



## COMPARISON OF MINERAL TRIOXIDE AGGREGATE, ENDOSEQUENCE ROOT REPAIR MATERIAL, AND BIODENTINE USED FOR REPAIRING ROOT PERFORATIONS: A SYSTEMATIC REVIEW

### ABSTRACT

The root perforation, in spite of being taken as a challenging accident in root canal treatment, has to offer favorable results when exposed to appropriate therapeutic conduct and the usage of materials that have convenient properties. The aim of the current review is to collect all updated and available studies including imperative information concerning the use of Mineral trioxide aggregate, EndoSequence root repair material and Biodentine in the treatment of root perforation approaching some of the key properties for treatment success. A search was performed in the two automated databases (Google Scholar and PubMed use English-language literature) for this systematic review, using specific inclusion and exclusion criteria and keywords. The electronic search was done in December 2018 and update in June 2019. Our inquiry uncovered Twenty-two studies that met the exclusion and inclusion criteria. These studies investigated the use of MTA, EndoSequence ERRM and Biodentine in the root perforation that happened during the endodontic treatment. It was confirmed that there is no unanimity in this review concerning the material that shows the best characteristics, once none of the materials discussed had all the major properties higher than the others, this way it is required the enforcement of further studies aimed at selecting the best characteristics of the material suggested in the root perforation treatment.

**Keywords:** EndoSequence root repair material, mineral trioxide aggregate, root canal filling materials, tooth root.

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## **INTRODUCTION**

Root perforation is an unintentional or pathological communication between the pulp cavity and the periodontal tissue arising from iatrogenic, reabsorption or caries.<sup>1,2</sup> It is taken as a big challenge to the most renowned endodontic specialists and clinicians, symbolizing one of the most unpleasant accidents during the endodontic treatment.<sup>3</sup> Pain during the instruments usage and intense and immediate bleeding are mentioned as clinical manifestations; Furthermore, a secondary inflammation and loss of bone insertion represent one of the biggest complications arising from perforation.<sup>4</sup>

The root perforation has as a causal element a pathological change like a large dental caries or root reabsorption, or it may happen through an operative surgical accident.<sup>5-8</sup> There are factors that make it hard to access to the root canal during the endodontic treatment, predisposing to dental perforation as examples: Errors regarding the canal identification, large caries, pulp calculations, badly positioned teeth, internal root reabsorption, excessive abrasion and debility of the dentin displayed in the danger zones.<sup>9</sup> The microorganisms deriving from the root canal, the periodontium or both may colonize the spot where the perforation happened, resulting in the contamination of the area and a probable inflammatory response.<sup>7</sup> As a result of the inflammation, it may cause bone resorption, pain, abscess, suppuration, fistula, and necrosis, which undermine the treatment's efficacy and consequently cause loss of the dental element.<sup>5</sup> The roots cervical third and the pulp-chamber floor are the spots most likely to be contaminated because of the closeness with the oral environment and the consequent facility for the bacteria's colonization in the area.<sup>6,7</sup>

Root perforation constitutes the second most common cause of endodontic flaws.<sup>10</sup> The prognosis is linked to the perforations location, extent, time, presence or absence of contamination, suitable treatment, early diagnosis, and usage of ideal materials.<sup>9, 11</sup> The diagnosis should be performed right away in order to provide proper treatment, favoring the prognosis and preventing bacterial colonization.<sup>10</sup> The treatment may be carried out

through the surgical method, although, since there is a possibility of pocket formation, the non-surgical technique is the most accepted, mainly in areas where the access is hard.<sup>8,12</sup> The treatment has as its aim to offer hermetic sealing and ought to be based immediately through surgical procedures or endodontic path. Because of the possibility of pockets formation in the surgical method, its more advantageous to endodontic therapy, particularly in regions of difficult access.<sup>12,13</sup> The treatment's success is directly associated with the perforations size, location, and level, the usage of suitable materials and techniques, presence or absence of inflammation and repair time.<sup>14</sup> Despite the dental element prognosis in which the root perforation happened being obscure, it is possible to reverse this scenario through good therapeutic practice and using materials that present favorable characteristics.<sup>15</sup>

The mineral trioxide aggregate (MTA) is taken as a gold standard material in the perforations sealing because it holds important properties like high pH, biocompatibility, fixation power even with humidity, periradicular regeneration and osteoinductive capacity.<sup>2,16-19</sup> Nevertheless, it displays some confining disadvantages, which are able to intervene in the clinical practice, expressed through the difficult manipulation and insertion on the spot to be filled, short working time and slow prey time.<sup>20</sup> With the requirement to enhance the physicochemical properties of the MTA and surpassing the limitations displayed, the EndoSequence root repair material (ERRM) was designed (Brasseler USA, Savannah, GA, USA).<sup>21,22</sup> It is a premixed material, its appearance is as a condensed mass or preloaded syringe, has excellent biological and mechanical properties, easy manipulation, highly biocompatible, hydrophilic, radiopacity, osteogenic and insoluble, prescribed for pulp capping and root's repair procedures.<sup>23</sup> The Biodentine (Septodont, Saint-Maur-des-Fossés, France) was manufactured with the goal of assembling the bioactivity and high biocompatibility of calcium silicate.<sup>24</sup> However, does not include aluminate in the formula, which diminishes the potential health risks. It holds properties as low cytotoxicity, excellent sealing ability, compressive resistance, easy handling, besides

keeping the bone-biomaterial interface, so it exhibits clinical indication in root perforation therapy.<sup>2,25</sup>

Overall, the ideal material for the perforation repair success must exhibit proper sealing, having biocompatibility, stimulating the cementogenesis and osteogenesis, being radiopaque, with easy manipulation, not being absorbable, having dimensional stability and not being soluble to tissue fluids.<sup>8,12,21,26,27</sup> Different materials have been designed for the treatment perforation, among these, we can cite the amalgam, zinc oxide, and eugenol cement, calcium hydroxide, resin cement, the hydroxyapatite, and glass ionomer.<sup>28</sup> Consequently, the aim of this review was to collect all updated and available studies including imperative information concerning the use of mineral trioxide aggregate (MTA), biodentine (BD), and Endosequence Root Repair Material (ERRM) in the root perforations treatment that happened during the endodontic treatment.

## **MATERIALS AND METHODS**

This review was reported in accordance with the PRISMA statement.

### ***Focused Question***

“What is the most appropriate repair material to be employed in the root perforation therapy?”

### ***Search Strategy***

The systematic way was performed to look-up for relevant information through several kinds of literature & search engines with great concern to the main question. Such a study was accomplished in December 2018 and applauded with new information until July 2019. A web search was done through PubMed (2008-2018) and Google Scholar (2008-2018) with MesH terms and/or in various combinations (“Endodontics”, “root perforation”, “repair material”, “bioceramic”, “biodentine”, “mineral-trioxide aggregate”, “endosequence”).

### ***Inclusion Criteria***

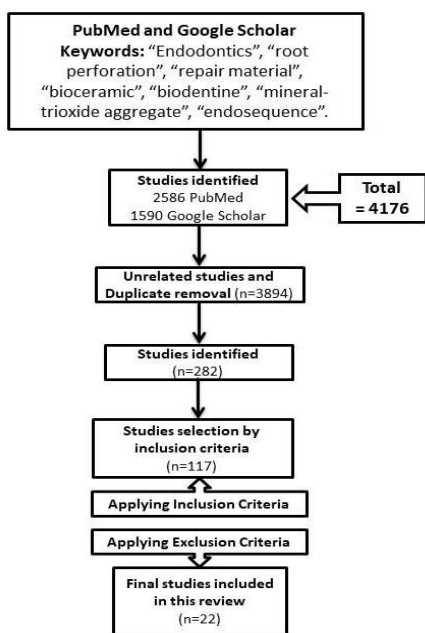
- Native research released in the English language.
- Time framed articles released within 10 years from 2008 - 2018.

- Studies carried out on human and animal subjects.

### ***Exclusion Criteria***

- Articles that described the different repair materials excluding EndoSequence root repair material, Biodentine, and Mineral Trioxide Aggregates.
- Articles that discussed the different clinical applications of repair materials excluding root perforation.
- Review articles.

Relevant articles had been read & assessed by the introduction of the close meaning ideas by the study reviewers. Full articles were obtained for most of the titles and abstracts that met the inclusion criteria, the full text was accessed. From each included article, Study design, interventions and controls, and findings were extracted. Articles used were categorized into two main groups (free & restricted). Free ones have been downloaded directly by the URLs generated from the database. The restricted group has been downloaded by the institutional access of the KAU library. Even though some articles didn't match the main idea, they have been reviewed again & decided to be either relevant or irrelevant. An understanding was there between the authors in relation to the suitability of the chosen articles. Even the reference was examined to identify any studies that haven't been covered by electronic searches. A summary of this review search strategy was summarized in (Figure 1).



**Figure 1.** Flow Chart of the Search Strategy used in this Systematic Review.

## RESULTS

Our exploration uncovered Twenty-two studies which met the exclusion and inclusion criteria. These studies investigated the use of MTA, EndoSequence ERRM and Biodentine in the root perforation that happened during the endodontic treatment on human and animal studies. All the studies included in this systematic review were eleven In-vitro studies<sup>8,10,12,13,20,26,28-32</sup>, two In-vivo studies<sup>2,17</sup>, one Randomized controlled trial study (RCT)<sup>33</sup>, four Retrospective clinical studies<sup>18,34-36</sup>, and four Case reports.<sup>1,7,9,37</sup> In regard to the types of root repair materials performed, fourteen studies were performed with MTA in a combination of other root repair materials such as ERRM and Biodentine.<sup>2,8,10,12,13,17,20,26,28-32,35</sup> The placement of Biodentine alone as a root repair material for root perforation was made in three studies.<sup>1,7,18</sup> On the other hand, five studies, MTA has placed alone.<sup>9,33,34,36,37</sup>

## DISCUSSION

The root perforation prognosis is affected by the chemical and physical properties of the materials used, independent of etiology or placement, the endodontic therapy ought to be performed with materials that display good characteristics.<sup>9,26</sup> This systematic review conducted to summarize, locate, appraise and synthesize all high-quality research evidence taken from 22 articles, which included original studies relevant to a scientific

research question. The question of this review is “What is the most appropriate repair material to be employed in the root perforation therapy?”. All included studies confirmed different repair materials used in the root perforations.

In the present time, the materials of choice for root perforation repair are the bioceramics, like the mineral trioxide aggregate (MTA), EndoSequence root repair material (ERRM) (Brasseler USA, Savannah, GA, USA) and Biodentine (Septodont, Saint-Maur-des-Fossés, France).<sup>10</sup> Bioceramics are materials made of calcium silicate, they have been widely employed in endodontics as a root repair material, in pulp coating, as cement sealing, and in periapical surgeries, they exhibit relevant characteristics like biocompatibility, dimensional stability, antimicrobial power, and elevated pH.<sup>38</sup> The MTA was the first bioceramic conducted and used in dental perforation treatment. It is primarily formed by tricalcium silicate, silicate oxides, bismuth, and Tricalcium aluminate.<sup>9,13</sup> On the other hand, in spite of the excellent characteristics, the MTA exhibits some limitations, as unpractical handling, granular consistency, long prey time and short work time.<sup>17</sup> With the purpose of enhancing the MTA characteristics and enhancing the reported difficulties, the bioceramic cements ERRM and Biodentine were elaborated.<sup>20</sup> Using calcium silicate, the ERRM is primarily comprised of zirconium oxide, monobasic calcium phosphate, and tantalum oxide, commercially it is obtainable in the consistency of mass that is ready for use, supplying a consistent material and making the Clinical management easier.<sup>26</sup> It is biocompatible, insoluble, hydrophilic and bioactive, does not have aluminum, the prey starts through contact with the humid environment and is able to provide excellent sealing, characteristics that define it as a proper material in the Dental perforations treatment.<sup>10,39-40</sup> The Biodentine bioceramic is comprised of calcium silicate, zirconium oxide, tricalcium silicate, and calcium carbonate, the commercial presentation is powder and liquid.<sup>1,26,28</sup> It exhibits biocompatibility, dimensional stability, excellent sealing capacity, easy manipulation, short prey time, so is suitable for clinical usage in roots repair.<sup>20,29</sup> Moreover, it keeps the bone-biomaterial interface, it displays low cytotoxic capacity and

good fluidity, which makes it easier to insert in the spot to be used.<sup>2</sup>

In this systematic review, few studies claimed that the perforations should be handled promptly with a biocompatible material which generates suitable sealing between the perforation and the adjacent tissues.<sup>1,6,8,10,12</sup> In addition, an in-vitro study conducted in 2016, after they assessed the sealing capacity of MTA and Biodentine declared that there are no considerable differences between the materials, advising for the use of Biodentine like an alternative to MTA in the perforations repair.<sup>29</sup> In another study done in 2017, they noticed that the MTA displayed better sealing in comparison to Biodentine.<sup>2</sup> Also, an in-vitro study conducted by Bampa, *et al.*<sup>31</sup> in 2015, they assessed the MTA ability to seal using three different insertion techniques. The study enabled the observation that irrespective of the technique used it was not possible to prevent the infiltration.<sup>31</sup> That way, they settled the requirement for more studies to be performing in order to enhance the materials sealing property in critical dental spots.<sup>31</sup> One study done in 2014, when comparing the sealing capacity between the Biodentine and Endosequence ERRM noticed that the Endosequence ERRM had better performance.<sup>10</sup> A study conducted by Lagisetti, *et al.*<sup>8</sup> in 2018 compared the Endosequence ERRM to the MTA and settled that there are no statistical differences between them. Also, an in-vitro study done in 2015, compared the MTA with different root repair materials and settled that there are comparable capabilities in sealing the furcal perforations of the primary molars.<sup>32</sup> There are four studies that assert the difficulty in MTA manipulation is a downside of this material.<sup>10,17,26,28</sup> In line with a retrospective study conducted in 2013, they appraised the effect of various endodontic irrigants on the push-out bond strength of Biodentine (Septodont, Saint Maur des Fossés, France) in comparison with different repair materials.<sup>35</sup> They found Biodentine illustrated great work as a perforation repair material even after being exposed to various endodontic irrigants.<sup>35</sup> In addition, another study done in 2017, when they are comparing the MTA to the Biodentine in the furcal perforation repair,

it was noticed an easier usage for Biodentine, because of the decreased prey time of almost 12 minutes which decreases the bacterial contamination risk, in addition to display an easy manipulation and being highly biocompatible, features that define it as positive material.<sup>1</sup> A retrospective study conducted in 2013, they found (73.3%) of cases that which the root perforations repaired with MTA classified as healed.<sup>34</sup> Also, another study done in 2010, they concluded to MTA seems to furnish a biocompatible and long-term effective seal for root perforations in all parts of the root.<sup>36</sup>

Silva, *et al.*<sup>2</sup> in 2017, states that mineralized tissue formation at the spot where the perforation happened is a key indicator regarding treatment success. These results were in agreement with the findings of Rifaey, *et al.*<sup>30</sup>, who provided the osteogenic potential between the ERRM and the MTA, settled that the ERRM promoted better osteoblasts differentiation. Silva, *et al.*<sup>2</sup> noticed that the MTA led to the formation of mineralized tissue with larger thickness and area, in comparison to Biodentine. Nevertheless, Biodentine exhibited good histopathologic outcomes and may be taken as a repair material.<sup>2</sup> Calcium silicate-based materials can have their physical and chemical properties changed when exposed to acidic pH, mainly when local acidosis is prompted by tissue or bacterial inflammation.<sup>2</sup> These results were similar to the findings of other authors, Wang, *et al.*<sup>41</sup> evidenced a decrease in the microhardness of the Endosequence ERRM and MTA in an acid environment. In addition, Deepthi, *et al.*<sup>26</sup>, conducted an in vitro study in which was noticed that MTA and Endosequence ERRM microhardness and microstructure were strongly changed in an acidic environment in comparison to Biodentine, decreasing adhesion to the dentin, materials hardness and sealing capacity. Also, Mancino, *et al.*<sup>18</sup>, claimed that Biodentine offers effective sealing when used in an acid environment. The dental perforation placement is a relevant factor in the perforation prognosis.<sup>18</sup>

Two studies affirmed that the closer to the oral cavity, the harshest prognosis is because of the

bacterial contamination arising from the oral environment.<sup>6,8</sup> In a case report mentioned by Kaushik, *et al.*<sup>7</sup>, Biodentine was the chosen material to a perforation repair situated at the cement-enamel junction due to mechanical properties, short prey time and excellent sealing, after 6 months of follow-up, the patient reported favorable outcomes in the healing of periodontal tissues. However, as a result of the absence of scientific evidence, further studies are required in order to highlight their characteristics over other materials. In accordance with one study done in 2014, they found the coronary situated perforations display unfavorable prognosis, with the Furcal perforation as the worst prognosis when compared to the other spots.<sup>6</sup> Alsulaimani<sup>33</sup>, states that the Furcal perforation is a serious issue in dental practice, being taken as a challenging accident. Also, two studies agree that the prognosis of the furcal perforation is questionable, due to the area displaying smaller dental structures, in addition to being close to the gingival sulcus and for that reason; it is taken as a “danger zone”.<sup>8,10</sup> Alsulaimani<sup>33</sup>, asserts that the size of dental perforation is directly associated with the trauma that can cause to the adjacent tissues, negatively impacting on the prognosis, the smaller the perforation and trauma will be and with easier repair as well. To clarify this, she settled that the periodontal tissues displayed a more favorable response to the MTA when it was put in smaller perforations, the greater the perforation was, and the more critical the treatment would be.<sup>33</sup> With the goal of promoting the recovery of the dental element affected by the perforation, the material of choice must encourage the repair and should be biologically neutral.<sup>17</sup> So toxic materials and pulp tissues ought to be spared.<sup>28</sup> When assessing the cytotoxic effect of MTA, ERRM, and Biodentine to the periodontal ligament fibroblasts, Samyuktha, *et al.*<sup>28</sup>, established that there was not noticed any statistical difference between the 3 materials. Another study conducted in 2016, when assessing the MTA and ERRM biocompatibility in the connective tissue of rats determined that the ERRM was comparatively more irritating, displaying higher biocompatibility after 6 weeks

of usage.<sup>17</sup> In addition, case reports done at 2008, they concluded to the use of MTA to seal small, new furcal root perforation is related to a perfect short-term (i.e., 5 years) clinical outcomes.<sup>37</sup>

## CONCLUSIONS

Through the current systematic review, it may be noticed that there is still no unanimity in this review concerning the most appropriate material to be employed in the root perforation therapy, once among the materials studied none showed all the required properties higher than the others. However, the MTA because of high usage of it among dentists and published different studies about this material as a repair material, while the ERRM and Biodentine were recently used, so they did not present long-term studies. For that issue, it is relevant to the implementation of different studies that have as objective to report using clinical and radiographical evidence, the behavior of the materials available for the dental practice.

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## CONFLICTS OF INTEREST STATEMENT

The authors declare no conflict of interest.

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