Comparison of MTA and Biodentine™ apical plugs used in apexification procedures: a clinical study

Authors: Dr. María Monsreal-Peniche, Dr. Marco Ramírez-Salomón, Dr. Elma Vega-Lizama, Dr. María López-Villanueva, Dr. Gabriel Alvarado-Cárdenas, Dr. Cemil Yesilsoy, Dr. Oscar Bolaños, Dr. Gabriela Martin

Abstract

Objective: Apexification represents an alternative treatment option for the management of immature permanent teeth with necrotic pulp. The aim of the present study was to compare clinical outcomes of MTA and Biodentine™ apical plugs in apexification procedures.

Design: Twenty-six teeth with immature apices and necrotic pulps from different patients were selected for apexification treatment. In the first appointment, after irrigation with 5.25% sodium hypochlorite and EDTA, calcium hydroxide was placed in the canal and then an IRM temporary restoration. For the second appointment, the patients were randomly divided in two groups of 13 patients each: Teeth in Group 1 received MTA apical plugs and those in Group 2 received Biodentine™ apical plugs. The root canals were obturated with gutta-percha and Sealapex sealer. A composite resin was placed to seal the coronal access. Follow-ups were done at six, twelve and eighteen months; and treatment outcomes were evaluated based on Strindberg's Criteria and the Periapical Index (PAI).

Results: From a total of 26 teeth, 6 were excluded from the study for missing follow-up appointments (4 treated with MTA and 2 with Biodentine™). At the 6-month evaluation, Group 1 showed 55% success (Strindberg's Criteria) and 66.66% improvement based on the PAI. Group 2 results were, 54.54% and 63.63% respectively. At the 12-month follow-up, both groups exhibited 100% success. Clinical and radiographic outcomes were maintained at the 18-month evaluation.

Conclusion: Based on the resolution of apical periodontitis and the absence of clinical signs and symptoms, there was no difference between the Biodentine™ and MTA apical plugs.

Introduction

The apical foramen remains open in the roots of immature teeth until apex closure, about three years after tooth eruption (Sheehy and Roberts 1997). Open apex constitutes a challenge for dentists because they can make it difficult to successfully obturate with a three-dimensional seal. Different techniques are used to improve the probability of a good apical seal (Nayak and Hassan 2014). One example is apexification, in which calcium hydroxide pastes ($Ca(OH)_2$) are used to induce formation of a calcified barrier. However, this technique requires multiple sessions and may weaken the tooth (Andreasen et al. 2002).

The search for alternatives has led to consideration of calcium silicate materials, which have become common in dental therapy (Huang 2009, Shabahang et al. 1999). Among these materials is Mineral Trioxide Aggregate (MTA), a mixture of dicalcium silicate, tricalcium silicate, tricalcium aluminate, plaster, tetracalcium aluminoferrite and bismuth oxide. Initially introduced in the 1990s by Torabinejad, it exhibits biocompatibility and is now widely used (Shabahang et al. 1999). Immediately after mixing, MTA has a pH of 10.2, but this increases to 12.5 after three hours (Wang 2015). The advent of MTA led to advances in dentistry, such as the ability to complete an apexification in a single session (Simon et al. 2007). It is also used in retro-fillings, root perforations and pulp caps, among other applications (Lee et al.1993). Mineral trioxide aggregate has some disadvantages, including long setting time, difficult handling, discoloration, low resistance to compression and low fluidity capacity. Nonetheless, it remains the gold standard among dental bioceramics (Wang 2015, Laurent et al. 2012).

Biodentine™ is a bioactive cement introduced in 2009 by Septodont (Saint-Maur-des-Fossés, France) as a “dentine substitute”. Product presentation consists of a powdered portion (in capsules) containing tricalcium silicate, dicalcium silicate, calcium carbonate, calcium oxide, and zirconium oxide, and a liquid portion (in pipettes) containing a hydrosoluble polymer and calcium chloride as an accelerator. Its 12-minute setting time is substantially shorter than that of MTA (Vidal et al. 2016). Preparation involves using an amalgamator to mix five drops of liquid with the content of one capsule for thirty seconds. During the first day after application, Biodentine™ exhibits little or no crown discoloration (Valles et al. 2015), and has an initial pH of 11.7, with no significant changes for 28 days thereafter (Wang 2015). Biodentine™ is also reported to have a high calcium ion release rate, and excellent resistance to compression (Laurent et al. 2012). Flow cytometry analyses have shown that cell viability is higher in Biodentine™ and MTA extracts than in a glass ionomer (Zanini et al. 2012). There are also reports of osteoblast differentiation in different stem cells with Biodentine™. The formation of a homogeneous dentine bridge in pulp lesions has been shown in Biodentine™ and MTA groups (Rossi et al. 2014).

These qualities have led some to conclude that Biodentine™ has maximized MTA’s desirable properties by improving treatment time and material handling properties. The present study objective was to compare the outcome of Biodentine™ and MTA used as apical plugs in teeth with an open apical foramen.

Materials and methods

Clinical diagnosis was made, and radiographs were taken of open apex cases in patients who visited the Endodontics Specialty Clinic of the Autonomous University of Yucatan Faculty of Dentistry (FOUADY). After a description of the study, the patients were invited to participate and provided an explanation of ethical considerations. Those who decided to participate signed an informed consent form approved by the ethical committee. Inclusion criteria were patient consent (or of parents/guardians for minors) and presence of an open apex, while exclusion criteria were an after-treatment crown or root fracture and a missing a follow-up appointment. Cases of teeth with vital pulp were treated with apexogenesis while those with necrotic pulp were evaluated to determine if regenerative endodontics or an apical plug were most appropriate. The decision of whether to use regenerative endodontics or an apical plug was made based on the grade of apical foramen aperture according to Cvek´s established criteria (Cvek 1992). Grade 1 cases were treated with regenerative endodontics while Grade 2, 3 and 4 cases were treated with an apical plug.

Cases meeting the criteria for an apical plug were randomly divided into two groups: Group 1 were treated with MTA plugs; and Group 2 with Biodentine™ plugs. Procedures were done under magnification (Omnipico Dental Microscope, Carl Zeiss, Gottingen, Germany).

2.1 MTA apical plug (Group 1)

In the first session, anesthesia was administered, the tooth was isolated and a #6 carbide bur was used to access and open the chamber. Once the canals were identified and the root canal length established, the canal was irrigated with 5.25% sodium hypochlorite and 17% EDTA (Smear Clear, Sybron Endo, Orange, CA), and then with saline solution for intermediate and final cleaning. The canals were then filled with $Ca(OH)_2$, and a temporary filling of zinc oxide and eugenol cement (IRM; Dentsply, Konstanz, Germany) put in place. At the second session the $Ca(OH)_2$ was removed, and the canals carefully washed with 5.25% sodium hypochlorite (NaOCl) followed by saline solution. Collacote (Zimmer Dental Inc., Carlsbad, CA, USA) was then placed in the apical third of the canal, to a depth 1 mm short of original canal length. An average of 3 to 5 mm apical plug was then made with MTA (MTA-Angelus, Londrina, PR, Brazil), and placed in the canal followed by a moist sterile cotton pellet to promote set. A temporary zinc oxide and eugenol cement filling was put in place. On the third session, the cap and cotton were removed, and MTA set confirmed. The root filling was completed with gutta-percha and Sealapex cement (Sybron-Kerr, Romulus, MI, USA) and the access sealed with a composite resin filling (Tetric Ceram, Vivadent).

2.2 Biodentine™ apical plug (Group 2)

This treatment required only two sessions. In the first, the chamber was opened, the canals located and opened, and cleaned as described in the above protocol. Again, $Ca(OH)_2$ was placed in the canals and a temporary filling made of zinc oxide and eugenol cement. In the second session the $Ca(OH)_2$ was removed, the canals carefully cleaned with 5.25% NaOCl and saline solution, the canals checked, and a resorbable collagen sponge placed in the apical third 1 mm short of original canal length. Biodentine™ was then prepared by using an amalgamator to mix six drops of liquid with the contents of one capsule for 30 seconds. About 3 to 5 mm. of this preparation were placed in the apical third and its correct placement confirmed with a radiograph. Once Biodentine™ set was confirmed, the root filling was completed with gutta-percha and Sealapex cement, and the crown sealed with a composite resin filling.

After apical plug placement, the patients in both groups were reminded of the importance of the follow-up appointments at six, twelve and eighteen months to confirm treatment progress both clinically and via radiographs.

2.3 Follow-up appointments

At each follow-up appointment the teeth were evaluated clinically and radiographically based on the Strindberg´s Criteria and the Periapical Index (PAI) (Ørstavik et al. 1986). All evaluations were done by two endodontists trained in these criteria.

Results

A total of 39 open apex teeth were examined. Five (12.82%) had vital pulp and were treated with apexogenesis; eight (20.51%) met the criteria for regenerative endodontics and 26 (66.66%) met the study inclusion criteria and were treated with an apical plug. Of the latter, fifteen patients were women and eleven were men. Thirteen of the apical plug cases were treated with MTA (Group 1) and thirteen with Biodentine™ (Group 2). Not all patients came to all the follow-up appointments, six of them were eliminated (four in Group 1 and 2 in Group 2) (Table 1 and 2).

Progress was generally parallel in all groups. At six months, 55% of those in Group 1 had successful outcomes based on the Strindberg´s Criteria and 66.66% exhibited improvement in radiographs according to the PAI. In Group 2, 54.54% had successful outcomes and 63.63% exhibited improvement. By twelve months both groups had 100% successful outcomes and favorable PAI values. The same was true at eighteen months, however, 81.81% of the Biodentine™ group showed a two-level reduction of the PAI, while in the MTA group only 44.44% reduced two PAI levels (Table 1 and 2).

Table 1. Group 1, MTA apical plugs

Case No.	Sex	Age	Tooth	Initial		6 months		12 months		18 Months		Final		PAI Final-Initial
				PAI	Strindberg	PAI	Strindberg	PAI	Strindberg	PAI	Strindberg	PAI	Strindberg	
1	F	7	19	5	Failure	3	Success	3	Success			3	Success	-2
2	M	10	29	5	Failure	4	Doubtful	3	Success	2	Success	2	Success	-3
3	F	10	19	5	Failure	3	Success	3	Success	2	Success	2	Success	-3
4	M	11	30	4	Failure	4	Doubtful	3	Success			3	Success	-1
5	F	19	9	4	Failure	3	Success	2	Success			2	Success	-2
6	F	12	31	4	Failure	4	Doubtful	3	Success			3	Success	-1
7	M	10	9	5	Failure	3	Success	2	Success	2	Success	2	Success	-3
8	M	20	29	4	Failure	3	Success	3	Success			3	Success	-1
9	F	16	9	4	Failure	4	Doubtful	3	Success			3	Success	-1

Table 2. Group 2, Biodentine™ apical plugs

Case No.	Sex	Age	Tooth	Initial		6 months		12 months		18 Months		Final		PAI Final-Initial
				PAI	Strindberg	PAI	Strindberg	PAI	Strindberg	PAI	Strindberg	PAI	Strindberg	
1	M	13	8	5	Failure	4	Doubtful	3	Success	3	Success	2	Success	-3
2	M	8	30	5	Failure	5	Doubtful	3	Success	2	Success	3	Success	-2
3	F	20	8	5	Failure	4	Success	3	Success	2	Success	2	Success	-3
4	F	20	9	4	Failure	4	Doubtful	2	Success			2	Success	-2
5	F	12	13	4	Failure	2	Success	2	Success			2	Success	-2
6	M	30	31	4	Failure	4	Doubtful	3	Success			3	Success	-1
7	M	8	10	5	Failure	3	Success	3	Success	3	Success	3	Success	-2
8	M	10	9	4	Failure	3	Success	3	Success			3	Success	-1
9	F	16	8	4	Failure	3	Success	2	Success			2	Success	-2
10	F	13	8	4	Failure	2	Success	2	Success			2	Success	-2
11	F	12	11	5	Failure	5	Doubtful	3	Success	2	Success	2	Success	-3

Discussion

Apexification is a method for inducing a calcified apical barrier or an apical development in an incompletely formed root in teeth with necrotic pulp (Rafter 2005). This was traditionally done using $Ca(OH)_2$ placement inside the canal until a calcified barrier was observed in the apical sector. However, Shabahang found that prolonged $Ca(OH)_2$ use could weaken tooth walls eventually leading to root fracture (Shabahang 2013). Even in the 1980s, it was clear that most apical periodontitis cases required apical plugs to ensure a proper seal and prevent bacterial filtration into the periapical zone (Holland 1984). Introduction of MTA in the 1990s opened the possibility of its use in root canals, pulpotomies, pulp caps, and apical plugs to induce apical barriers in immature permanent teeth (Torabinejad et al. 1997).

In 1999, Shabahang showed that MTA promotes high pH and an antimicrobial environment, thus inducing formation of a calcified barrier. One study reported no differences between the calcified barriers formed by MTA and those formed by calcium hydroxide. However, the time required for barrier formation was much less with MTA (Shabahang et al. 1999). Biodentine™ has been shown to induce differentiation in odontoblastic cells, murine proliferation in the pulp and biomineralization. It also simulates collagen fibers and induces fibroblast formation (Zanini et al. 2012) and is known to have higher push-out bond strength than MTA (Wang 2015).

No research has been done to date comparing the performance of Biodentine™ to MTA in apical plugs. The first report of Biodentine™ use in apical plugs was in 2014 (Nayak and Hassan 2014), followed by another in 2016 (Vidal et al. 2016). Both reported favorable outcomes and a notable decrease in the number of sessions required for treatment since the filling can be completed in one session with Biodentine™.

The present study is the first comparison of the performance of MTA and Biodentine™ in apical plugs. Clinical outcomes did not differ between these two bioceramics with 100% improvement in all cases, also the same happened at a radiographic level. Both clearly promote complete wound healing in real world scenarios. However, Biodentine™ exhibited superior performance in terms of ease of handling and placement, and set time, which all contributed to a shorter overall treatment time.

Biodentine™ apical plug group, tooth #11

Fig. 1a: Preop Tooth #11

Fig. 1b: Postop

Fig. 1c: Recall 18 months

MTA apical plug group, tooth #8

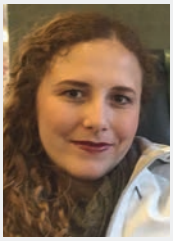
Fig. 2a: Preop Tooth #8

Fig. 2b: Postop

Fig. 2c: Recall 18 months

Conclusion

Both MTA and Biodentine™ produced complete treatment success in clinical and radiographic terms. All patients were asymptomatic after eighteen months and exhibited a clear increase of a visible apical barrier in the radiographs. However, Biodentine™ is easier to handle than MTA and sets in twelve minutes, much less time than MTA. This allows treatment completion in fewer sessions, with consequent advantages to both care providers and patients.



Author:
Dr. María Monsreal-Peniche

Dr. María Monsreal-Peniche (DDS, ME 2016, Universidad Autónoma de Yucatán) is clinical assistant professor at the Department of Endodontics of the Universidad Autónoma de Yucatán.
She has published scientific studies. Her current field research is in obturation of root canals with open apices. She is recipient of some Awards, and she can be reached at maribeth_peque17@hotmail.com

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Biodentine™

Biodentine can be used both in the crown and in the root:

In the crown: temporary enamel restoration, permanent dentin restoration, deep or large carious lesions, deep cervical or radicular lesions, pulp capping, pulpotomy (reversible and irreversible pulpitis).

In the root: root and furcation perforations, internal/external resorptions, apexification, retrograde surgical filling.