion.

Treatment was recorded as a clinical failure if any of the above parameters were met. The following radiographic parameters were also assessed once every 6-month:

- Normal periodontal ligament space
- Reduction in the size of the periapical lesion as compared to preoperative radiographs
- No evidence of inflammatory external root resorption.

Treatment was recorded as a radiographical success when all three of the above parameters were met. In cases where a locally widened periodontal ligament space remained after healing of an extensive periapical lesion, this defect was considered to be scar tissue rather than a sign of persisting disease, and in such situations, apical barrier material was classified as a success. In cases where no reduction was observed in the size of the periapical radiolucency, the success of apical barrier materials were deemed inconclusive. Radiographical evidence of failure included enlargement of an existing periapical lesion, the formation of a new lesion after placement of the root filling, and signs of root resorption or hypercementosis.

Statistical analysis

Statistical analysis was performed using the SPSS 12.0 software program (SPSS Inc, Chicago, IL, USA) with the level of significance set at 0.05. Intra-examiner calibration was measured using Kappa-Cohen test.

Results

This study was conducted with 26 incisor teeth in 20 healthy and cooperative children (10 girls, 10 boys) aged 7–11 years (mean age: 8.7 ± 1.5 years; mean age of girls: 8.50 ± 1.72 years; mean age of boys: 8.90 ± 1.1). The demographic and baseline data for each group are presented in Table 2. 26 teeth included in this study were evaluated for the 24-month

Table 1: Inclusion and exclusion criteria of the teeth

Inclusion criteria
Restorable tooth
Possibility of rubber-dam isolation
Root formation at stage 8 (two-thirds of root completed) or 9 (root almost completed-open apex), in according to Nolla[24]
Nonvital immature permanent incisor requiring endodontic therapy
Exclusion criteria
Pathological external or internal root resorption
Horizontal or vertical root fracture
Pulp calcification
Ankylosis
Severe luxation injury

Table 2: Demographic and baseline characteristics for each group

	MTA (n=13)	BioAggregate (n=13)
Age (years)	8.69±0.41	8.85±0.45
Sex		
Male	5	6
Female	8	7
Tooth		
11	6	3
21	6	8
12	0	1
22	1	1

MTA=Mineral trioxide aggregate

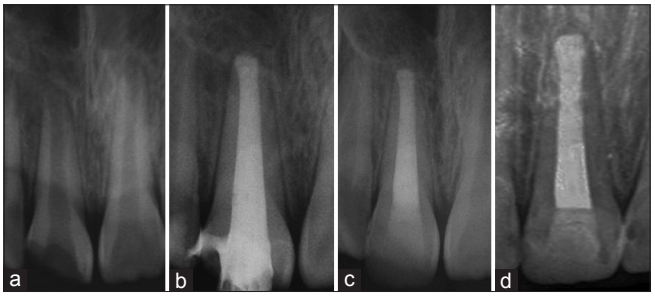

Figure 1: Radiographs of tooth 11 treated with mineral trioxide aggregate (a) Preoperative radiograph (b) Postoperative radiograph (c) 12-month follow-up (d) 24-month follow-up

Table 3: Clinical findings of the 13 teeth in each group

Clinical parameters	Materials	Posttreatment interval							
		3 month	6 month	9 months	12 month	15 months	18 months	21 months	24 month
No pain	MTA	13	13	13	13	13	13	13	13
	BioAggregate	13	13	13	13	13	13	13	13
No tenderness to percussion	MTA	13	13	13	13	13	13	13	13
	BioAggregate	13	13	13	13	13	13	13	13
No tenderness to palpation	MTA	13	13	13	13	13	13	13	13
	BioAggregate	13	13	13	13	13	13	13	13
No swelling or sinus tract	MTA	13	13	13	13	13	13	13	13
	BioAggregate	13	13	13	13	13	13	13	13

MTA=Mineral trioxide aggregate

Table 4: Radiographic findings of the 13 teeth in each group

Radiographic parameters	Materials	Posttreatment interval			
		6 month	12 month	18 months	24 month
Normal periodontal ligament	MTA	13	13	13	13
	BioAggregate	13	13	13	13
No external root resorption	MTA	13	13	13	13
	BioAggregate	13	13	13	13
No enlargement of an existing periapical lesion	MTA	8*	8	8	8
	BioAggregate	9*	9	9	9

*Preoperative radiographic periapical lesions were observed 8 teeth in MTA group and 9 teeth in BioAggregate group. MTA=Mineral trioxide aggregate

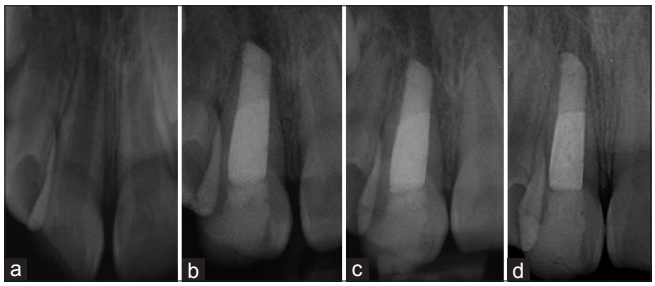

Figure 2: Radiographs of tooth 11 treated with BioAggregate (a) Preoperative radiograph (b) Postoperative radiograph (c) 12-month follow-up (d) 24-month follow-up

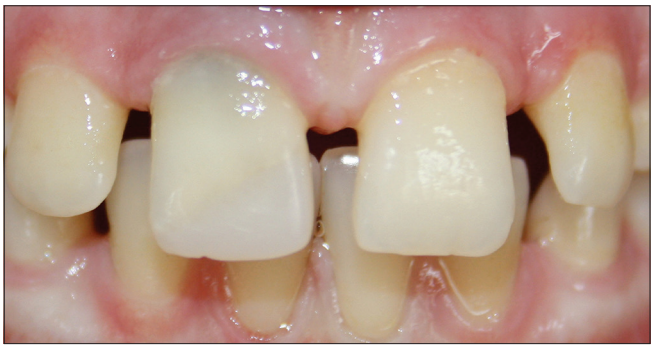

Figure 3: Intraoral appearance of coronal discoloration of maxillary right central incisor treated with mineral trioxide aggregate

follow-up period. No patients were lost during the follow-up period. The clinical and radiographic findings for each group at follow-up period are given in Tables 3 and 4, respectively.

Among the 26 teeth included in this study, the following symptoms were observed: Enamel fractures, 4 teeth; non-complicated crown fractures, 3 teeth; complicated crown fractures, 13 teeth; luxation injuries, 6 teeth; acute pain, 12 teeth; sensitivity to percussion, 19 teeth; sensitivity to palpation, 8 teeth; preoperative apical abscesses, 4 teeth; sinus tract, 6 teeth; preoperative radiographic periapical lesions, 17 teeth (8 teeth in MTA group and 9 teeth in BioAggregate group); the root formation at Stage 8, 19 teeth; (9 teeth in MTA group and 10 teeth in BioAggregate group) the root formation at Stage 9, 7 teeth (4 teeth in MTA group and 3 teeth in BioAggregate group).

All teeth in both the MTA and BioAggregate groups were rated clinically and radiographically successful throughout the 24-month follow-up period. This finding of the present study cannot be evaluated as statistically because of the success in all teeth [Figures 1 and 2]. Interestingly, the coronal discoloration was coincidentally observed in 2 teeth (15.39%) from the MTA group in the 6-month follow-up [Figure 3], but no teeth in the BioAggregate group. No bleaching was performed to discolored teeth until the end of the study.

Discussion

The management of dental trauma to immature permanent teeth in young children can be challenging. As a result of dental trauma, these teeth may become nonvital, which leads to arrested root development.[22] Root-canal treatment at this time is a significant challenge, because of the thin and

fragile dentin walls, and the large open apex.[5] Apexification has long been the treatment of choice, enjoying considerable success in preserving traumatized nonvital immature teeth.[5] $Ca(OH)_2$ has been the material most frequently used to induce the formation of a calcified apical barrier in teeth with nonvital immature apices.[5] However, $Ca(OH)_2$ pastes have several disadvantages such as a prolonged treatment period, difficulties in managing patient recall, loss of temporary dressings and re-infection, and treatment delays that increase the risk of tooth fracture following dressing with $Ca(OH)_2$ over extended periods.[2,5,7,25] Recently, regenerative endodontic procedures have become a viable treatment option for traumatized nonvital immature teeth.[2,6] Regenerative endodontics promotes a paradigm shift from performing apexification procedures to conserving any dental stem cells that might remain in the disinfected viable tissues to allow tissue regeneration and repair and achieve apexogenesis or maturogenesis.[2,6] Although regenerative endodontic seems promising, this procedure may have potential disadvantage such as the development of resistant bacterial strains, allergic reaction to the intracanal medication, increased number of appointments, and longer treatment times.[6,26,27] Unlike apexification and regenerative endodontic procedures, apical barrier technique entails closing the open apex with a biological material to permit immediate filling of the root-canal.[5] Therefore, this clinical pilot study was preferred apical barrier technique for treatment of traumatized nonvital immature teeth.

Although MTA has been the material most frequently used in apical barrier technique,[2-6] due to its disadvantages[7,8,12-14] necessitate more ideal apical barrier materials, with adequate biological and mechanical properties. Recently, a new calcium silicate-based bioceramic material, BioAggregate has been introduced with the intention of preserving the properties and clinical applications of MTA without its negative characteristics. BioAggregate is composed of tricalcium silicate, dicalcium silicate, tantalum pentoxide, calcium phosphate monobasic, hydroxyapatite, and amorphous silicon dioxide.[15,16] BioAggregate is also aluminum-free content, a fact that contributes to its greater biocompatibility with a periradicular tissue.[16] Moreover, the various advantages of BioAggregate include ease of application and manipulation; working time is more than 5 min and convenient setting time;[15] higher fracture strength,[22] and better sealing ability[20,21] than MTA. Despite these advantages of BioAggregate, to our knowledge, there have not yet been any clinical researches examining the use of BioAggregate in apical barrier techniques. Therefore, this clinical pilot study aimed to evaluate and compare the clinical and radiographic success of MTA and BioAggregate when used as an apical barrier material in traumatized nonvital, immature permanent maxillary incisors.

This clinical pilot study was carried out on a relatively small sample of nonvital, immature teeth (26 teeth in 20 children) over a relatively short follow-up period (24-month). In this regard, the limitations in terms of collecting a sample of nonvital teeth with open apices that meet the inclusion criteria should be kept in mind. Moreover, whereas a larger sample size would allow for the identification of statistical differences between materials, the design of the present study (i.e. small sample size and relatively short follow-up period) is consistent with other apexification studies in the literature.[4,7-9]

Simon *et al*.[10] examined the radiographic success of MTA when used as an apical barrier material on 57 immature permanent incisors over a follow-up period ranging from 6 to 36 months and reported reductions in preexisting periapical lesions in 81% of cases. Moore *et al*.[8] compared ProRoot MTA and MTA Angelus as an apical barrier material and found clinical and radiographic success rates of 95.5% for both materials. Another study evaluated apical barrier formation of 17 nonvital immature permanent incisors using MTA and found clinical and radiographic success rates of 94.1% and 76.5%, respectively.[7] A retrospective study by Mente *et al*.[11] assessing healing of immature teeth treated with MTA apical barriers found successful healing in 84% of cases. El-Meligy and Avery[9] demonstrated a clinical and radiographic success rate of 100% with MTA, which was found to be a suitable replacement for $Ca(OH)_2$ in apexification treatment. Overall, a review of clinical studies indicates that clinical and radiographic success rates of apical barrier formation with MTA range from 81% to 100% and 76–95%, respectively.[4,7-11] In line with these findings, the present study showed that all teeth treated using MTA was clinically and radiographically successful over the course of 24-month of follow-up. With regard to BioAggregate, given that the literature contains no previous reports on apical barrier formation using BioAggregate, no comparisons can be made with the clinical and radiographic success rates of apical barrier formation with this material found in the present study.

Tooth discoloration is an important aesthetic concern in young patients. Studies by Sarris *et al*.[7] and Moore *et al*.[8] found coronal discoloration in 11.8% and 22.7% of cases, respectively, following the placement of MTA as an apical barrier material. In the present study, coronal discoloration was coincidentally observed in 2 teeth (15.39%) treated with MTA, whereas no coronal discoloration was observed among teeth treated with BioAggregate. Discoloration caused by MTA has been attributed to the metal oxides (e.g. Bi_2O_3, Al_2O_3, FeO) contained in the material.[28,29] Unlike MTA, BioAggregate contains no metal oxides,[16] which could explain the lack of coronal discoloration in the BioAggregate group in the present study. Additional *in vitro* and *in vivo* studies are needed to provide a more definitive determination of the cause of discoloration with MTA and BioAggregate.

Conclusions

This study found excellent clinical and radiographic results when either MTA or BioAggregate is used as an apical barrier material in children with traumatized nonvital, immature permanent maxillary incisors. Within the limitation of this study, BioAggregate can be considered a possible alternative to the MTA. However, MTA still remains as one of the important materials used in apical barrier technique. Further clinical studies with larger sample sizes and longer follow-up periods are required to find the best apical barrier material in dental practice.

Acknowledgments

This study was funded by the Ondokuz Mayis University Scientific Research and Development Support Program (PYO. DİS.1904.10.001).

References

1. Melfi RC, Alley EK, editors. Permar's Oral Embryology and Microscopic Anatomy. 10th ed. Philadelphia: Wolters Kluwer Co.; 2000.
2. Jyothi M. Management of immature teeth – A paradigm shift from apexification to apexogenesis. Ann Essences Dent 2012;IV: 34-8.
3. Nayak G, Hasan MF. Biodentine-a novel dentinal substitute for single visit apexification. Restor Dent Endod 2014;39:120-5.
4. Pradhan DP, Chawla HS, Gauba K, Goyal A. Comparative evaluation of endodontic management of teeth with unformed apices with mineral trioxide aggregate and calcium hydroxide. J Dent Child (Chic) 2006;73:79-85.
5. Rafter M. Apexification: A review. Dent Traumatol 2005;21:1-8.
6. Flanagan TA. What can cause the pulps of immature, permanent teeth with open apices to become necrotic and what treatment options are available for these teeth. Aust Endod J 2014;40:95-100.
7. Sarris S, Tahmassebi JF, Duggal MS, Cross IA. A clinical evaluation of mineral trioxide aggregate for root-end closure of non-vital immature permanent incisors in children-a pilot study. Dent Traumatol 2008;24:79-85.
8. Moore A, Howley MF, O'Connell AC. Treatment of open apex teeth using two types of white mineral trioxide aggregate after initial dressing with calcium hydroxide in children. Dent Traumatol 2011;27:166-73.
9. El-Meligy OA, Avery DR. Comparison of apexification with mineral trioxide aggregate and calcium hydroxide. Pediatr Dent 2006;28:248-53.
10. Simon S, Rilliard F, Berdal A, Machtou P. The use of mineral trioxide aggregate in one-visit apexification treatment: A prospective study. Int Endod J 2007;40:186-97.
11. Mente J, Hage N, Pfefferle T, Koch MJ, Dreyhaupt J, Staehle HJ, *et al.* Mineral trioxide aggregate apical plugs in teeth with open apical foramina: A retrospective analysis of treatment outcome. J Endod 2009;35:1354-8.
12. Torabinejad M, Hong CU, McDonald F, Pitt Ford TR. Physical and chemical properties of a new root-end filling material. J Endod 1995;21:349-53.
13. Santos AD, Moraes JC, Araújo EB, Yukimitu K, Valério Filho WV. Physico-chemical properties of MTA and a novel experimental cement. Int Endod J 2005;38:443-7.
14. Srinivasan V, Waterhouse P, Whitworth J. Mineral trioxide aggregate in paediatric dentistry. Int J Paediatr Dent 2009;19:34-47.
15. Marwah N. The era of endodontic research. Root-end filling materials. Int J Clin Pediatr Dent 2014;7:v-vii.
16. Zhang H, Pappen FG, Haapasalo M. Dentin enhances the antibacterial effect of mineral trioxide aggregate and bioaggregate. J Endod 2009;35:221-4.
17. Yan P, Yuan Z, Jiang H, Peng B, Bian Z. Effect of bioaggregate on differentiation of human periodontal ligament fibroblasts. Int Endod J 2010;43:1116-21.
18. Yuan Z, Peng B, Jiang H, Bian Z, Yan P. Effect of bioaggregate on mineral-associated gene expression in osteoblast cells. J Endod 2010;36:1145-8.
19. De-Deus G, Canabarro A, Alves G, Linhares A, Senne MI, Granjeiro JM. Optimal cytocompatibility of a bioceramic nanoparticulate cement in primary human mesenchymal cells. J Endod 2009;35:1387-90.
20. Memis Özgül B, Bezgin T, Sahin C, Sari S. Resistance to leakage of various thicknesses of apical plugs of Bioaggregate using liquid filtration model. Dent Traumatol 2014. doi: 10.1111/edt.12150.
21. Leal F, De-Deus G, Brandão C, Luna AS, Fidel SR, Souza EM. Comparison of the root-end seal provided by bioceramic repair cements and White MTA. Int Endod J 2011;44:662-8.
22. Tuna EB, Dinçol ME, Gençay K, Aktören O. Fracture resistance of immature teeth filled with BioAggregate, mineral trioxide aggregate and calcium hydroxide. Dent Traumatol 2011;27:174-8.
23. Hashem AA, Wanees Amin SA. The effect of acidity on dislodgment resistance of mineral trioxide aggregate and bioaggregate in furcation perforations: An *in vitro* comparative study. J Endod 2012;38:245-9.
24. Nolla CM. The development of permanent teeth. J Dent Child 1960;27:254-66.
25. Andreasen JO, Farik B, Munksgaard EC. Long-term calcium hydroxide as a root canal dressing may increase risk of root fracture. Dent Traumatol 2002;18:134-7.
26. Reynolds K, Johnson JD, Cohenca N. Pulp revascularization of necrotic bilateral bicuspids using a modified novel technique to eliminate potential coronal discolouration: A case report. Int Endod J 2009;42:84-92.
27. Nosrat A, Homayounfar N, Oloomi K. Drawbacks and unfavorable outcomes of regenerative endodontic treatments of necrotic immature teeth: A literature review and report of a case. J Endod 2012;38:1428-34.
28. Akbari M, Rouhani A, Samiee S, Jafarzadeh H. Effect of dentin bonding agent on the prevention of tooth discoloration produced by mineral trioxide aggregate. Int J Dent 2012;2012:563203.
29. Vallés M, Mercadé M, Duran-Sindreu F, Bourdelande JL, Roig M. Color stability of white mineral trioxide aggregate. Clin Oral Investig 2013;17:1155-9.

How to cite this article: Tuloglu N, Bayrak S. Comparative evaluation of mineral trioxide aggregate and bioaggregate as apical barrier material in traumatized nonvital, immature teeth: A clinical pilot study. Niger J Clin Pract 2016;19:52-7.

Source of Support: This study was funded by the Ondokuz Mayis University Scientific Research and Development Support Program (PYO. DİS.1904.10.001), **Conflict of Interest:** None declared.