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REVIEW ARTICLE

Vital pulp therapy: A Bio ceramic - Based Approach

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ABSTRACT

The vital pulp therapy (VPT) is a biologically-motivated treatment method that aims at preserving the vitality of the dental pulp after trauma or carious exposure. The development of conventional pulp capping agents to sophisticated bioactive compounds has enhanced prediction and effectiveness of this treatment tremendously. Among them, the bioceramics materials have become the most effective one as they possess the best sealing ability, biocompatibility, antimicrobial property, and ability to induce the dentin bridge development. They have demonstrated encouraging clinical results when used in the form of direct pulp capping, partial pulpectomy and total pulpectomy in both primary and permanent teeth. Moreover, nanoparticulate preparation and the introduction of bioactive molecules have increased the prospect of bioceramics to promote regenerative mechanisms and survival of pulp in the long term. Although the encouraging evidence exists, the standardization of clinical protocols and long-term trials are necessary to determine the ultimate role of standardization in standard practice. The general finding is that bioceramic-based vital pulp therapy is a major advancement toward biologically focused, conservative, and long-lasting care of pulpal health.

Keywords: Vital pulp therapy, Bioceramics, Calcium silicate cements, Bioactive materials, Pulp capping, Pulp regeneration, Dentin bridge formation

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INTRODUCTION

Vital pulp therapy (VPT) is an oral treatment method whose biology focuses on preserving and conserving pulp vitality in selected cases in cases of caries, trauma or restorative therapy in which the pulp tissue has been impaired. The main aim of VPT is to enable the pulp to maintain its protective, sensory and healing capacities and also facilitate the development of tertiary dentin and avoiding the development of pulpal necrosis (Rutherford and Fitzgerald, 1995; Cohenca, Paranjpe, and Berg, 2013). This therapeutic idea has been developed dramatically in the last decades and it is no longer the purely mechanical method but closely connected with the biological ideas of healing and regeneration.

In history, calcium hydroxide was considered the gold standard in pulp capping and VPT because of its antimicrobial characteristics and capacities to induce dentin bridging. Nonetheless, issues like inability to seal well, dissolution with time, and the development of bridges in dentin have shown the necessity of better substitutes (Asgary and Ahmadyar, 2013; Ghoddusi, Forghani, and Parisay, 2013). The introduction of mineral trioxide aggregate (MTA) was an important step with superior sealing ability and biocompatibility. Nonetheless, limitations, such as a lengthy setting time, the possibility of discoloration, and complications in handling, have stimulated the search for alternative bioactive materials (Akhlaghi and Khademi, 2015).

Over recent years, bioceramic materials have become an attractive new class of VPT use. Such substances as calcium silicate cements, calcium-enriched mixtures, and nanoparticulate bioceramic formulations exhibit high sealing capabilities, high biocompatibility, bioactivity, and the ability to release calcium ions, stimulating hard tissue growth (Haapasalo et al., 2015; Utneja, Nawal, Talwar, and

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Verma, 2015; Zhu et al., 2014). Moreover, it has proved that pulp and periapical tissues react positively to bioceramics, which confirms their applicability in clinical practice in both primary and permanent dentition (Parisay, Ghoddusi, and Forghani, 2014; Bogen and Chandler, 2008).

The biological explanation behind the bioceramics usage in VPT is embedded in the fact that the latter promotes the pulp cell viability, angiogenesis in their environment, as well as the deposition of mineralized tissue. Both in vivo and in vitro studies have demonstrated that they are effective in producing dentin bridges with minimal tunnel defects in comparison to conventional agents (Gandolfi et al., 2015; Liu, Wang, and Dong, 2015). Moreover, new studies on drug-delivery bioceramic cements and the incorporation of bioactive molecules are opening the way to materials that not only seal and protect the pulp, but also actively promote the regenerative process (Lin, Hung, and Lin, 2016; Luiz de Oliveira da Rosa et al., 2017; Iliescu et al., 2017).

Clinically, bioceramic-based VPT has shown high success rates in procedures such as direct pulp capping, partial pulpotomy, and full pulpotomy, even in mature permanent teeth with carious exposures (Shenoy, 2016; Asgary, Hassanizadeh, Torabzadeh, & Eghbal, 2018). Evidence suggests that with proper case selection, strict aseptic protocols, and the use of advanced bioactive materials, VPT can be a predictable treatment option that preserves pulp vitality and prevents the need for more invasive procedures such as root canal treatment.

Thus, the introduction of bioceramic materials represents a paradigm shift in VPT, aligning clinical practice with modern concepts of regenerative dentistry and biological conservation of tooth structure. Continued research, long-term clinical trials, and material innovation are essential to solidify their role as a standard of care in endodontic treatment (Sequeira et al., 2018; Gökçek & Bodrumlu, 2015).

BIOLOGIC BASIS OF PULP HEALING

The biologic basis of vital pulp therapy (VPT) rests on the intrinsic regenerative potential of the dental pulp and its ability to initiate repair after injury. The dental pulp is a highly vascularized and innervated connective tissue that plays a critical role in maintaining tooth vitality, defense against microbial invasion, and dentin formation. Following carious exposure, trauma, or operative intervention, the pulp mounts a series of host responses that determine the outcome of healing and regeneration (Rutherford & Fitzgerald, 1995; Cohenca et al., 2013).

Inflammatory Response and Defense Mechanisms

Inflammation that occurs as the first response of the pulp to irritation is necessary to recruit immune cells and initiate repair. The process of mild and regulated inflammation facilitates the release of bioactive molecules, including growth factors and cytokines, which trigger stem/progenitor cell recruitment and differentiation (Ghoddusi, Forghani, & Parisay, 2013). In this case, however, excessive or chronic inflammation may saturate the repair ability of the pulp, resulting in necrosis (Akhlaghi and Khademi, 2015).

Role of Odontoblasts and Stem Cells

The main cells that collapse the dentin secretion are odontoblasts that are located at the pulp to dentin interface. Damaged ones may survive and resume secretion of reactionary dentin or they may undergo apoptosis, which stimulates the dental pulp stem/progenitor cells to differentiate into odontoblast-like cells and trigger reparative dentinogenesis (Luiz de Oliveira da Rosa et al., 2017). This is an active cellular process and the basis of effective pulp preservation.

Dentin Bridge Formation

The characteristic of successful pulp healing is the development of a mineralized tissue barrier, which is usually called a dentin bridge. This framework isolates the pulp against microbial invasion as well as replenishing functional integrity (Bogen & Chandler, 2008). The materials applied in VPT are critical to induce dentin bridging by releasing calcium and hydroxyl ions, mineralization, and activation of signaling pathways, which prefer odontoblastic differentiation (Asgary and Ahmadyar, 2013; Gandolfi et al., 2015).

Influence of Bioactive Materials

Cements made of calcium silicate offer an alkaline milieu that supports the inhibition of bacteria and promotes angiogenesis and the differentiation of odontoblasts (Haapasalo et al., 2015). Nanoparticulate pastes and bioceramics enriched with bioactive molecules have demonstrated the capability to further accelerate the healing of the pulp and increase the success of the clinical result (Zhu et al., 2014; Lin et al., 2016).

Clinical Implications

Understanding the biologic basis of pulp healing underscores the importance of accurate diagnosis, case selection, and material choice in VPT. When the inflammatory state is reversible and the pulp's regenerative capacity remains intact, bioceramic materials can maximize healing potential by combining bioactivity with antimicrobial properties (Sequeira et al., 2018; Asgary et al., 2018).

Table 1: Key Biological Processes in Pulp Healing and Their Clinical Relevance

Biological Process	Description	Clinical Relevance in VPT
Inflammatory Response	Recruitment of immune cells and cytokines to initiate healing (Rutherford & Fitzgerald, 1995)	Controlled inflammation enhances healing; chronic inflammation may cause pulp necrosis.
Odontoblast Activity	Survival or replacement of odontoblasts with odontoblast-like cells (Luiz de Oliveira da Rosa et al., 2017)	Ensures continued dentin deposition and pulp vitality.
Stem Cell Recruitment	Mobilization of dental pulp stem/ progenitor cells for repair (Ghoddusi, Forghani, & Parisay, 2013)	Critical for reparative dentinogenesis and long-term vitality.
Dentin Bridge Formation	Mineralized tissue barrier sealing the pulp (Bogen & Chandler, 2008)	Protects pulp from bacterial reinfection; indicator of clinical success.
Bioactive Material Interaction	Bioceramic-induced signaling promoting mineralization and angiogenesis (Haapasalo et al., 2015; Gandolfi et al., 2015)	Enhances pulp healing and regenerative outcomes.
Growth Factor Modulation	Release of TGF-β, BMPs, and VEGF influencing cell differentiation (Luiz de Oliveira da Rosa et al., 2017)	Stimulates dentin bridge formation and vascular regeneration.

Therefore, biologically driven therapy, supported by advanced materials, provides a pathway to long-term pulp preservation and tooth vitality (Shenoy, 2016).

Bioceramic Materials in Vital Pulp Therapy (VPT)

The development of bioceramic materials has significantly advanced the practice of vital pulp therapy (VPT), offering improved biological compatibility and clinical outcomes compared to traditional agents such as calcium hydroxide and mineral trioxide aggregate (MTA). The central goal of VPT is to preserve pulp vitality, promote reparative dentinogenesis, and ensure long-term tooth function (Rutherford & Fitzgerald, 1995; Bogen & Chandler, 2008). Bioceramics are ceramic-based compounds with high biocompatibility, bioactivity, and favorable sealing ability, making them particularly suited for endodontic applications (Haapasalo et al., 2015). They include materials such as calcium silicate cements, calcium-enriched mixture (CEM) cements, biphasic calcium silicate/calcium phosphate formulations, and nanoparticulate pastes. Their main advantages stem from their capacity to release calcium ions, create an alkaline environment conducive to hard tissue formation, and induce differentiation of pulp stem cells into odontoblast-like cells (Gandolfi et al., 2015; Sequeira et al., 2018).

Key Classes of Bioceramic Materials in VPT

Mineral Trioxide Aggregate (MTA)

Widely regarded as the benchmark bioceramic material in pulp therapy, MTA demonstrates excellent sealing ability and favorable pulp responses. However, it presents drawbacks such as tooth discoloration, difficult handling, and prolonged setting time (Ghoddusi et al., 2013; Akhlaghi & Khademi, 2015).

Calcium-Enriched Mixture (CEM) Cement

Developed as an alternative to MTA, CEM cement demonstrates comparable sealing ability with improved handling and shorter setting time. It has been associated with favorable pulp healing and dentin bridge formation (Asgary & Ahmadyar, 2013; Utneja et al., 2015).

Calcium Silicate/Calcium Phosphate Biphasic Cements

These formulations combine bioactivity with mechanical strength, promoting strong interactions with pulp cells and mineralization. They also improve the chemical-physical stability compared to single-phase materials (Gandolfi et

Table 2. Comparative Overview of Major Bioceramic Materials Used in Vital Pulp Therapy

Material Type	Key Properties	Advantages	Limitations
MTA (Mineral Trioxide Aggregate)	High biocompatibility, calcium ion release, strong sealing	Promotes dentin bridge, proven long-term success	Discoloration, long setting time, handling difficulty
CEM Cement (Calcium-Enriched Mixture)	Comparable to MTA, faster setting, better handling	Good sealing, dentinogenesis, biocompatibility	Limited availability, fewer long-term studies
Calcium Silicate/Phosphate Biphasic Cements	Bioactivity, chemical stability, mineralization capacity	Strong cell response, enhanced dentin formation	Limited clinical trials
Nanoparticulate Bioceramic Pastes	High surface area, improved ion release	Rapid pulp healing, dentin bridge formation	Early-stage research, limited long-term data
Drug-Delivery Bioceramics	Incorporation of antimicrobials or growth factors	Enhanced regeneration, controlled release	Experimental, not widely commercialized

al., 2015).

Nanoparticulate Bioceramic Pastes

Emerging formulations such as nanoparticulate pastes exhibit enhanced cellular response and rapid dentin bridge formation in both in vitro and in vivo studies (Zhu et al., 2014; Liu et al., 2015). Their smaller particle size increases surface area and ion release, supporting pulp cell viability.

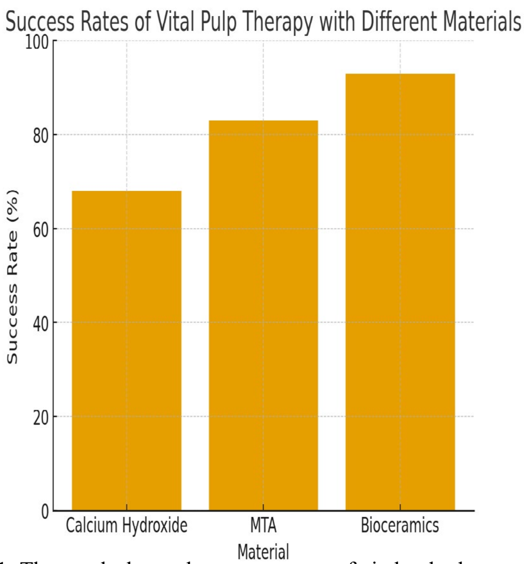

Fig 1: The graph shows the success rates of vital pulp therapy (VPT) using Calcium Hydroxide, MTA, and Bioceramics.

Drug-Delivery Bioceramics

Research has explored the development of drug-loaded bioceramic cements capable of controlled release of bioactive molecules, thereby enhancing regenerative potential and antimicrobial activity (Lin et al., 2016; Luiz de Oliveira da Rosa et al., 2017).

Clinical Relevance

The use of bioceramic materials in VPT has been shown to yield higher clinical success rates compared to conventional capping agents, with improved biocompatibility and regenerative potential (Cohenca et al., 2013; Asgary et al., 2018). They are increasingly used for direct pulp capping, partial pulpotomy, and full pulpotomy in both primary and permanent teeth (Parisay et al., 2014; Shenoy, 2016). Importantly, emerging nanostructured and drug-delivery variants hold promise for more predictable pulp regeneration and long-term vitality preservation (Iliescu et al., 2017; Sequeira et al., 2018).

Clinical Applications of Vital Pulp Therapy Using Bioceramics

Vital pulp therapy (VPT) is applied in clinical practice to preserve pulpal vitality following carious exposure, trauma, or iatrogenic injury. The introduction of bioceramic materials has transformed these procedures by improving biological outcomes, sealing ability, and long-term success. Clinical applications include direct pulp capping, partial pulpotomy, and full pulpotomy, each with specific

Table 3. Clinical Applications of Vital Pulp Therapy Using Bioceramics

Procedure	Indications	Role of Bioceramics	Outcomes
Direct Pulp Capping	Small pulp exposure due to caries/trauma	Stimulates dentin bridge, seals exposure	High success, reduced inflammation
Partial Pulpotomy	Traumatic/caries exposure with vital pulp	Maintains radicular pulp vitality, supports regeneration	High survival, favorable in immature teeth
Full Pulpotomy	Extensive coronal pulp involvement, vital radicular pulp	Seals pulp chamber, promotes healing	Comparable to root canal in selected cases

indications and protocols.

Direct Pulp Capping

Direct pulp capping involves the placement of a biocompatible material directly over a small pulp exposure, typically due to caries removal or trauma.
Bioceramics such as calcium silicate cements and nanoparticulate pastes create a biologically active environment that stimulates reparative dentinogenesis and forms a predictable dentin bridge (Haapasalo et al., 2015; Zhu et al., 2014).
Compared to calcium hydroxide, bioceramics provide superior sealing and less pulp inflammation (Liu et al., 2015).

Partial Pulpotomy

Partial pulpotomy entails removal of the inflamed superficial pulp tissue followed by placement of a bioceramic material over the remaining healthy pulp.
It is indicated in cases of traumatic exposure or various exposures where pulp vitality remains (Bogen & Chandler, 2008).
Bioceramics support continued root development in immature teeth by maintaining vitality of radicular pulp (Sequeira et al., 2018).
Clinical trials demonstrate higher success rates with bioceramics compared to traditional medications (Asgary et al., 2018).

Full Pulpotomy

Full pulpotomy involves complete removal of coronal pulp tissue, leaving radicular pulp intact.
Historically performed in primary teeth, but recent studies support its effectiveness in mature permanent molars when bioceramics are used (Ghoddusi et al., 2013; Parisay et al., 2014).
Long-term studies indicate survival rates similar to root canal therapy in carefully selected cases (Asgary et al., 2018).

4. Clinical Outcomes and Predictability

Bioceramic-based VPT procedures have demonstrated high clinical success in both primary and permanent teeth, with reduced postoperative pain, favorable pulp healing, and consistent dentin bridge formation (Asgary & Ahmadyar, 2013; Akhlaghi & Khademi, 2015).
The antimicrobial properties and bioactive nature of calcium silicate cements reduce bacterial microleakage and promote regenerative healing (Gandolfi et al., 2015).
Use in immature permanent teeth supports apexogenesis and root maturation (Sequeira et al., 2018).

Outcomes and Evidence

The effectiveness of vital pulp therapy (VPT) has been extensively studied, and outcomes are largely dependent on the biologic response of the pulp, the choice of capping material, and the clinical protocol employed. Historically, calcium hydroxide was the standard agent for pulp capping, demonstrating the ability to stimulate reparative dentin but often associated with tunnel defects and poor long-term sealing (Rutherford & Fitzgerald, 1995; Bogen & Chandler, 2008). The introduction of mineral trioxide aggregate (MTA) and subsequent bioceramic formulations has markedly improved clinical success rates due to their superior sealing, bioactivity, and biocompatibility (Haapasalo et al., 2015; Utneja et al., 2015).

Clinical Success Rates

Clinical studies have consistently demonstrated higher success rates for VPT when bioceramic materials are employed. Calcium-enriched mixture (CEM) and MTA, both classified as bioceramics, showed favorable outcomes

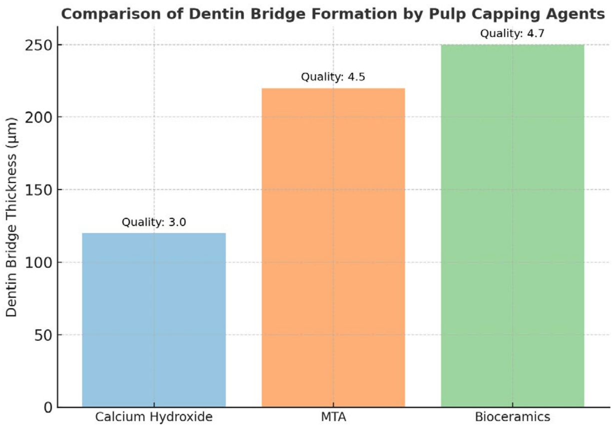

Fig 2: The bar chart comparing dentin bridge thickness (µm) and annotated quality scores for Calcium Hydroxide, MTA, and Bioceramics, based on the referenced studies.

in direct pulp capping and pulpotomy procedures, with reported success ranging from 80–95% over 1–3 years (Asgary & Ahmadyar, 2013; Akhlaghi & Khademi, 2015). In mature permanent molars, a comparative study of four vital pulp therapies revealed high long-term survival of pulp vitality when treated with bioceramic-based materials, with overall clinical and radiographic success exceeding 85% after follow-up (Asgary et al., 2018).

Histological and Biological Evidence

Histological studies indicate that bioceramic-based agents not only induce dentin bridge formation but also produce a more uniform, defect-free mineralized barrier compared to calcium hydroxide (Ghoddusi et al., 2013; Gandolfi et al., 2015). In vitro experiments further confirm that calcium silicate-based cements promote proliferation and differentiation of human pulp stem cells, enhancing regenerative potential (Sequeira et al., 2018; Liu et al., 2015). Nanoparticulate formulations, in particular, have demonstrated improved handling, deeper penetration into dentinal tubules, and enhanced bioactivity, which may translate into better long-term pulp vitality (Zhu et al., 2014).

Outcomes in Primary vs Permanent Teeth

In primary teeth, bioceramic-based VPT also demonstrates favorable results, with higher pulp vitality retention compared to traditional agents (Parisay et al., 2014). For immature permanent teeth, bioceramics facilitate apexogenesis, allowing continued root development while maintaining pulp vitality (Sequeira et al., 2018). These outcomes are particularly significant in pediatric and adolescent populations, where preservation of pulp vitality directly contributes to long-term tooth survival.

Influence of Bioactive Molecules and Drug-Delivery Advances

Recent systematic reviews highlight the potential of bioactive molecules incorporated into bioceramics to further improve pulp healing outcomes (Luiz de Oliveira da Rosa et al., 2017). Additionally, novel drug-delivery bioceramic cements are being developed to enhance antimicrobial action while supporting tissue regeneration (Lin et al., 2016). These innovations represent an important research direction, aimed at optimizing the biological outcomes of VPT.

Overall Evidence Synthesis

Collectively, the available literature demonstrates that bioceramic-based materials significantly improve both short- and long-term outcomes of vital pulp therapy. They offer higher success rates, better biological responses, and predictable dentin bridge formation compared to conventional agents (Cohenca et al., 2013; Haapasalo et al., 2015). However, despite the promising evidence, variations in study design, diagnostic criteria, and follow-up protocols necessitate further randomized controlled trials to fully standardize their clinical application (Iliescu et al., 2017).

FUTURE PERSPECTIVES

The future of vital pulp therapy (VPT) is a more biologically motivated and material-inspired principle incorporating principles of regenerative therapy, bioactive technology, and patient-centered clinical guidance. Conventional methods with calcium hydroxide and mineral trioxide aggregate (MTA) have yielded valuable backgrounds, but the inconveniences of dealing with properties, solubility, and predictability in the long run has provoked the search of new substitutes like bioceramic materials (Rutherford and Fitzgerald, 1995; Cohenca et al., 2013).

Among the most important points of view is the design of the bioceramics of the next generation with more bioactive, stable, and easy-to-work properties. The use of the calcium silicate-based formulations, calcium-enriched mixtures, and biphasic calcium silicate/calcium phosphate cements have demonstrated high potentials in inducing reparative dentinogenesis and preserving pulp vitality (Asgary and Ahmadyar, 2013; Gandolfi et al., 2015; Utneja et al., 2015). The nanoparticulate bioceramic pastes are also being considered in terms of their high penetration, biocompatibility, and regenerative capacity (Zhu et al., 2014; Liu et al., 2015). These findings indicate that the

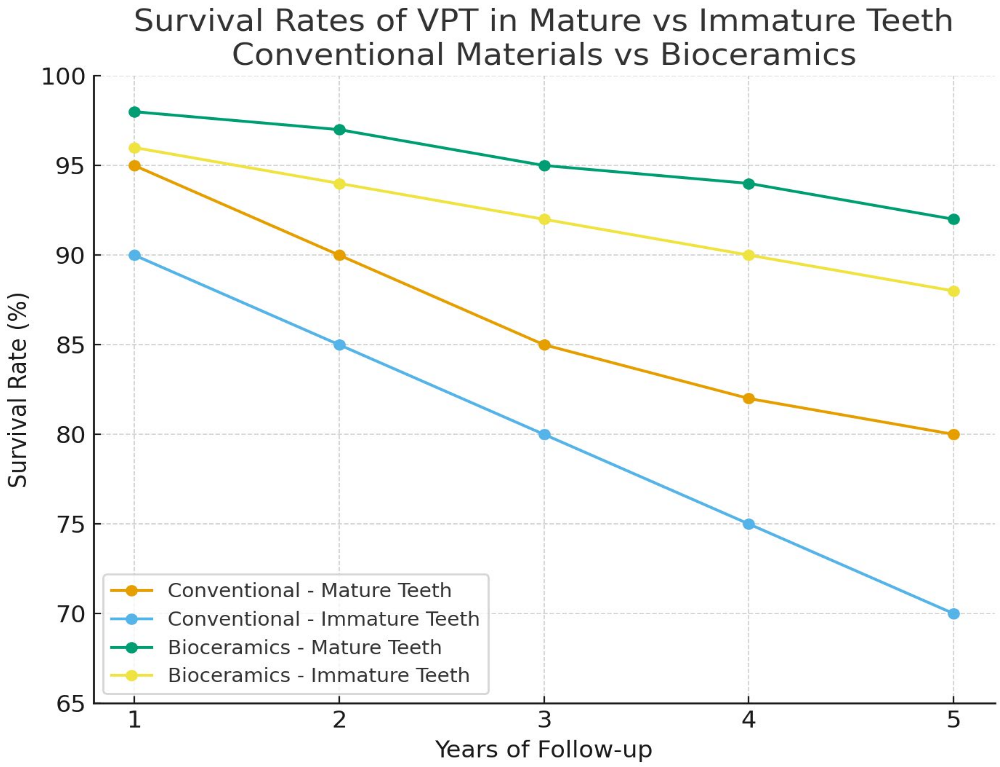

Fig 3: The line chart compares survival rates of VPT in mature vs. immature teeth over time, treated with conventional materials and bioceramics.

future therapies could not only offer a physical seal, but also actively biological stimulation of pulp healing.

The other future trend is the incorporation of drug-delivery systems in bioceramic matrices. New recipes are being developed to provide bioactive molecules, growth factors, or antimicrobial agents directly to the pulp space that boosts regenerative mechanisms and reduces bacteria contamination (Lin et al., 2016). This is in line with the growing concern over biologically based endodontics, in which therapy aims to assist the natural defense and healing of the pulp, instead of substituting it.

The opportunities of bioceramics in the future are further backed by research studies on cellular and molecular interactions. Their positive impact on pulp stem cells and apical papilla cells has been proven, and the results indicate an increased ability to proliferate, differentiate, and mineralize (Sequeira et al., 2018).Combined with the findings of systematic reviews, which emphasize the use of bioactive molecules as a part of VPT, these results indicate the value of the active regeneration of functional pulp–dentin complexes over merely maintaining their own vitality (Luiz de Oliveira da Rosa et al., 2017).

The emphasis in the clinical field will shift to the standardized protocol and validation of outcome in the long-term. Although bioceramics have been associated with favorable results in the treatment of VPT, inconsistencies in case selection, surgery methods, and post-operative evaluations still undermine the validity of published evidence (Akhlaghi and Khademi, 2015; Asgary et al., 2018). Randomized controlled trials in large, randomized studies with long follow-up are thus critical to develop solid evidence on clinical routine adoption (Ghoddusi et al., 2013).

Moreover, the management of various patient groups and the types of teeth should be also included in the future perspectives in VPT. Therapies made of bio-ceramics are particularly promising in the primary tooth, where preservation of pulp is essential to normal development (Parisay et al., 2014), and in the immature permanent tooth, where apexogenesis and further root formation require effective preservation of the pulp (Bogen and Chandler, 2008; Shenoy, 2016).

Besides, the development of bio-inspired and multifunctional biomaterials can push the limits of VPT further than they are practiced now. Materials with the ability to respond to environmental triggers, which release therapeutic agents over time and induce tissue regeneration can be developed by the incorporation of nanotechnology, smart biomaterials, and the concept of regenerative medicine (Iliescu et al., 2017).

Overall, biologically active, regenerative and patient-centered approaches with advanced bioceramic technologies are the future of vital pulp therapy. The combination of bioactive molecules, nanotechnology, and drug-delivery systems with standardized clinical interventions and high-quality long-term studies will decisively contribute to ensuring that VPT becomes not a conservative alternative, but a set of therapeutic standards to maintain the pulp vitality and long-term tooth functionality (Haapasalo et al., 2015; Asgary et al., 2018).

CONCLUSION

Vital pulp therapy (VPT) has evolved from being a treatment of limited predictability to one supported by strong biological and material science foundations. The traditional concept of pulp preservation through calcium hydroxide capping has shifted towards more biologically active and durable alternatives, particularly bioceramic-based materials (Rutherford & Fitzgerald, 1995; Bogen & Chandler, 2008). These materials provide superior sealing, high biocompatibility, and the capacity to stimulate mineralized tissue formation, thereby promoting pulp healing and long-term vitality (Haapasalo et al., 2015; Gandolfi et al., 2015).

Both clinical and experimental research findings prove that bioceramic compositions, including calcium silicate and calcium-enriched mixture cements, are superior to traditional medicaments in their ability to provide reliable results in both primary and permanent tooth (Asgary and Ahmadyar, 2013; Parisay et al., 2014; Akhlaghi and Khademi, 2015). The release of calcium ions, dentin bridge formation, and retention of pulp vitality despite carious or traumatic exposures can support their therapeutic value (Ghoddusi et al., 2013; Shenoy, 2016). Furthermore, newer innovations, such as nanoparticulate and drug-delivery bioceramic delivery systems, have showed a greater regenerative potential extending the frontiers of pulp-preserving therapies (Zhu et al., 2014; Lin et al., 2016; Sequeira et al., 2018).

Clinical trials show that bioceramics are highly successful when they are applied in direct pulp capping, partial pulpotomy, and full pulpotomy surgeries, especially on mature molars and young permanent teeth (Asgary et al., 2018; Liu et al., 2015). These results confirm bioceramics as restorative adjunct but as active biologic mediators that may aid tissue repair and regeneration. Nevertheless, such issues as standardization of protocols, proper selection of cases, and long-term follow-up research to verify the stability of these findings is still a problem (Cohenca et al., 2013; Iliescu et al., 2017).

Finally, bioceramic vital pulp therapy is a paradigm shift toward the biologically-focused and less invasive endodontic treatment. Bioceramics are effective at stimulating healing and regeneration, making their use a reliable means of clinicians to maintain the vitality of the pulp and resist or prevent more invasive endodontic treatment. Their applications will be optimized through future studies of bioactive molecule integration, improved delivery systems, and multicenter clinical trials to make VPT a part of the conservative dentistry foundation of the modern era (Luiz de Oliveira da Rosa et al., 2017; Utneja et al., 2015).

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