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Biodentine: an alternative to MTA?

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ABSTRACT

Introduction: This study aim to review the literature about the physicochemical and biological characteristics of Biodentine, a cement used in endodontics, and discussed whether this material might be an alternative to MTA according to the scientific evidence found in the literature. **Methods:** A literature search was performed on PubMed using the following terms: Biodentine, calcium silicate, MTA, properties, setting time, radiopacity, solubility, physicochemical properties, porosity, hydration, biocompatibility, bioactivity, microhardness, compressive strength, bond strength, irrigants, furcal perforation, retrograde filling, revitalization, revascularization, endodontics, apexification. Fifty studies met inclusion criteria. **Results:** Biodentine seems to have favorable characteristics, and the results of its use are promising when compared with those of MTA. **Conclusion:** Biodentine may be a possible alternative to MTA.

Keywords: Dental Cements. Endodontics. Root Canal Restauration Materials. Physicochemical Properties. Material Testing.

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Introduction

Mineral trioxide aggregate (MTA) is a calcium silicate-based cement that has become the reference material in the treatment of perforations, pulp capping, apical buffering in teeth with an open apex, cervical barrier in cases of revascularization, and root-end filling.[3,4] However, it has some unwanted characteristics, such as solubilization, difficult manipulation, long setting time and possible tooth discoloration.[3,5]

To improve the properties of cements such as MTA, new tricalcium silicate-based cements have been developed, such as Biodentine (Septodont, St-Maur-des-Foss, France), which is commercialized as a capsule with a powder and a liquid that are packed separately (Figure 1). The powder's main components are tricalcium and dicalcium silicate, as well as calcium carbonate, used to accelerate cement setting, and zirconium oxide, used as a radiopacifier. The liquid contains calcium chloride, used as an accelerator, and a water-soluble polymer to reduce water content.[6] One of the main advantages of Biodentine is its shorter setting time, which ranges from 10 to 12 minutes.

Biodentine is indicated for use in permanent dentin restorations under composites, temporary dentin-enamel restorations, restorations of cervical or deep carious lesions, pulp capping, pulpotomy, repair of root and furcal perforations, internal and external resorptions, apexification, and retrograde fillings.[7] Moreover, it has also been used as a cervical barrier in cases of revascularization.[8-10]

Figure 1. Biodentine - commercial presentation.

Biodentine was launched in 2009[6], and studies have been carried to prove its effectiveness and to compare it with MTA. This study reviewed the literature about the physicochemical and biological characteristics of Biodentine used in endodontics, and discussed whether this material might be an alternative to MTA, according to the scientific evidence found in the literature.

Material and methods

A literature search was performed on PubMed using the following terms (alone and in combinations): Biodentine, calcium silicate, MTA, properties, setting time, radiopacity, solubility, physicochemical properties, porosity, hydration, biocompatibility, bioactivity, microhardness, compressive strength, bond strength, irrigants, furcal perforation, retrograde filling material, revitalization, revascularization, endodontics, apexification.

Initially, 178 studies were selected. After all abstracts were read, 50 studies were included in this review. The inclusion criterion was: full article in English comparing MTA and Biodentine.

Literature Review

Physicochemical properties

Grech, Mallia and Camilleri[11] evaluated the basic composition of the material and investigated the presence of arsenic, chromium and lead in Portland cement, Biodentine, BioAggregate and mineral trioxide aggregate (MTA, Angelus). The authors found that the cements compared had a similar oxide composition, and that the main components were calcium oxide and silicon oxide. Both Portland cement and MTA Angelus had aluminum oxide in their composition. All cements had radiopacifiers. The amounts of arsenic and lead were acceptable in all the materials.

Camilleri, Sorrentino and Damidot[12] compared Biodentine, a laboratory-manufactured tricalcic silicate-based cement and MTA Angelus. They found that the composition of unhydrated cements included tricalcic silicate and radiopacifier. Biodentine and the laboratory-manufactured cement had zirconium oxide, whereas MTA had bismuth oxide. Moreover, Biodentine had calcium carbonate particles, and MTA Angelus had dicalcium silicate, tricalcium aluminum, aluminum and silicon oxides.

One of the major advantages of Biodentine when compared to MTA is its setting time, as setting for MTA takes longer and requires the presence of humidity.

Grech, Mallia and Camilleri[11] evaluated setting time for BioAggregate, Biodentine, IRM and a laboratory-manufactured tricalcium silicate-based cement. They found a setting time of 45 minutes for Biodentine.

Jang et al.[13] found a setting time of 15 ± 1 min for Biodentine, and of 275 ± 15 for MTA. In contrast, Kaup et al.[14] found 85.66 ± 6.03 for Biodentine and 228.33 ± 2.88 min for ProRoot MTA. According to Butt et al.[15], initial setting time was 8.5 ± 2.4 min for white MTA Angelus and 6.5 ± 1.7 min for Biodentine.

Grech, Mallia and Camilleri[11] found that Biodentine was less radiopaque than MTA. However, radiopacity values found for Biodentine were greater than the 3 mm of aluminum thickness. Camilleri, Sorrentino and Damidot[12] also reported values greater than 3 mm for Biodentine. Ceci et al.[16] confirmed previous findings and found that the values of radiopacity of Biodentine were lower than those of ProRoot MTA and MTA Angelus.

Kaup et al.[14] and Ceci et al.[16] found that Biodentine, ProRoot MTA and MTA Angelus met the requisites of the International Standard 6876, as they had low solubility and a weight loss of less than 3%. Grech, Mallia and Camilleri[11] found that solubility for Biodentine was very low.

Elnaghy[17] found that microhardness values of Biodentine were greater than those of white MTA (Dentsply), corroborating the report by Kaup et al.,[14] who found that microhardness for Biodentine was greater than that of ProRoot MTA. However, Caronna et al.,[18] evaluated superficial hardness in an experimental apexification model and found that microhardness of white MTA was greater than that of Biodentine.

Grech, Mallia and Camilleri[11] found that compressive strength of Biodentine was greater than that of Bioaggregate and IRM. In contrast, Butt et al.[5] found greater values for Biodentine than for MTA Angelus. Elnaghy[17] reported similar results of the comparison of Biodentine and white MTA (Dentsply), and Govindaraju et al.,[19] of the comparison of Biodentine with ProRoot MTA, NeoMTA Plus and MTA Angelus.

In the analysis of porosity, Camilleri et al.[20] found a smaller amount of tricalcium silicate in MTA than in Biodentine. According to the authors, this smaller amount results in a slower reaction rate and a more porous microstructure for MTA Angelus. Confirming these results, Gandolfi et al.[21] found that porosity values were greater for MTA Plus gel and MTA Angelus than for Biodentine.

Elnaghy[22] compared bond strength of Biodentine and MTA. The materials were placed inside the canal of 1.0-mm thick dentin slices. The push-out test was used to evaluate bond strength. The authors found greater bond strength values for Biodentine than for MTA. Aggarwal et al.[23] found bond strength values greater for Biodentine than for MTA.

Biological properties

Mori et al.[3] evaluated the biocompatibility of Biodentine, as well as of MTA, in subcutaneous tissues of rats. MTA was biocompatible at all time points (7, 14 and 30 days), whereas Biodentine resulted in moderate inflammation at 7 days, but the inflammatory response decreased over time and the material was biocompatible at 14 days.

Simsek et al.[24] evaluated biocompatibility of Biodentine and MTA in subcutaneous tissues of rats and found that Biodentine was more biocompatible than MTA in the first week. However, there were no differences between materials at 45 days.

Ceci et al.[16] and Saberi et al.[25] noted an excellent percentage of cell viability in the evaluation of cytotoxicity of MTA and Biodentine.

In the study by Margunato et al.,[26] ProRoot MTA, Biodentine and MicroMega-MTA had no cytotoxic effect after 14 days in cell cultures. All the material evaluated had a potential for osteogenic differentiation when compared with the negative control. However, ProRoot MTA had greater osteoinductivity than Biodentine and MicroMega-MTA.

Gomes-Cornélio et al.[27] evaluated Biodentine and MTA Plus and found that both materials had good biocompatibility and bioactivity. Rodrigues et al.[28] also found that both MTA and Biodentine were biocompatible and bioactive. However, Biodentine had a significantly greater effect on mineralization than MTA.

Biodentine and perforation repair

Endodontic treatment has a vital role in preserving the integrity of natural dentition. However, complications may occur during treatment, such as perforations. The prognosis for perforation repair depends on the location of perforation, waiting time to repair and sealability of the material used. According to Ricardo Pace et al.,[29] the purpose of repairing perforations is to seal the artificial communication created between periradicular tissues and the endodontic space.

With the development of new calcium silicate-based cements, new studies compared them to MTA to evaluate their effectiveness in terms of not only their properties, but also the clinical environment to which they are exposed.

For that, Aggarwal et al.[23] analyzed push-out bond strength of Biodentine, MTA Plus and ProRoot MTA. The authors found that the presence of blood, as well as waiting time to perform the test, is a factor that affects bond strength. In 24 hours, Biodentine had bond strength values greater than those of MTA Plus, and the values of both Biodentine and MTA Plus were greater than those of ProRoot MTA. Seven days later, Biodentine and MTA had similar push-out bond strength values.

According to Rahimi et al.[30], contamination of the perforation by blood may affect the retention characteristics of different biomaterials used in simulated furcal perforations. However, for Üstün et al.,[31], blood contamination does not affect the bond strength of Biodentine.

As Biodentine has a shorter setting time, perforation repair and endodontic treatment may be performed on the same visit. Several studies evaluated the effect of different irrigants on Biodentine's surface and compared them with those found for MTA.

Guneser et al.[5] evaluated the effect of 3.5% sodium hypochlorite (NaOCl), 2% chlorhexidine (CHX) and saline solution on adherence strength of Biodentine and ProRoot MTA. The bond strength values for Biodentine were greater than those of ProRoot MTA. The irrigants studied had no significant effect on Biodentine, but chlorhexidine had a deleterious effect on MTA. Elnaghy[22] found that QMix did not affect bond strength of Biodentine.

Nagas et al.[32] evaluated the effect of laser-activated NaOCl irrigation on bond strength of Biodentine and ProRoot MTA. They noted that Biodentine's bond strength was significantly greater than that of ProRoot MTA, and that laser activation of 5.25% NaOCl did not affect bond strength.

Al-Zubaidi and Al-Azzawi[33] analyzed the effect of NaOCl, EDTA and saline solution on the sealability of Biodentine and MTA used to repair furcal perforations. There were no differences between the level of dye penetration between Biodentine and MTA. Saline solution and NaOCl increased sealability of materials, whereas EDTA significantly increased dye penetration in Biodentine and MTA.

Biodentine as retrograde filling material.

According to Saunders et al.,[34] MTA has an 88% success rate when used as a retrograde filling material. Failures may be associated with prolonged setting time, as well as difficult manipulation and material porosity, which affects apical sealing. To reduce the unwanted characteristics of MTA, Biodentine has been tested as a substitute material for retrograde filling.

Soundappan et al.[35] compared the marginal adaptation of Biodentine and MTA as retrograde filling material using scanning electron microscopy (SEM). A 3-mm retro cavity was prepared, and the samples were filled with the test materials. The root ends were sectioned transversely at 1 mm and 2 mm and examined under SEM to evaluate marginal adaptation. There were no statistically significant differences between materials at 1 mm However, MTA was superior to Biodentine at 2 mm. General results showed statistically significant differences, and MTA was superior to Biodentine.

Mandava et al.[36] compared infiltration of MTA and Biodentine as a retrograde filling material. The cavities were prepared using conventional burs or ultrasonic retrotips. The authors did not find any differences in type of preparation. The comparison revealed that MTA had significantly less microleakage than Biodentine.

In contrast, Naik et al.[37] found that apical sealing using Biodentine was superior to that obtained with MTA. Moreover, the authors evaluated the effect of irrigation with MTAD before the placement of retrograde filling material, and found that MTAD irrigation significantly improved apical sealing of Biodentine when compared with MTA.

Akcay et al.[38] evaluated bond strength of Biodentine and MTA as retrograde filling materials in the presence or absence of blood. They found that blood contamination significantly affects bond strength. Also, Biodentine had a better adhesive strength than MTA.

Pawar et al.[39] and Caron et al.[40] reported successful clinical cases of use of Biodentine as retrograde filling material. No clinical study of Biodentine was found in the literature.

Biodentine as a cervical barrier in pulp revascularization or revitalization

Pulp revascularization or revitalization is a favorable treatment option, particularly for teeth with pulp necrosis in the initial stages of root formation. This treatment may lead to an increase in dentin width and in root length, with apical closing.[41, 42]

This procedure includes root canal cleaning with an irrigant, the use of intracanal medication (ICM), induction of a blood clot in the root canal space, and cervical sealing using a biocompatible and bioactive material.[43,44]

In the last few years, MTA has been the material of choice for cervical barrier; however, studies in the literature describe crown discoloration with the use of this material[45,46].

Yoldas et al.[47] evaluated the potential for tooth surface discoloration of Biodentine, BioAggregate and MTA Angelus and found that Biodentine had the lowest results of all the materials tested. This corroborates the findings by Kohli et al.,[48] who found significant crown discoloration due to the use of grey and white MTA, and no discoloration when Biodentine was used. Also, Marconyak et al.[49] found a less discoloration with the use of Biodentine than with white ProRoot MTA, MTA Angelus and ProRoot MTA.

Nagas et al.[50] evaluated the effect of different ICM on the bond strength of ProRoot MTA and Biodentine. The authors found that regardless of type of ICM, Biodentine had a significantly greater bond strength than MTA in the root canal. The use of calcium hydroxide as ICM improved resistance to displacement for both materials.

Case reports revealed promising results of absence of discoloration, good pulp revascularization or revitalization and conclusion of root formation with the use of Biodentine. This review did not find any prospective clinical studies about the use of Biodentine for pulp revascularization or revitalization.

Results

The studies analyzed showed that some of the physicochemical properties of Biodentine are better than those of MTA, such as setting time[11,13-15], bond strength[22,23], lower solubility[11,14,16] and porosity.[20,21] Moreover, Biodentine yields good results when used to seal perforations, to fill retrograde cavities and to form a cervical barrier during revascularization (Table 1).

Discussion

MTA has been used for many years in innumerable clinical cases of tissue regeneration. MTA has some negative characteristics, such as solubility, difficult manipulation, prolonged setting time and possible discoloration of tooth structures[3,5] so, new materials are likely to replace it. A material that has been studied as an option to replace MTA is Biodentine. Several studies have been conducted to prove the efficiency of Biodentine, also a calcium silicate-based material, and its physical properties and material manipulation have been improved.

The analysis of their physicochemical properties revealed that both Biodentine and MTA are biocompatible and bioactive. Biodentine has a shorter setting time than MTA[11,13-15] (Table 1), which makes it possible to conduct endodontic treatment and perforation sealing on the same visit.

Moreover, Biodentine has lower solubility[11,14,16], porosity[20,21], greater compressive strenght[15,17,19] and bond strength[22,23] than MTA, which may lead to an increase in the rates of endodontic treatment success. In contrast, MTA has greater radiopacity[11,16] than Biodentine, which favors the visualization of MTA on radiographs when compared with Biodentine (Table 1).

The use of these materials for furcal reparation showed that Biodentine has greater bond strength than MTA,[5,23,32] and both had similar sealability.[33] Greater bond strength may favor keeping the material in the cavity without affecting its sealing capability.

As a retrograde filling material, Biodentine had greater bond strength, whereas MTA had a better marginal adaptation.[35]

As a cervical barrier in cases of pulp revascularization, Biodentine had better results for bond strength and absence of crown discoloration than MTA ($p < 0.05$).[47-49] Therefore, Biodentine has become a highly recommended option for cervical barriers.

Table 1. Comparison of physicochemical and biological properties of Biodentine and MTA, perforation repair, retrograde obturation and pulp revascularization.

	Property evaluated	Authors	Findings
Physicochemical Properties.	Setting time	Grech, Mallia e Camilleri[11]	Biodentine < MTA *
		Jang et al.[13]	Biodentine < MTA*
		Kaup et al.[14]	Biodentine < MTA*
		Butt et al.[15]	Biodentine < MTA *
	Radiopacity	Grech, Mallia e Camilleri[11]	Biodentine < MTA*
		Ceci et al.[16]	Biodentine < MTA*
	Solubility	Grech, Mallia e Camilleri[11]	Biodentine < MTA*
		Ceci et al.[16]	Biodentine = MTA
		Kaup et al.[14]	Biodentine = MTA
	Microhardness	Elnaghy[17]	Biodentine > MTA*
		Kaup et al.[14]	Biodentine > MTA*
		Caronna et al.[18]	Biodentine < MTA*
	Compressive strength	Butt et al.[15]	Biodentine > MTA*
		Elnaghy[17]	Biodentine > MTA*
		Govindaraju et al.[19]	Biodentine > MTA*
	Porosity	Camilleri et al.[20]	Biodentine < MTA*
		Gandolfi et al.[21]	Biodentine < MTA*
	Bond strength	Elnaghy[22]	Biodentine > MTA*
		Aggarwal et al.[23]	Biodentine > MTA*
Biological Properties	Biocompatibility and bioactivity	Mori et al.[3]	Biodentine < MTA*
		Simsek et al.[24]	Biodentine > MTA*
		Ceci et al.[16]	Biodentine = MTA
		Saberi et al.[25]	Biodentine = MTA
		Margunato et al.[26]	Biodentine < MTA*
		Gomes-Cornélio et al.[27]	Biodentine = MTA
		Rodrigues et al.[28]	Biodentine > MTA*
Perforation repair	Bond strength	Aggarwal et al.[23]	Biodentine > MTA*
		Guneser et al.[5]	Biodentine > MTA*
		Nagas et al.[32]	Biodentine > MTA*
	Sealability	Al-Zubaidi, Al-Azzawi[33]	Biodentine = MTA
Retrograde Filling Material.	Marginal adaptation	Soundappan et al.[35]	Biodentine < MTA*
	Leakage	Mandava et al.[36]	Biodentine > MTA*
	Apical sealing	Naik et al.[37]	Biodentine > MTA*
	Bond strength	Akcay et al.[38]	Biodentine > MTA*
Cervical barrier	Discoloration potential	Yoldas et al.[47]	Biodentine < MTA*
	Bond strength	Kohli et al.[48]	Biodentine < MTA*
		Marconyak et al.[49]	Biodentine < MTA*
		Nagas et al.[50]	Biodentine > MTA*

* diferença estatisticamente significativa entre o Biodentine e o MTA.

Conclusion

Biodentine has promising results and may be a future alternative to MTA.

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