MedNEXT
Journal of Medical an Health Sciences

REVIEW ARTICLE

DOI: 10.54448/mdnt22309

Main clinical considerations of bioceramic cement in endodontic treatment: a brief systematic review

Lucas Castro Giraldi[1*], Arnaldo Sant'anna Jr[2]

[1] UNORTE - University Center of Northern São Paulo, Dentistry department, São José do Rio Preto, São Paulo, Brazil.
[2] UNIPOS - Post graduate and continuing education, Dentistry department, São José do Rio Preto, São Paulo, Brazil.

*Corresponding author: Dr. Lucas Castro Giraldi.
Unorte/Unipos – Graduate and Postgraduate education,
Dentistry department, São José do Rio Preto, São
Paulo, Brazil. E-mail: dr.lucas.cg@hotmail.com
DOI: https://doi.org/10.54448/mdnt22309
Received: 05-12-2022; Revised: 07-23-2022; Accepted: 08-07-2022; Published: 08-24-2022; MedNEXT-id: e22309

Abstract

Introduction: Endodontic treatment is usually indicated when periapical lesions are found, deep caries reach the pulp chamber, or in specific cases of prosthetic rehabilitation. The repair of periapical tissues depends on the total obturation of the root canal system and its hermetic sealing employing physically and biologically compatible materials. **Objective:** A brief systematic review was carried out to list the main clinical studies on the use of bioceramic cement in endodontic treatments and endodontic surgery. **Methods:** The rules of the Systematic Review-PRISMA Platform (Transparent reporting of systematic reviews and meta-analysis-HTTP://www.prisma-statement.org/) were followed. The research was carried out from May 2022 to June 2022 and developed based on Scopus, PubMed, Science Direct, Scielo, and Google Scholar. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** Current endodontic surgery has achieved high success rates, through the use of modern techniques such as operative microscopy, ultrasonic inserts, and the choice of good materials to fill the retro filling cavity. MTA was the first bioceramic cement developed and has provided much better results than previously used materials, such as amalgam and Super Eba. This is mainly due to its better sealing properties and its low cytotoxicity. MTA is still the standard material of choice for most endodontists who opt for Endodontic Surgery. However, new bioceramic types of cement are being developed rapidly, trying to improve biological responses, accelerate tissue regeneration, and decrease the rate of residual microorganisms.

Keywords: Bioceramic cement. Pulp protection. Endodontic treatment. Endodontic Surgery.

Introduction

Endodontic treatment is normally indicated when periapical lesions are found, deep caries reach the pulp chamber, or in specific cases of prosthetic rehabilitation [1,2]. The repair of periapical tissues depends on the total obturation of the root canal system and its hermetic sealing employing physically and biologically compatible materials [3]. However, in some situations, endodontic treatment may fail. In these cases, a possible solution to preserve the tooth is endodontic surgery [4,5].

In this sense, several techniques have been described in the literature, with variable results. The introduction of modern devices has significantly improved the prognosis of endodontic surgery [4]. Operating microscopes, magnifying loupes, microinstruments, ultrasonic inserts, and biologically acceptable filling and sealing materials have greatly increased the success rate of endodontic surgery [6,7].

In this context, during the last few decades, various materials have been used to fill and seal the reprofiling cavity. We have described in the literature the use of Amalgam, Super Eba Cement, Mineral Trioxide Aggregate Cement (MTA) [8], and more recently, several types of bioceramic types of cement that may include alumina, zirconia, bioactive glass, glass ceramic, hydroxyapatites, resorbable calcium, among others [9]. The individual properties of each of the materials, such as cytotoxicity and sealing capacity, contribute greatly to the success in controlling apical infection and consequent regression of the lesion [10].

Therefore, the present study aimed to carry out a brief systematic review to list the main clinical studies on the use of bioceramic cement in endodontic treatments and endodontic surgery.

Methods

Study Design

The rules of the Systematic Review-PRISMA Platform (Transparent reporting of systematic reviews and meta-analysis-HTTP://www.prisma-statement.org/) were followed.

Data sources and research strategy

The search strategies for this systematic review were based on the keywords (MeSH Terms): "*Bioceramic cement. Pulp protection. Endodontic treatment. Endodontic Surgery*". The research was carried out in May 2022 to June 2022 and developed based on Scopus, PubMed, Science Direct, Scielo, and Google Scholar. Also, a combination of the keywords with the booleans "OR", "AND", and the operator "NOT" were used to target the scientific articles of interest.

Study Quality and Bias Risk

The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument.

Results and Discussion

A total of 244 articles were found. Initially, duplication of articles was excluded. After this process, the abstracts were evaluated and a new exclusion was performed, removing the articles that did not address the theme of this article. In total, 102 articles were fully evaluated and 32 were included and evaluated in this study (**Figure 1**).

The pulp repair process occurs from the moment the aggression involves the odontoblasts. There is an inflammatory response involving neutrophils and macrophages. New fibroblasts differentiate and produce a collagen matrix. The use of a protective material such as bioceramics stimulates the formation of a dentin matrix and its subsequent mineralization. A protective material can be considered ideal if it has the characteristics described in **Table 1** [1].

Figure 1. Flow Chart of Study Eligibility (Systematic Review).

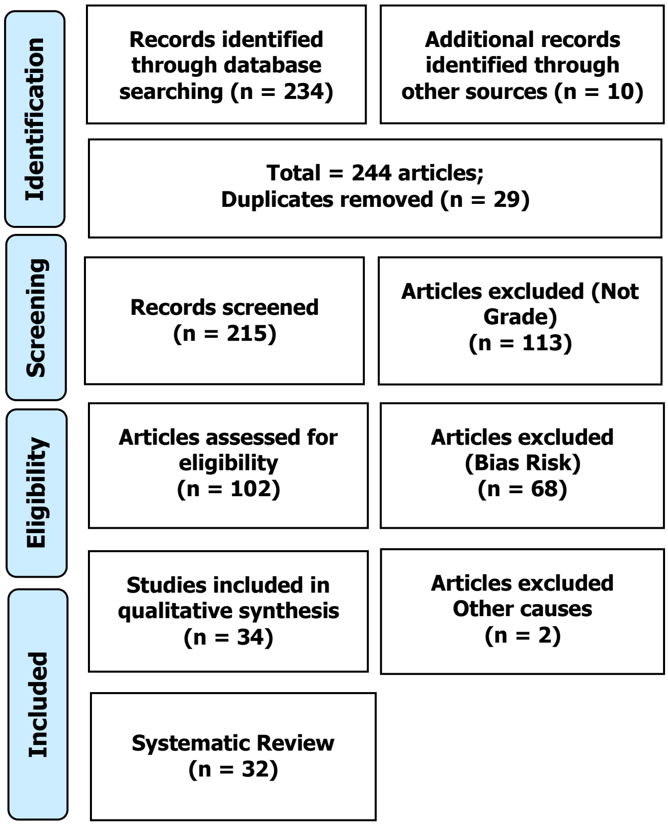

Table 1. Major characteristics about bioceramics.

✓ Protect the Dentinopulpar Complex from thermal and electric shocks;
✓ Be useful as a bactericidal agent or inhibit bacterial activity, sterilizing healthy and residual dentin in deep carious lesions;
✓ Adhere and release fluorides to the tooth structure;
✓ Remineralize part of the decalcified and/or affected dentin remaining in rapidly evolving lesions;
✓ Hypermineralize underlying healthy dentin after mechanical dentin removal (dentin tubule sclerosis);
✓ Stimulate the formation of tertiary or reparative dentin in deep lesions or pulp exposures;
✓ Be anodyne, biocompatible, maintain pulp vitality, and stimulate the formation of new dentin (calcified barrier) in direct protection, curettage, and pulpotomies;
✓ Inhibit the penetration of metal ions from amalgam restorations to the underlying dentin, thus preventing discoloration (darkening) of the tooth;
✓ Avoid the infiltration of toxic or irritating elements constituting the restorative materials and cementing agents into the dentinal canaliculi and pulp;
✓ Improve the marginal sealing of restorations, preventing the infiltration of saliva and microorganisms through the cavity wall/restoration interface.

Apical surgery is the last resort for the maintenance of an endodontically treated tooth with persistent periapical pathology. The objective is to create optimal conditions that allow tissue regeneration, including the formation of a new periodontal ligament. An airtight seal and low cytotoxicity are expected from the filling material of the retro filing cavity [1,2,11].

Therefore, Aqrabawi (2000) [8] carried out a comparative study of the sealing ability of amalgam, super EBA cement, and MTA when used as retrograde filling materials. 79 teeth were extracted, instrumented, and filled with gutta-percha. The apices were prepared with ultrasound at a depth of 3 mm and the teeth were divided into three random groups. 56% of the amalgam-filled group and 20% of the super EBA cement-filled group had dye leakage beyond the retro fund material, while the MTA group showed no leakage.

According to Torabinejad et al (1995) [12], MTA has some advantages over other retro-filling materials: ease of handling, insertion into the prepared cavity, adaptation to dentinal walls, requiring less condensation force, being related to small degrees of apical infiltration. Many studies have been carried out to find a material that offers adhesion, promotes hermetic sealing, is biocompatible, radiopaque, and provides an environment conducive to tissue regeneration.

Also, Gonçalves (2000) [3] researched the apical sealing capacity of four retrograde sealing techniques, using two different filling materials. Ninety human upper canine teeth were used, which had their canals instrumented and filled. After resection of the apical portion, the roots were divided into nine groups. The techniques used were as follows: retrograde filling, retro instrumentation with retro filling, retro instrumentation with retro filling associated with retrograde filling, canalization, and apicectomy (control group). Each technique used Super-EBA and MTA materials. The best sealing results were found in the MTA channeling technique group.

In addition, the authors Kim et al (2016) [13] performed a long-term clinical study of endodontic microsurgery where MTA and Super EBA were used as filling materials. The objective was to compare the clinical outcome of endodontic microsurgery at 1-year follow-up with 4-year follow-up. Two hundred and sixty teeth were randomly assigned to the MTA or Super EBA group in equal numbers using the minimization method. In one year 192 teeth were examined, revealing a success rate of 95.6% for MTA and 93.1% for Super EBA. At the 4-year follow-up, 182 teeth were examined and the success rate was 91.6% for the MTA and 89.9% for the Super EBA. Statistical analysis of the success rate showed no significant difference between the 2 materials.

Also, the authors Baek et al (2010) [10] studied the regeneration potential of different root filling materials by evaluating the distance between the material and the new bone formed after endodontic surgery. They induced apical lesions in the premolars and molars of 5 beagles. The teeth were endodontically treated and after one week endodontic surgeries were performed using microsurgical techniques. The filling materials used were amalgam, super EBA, and MTA. After 4 months the puppies were sacrificed and histological sections prepared. The MTA showed the most favorable periapical tissue response and the distance between the MTA and the regenerated bone was similar to the normal distance from the periodontal ligament in healthy dogs.

Moreover, authors Steining et al (2003) [14] report the use of MTA for apexification of teeth with an open apex in a single visit. According to the authors, the current literature supports its effectiveness in a multiplicity of procedures, including specification. The use of MTA in these cases would be an alternative to traditional practices of treatment with Ca(OH)2. The importance of this approach lies in the cleaning and molding of the root canal system, followed by its apical sealing with a material that favors regeneration, in this case, the material of choice would be MTA.

According to Costa et al (2012) [15], MTA induces the formation of a layer of crystalline structures. This effect is due to the reaction of calcium oxide with tissue fluids and calcium hydroxide, which reacts with CO2 in the bloodstream, forming calcium carbonate. An extracellular matrix rich in fibrin is secreted in close contact with these products, initiating the formation of hard tissue.

The authors Coaguila-Llerena et al (2016) [16] evaluated in vitro the cytotoxicity to the human periodontal ligament of three root filling materials: MTA Ângelus, Endosequence Root Repair Material Putty, and Super EBA. The primary culture of human periodontal ligament fibroblasts was previously obtained and the three material extracts were inserted and evaluated after 2 and 7 days. Various dilutions of these extracts were evaluated. Large differences were found at high dilutions, but there was no significant difference at low dilutions. Cell viability was higher for MTA Angelus in the 2-day sample compared to the other materials. There was no statistically significant difference between MTA Angelus and Endosequence Root Repair Material Putty in the 7-day samples. Super Eba showed the lowest cell viability.

Besides, Baraba et al (2016) [17] also carried out a study to investigate the cytotoxicity of two endodontic types of cement: MTA Fillapex and Endosequence BC Sealer. The study was carried out in the subcutaneous tissue of rats, where 6 mm diameter Teflon discs were placed and filled with the materials. After incubation times of 1, 6, 20, and 24 hours, the Teflon discs were removed and the number of viable cells was determined. MTA Fillapex was significantly less viable for cells at all incubation periods, while Encoseequence BC Sealer was less viable for samples after 6, 20, and 24 hours of incubation. The authors concluded that both types of cement are cytotoxic in rat L929 fibroblast cultures.

Also, Jitaru et al (2016) [18] performed a major literature review on bioceramics used in endodontics. Bioceramics are materials obtained through several chemical processes, they exhibit excellent biocompatibility due to their similarity to biological materials, such as hydroxyapatite. According to the authors, MTA (Mineral Trioxide Aggregate) cement was the first successful bioceramic used in endodontics, developed from Portland cement, at Loma Linda University, California, in the 1990s. Subsequent studies showed that the material has good adhesion to dentin with good antimicrobial activity. The Endosequence sealer is another highly radiopaque and hydrophilic calcium silicate-based material and contains monocalcium phosphate, which is responsible for the formation of hydroxyapatite in situ, studies show good results when used for the treatment of perforations and filling of retro filling cavities. Biodentine, created in 2009, contains tricalcium silicate, calcium carbonate, zirconium oxide, and calcium chloride, which is indicated for the treatment of resorptions, root perforations, pulp capping procedures, specification and filling of retro-fillings. aggregate, produced in Canada, has similar qualities to MTA cement in terms of marginal sealing, superior adhesion, and pulp cell migration. Finally, Generex A is a calcium silicate-based material with some characteristics similar to MTA, but it is mixed only with gel without water in the composition. It was developed for filling the cavities of endodontic surgery and root perforations and appears to have superior moisture resistance and good radiopacity.

In another review of bioceramics, Raghavendra et al (2017) [9] concluded that although MTA is the reference bioceramic material, new materials are constantly being developed to discard the disadvantages of MTA and improve its properties. Many of these materials are already on the market, and have a range of applications, both in endodontics and restorative dentistry. The knowledge of the bioactive properties of each one of them is essential for the selection of the best material for each clinical situation.

In addition, Ogutlu and Karaca (2018) [4] performed a study to assess the clinical and radiographic outcomes of teeth treated with endodontic surgery. A total of 112 teeth were included, Super EBA and MTA were used with retro filling materials. The success rate was 88.4%, the only statistically significant difference found was the type of tooth treated, and no significant differences were found between the filling materials used.

The authors Agrafioti et al (2015) [19] studied the possibility of portraying canals to patency filled with gutta-percha and with two types of cement based on calcium silicate, TotalFill BC Sealer (BCS) and mineral trioxide aggregate Fillapex. (MTA F), versus calcium silicate-based types of cement are negotiable in teeth with simple root canal anatomy. However, conventional retreatment techniques are not able to remove them.

The authors Jiang et al (2016) [20] reported the use of bioceramic types of cement to induce apexification in immature teeth with pulp necrosis. They used iRoot BP in two cases and MTA in one case. After 8 months of follow-up, no abnormal clinical or symptomatological signs were observed and radiographically apexification of the tooth was observed, with a significant decrease in periapical radiolucency. Both types of cement produced excellent results, but iRoot BP was superior in terms of clinical ease of application and can be considered an alternative treatment to MTA.

Asgary & Fayazi (2017) [21] also reported a successful case using MTA for apexification in a tooth with an open apex. However, excess apical extravasation of MTA was detected radiographically, and a curettage surgery was chosen to remove the MTA particles and adjacent granulation tissue. Follow-up radiographs for 18 months showed favorable results, but extrusion of MTA into the periapical area should be avoided.

Conclusion

Current endodontic surgery has achieved high success rates, through the use of modern techniques such as operative microscopy, ultrasonic inserts, and the choice of good materials to fill the retro filling cavity. MTA was the first bioceramic cement developed and has provided much better results than previously used materials, such as amalgam and Super Eba. This is mainly due to its better sealing properties and its low cytotoxicity. MTA is still the standard material of choice for most endodontists who opt for Endodontic Surgery. However, new bioceramic types of cement are being developed rapidly, trying to improve biological responses, accelerate tissue regeneration, and decrease the rate of residual microorganisms.

Acknowledgement
Not applicable.

Funding
Not applicable.

Ethics approval
Not applicable.

Informed consent
Not applicable.

Data sharing statement
No additional data are available.

Conflict of interest
The authors declare no conflict of interest.

Similarity check
It was applied by Ithenticate@.

About the License

References

1. Zafar K, Jamal S, Ghafoor R. Bio-active cements-Mineral Trioxide Aggregate based calcium silicate materials: a narrative review. J Pak Med Assoc. 2020 Mar;70(3):497-504. doi: 10.5455/JPMA.16942. PMID: 32207434.
2. Montero-Miralles P, Ibáñez-Barranco R, Cabanillas-Balsera D, Areal-Quecuty V, Sánchez-Domínguez B, Martín-González J, Segura-Egea JJ, JiménezSánchez MC. Biomaterials in periapical regeneration after microsurgical endodontics: A narrative review. J Clin Exp Dent. 2021 Sep 1;13(9):e935-e940. doi: 10.4317/jced.58651. PMID: 34603623; PMCID: PMC8464390.
3. Gonçalves, S B. Avaliação in vitro da capacidade seladora do Super-EBA e do MTA em quarto técnicas de obturação retrógrada. Dissertação de Mestrado, Faculdade de Odontologia de Bauru (Catálogo USP), Bauru, 2002.
4. Ogutlu F, Karaca I. Clinical and Radiographic Outcomes of Apical Surgery: A Clinical Study. J Maxillofac Surg. 2018 Mar; 17(1): 75-83.
5. Abusrewil SM, McLean W, Scott JA. The use of Bioceramics as root-end filling materials in periradicular surgery: A literature review. Saudi Dent J. 2018 Oct;30(4):273-282. doi: 10.1016/j.sdentj.2018.07.004. Epub 2018 Jul 24. PMID: 30202163; PMCID: PMC6128316.
6. Bianco E, Calvelli C, Citterio CL, Pellegatta A, Venino PM, Maddalone M. Evaluation with Micro-CT of the Canal Seal Made with Two Different Bioceramic Cements: GuttaFlow Bioseal and BioRoot RCS. J Contemp Dent Pract. 2020 Apr 1;21(4):359-366. PMID: 32584269.
7. Olcay K, Taşli PN, Güven EP, Ülker GMY, Öğüt EE, Çiftçioğlu E, Kiratli B, Şahin F. Effect of a novel bioceramic root canal sealer on the angiogenesisenhancing potential of assorted human odontogenic stem cells compared with principal tricalcium silicate-based cements. J Appl Oral Sci. 2020 Jan 10;28:e20190215. doi: 10.1590/1678-7757-2019-0215. PMID: 31939521; PMCID: PMC6919198.
8. Aqrabawi J. Capacidade de vedação de amálgama, cimento super EBA e MTA quando usado como materiais de enchimento retrógrados. Br Dent J, 2000 11 de março; 188(5): 266-8.
9. Raghavendra S S, Jadhav G R, Gathani K M, Kotadia P. Bioceramics in endodontics – a review. J Istanb Univ Fac Dent. 2017; 51 (3 suppl 1): S128S137.
10. Baek SH, Lee WC, Setzer FC, Kim S. Periapical bone regeneration after endodontic microsurgery with three different root-end filling materials: amalgam, SuperEBA, and mineral trioxide aggregate. J Endod. 2010 Aug; 36(8): 1323-5.
11. Coaguila-Llerena H, Vaisberg A, Velasques-Huamán Z. In Vitro Cytotoxicity Evaluation of Three Root-End Filling Materials in Human Periodontal Ligament Fibroblasts. Braz. Dent. J. vol 27 n. 2 Ribeirão Preto Mar/Apr. 2016.
12. Torabinejad M, Pitt Ford T, Hong C. Investigation of mineral trioxide aggregate for root and filling in dogs. J Endod. 1995 21(12): 603-8.
13. Kim S, Song M, Shin S J, Kim E. Um estudo controlado aleatório de trióxido mineral agregado e ácido super etoxibenzoico como materiais de preenchimento de ponta final em microcirurgia endodontica: resultados a longo prazo. J Endod. 2016 Jul;42(7): 997-1002.
14. Steining TH, Regand JD, Gutmann JL. O uso e a colocação previsível de Mineral Trioxide Aggegate em casos de apexificação de uma visita. Aust Endod J. 2003 Apr; 29(1): 34-42.
15. Costa DD, Mariano MMC, Muniz YS, Duplat CBS,

Patrocinio DSJ, Santos JLS. Agregado de trióxido mineral: uma revisão da sua composição, mecanismo de ação e indicações clínicas. Rev. Saúde Com. 2012, 8(2): 24-33.

16. Coaguila-Llerena H, Vaisberg A, Velásquez-Huamán Z. In Vitro Cytotoxicity Evaluation of Three Root-End Filling Materials in Human Periodontal Ligament Fibroblasts. Braz Dent J. 2016 Mar-Apr;27(2):187-91. doi: 10.1590/01036440201600447. PMID: 27058382.
17. Baraba A, Pejelij-Ribaric, Roguljic M, Miletic I. Cytotoxicity of Two Bioactive Root Canal Sealers. Acta Stomatol Croat. 2016 Mar; 50(1): 8-13.
18. Jitaru S, Hodisan I, Timis L, Lucian A, Bud M. The use of bioceramics in endodontics – literature review. Clujul Med. 2016; 89(4): 470-473.
19. Agrafioti A, Koursoumis A D, Kontakiotis E G. Re-establishing apical patency after obturation with Gutta-percha and two novel calcium silicate-based sealers. Eur j Dent 2015 Oct-Dec; 9(4): 457-461.
20. Jiang S, Wu HAO, Zhang C F. Partial Pulpotomy of Immature Teeth wih Apical Periodontitis using Bioceramics and Mineral tRioxide Aggregate: A Report of Three Cases. Chin J Dent Res 2016; 19(2): 115-120.
21. Asgary S, Fayazi S. Endodontic Surgery of a Symptomatic overfilled MTA apical plug: A Histological and Clinical Case Report. Iran Endod J. 2017; 12(3): 376-380.