International Summit on Science Technology and Humanity (ISETH) 2022
Academic Improvement for Recovery Acceleration
p-ISSN: 2477-3328 e-ISSN: 2615-1588

Comparison of Success Rates of Biodentine and MTA Materials in Pulp Revascularization Treatment of Immature Permanent Teeth

Raden Bryan Sukma Ramadhan [1,*], Cahyani[2] , Juwita Raditya Ningsih [3], Noor Hafida Widyastuti [1]

[1,4] Department of Dentistry, Faculty of Dentistry, Muhammadiyah University, Surakarta

Abstract

Purpose: To determine the success rate of biodentine and MTA materials in pulp revascularization treatment of immature permanent teeth.
Methodology: The literature review approach was used in the research design, which was a means of gathering data from library sources. What performed data searches on Pubmed, ScienceDirect, and Google Scholar sites by specified keywords and filtered based on their association with the research title, inclusion, and exclusion criteria to ensure that publications fit the requirements.
Results: Revascularization has been shown to be effective when performed on teeth with disinfected root canals, so it is important to obatain a good coronal seal. Coronal seal used biodentine is better than MTA. Biodentin has a better consistency, allows its condensation without apical displacement, and the short setting time allows the composite restoration to be placed simultaneously. Biodentin has the same mechanical properties as human dentin with very low cytotoxicity and can overcome the clinical drawbacks of MTA. Biodentine is tooth-colored and does not cause discoloration.
Applications/Originality/Value: *Literature review* contributes to comparing Success Rates of Biodentine and MTA Materials to increase knowledge and success in Immature Permanent Dental Pulp Revascularization Treatment. The results obtained are better because *the literature review* of this study compares several journals with different research objects, research samples, methods, and results.

Introduction Section

Immature permanent teeth are young or newly erupted teeth with incomplete root tip formation. The eruption of permanent teeth begins from the crown, usually taking about three years to complete root development. The shape of the developing root is determined by a two-layered cellular structure called the Hertwig epithelial root sheath (Aldakak *et al.*, 2016). Root development after eruption consists of increasing root length, increasing root wall thickness, and narrowing the root canal in the apical region or root tip. Disturbances in the blood supply to HERS due to pulpal necrosis can interfere with cell proliferation and differentiation, causing root development to stop. Abnormal complex tissue deposition can also occur in this situation (Zizka *et al.*, 2018).

Termination of root growth is a significant problem in endodontic treatment. Tooth root growth that has the potential not to continue occurs in young or immature teeth with an open apex. Possible indications of immature permanent teeth experiencing cessation of root formation include trauma (33.8%), den evaginates (25.9%), and dental caries (12.9%) (Mccabe, 2015). This condition causes the roots of the teeth to be short and the walls thin so that they fracture easily. The results of these data show how crucial endodontic treatment is in maintaining the vital pulp of immature permanent teeth due to trauma and dental caries. If this problem is not treated immediately, it can cause bacteria to enter the exposed pulp, which can cause other diseases such as reversible pulpitis, irreversible pulpitis, and pulp necrosis. (Singh *et al*., 2017).

In the case of developing permanent teeth, endodontic therapy typically involves apexification. Application of calcium hydroxide [Ca(OH)2] paste or one-visit apical sealing with the placement of an apical barrier using mineral trioxide aggregate was used in the procedure for apexification (MTA) (Godoy, 2012). Apexification the

* Corresponding author: author@email.org.me

disadvantage is that there is a risk of fracture that may occur due to the cessation of thickening of the dentin wall. Alternative treatment procedures, such as implants in pediatric patients, are contraindicated. Implants can not be done because framework The craniofacial area in children is still developing, and implants can interfere with this developmental process (Li *et al.*, 2019). Alternative procedure gradual apical closure through surgery can be performed, but the procedure is invasive, and the risk of complications is greater clinically and psychologically, especially for children. New treatment alternatives are urgently needed to avoid the risk of future fractured front and are certainly appropriate for children both clinically and psychologically (Hargreaves *et al.*, 2013).

Long-term success rate apexification use a higher MTA than apexification using Ca(OH)2. Apexification with MTA takes less time with just one visit in comparison to apexification with Ca(OH)2, need many times-visits over a long time(6-24 months with an average of a year± seven months) (Jeeruphan *et al.*, 2012)

Revascularization, the newest method for treating additional root growth brought on by immature permanent teeth with incomplete (long) root development and wide open apex because the periapical tissue surrounding the immature permanent tooth has an abundant blood supply, is a regenerative treatment and a biologically based alternative approach to endodontic treatment. It has a significant amount of stem cells that can regenerate damaged tissue (Bukhari *et al.*, 2016). Over time, root fracture incidence is intended to be decreased by revascularization. The treating the pulp involves chemically disinfecting the root canal with irrigation solutions and intracanal therapy, followed by the induction of clots, coronal sealing of the MTA, and placement of a crown restoration (Albuquerque *et al*, 2014). Revascularization was defined as the invagination of undifferentiated periodontal cells from the apical area of an immature permanent tooth.

In this writing, the author is interested in digging deeper about revascularization pulp, especially in immature permanent teeth, and its level of effectiveness.

Literature review

Invagination of undifferentiated cells into the root canals of developing immature permanent teeth is known as revascularization. The desired results of pulpal revascularization have been linked to periapical cells (root tip development and apical closure) (Sourabh, 2020). The development of vital tissue inside the root canal is referred to as "pulp revitalization." The root canal of the tooth is cleaned and sterilized during regenerative endodontic therapy using the revascularization technique (Rizk *et al.*, 2020).

Immature permanent teeth have multipotent periodontal cells in the periapical regions that have a high potential to differentiate into fibroblasts and cementoblasts. These fibroblasts and cementoblasts differentiate to thicken the dentin wall and complete the apical closure (Shi *et al.*, 2013). In order to allow for the growth of vital pulp tissue from periapical tissue stem cells transported by a blood clot, the root canal is not filled with artificial obturation material. Root tip development and apical closure are caused by the formation of dentine and cementum by periapical stem cells (Hajizadeh *et al.*, 2019).

Apical growth could result from the proliferation of stem cells from the apical papilla inside the root canal as a result of the infusion of blood into the periapical tissues (Shi et al., 2013). Because of the periapical tissues' ability to cause bleeding, these cells have a high proliferative capacity that enables them to be transported into the root canal. (Singh *et al.*, 2017) suggested that different growth factors included in blood clots in dentine may be crucial for cell proliferation within the root canal space. Eventually, the roots of the developing immature permanent teeth close, enabling apical healing through the periodontal tissues.

The revascularization procedure has several stages, as follows:

A. First Visit

1. Dental anesthesia
2. Isolate with a rubber dam
3. Creation of coronal cavity access.
4. Root canal disinfection

   (Singh *et al.*, 2017) It was explained that using chemical and mechanical devices for root canal disinfection is the first step in the endodontic treatment of infected root canals. As a result of the fragile and thin root walls that restrict the use of intracanal irrigation solutions and medications to disinfect immature

permanent teeth, mechanical removal of microorganisms is not advised. Sodium hypochlorite (NaOCl) and chlorhexidine (CHX) are the most frequently used for root canal irrigation worldwide.

The most effective intracanal medication for controlling infection inside the root canal and enabling growth into new tissue to continue root development is *Triple Antibiotic Paste* (TAP). Minocycline, metronidazole, and ciprofloxacin are examples of intracanal medications. Ciprofloxacin and metronidazole are combined to make the antibiotic paste known as "*Double Antibiotic Paste*" (DAP). DAP does not contain minocycline, but it is less effective than TAP at getting rid of DAP bacteria. Antibiotics with nanofiber are known as 3D antibiotics. Antibiotics given in low doses with a gradual drug release will be able to treat the infection and produce a bacterial-free environment in the root canal.

5. After intramedical application, the tooth is temporarily filled in, and the patient is asked to return after 3 to 4 weeks.

B. Second visit

6. Do an evaluation
   Acute infection symptoms and signs are looked for during the evaluation process. Revascularization can be used as a form of treatment if there are no symptoms or indicators of infection.
7. Do local anesthesia.
8. Isolate the tooth with a rubber dam and temporarily clean the filling.
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9. Isolate the tooth with a rubber dam and temporarily clean the filling.
10. Perform periapical induction of bleeding
    For immature permanent teeth with necrotic pulp, inducing periapical bleeding into the root canal is a crucial step in the revascularization process. Blood clots that form in the root canals act as a matrix or scaffold in the pulp tissue's wound-healing process. Blood containing fibrin scaffolding material, mesenchymal stem cells, and bioactive growth factors enters the root canal as a result of inducing periapical bleeding. The goal of the periapical bleeding procedure was to fill the entire root canal with blood up to the CEJ. The procedure involved inserting a sterile file 2-3 millimeters outside of the apical foramen to cause bleeding into the root canal. (Jung et al., 2019)
11. Create a blood clot
    A cotton pellet or dry cotton is placed in the cavity approximately 3-4mm into the canal and left for 7-10 minutes to allow the formation of a blood clot.
12. Sealing the coronal pulp
    The root canal filled with a blood clot is then applied collagen barrier (Colla-Plug) just above the blood clot, followed by an application of MTA or biodentine 3-4 mm thick. Coronal pulp sealing materials commonly used are Mineral Trioxide Aggregate (MTA) and Biodentine. The only difference in the response of the pulp to either MTA or Biodentin is the density of the tissue bridges formed. Intracanal drug dressing is carried out in approximately three weeks. (Jung et al., 2019)
13. The final restoration was carried out.
14. Evaluation of treatment success
    Evaluation is carried out through clinical examination and radiographic examination, which is carried out at least after 12 to 18 months to evaluate root development.

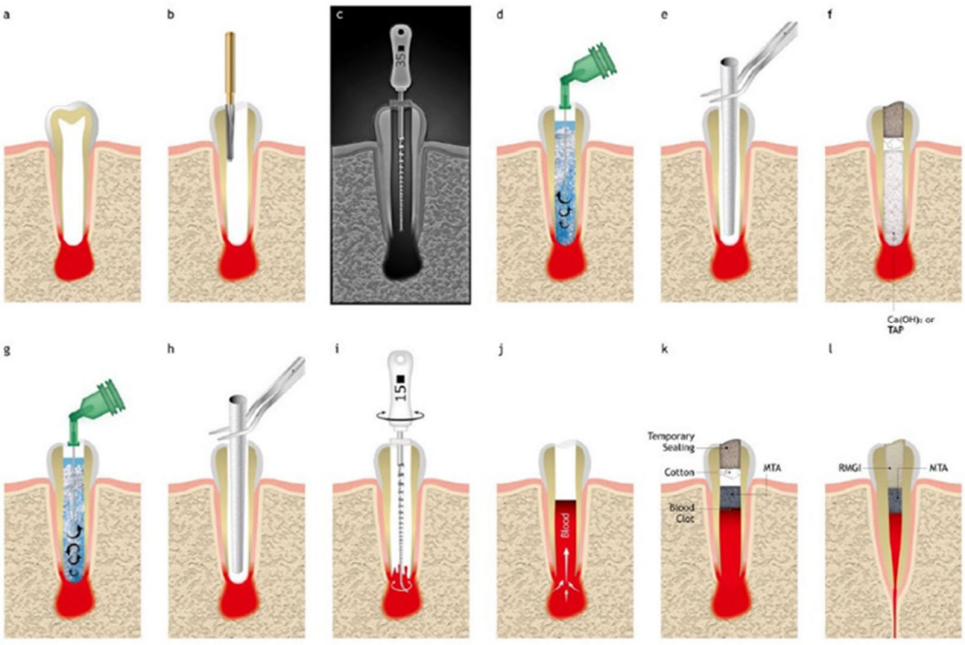

Figure 1. Schematic illustration of the revascularization procedure. Revascularization is considered for immature permanent teeth with open apex, pulpal necrosis, and apical periodontitis. (a) After accessing the root canal. (b) Gently irrigate the coronal section (a radiograph is required to confirm K-file height). (c) Provides an approximate tooth length, which helps to determine: Working length. Low concentrations of NaOCl (1.5 or less than 3%, 20 mL/channel, 5 minutes) are used for disinfection. (d) Saline irrigation, or 17% EDTA used. After irrigation, drain the canals with paper points. (e) Intracanal drug application, such as: Ca(OH)2 or TAP, is placed and covered with a temporary filling material. (f) After confirming no signs of infection, Final irrigation was carried out with sterile saline and 17% EDTA (g). Dry the root canal with paper points. (h) K-file was inserted 2mm past the apical foramen and rotated to induce bleeding. (i) Blood fills the root canal from the bottom to the CEJ. (j) After the clot has formed, a covering material such as MTA is placed over the clot. (k) Pulp-dentin regeneration leads to root development with apical thickening, elongation, and closure, as well as maintenance of tooth vitality. (Jung *et al.*, 2019)

Before performing revascularization, it was essential to achieve good coronal closure to stop bacterial invasion into the pulp chamber because revascularization only works on teeth with disinfected root canals. Coronal closure materials must be compatible for stem cells to survive and regenerate new, condition-sensitive tissues inside the canal (Aldakak *et al*, 2016).

For regenerative procedures, MTA is regarded as a recommended material. Since biodentine has the same mechanical properties as human dentin and very low cytotoxicity, it is also required for this procedure and can compensate for MTA's clinical limitations. Among the MTA's drawbacks that necessitate seeking MTA replacement are complex manipulation, a slow setting time, a high cost, and crown discolouration (Jung *et al.*, 2019)

Biodentin is considered an ideal replacement for MTA because it has better consistency allowing perfect condensation, short setting time, low cost, less discolouration, and allows good condensation consistency (Džanković et al., 2020). Biodentin has superior compressive strength and flexibility than MTA. High biocompatibility and excellent bioactivity support this tooth replacement material (Aly *et al.*, 2019).

Method

The literature review approach was used in the research design, which was a means of gathering or collecting data from literary sources connected to the subject to be examined. The data used was secondary data. , and a lot of time. The main or original publications or papers were obtained through Pubmed, Science Direct, and

Google Scholar by putting in the keywords that were identified and corresponded to what was desired in the problem formulation.

The following were the inclusion criteria for this study: Scientific journals or articles on revascularization and immature permanent teeth, full-text scientific journals or articles in pdf format, scientific journals or articles for the last ten years, 2011-2021, Indonesian and English language journals or scientific articles, scientific journals or articles organized by research topic. The following were the study's exclusion criteria: Journals or scientific publications published more than ten years prior to 2011, journals or articles that are not in full text and abstract form, or that are not available over the internet.

Results

From searching data on the Pubmed, ScienceDirect, and Google Scholar pages using predetermined keywords, 103 journals were obtained as initial data. Then journals were filtered based on their association with research titles and inclusion and exclusion criteria found in 31 journals. Re-filtered journals based on the reference year of the last ten years found four journal titles that met the criteria. The results of screening journals that are appropriate and meet the criteria can be seen in table 1.

Table 1. Screening Results for Appropriate Journals and Meets the Criteria

No.	Journal Title	Year	Source	Destination	Research methods	Results
1.	Clinical and Radiographic Evaluation of Biodentine and Mineral Trioxide Aggregate in Revascularization of Non-Vital Immature Permanent Anterior Teeth (Randomized Clinical Study)	2018	*Google Scholar*	Assess clinically and radiographically the effect of using two types of coronal sealing materials in the revascularization of non-vital immature teeth.	Clinical and radiographic assessment to evaluate the success of treatment	Biodentin has better clinical success than MTA. Biodentin has less discoloration than MTA. Evaluation of root length in biodentin is better than MTA.
2.	Sealing Ability of Biodentine versus Proroot Mineral Trioxide Aggregate as Root-End Filling Materials	2018	*Science Direct*	Evaluate the sealing ability of ProRoot MTA and Biodentine as root tip-filling materials.	Fluid filtration method	The sealing ability of ProRoot MTA is superior to Biodentin in the long term.
3.	Sealing Ability of Mineral Trioxide Aggregate, Biodentine, and Glass Ionomer as Root-End Materials: A Question of Choice	2020	*Pubmed*	It was knowing the sealing ability of MTA, Biodentin, and Fuji IX as root tip materials after retrograde ultrasonic preparation.	The dye penetration method was assessed under a stereomicroscope (x10).	Biodentin provides better sealing ability as a root tip material than MTA and Fuji IX. There was no statistically significant difference between the sealing ability of MTA and Fuji IX as a root tip material.

4.	Evaluation of Tooth Discoloration after Treatment with Mineral Trioxide Aggregate, Calcium-Enriched Mixture, and Biodentine in The Presence and Absence of Blood	2019	*Pubmed*	Evaluate tooth discoloration after treatment with mineral trioxide aggregate (MTA), calcium-enriched mixed cement (CEM), and Biodentine.	Spectrophotometric analysis.	Biodentin induces discoloration of the lowest teeth in the presence and absence of blood. The rate of discoloration is significantly lower than that of MTA.

Discussion

It was crucial to achieving a bacteria-tight coronal seal to stop bacterial invasion into the pulp chamber before revascularization was done because it was only effective in teeth with disinfected root canals. The compatibility of the coronal seal material was essential for stem cells to survive and regenerate new, condition-sensitive tissues within the intra-canal environment (El-Khatib *et al.*, 2020). Research results (Aly *et al.*, 2019) Clinical success rates for most cases ranged from (96%) to (100%) for the Biodentine group and (91.66%) to (91.66%) for the MTA group, respectively. Clinical outcomes such as the resolution of biting pain, pain on percussion, mobility, swelling, sinus, and fistula were not statistically significantly different between the two groups (P-value = 0.33). The common disinfection procedure and the effective coronal seal that the two materials used in both groups could achieve can be used to explain this. The results, this information (El-Khatib *et al.*, 2020), A 12-month follow-up revealed that all 20 treated teeth had survived and met the criteria for clinical success outlined in the study (dental survival without clinical symptoms, including pain on percussion or palpation, swelling, sinus, or spontaneous pain) (Džanković *et al.*, 2020). After a 12-month follow-up, one case in the MTA group was determined to have clinically failed due to biting and percussion pain. As stated in several reports, failure might result from increased bacterial growth in the accessory canals, dentinal tubules, or biofilms on the canal walls. As a result, tissue damage is brought on by the canals' re-infection (Madani *et al*, 2019).

Biodentine provides better coronal sealing ability than MTA. The research of (El-Khatib *et al.*, 2020) explained that the differences in microleakage seen in Biodentine compared to ProRoot MTA when evaluated one day after installation could be related to the formation of calcium or phosphate-rich crystal deposits, which increased over time and decreased gaps between the teeth and the material. Root tip filler Because of the MTA's longer setting time, the relatively high MTA ProRoot leakage seen during the first 24 hours may have occurred. One of the most clinically important determining factors is time.*(Aly et al.*, 2019). The risk of the root tip filling material becoming loose or contaminated is decreased by the quick setting time of biodentine (Džanković *et al.*, 2020).

According to a research finding (Džanković *et al.*, 2020) Biodentine's superior sealing capacity is due to its smaller particle size and low porosity. The porosity and average pore size of biodentine are both low, ranging from 0.01 to 0.05 m. Products of the hydration reaction fill the spaces left by the unhydrated cement grains. These physical characteristics help to improve marginal adaptation to the cavity walls and lessen the possibility of leakage. Better penetration into the dentinal tubules is made possible by the material's small pore volume (Aly *et al.*, 2019). MTA's lower sealing ability can be attributed to its larger particle size. This is supported by El-Khatib *et al.* (2020), reported that Biodentine showed better marginal adaptation as a root tip material than MTA and Glass Ionomer Cement.

Evaluation of the success of revascularization treatment can be seen from the increase in root length/coverage. According to study El-Khatib *et al*, (2020) The percentage increase in root length was 5.64 (2.39)% in the biodentine group and 5.02 (1.65)% in the MTA group. This outcome is comparable to the finding made public by Saoud et al. Because biodentine is comparable to typical calcium silicate-based materials, many of its physical, chemical and biological properties are the same as those of MTA. As a result, there was no

statistically significant difference in the percentage increase in root length between the two groups (P-value 0.48). MTA can be replaced with Biodentine because it is almost as effective at improving clinical conditions (Džanković *et al.*, 2020). The correlation coefficient between elapsed time and an increase in root length (mm) was negative, with an R-value of 0.4479, indicating that the shorter the interval between injury and treatment, the more significant the increase in root length (mm). The presence of clinically viable cells, or the capacity of the cells to survive and differentiate, is related to the time of injury; the length of infection is a predictor of this potency (Madani *et al*, 2019).

The success of revascularization treatment can be seen in aesthetics, namely discoloration. Research results from (Aly *et al.*, 2019) Biodentine displayed significantly less discoloration than MTA. The presence of bismuth oxide in the MTA composition is thought to be the cause of the color change. The tooth tissue contains bismuth oxide, which interacts with collagen. As a result, sodium hypochlorite will precipitate as a dark substance. When bismuth oxide is oxidized, its oxygen molecules become unstable and react with the carbon dioxide in the air to create bismuth carbonate, a discoloring agent (Džanković *et al.*, 2020). Iron oxidation in the substance, linked to the calcium aluminoferrite phase in the cement powder, is one additional potential mechanism for MTA-induced discolouration. In its formulation, biodentine substitutes zirconium oxide for bismuth oxide, which is absent. Due to its comparable radiopacity, inability to affect the material's hydration, and lack of colouration, this substitute radiopacifier is adequate (Madani, 2019).

They are taking into account the benefits of Biodentin compared to MTA and keeping in mind that the coronal sealing capabilities of Biodentin are superior to those of MTA, according to research findings. The composite restoration can be placed at the same time as Biodentin's better consistency, ability to allow condensation without apical displacement, and 12-minute set time (El-Khatib *et al.*, 2020). The same mechanical properties as human dentin, very low cytotoxicity, and the ability to circumvent MTA's clinical limitations make biodentine essential for revascularization procedures. Better aesthetics are provided by biodentine because it is coloured like teeth and does not cause discolouration due to material in the orifice (Kaur *et al.*, 2017).

Conclusion

It can be concluded that the success rate of revascularization treatment is higher using biodentine materials than MTA materials.

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