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Major considerations of sealing materials in parendodontic surgery: a concise systematic review

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Abstract

Introduction: Parendodontic surgery or periapical surgery has been described in the literature for several decades as a treatment option for endodontic failure. Several techniques have been described; however, we can currently say that the success of periapical surgery is directly linked to new technologies, such as operating microscopy, ultrasonic inserts for proper decontamination of the region, and new materials that provide adequate sealing of the retrograde filling cavity. **Objective:** It was to conduct a concise systematic review on the main considerations of sealing materials in periapical surgery. **Methods:** The PRISMA Guidelines were followed. The search was conducted from January to February 2026 across the Web of Science, Scopus, Embase, PubMed, ScienceDirect, SciELO, and Google Scholar databases. The quality of the studies was assessed using the GRADE instrument, and the risk of bias was evaluated according to the Cochrane instrument. **Results and Conclusion:** According to the GRADE instrument, most studies presented homogeneous results, with X^2 = 78.7% > 50%. A total of 126 articles were found and submitted for eligibility analysis, with 30 final studies selected to compose the results of this systematic review. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 30 studies with a high risk of bias and 21 studies that did not meet GRADE and AMSTAR-2 standards. Among the desired properties of new materials for sealing the retrograde filling cavity, low cytotoxicity, good radiopacity, ease of handling, and the ability to seal and adhere to dentin stand out. With the discovery of MTA in the 1990s, a new class of materials, bioceramics, has been developed for this purpose.

Keywords: Parendodontic surgery. Periapical surgery. Endodontic cements. Apical sealing. Cytotoxicity. Bioceramics.

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 complete obturation of the root canal system and its hermetic sealing using physically and biologically compatible materials [1,2]. However, in some situations, endodontic treatment may fail. In these cases, a possible solution to preserve the tooth is periapical surgery [3].

Several techniques have been described in the literature, with varying results. The introduction of modern devices has significantly improved the prognosis of parendodontic surgery or periapical surgery. Operating microscopes, magnifying loupes, microinstruments, ultrasonic inserts, and biologically acceptable filling and sealing materials have greatly increased the success rate of periapical surgery [4-7].

During the last few decades, various materials have been used for the purpose of filling and sealing the retrograde filling cavity. We have described in the literature the use of Amalgam, Super Eba Cement, Mineral Trioxide Aggregate (MTA) Cement, and, more recently, various types of bioceramic cements that may include alumina, zirconia, bioactive glass, ceramic glass, hydroxyapatites, resorbable calcium phosphates, among others [8,9]. 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 [9].

Therefore, the present study aimed to carry out a concise systematic review on the main considerations of sealing materials in parendodontic surgery.

Methods

Study Design

This study followed the international systematic review model, following the PRISMA (preferred reporting items for systematic reviews and meta-analysis) rules. Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed at: 02/15/2026. The AMSTAR 2 (Assessing the methodological quality of systematic reviews) methodological quality standards were also followed. Available at: https://amstar.ca/. Accessed at: 02/15/2026.

Search Strategy and Search Sources

The literature search process was carried out from January to February 2026 and developed based on Web of Science, Embase, Scopus, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various periods to the present day. The following descriptors were used in health sciences (DeCS/MeSH terms): *"Parendodontic surgery. Periapical surgery. Endodontic cements. Apical sealing. Cytotoxicity. Bioceramics"*, and the Boolean "and" was used between the MeSH terms and "or" between the historical findings.

Study Quality and Risk of Bias

Quality was classified as high, moderate, low, or very low regarding the risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analyses of randomized clinical trials, followed by randomized clinical trials. Low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using Cohen's test (d).

Results and Discussion

Summary of Findings

A total of 126 articles were found and submitted to eligibility analysis, with 30 final studies selected to compose the results of this systematic review. The listed studies were of medium to high quality (Figure 1), considering the level of scientific evidence of studies such as meta-analysis, consensus, randomized clinical, prospective, and observational. Biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies presented homogeneity in their results, with X^2=78.7%>50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 30 studies with a high risk of bias and 21 studies that did not meet GRADE and AMSTAR-2.

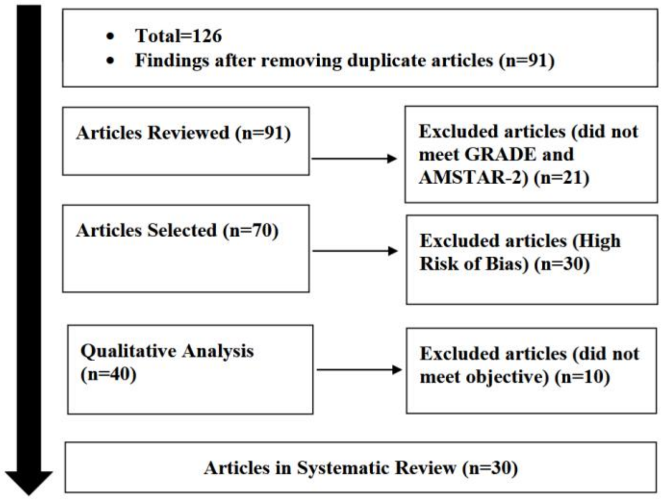

Figure 1. Flowchart showing the article selection process. Source: Own Authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using Cohen's Test (d). Precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). This graph did not have a symmetrical behavior, suggesting a significant risk of bias, both among studies with small sample sizes (lower precision) that are shown at the base of the graph and in studies with large sample sizes that are presented at the top.

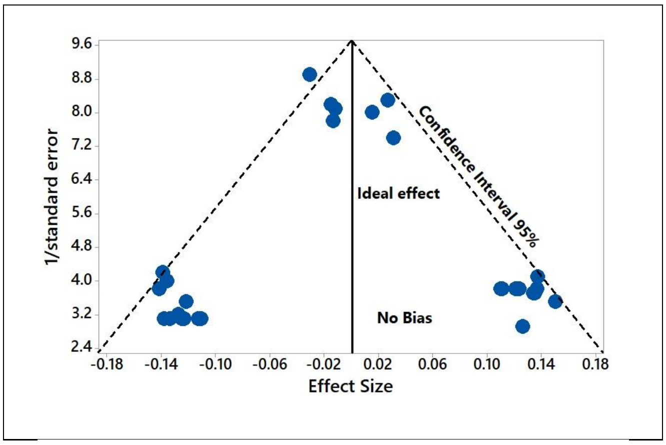

Figure 2. The non-symmetrical funnel plot suggests risk of bias among the studies with small sample sizes that are shown at the bottom of the graph. High confidence and high recommendation studies are shown above the graph (n=30 studies). Source: Own Authorship.

Major Considerations and Findings

Parendodontic surgery or apical surgery is the last resort for maintaining an endodontically treated tooth with persistent periapical pathology [1-4]. The goal is to create optimal conditions that allow tissue regeneration, including the formation of a new periodontal ligament [5-9]. A hermetic seal and low cytotoxicity are expected from the retrograde filling material [10-15].

Aqrabawi (2000) [16] conducted a comparative study of the sealing capacity of amalgam, Super EBA cement, and MTA when used as retrograde filling materials. Seventy-nine extracted, instrumented, and gutta-percha obturated teeth were used. The apices were prepared with ultrasound to 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 showed dye leakage beyond the retrograde material, while the MTA group showed no leakage.

According to Torabinejad et al (1995) [17], MTA has a number of advantages over other retrograde filling materials: ease of handling, insertion into the prepared cavity and adaptation to the dentinal walls, requiring less condensation force, and 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 a favorable environment for tissue regeneration.

Gonçalves (2000) [18] researched the apical sealing capacity of four retrograde sealing techniques, using two different obturation materials. Ninety human maxillary canine teeth were used, which had their canals instrumented and obturated. After resection of the apical portion, the roots were divided into nine groups. The techniques used were as follows retrograde obturation, retroinstrumentation with retrofilling, retroinstrumentation with retrofilling associated with retrograde obturation, root canalization, and apicoectomy (control group). Each technique used Super-EBA and MTA materials. The best sealing results were found in the root canalization technique group with MTA.

Kim et al (2016) [19] conducted 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 a 4-year follow-up, 182 teeth were examined, and the success rate was 91.6% for MTA and 89.9% for Super EBA. Statistical analysis of the success rate showed no significant difference between the two materials.

Baek et al (2010) [20] studied the regenerative potential of different root filling materials by evaluating the distance between the material and the new bone formed after parendodontic surgery. They induced apical lesions in premolars and molars of 5 beagles. The teeth were endodontically treated, and after one week parendodontic surgeries were performed using microsurgical techniques. The filling materials used were amalgam, Super EBA, and MTA. After 4 months, the dogs were sacrificed, and histological sections were prepared. MTA showed the most favorable periapical tissue response, and the distance between the MTA and the regenerated bone was similar to the normal distance of the periodontal ligament in healthy dogs.

Steining et al (2003) [21] report the use of MTA for apexification of teeth with open apices in a single visit. According to the authors, the current literature supports its effectiveness in a multiplicity of procedures, including apexification. The use of MTA in these cases would be an alternative to traditional $Ca(OH)_2$ treatment practices. The importance of this approach lies in cleaning and shaping 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) [22], 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 CO_2 from 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.

Coaguila-Llerena et al (2016) [23] evaluated *in vitro* the cytotoxicity to the human periodontal ligament of three root canal filling materials: MTA Angelus, Endosequence Root Repair Material Putty, and Super EBA. Primary cultures of human periodontal ligament fibroblasts were obtained beforehand, and the three extracts of the materials were inserted and evaluated after 2 and 7 days. Several 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.

Baraba et al (2016) [24] also conducted a study to investigate the cytotoxicity of two endodontic cements:

MTA Fillapex and Endosequence BC Sealer. The study was performed on the subcutaneous tissue of rats, where 6 mm diameter Teflon discs filled with the materials were placed. 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 in samples after 6, 20, and 24 hours of incubation. The authors concluded that both cements are cytotoxic in rat L929 fibroblast cultures.

Jitaru et al (2016) [25] conducted a large literature review on bioceramics used in endodontics. Bioceramics are materials obtained through various chemical processes, exhibiting excellent biocompatibility due to their similarity to biological materials, such as hydroxyapatite. According to the authors, MTA (Mineral Trioxide Aggregate) cement was the first bioceramic successfully 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 and good antimicrobial activity. Endosequence sealer is another highly radiopaque and hydrophilic calcium silicatebased material containing monocalcium phosphate, responsible for the formation of hydroxyapatite in situ; studies show good results when used for the treatment of perforations and filling of retrograde filling cavities. Biodentine, created in 2009, contains tricalcium silicate, calcium carbonate, zirconium oxide, and calcium chloride, and is indicated for the treatment of resorptions, root perforations, pulp capping procedures, apexification, and filling of retrograde fillings. BioAggregate, produced in Canada, has qualities similar 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 its composition. It was developed for filling cavities in periapical surgery and root perforations and appears to have superior moisture resistance and good radiopacity.

In another review on bioceramics, Raghavendra et al (2017) [26] concluded that although MTA is the reference bioceramic material, new materials are constantly being developed with the intention of discarding the disadvantages of MTA and improving its properties. Many of these materials are already on the market and have a range of applications, both in endodontics and restorative dentistry. Knowledge of the bioactive properties of each of them is essential for selecting the best material for each clinical situation.

Ogutlu and Karaca (2018) [27] conducted a study to evaluate the clinical and radiographic results of teeth treated with parendodontic surgery. A total of 112 teeth were included. Super EBA and MTA were used as retrograde filling materials. The success rate was 88.4%; the only statistically significant difference found was the type of tooth treated. No significant differences were found between the filling materials used. Agrafioti et al (2015) [28] studied the possibility of retreating canals to patency obturated with gutta-percha and with two types of calcium silicate-based cements, TotalFill BC Sealer (BCS) and mineral trioxide aggregate Fillapex (MTA F), versus calcium silicate-based cements, which are negotiable in teeth with canals of simple anatomy. However, conventional retreatment techniques are not able to remove them.

Jiang et al (2016) [29] reported the use of bioceramic cements 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 symptomatic signs were observed, and radiographically, apexification of the tooth was observed, with a significant decrease in periapical radiolucency. Both cements produced excellent results, but iRoot BP was superior in terms of ease of clinical application and can be considered an alternative treatment to MTA.

Asgary & Fayazi (2017) [30] also reported a successful case using MTA for apexification in a tooth with an open apex. However, excessive apical leakage of MTA was detected radiographically, and a curettage surgery was chosen to remove the MTA particles and adjacent granulation tissue. Follow-up radiographs at 18 months showed favorable results; however, extrusion of MTA in the periapical area should be avoided.

Conclusion

It was concluded that current periapical surgery has achieved high success rates through the use of modern techniques such as operating microscopy, ultrasonic inserts, and the selection of good materials for filling the retrograde 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 superior sealing properties and low cytotoxicity. MTA is still the standard material of choice for most endodontists who opt for periapical surgery. However, new bioceramic cements are being developed rapidly, attempting to improve biological responses, accelerate tissue regeneration, and reduce the rate of residual microorganisms.

CRediT

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All authors; **Project administration-** All authors; **Supervision-** Fábio Pereira Linhares de Castro; **Writing - original draft-** All authors; **Writing-review & editing-** All authors.

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The authors declare no conflict of interest.

Similarity Check

It was applied by Ithenticate@.

Application of Artificial Intelligence (AI)

Not applicable.

Peer Review Process

It was performed.

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