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Bioceramic Materıals in Vital Pulp Therapy of Prımary Teeth: A Contemporary Approach from Mta to New-Generatıon Calcıum Silicate-Based Materials

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ABSTRACT

Maintaining primary teeth in the oral cavity until the time of physiological exfoliation is important for mastication, speech, esthetics, preservation of arch integrity, and guidance of permanent tooth eruption. Preserving pulp vitality in the treatment of deep dentinal caries has become one of the fundamental goals of modern pediatric dentistry. In the past, materials such as formocresol, ferric sulfate, and calcium hydroxide were used in pulpotomy techniques; however, advances in pulp biology and the development of bioactive materials have shifted treatment strategies from fixation or devitalization toward pulp preservation and support of biological healing. In this evolution, the high biocompatibility, sealing ability, capacity to create an alkaline environment, and ability to support mineralized tissue formation of mineral trioxide aggregate (MTA) have played an important role. Nevertheless, disadvantages of some MTA formulations, including long setting time, difficult handling, high cost, and discoloration, have led to the development of new calcium silicate-based materials. Biodentine, NeoMTA Plus, NeoMTA 2, and NeoPutty were developed to improve handling characteristics, physical properties, and color stability. Current clinical studies, systematic reviews, and meta-analyses report that MTA and Biodentine show high and generally comparable clinical and radiographic success rates in primary-tooth pulpotomy. Although new-generation premixed materials also show promising short- and medium-term results, their long-term clinical evidence is not as extensive as that for MTA and Biodentine. The aim of this review is to evaluate the biological properties, clinical applications, advantages, disadvantages, and current clinical evidence for calcium silicate-based bioceramic materials used in vital pulp therapy of primary teeth [1-4].

KEYWORDS: Primary teeth, vital pulp therapy, pulpotomy, mineral trioxide aggregate, Biodentine, bioceramic, calcium silicate.

1. INTRODUCTION

Preservation of primary teeth in the oral cavity until the time of physiological exfoliation is of great importance for maintaining masticatory function, supporting speech development, preserving esthetics and vertical dimension, maintaining dental arch stability, and enabling proper eruption of permanent teeth. Therefore, the goal in treating severely carious primary teeth is not only to remove carious tissue but also, whenever possible, to preserve the vitality and biological function of the pulp-dentin complex [3,4].

Vital pulp therapy encompasses procedures aimed at maintaining the vitality of healthy pulp or pulp with reversible inflammation, reducing ongoing bacterial irritation, and creating a biologically favorable environment for pulpal healing. Within this approach, indirect pulp treatment, direct pulp capping, partial pulpotomy, and coronal pulpotomy may be considered in primary teeth [1,2].

In recent years, there has been a major change in the approach to pulpal diseases. Whereas the reversibility of pulpal inflammation was previously considered limited, it is now recognized that the pulp has considerable healing potential when adequate infection control, hemostasis, and coronal sealing are achieved. This development has transformed vital pulp therapy from a symptom-oriented approach into a minimally invasive treatment strategy aimed at preserving biological tissue.

The American Academy of Pediatric Dentistry's 2024 evidence-based guideline strongly recommends indirect pulp treatment with selective caries removal in vital primary teeth with deep caries. When pulpotomy is indicated, calcium silicate cements such as MTA or Biodentine are preferred over traditional pulpotomy materials. Similarly, the International Association of Paediatric Dentistry's 2026 Porto Consensus recommends minimally invasive, pulp-preserving techniques and emphasizes the importance of calcium silicate-based materials.

Formocresol and ferric sulfate were widely used for many years in conventional pulpotomy of primary teeth; however, their principal effects are based on tissue fixation or hemostasis rather than support of pulpal regeneration. The introduction of MTA represented an important shift in the approach to vital pulp therapy. Calcium silicate-based bioactive materials were developed on the basis of MTA's biocompatibility, sealing ability, and capacity to stimulate hard-tissue formation.

Despite limitations such as a long setting time, difficult handling, and a risk of discoloration, the high clinical efficacy of MTA encouraged the development of Biodentine and, later, premixed or modified MTA-based materials. Current research is increasingly focused not on whether bioceramics are superior to conventional pulpotomy materials, but rather on clinically meaningful differences among different calcium silicate cements [16-19].

The aim of this review is to examine the evolution of calcium silicate-based bioceramic materials used in vital pulp therapy of primary teeth, from MTA to current alternatives, and to evaluate their biological properties, clinical performance, advantages and disadvantages, and place in the literature.

2. BIOLOGICAL BASIS OF VITAL PULP THERAPY IN PRIMARY TEETH

The dental pulp is a living connective tissue composed of odontoblasts, fibroblasts, progenitor cells, immune cells, vascular elements, and neural structures. Its main functions include dentin formation, nutrition, sensory transmission, and protection against external stimuli. As carious lesions progress, bacterial products can reach the pulp through dentinal tubules and initiate an inflammatory response.

However, the presence of pulpal inflammation does not mean that the entire pulp has been irreversibly damaged. Particularly when the irritant is removed and bacterial microleakage is prevented, the remaining pulp tissue retains its regenerative capacity and potential to form a mineralized barrier [2,3,7]. Therefore, the biological basis of contemporary vital pulp therapy relies on evaluating the degree of inflammation together with the likelihood of pulpal healing.

The anatomical characteristics of primary teeth are clinically important. Their pulp chambers are relatively large, pulp horns lie closer to the occlusal surface, and dentin is thinner than in permanent teeth; this allows caries to progress more rapidly toward the pulp [3]. In addition, accessory canals in the furcation region may explain why pulpal infections in primary molars are seen radiographically more often in the furcation area than in the periapical region [3,4].

Therefore, the success of vital pulp therapy cannot be attributed solely to the pulp-capping material or pulpotomy agent. Accurate pulpal assessment, management of infected tissue, effective hemostasis, proper placement of the material, and long-term coronal sealing with the final restoration are factors that collectively influence treatment outcome [1-4].

3. CASE SELECTION AND PULPAL DIAGNOSIS

Before vital pulp therapy in primary teeth, a detailed pain history should be obtained and clinical and radiographic examinations should be performed. Spontaneous or persistent pain, nocturnal pain, swelling, fistula formation, abnormal mobility, tenderness to percussion, furcation or periapical radiolucency, and pathological internal or external root resorption may indicate advanced pulpal disease [1-4].

In primary teeth with deep carious lesions but no pulp exposure and with clinical findings consistent with a healthy pulp or reversible pulpitis, selective caries removal and indirect pulp treatment are currently among the preferred conservative treatment options. According to the AAPD, selective caries removal reduces the risk of pulp exposure compared with complete caries removal, and indirect pulp treatment has a high success rate.

When pulp exposure occurs during caries removal, vital pulp therapy may be considered according to the clinical condition of the pulp. The ability to control bleeding after removal of the coronal pulp tissue is an important clinical indicator when assessing whether the remaining radicular pulp is suitable for treatment [1-3].

Therefore, in vital pulp therapy, the fundamental question that should be answered before asking "which material should be used?" is "is this pulp suitable for preservation?" [1,2].

4. BIOCERAMICS AND HYDRAULIC CALCIUM SILICATE CEMENTS

In the dental literature, the term "bioceramic" is widely used to describe various biocompatible ceramic materials. However, the term "hydraulic calcium silicate cement" is more accurate for describing the chemical properties of materials such as MTA and Biodentine used in vital pulp therapy.

These materials consist mainly of tricalcium silicate and/or dicalcium silicate components. Hydration produces calcium silicate hydrate phases and calcium hydroxide; the pH rises and calcium ions are released [5-7]. Calcium ion release and the alkaline environment are thought to be important in supporting mineralization processes [5-10].

The ability of calcium silicate cements to promote mineral deposition when in contact with dentin and tissue fluids is one of the main reasons these materials are described as "bioactive" [5,6,8-10]. The goal of vital pulp therapy is not merely to cover the pulp mechanically, but also to create a biocompatible, well-sealed interface that supports healing of the remaining tissue.

5. MINERAL TRIOXIDE AGGREGATE (MTA)

5.1. Composition and Biological Properties

MTA is a hydraulic calcium silicate-based material that was initially developed for endodontic repair procedures and was subsequently introduced into various vital pulp therapies, including pulp capping and pulpotomy [5-7].

The main mineral components of MTA are calcium silicate compounds. Traditional MTA formulations use bismuth oxide as a radiopacifying agent [5]. The hydration reaction initiated by the addition of water produces calcium-containing by-products and raises the pH of the environment.

High biocompatibility plays an important role in the effectiveness of MTA. Torabinejad and Parirokh reviewed numerous studies evaluating the tissue compatibility and sealing properties of MTA and reported that the material generally exhibits favorable biological characteristics [6]. Under appropriate biological conditions, MTA can also stimulate formation of a mineralized tissue barrier [6,7].

These properties made MTA an important option in the transition from fixative agents used in pulpotomy to materials intended to preserve vital radicular pulp [3,7].

5.2. Effectiveness of MTA in Pulpotomy of Primary Molars

Early clinical studies demonstrating the effectiveness of MTA in primary-tooth pulpotomy contributed substantially to its widespread acceptance. Holan et al. compared MTA and formocresol in primary molar pulpotomies and reported success rates of 97% and 83%, respectively [11].

Farsi et al. evaluated 120 primary molars and reported high clinical and radiographic success at 24 months in teeth treated with MTA, concluding that MTA may be an appropriate alternative to formocresol [12].

Subsequent studies focused on comparing MTA with conventional materials or other calcium silicate-based cements [13-19]. The systematic review and meta-analysis by Coll et al. also supported the strong clinical effectiveness of MTA in vital pulp therapy of primary teeth [4].

Based on 24-month evidence, the AAPD's 2024 guideline strongly recommends pulpotomy with calcium silicate cements instead of pulpotomies using formocresol, ferric sulfate, or zinc oxide-eugenol [1].

5.3. Disadvantages of MTA

Despite its clinical effectiveness, MTA is not an ideal material. Its main limitations include difficult handling of traditional powder-liquid mixtures, operator-dependent variations in consistency, a long setting time, and high cost.

Some traditional MTA formulations containing bismuth oxide have also been associated with tooth discoloration [7]. This may be clinically important, particularly in the anterior region or in cases with high esthetic expectations.

These disadvantages have led to the development of new materials intended to improve physical properties and clinical handling while preserving the biological benefits of MTA [8-10].

6. BIODENTINE

Biodentine is one of the most extensively studied calcium silicate-based materials after MTA. Its main component is high-purity tricalcium silicate, and it contains a radiopacifying system different from that of traditional MTA [8-10].

In their review of the physical, chemical, and clinical properties of Biodentine, Rajasekharan et al. reported that the material has useful bioactive properties for pulp capping, pulpotomy, and endodontic repair procedures [8]. In a subsequent update by the same research group, the growing body of laboratory and clinical data was reported to support the broad clinical use of Biodentine [9].

Malkondu et al. evaluated Biodentine as a contemporary dentin replacement and repair material and reported that its shorter clinical setting time and improved handling characteristics may provide advantages over MTA [10].

Hydration of Biodentine leads to calcium ion release and formation of an alkaline microenvironment [8-10]. These features are considered an important part of the biological mechanism by which the material supports mineralization and repair in the pulp-dentin complex.

7. CLINICAL COMPARISON OF BIODENTINE AND MTA

MTA and Biodentine have been directly compared in numerous randomized clinical trials. Cuadros-Fernandez et al. compared MTA and Biodentine in pulpotomy of primary molars and found no significant difference in 12-month clinical and radiographic outcomes [13].

In a 24-month randomized clinical trial conducted by Bani et al., the clinical success rate was 96.8% in both groups. Radiographic success was 93.6% for Biodentine and 87.1% for MTA; however, the difference was not statistically significant [14].

Guven et al. compared Biodentine, MTA Plus, ProRoot MTA, and ferric sulfate over 24 months and reported overall success rates of 82.75%, 86.2%, 93.1%, and 75.86%, respectively. Although no statistically significant difference was found among the groups, the results supported calcium silicate-based materials as effective clinical options.

The results of randomized trials have also been evaluated in systematic reviews and meta-analyses. Nagendrababu et al. found no difference between MTA and Biodentine in clinical or radiographic success at 6, 12, and 18 months of follow-up [16].
Similarly, Stringhini Junior et al. did not demonstrate a clear superiority of MTA over Biodentine in 6-, 12-, and 18-month clinical and radiographic outcomes [17].
In a 24-month randomized clinical trial conducted by Vilella-Pastor et al., overall success rates were reported as 99.4% for Biodentine and 97.2% for MTA, with no significant difference between the two materials [18].
When these findings are considered together, Biodentine should not be regarded as a "secondary" alternative to MTA. Current clinical evidence indicates that, with appropriate case selection and correct clinical protocols, the two materials can provide highly similar outcomes.

8. COMPARISON WITH CONVENTIONAL PULPOTOMY MATERIALS

The clinical effectiveness of MTA and Biodentine should be evaluated not only in comparison with one another, but also in the context of data on formocresol, ferric sulfate, calcium hydroxide, and other conventional pulpotomy methods [1,4,19].
In a network meta-analysis including 43 randomized controlled trials, Guo et al. evaluated MTA, Biodentine, formocresol, ferric sulfate, sodium hypochlorite, calcium hydroxide, and laser applications [19]. Calcium hydroxide showed lower effectiveness than the other treatments, whereas MTA and Biodentine emerged as strong options in terms of clinical and radiographic outcomes [19].
These findings are consistent with the current AAPD guideline recommending the use of calcium silicate cements such as MTA or Biodentine instead of formocresol, ferric sulfate, zinc oxide-eugenol, and other conventional pulpotomy techniques in primary teeth [1].
Accordingly, the discussion in pediatric dentistry has gradually moved away from the question "formocresol or MTA?" and toward the question of which bioactive calcium silicate system may provide the most important practical or long-term clinical benefit [1,2,19].

9. NEW-GENERATION CALCIUM SILICATE-BASED MATERIALS

9.1. Rationale for the Development of New Materials

The clinical success of MTA has not eliminated the need for better materials. The main objectives of new-generation products are to eliminate the powder-liquid mixing step, provide a more homogeneous consistency, shorten application time, improve color stability, and simplify clinical procedures in pediatric patients [7,20,21].
To achieve these goals, premixed putty formulations, syringe-deliverable systems, and modified MTA compositions have been developed.

9.2. NeoMTA and NeoPutty

The NeoMTA family was developed to improve clinical handling while preserving the bioactive calcium silicate properties of MTA. The use of alternative radiopacifiers may offer an advantage in color stability compared with traditional MTA formulations.
NeoPutty is a premixed bioceramic putty material that requires no mixing before use. Its ready-to-use formulation may provide greater standardization in clinical use by eliminating operator-dependent variability related to the powder-liquid ratio.
Alqahtani et al. compared NeoPutty and NeoMTA 2 in pulpotomy of primary molars [20]. At 12 months, clinical and radiographic success rates were 100% and 94.1%, respectively, for NeoMTA 2 and 97.1% and 92.8%, respectively, for NeoPutty, with no significant difference between the two materials.
These results suggest that premixed putty materials may be useful for pulpotomy in children. However, a 12-month follow-up period is insufficient to establish equivalence with the extensive clinical data accumulated for MTA over several decades [20].

9.3. Fast-Setting Premixed Bioceramics

One of the main objectives of contemporary bioceramics is to shorten clinical application time. This feature is particularly important in pediatric dentistry, where patient cooperation may be limited.
In a randomized controlled trial, Abdelwahab et al. compared a fast-setting premixed bioceramic root repair material with MTA and reported promising clinical and radiographic outcomes at one year after pulpotomy of primary molars [21]. The effect of the final restoration was also evaluated, showing that treatment success depends on both the pulpotomy material and the coronal seal [21].

9.4. Partial Pulpotomy and Bioceramics

Increasing knowledge of pulp biology has influenced not only the materials used but also the amount of pulp tissue removed. Whereas conventional coronal pulpotomy involves removal of the entire coronal pulp, partial pulpotomy removes only the superficially inflamed pulp tissue.
Tungjitphianpong et al. compared MTA, Biodentine, and acemannan for 24 months after partial pulpotomy in severely carious primary molars [22]. At 24 months, success rates were 83.3% for MTA, 76.9% for Biodentine, and 74.1% for acemannan, with no

statistically significant differences among the groups [22]. This study shows that more conservative approaches aimed at preserving the pulp in primary teeth continue to be investigated.

10. 24-MONTH OUTCOMES OF NEW-GENERATION BIOCERAMICS

One of the main limitations of current materials is the lack of long-term clinical evidence. Therefore, clinical studies evaluating premixed materials alongside established materials such as conventional MTA and Biodentine are of great importance.

Talekar et al. evaluated 117 primary molars treated with NeoPutty, NeoMTA Plus, or Biodentine over 24 months [23]. All three materials showed high clinical and radiographic success, with no significant differences among the groups [23].

These results suggest that the clinical effectiveness of modern premixed MTA materials may be close to that of traditional powder-liquid MTA or Biodentine. However, the number of studies and the total number of patients evaluated for the new materials remain considerably lower than for MTA and Biodentine [20,21,23].

Therefore, easier handling of a new material should not be interpreted as evidence of greater biological effectiveness. At present, the most evident advantages of premixed products appear to be ease of use and standardization rather than increased clinical success.

11. MTA AND BIODENTINE IN LIGHT OF CURRENT META-ANALYSES

In recent years, the amount of evidence comparing MTA and Biodentine has increased substantially. In a 2025 systematic review and meta-analysis by Lu et al., 11 randomized controlled trials published through March 2025, involving 649 patients and 706 primary teeth, were evaluated [24].

No significant difference was found between MTA and Biodentine in clinical success at 6, 12, 18, or 24 months. Likewise, radiographic success rates did not differ significantly between the two materials at any follow-up period [24]. The frequency of radiographic findings such as root resorption and pulp canal obliteration was also similar between the two materials [24].

These findings are consistent with previous meta-analyses [16,17]. The current evidence does not support a consistent clinical superiority of either MTA or Biodentine over the other in primary molar pulpotomy [16-18,24].

12. 2026 UMBRELLA REVIEW: CURRENT STATE OF THE EVIDENCE

In 2026, Ardila et al. conducted an umbrella review of systematic reviews evaluating the clinical and radiographic outcomes of calcium silicate-based materials in primary-tooth pulpotomy [25].

Eleven systematic reviews and 78 unique primary-study reports were included. MTA and Biodentine were reported to show similar clinical and radiographic effectiveness up to 24 months [25].

The authors noted that a high degree of overlap among primary studies included in different meta-analyses was an important concern and that the quality of evidence was low or very low for many comparisons. Therefore, the existence of numerous meta-analyses does not necessarily mean that the underlying evidence is of higher quality.

The same review emphasized that data on newer calcium silicate formulations remain relatively limited and that no material has demonstrated definitive long-term superiority [25].

This finding is clinically important. Although MTA and Biodentine have extensive clinical experience and a strong evidence base, the promising early results of new-generation bioceramics should not be interpreted as showing that these materials are "better than MTA."

13. FACTORS AFFECTING TREATMENT SUCCESS INDEPENDENT OF MATERIAL SELECTION

Pulpal Assessment

The healing potential of the pulp should be carefully evaluated before treatment. Teeth with clinical or radiographic signs of necrosis or advanced radicular pulp pathology are not suitable for vital pulp therapy [1,2].

Hemostasis

The ability to control bleeding after removal of the coronal pulp is an important criterion for assessing the condition of the remaining radicular pulp. Excessive or uncontrollable bleeding may indicate more advanced inflammation [1-3].

Aseptic Technique

To create an appropriate environment for pulpal healing, it is important to prevent additional bacterial contamination during treatment [3,4].

Coronal Seal

The final restoration should provide a reliable barrier against bacterial reinfection of the pulp. Therefore, pulpotomy success should be evaluated not only according to the material covering the pulp but also in conjunction with the quality of the final restoration.

Accordingly, clinical success should be considered as the combined result of the following components:
accurate pulpal diagnosis + appropriate case selection + adequate hemostasis + bioactive material + good coronal seal [1-4,21]

14. MTA OR BIODENTINE?

Based on the current scientific evidence, it is not possible to state definitively that one material is better than the other.
The main advantage of MTA is its long history of clinical use and extensive scientific evidence base. Evidence supporting its effectiveness in primary-tooth pulpotomy extends from early clinical studies to current meta-analyses [11,12,16-19].
The main advantages of Biodentine are easier handling, faster clinical setting, and a lower risk of discoloration than some traditional bismuth oxide-containing MTA formulations [8-10].
Up to 24 months, no significant and consistent difference in clinical effectiveness has been demonstrated between MTA and Biodentine [14,16-18,24,25].

Therefore, clinicians may consider the following factors when selecting a material:
• level of evidence
• ease of use
• treatment time
• restorative approach
• material cost
• color stability
• personal clinical experience

15. CAN NEW-GENERATION MATERIALS REPLACE MTA?

Premixed materials such as NeoPutty offer many practical advantages. The absence of a mixing step may improve standardization, reduce application time, and facilitate treatment in pediatric patients with limited cooperation [20,23].
The 12-month results for NeoPutty and NeoMTA 2 reported by Alqahtani et al. [20], as well as the high 24-month success rates for NeoPutty, NeoMTA Plus, and Biodentine reported by Talekar et al. [23], are promising.
Other randomized clinical studies using fast-setting premixed materials have also reported favorable results [21].
However, decades of data supporting MTA cannot be considered equivalent to the limited follow-up periods currently available for new products. According to the 2026 umbrella review, evidence regarding newer formulations remains limited [25].
Therefore, new-generation materials should not be described as "materials that have definitively replaced MTA," but rather as promising alternatives designed to improve clinical handling while preserving the biological principles of MTA.

16. DISCUSSION

Vital pulp therapy in primary teeth has evolved substantially over the past two decades. At the center of this change is the transition from pulp fixation or devitalization toward preservation of the remaining vital pulp tissue [1-4]. Calcium silicate-based materials can be regarded as the material-science counterpart of this biological treatment approach.
Because of its high biocompatibility and sealing properties, MTA has long been considered a reference material for primary-tooth pulpotomy [5-7,11,12]. However, its handling difficulties and physical characteristics have led to the development of more user-friendly calcium silicate cements [7-10].
Biodentine represents one of the major developments in this field. Early clinical studies [13-15], 24-month randomized trials [14,18], and systematic reviews and meta-analyses [16,17,24] show that Biodentine can provide clinical outcomes similar to those of MTA.
In the 2025 meta-analysis by Lu et al., which included 706 primary teeth, no significant difference was found between MTA and Biodentine at any follow-up period from 6 to 24 months, supporting similar clinical effectiveness for the two materials.
However, similar clinical success rates among different calcium silicate materials do not mean that they are completely equivalent biologically or physicochemically. These materials may differ in particle size, radiopacifying agent, liquid formulation, resin content, setting mechanism, and application technique [5,7-10].
New-generation premixed materials should be evaluated independently. Although NeoPutty and similar products may offer clinical advantages because of their ease of use, the current literature is insufficient to demonstrate that they provide better biological outcomes than MTA or Biodentine [20,21,23,25].
One important issue is the lack of standardization in the definition of "success" in primary-tooth pulpotomy studies. The absence of clinical findings, such as pain or fistula, and the absence of radiographic pathology are separate outcome measures. In addition, classification of findings such as pulp canal obliteration as treatment failure varies among studies [14,16,24]. This heterogeneity makes direct comparison of reported success rates difficult.

Another important factor specific to the primary dentition is physiological root resorption. In long-term follow-up of treated teeth, monitoring until physiological exfoliation, whenever possible, is more meaningful than relying only on fixed monthly follow-up periods [11,25].

Current data indicate that MTA and Biodentine are the most strongly supported bioactive materials for primary-tooth pulpotomy [1,19,24,25]. Nevertheless, the ease of use and favorable early- to medium-term clinical performance of new-generation premixed materials may allow them to assume a more important role in the future [20,21,23].

17. FUTURE RESEARCH

Future research on new bioceramic materials should evaluate not only clinical and radiographic success but also patient- and clinician-centered outcomes. Such outcomes may help identify clinically meaningful differences among materials.

In future clinical studies, it would be useful to evaluate the following outcomes in particular:

- postoperative pain
- pediatric patient cooperation
- total treatment time
- material cost
- tooth discoloration
- pulp canal obliteration
- internal resorption
- physiological root resorption
- long-term success of the restoration
- duration of tooth retention in the oral cavity until physiological exfoliation [20-25]

In addition, standardization of pulpal diagnostic criteria, hemostasis methods, types of final restorations, and failure criteria will improve the reliability and comparability of future meta-analyses [24,25].

CONCLUSION

The aim of vital pulp therapy in primary teeth is to preserve the biological integrity of the pulp and maintain the functional life of the tooth until physiological exfoliation. The contemporary approach focuses on preserving the healing potential of the pulp-dentin complex rather than fixation or necrosis of the pulp tissue [1-4].

Through its good biocompatibility, sealing properties, and capacity to support mineralization, MTA has made an important contribution to the development of this approach and has demonstrated high clinical success in primary-tooth pulpotomy [5-7,11,12]. Biodentine is a well-known tricalcium silicate-based material developed to overcome some of the clinical limitations of MTA. Randomized clinical trials and current meta-analyses show that Biodentine and MTA provide largely similar clinical and radiographic outcomes up to 24 months [13-18,24].

New materials such as NeoMTA Plus, NeoMTA 2, NeoPutty, and fast-setting premixed bioceramics offer important advantages in terms of ease of use and standardization [20,21,23]. Although initial clinical results are promising, long-term data are not as extensive as those for MTA and Biodentine [23,25].

Therefore, based on the current evidence, MTA and Biodentine remain the calcium silicate-based materials with the strongest scientific support for primary-tooth pulpotomy [1,19,24,25]. New-generation premixed bioceramics should be regarded as promising alternatives with the potential to play a more important role in the future.

In conclusion, material selection is not the sole determinant of success in vital pulp therapy. Accurate pulpal diagnosis, appropriate case selection, adequate hemostasis, aseptic technique, and an effective coronal seal are fundamental components of successful treatment [1-4].

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