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Review Article

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# Vital Pulp Therapy—Direct Pulp Cap Revived and Revisited

Todd Brower DDS, MA\*

Assistant Clinical Professor, Department of Restorative Clinical Sciences, University of Missouri–Kansas City School of Dentistry, Kansas City, Missouri, USA

**\*Corresponding author:** Todd Brower DDS, MA, Assistant Clinical Professor, Department of Restorative Clinical Sciences, University of Missouri–Kansas City School of Dentistry, Kansas City, Missouri, USA.

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## Abstract

Direct pulp capping (DPC), now rebranded as “Vital Pulp Therapy” has experienced a remarkable resurgence over the past two decades owing to significant advances in biologically active dental materials, improved understanding of pulpal wound healing, and greater emphasis on minimally invasive dentistry. Historically, direct pulp capping demonstrated inconsistent clinical outcomes, primarily because of bacterial contamination, inadequate case selection, and the use of calcium hydroxide, which exhibited limited long-term sealing ability and structural stability. Contemporary calcium silicate-based biomaterials, including mineral trioxide aggregate (MTA) and newer bioceramic cements, have dramatically improved clinical success by promoting dentin bridge formation, reducing inflammation, and providing superior sealing capabilities.

The preservation of pulp vitality has become a primary therapeutic objective whenever feasible, allowing continued immune defense, proprioception, dentinogenesis, and maintenance of tooth biomechanics. Careful diagnosis, strict aseptic technique, hemorrhage control, and immediate placement of a well-sealed definitive restoration remain essential determinants of treatment success. This review summarizes current concepts in direct pulp capping, discusses indications and contraindications, reviews the biological mechanisms of pulpal repair, compares contemporary pulp-capping materials, and highlights recent evidence supporting vital pulp therapy as a predictable alternative to conventional root canal therapy in appropriately selected cases.

**Keywords:** Vital pulp therapy; Direct pulp capping; Mineral trioxide aggregate; Bioceramics; Calcium silicate cement; Pulp preservation; Dentin bridge; Pulp healing; Bioactive materials; Regenerative endodontics

## Introduction

Preservation of pulp vitality has become one of the fundamental goals of contemporary restorative dentistry and endodontics. Rather than viewing pulp exposure as an automatic indication for root canal treatment, clinicians increasingly recognize that healthy or reversibly inflamed pulp tissue possesses substantial regenerative capacity when bacterial contamination is minimized and appropriate bioactive materials are employed.

Direct pulp capping, now rebranded as Vital Pulp Therapy,

represents one of the most conservative procedures within the spectrum of vital pulp therapy. The procedure involves placement of a biocompatible material directly over an exposed vital pulp with the objective of maintaining pulp vitality while stimulating reparative dentin formation. Improvements in clinical protocols and biomaterials have led to significantly higher success rates than those historically reported, prompting a renewed interest in this conservative treatment modality.



## Historical Perspective

The concept of direct pulp capping has existed for more than a century. Calcium hydroxide became the gold standard during the 1960s and remained the material of choice for decades because of its antibacterial properties and ability to induce tertiary dentin formation.

Despite its widespread use, calcium hydroxide demonstrated several shortcomings, including:

- High solubility
- Poor long-term seal
- Tunnel defects within reparative dentin
- Material degradation over time
- Variable long-term clinical outcomes

Consequently, many clinicians questioned the predictability of direct pulp capping, and root canal therapy became the preferred treatment following pulp exposure.

The introduction of mineral trioxide aggregate in the 1990s dramatically altered this perception. Numerous clinical studies demonstrated superior pulp healing, improved sealing ability, and more consistent dentin bridge formation compared with calcium hydroxide. Subsequent generations of calcium silicate bioceramic materials have continued this trend while improving handling characteristics and reducing setting times.

## Biology of Pulp Healing

Dental pulp is a highly vascularized and innervated connective tissue possessing remarkable regenerative potential. Following a controlled mechanical or traumatic exposure, successful healing depends upon several biological events:

- Rapid hemostasis
- Elimination of bacterial contamination
- Controlled inflammatory response
- Recruitment of pulp stem cells
- Differentiation into odontoblast-like cells
- Deposition of reparative dentin
- Formation of a biologic barrier sealing the exposure

Calcium silicate biomaterials release calcium ions and create an alkaline environment that stimulates growth factor release from dentin matrix proteins. These biological signals promote odontoblastic differentiation and encourage deposition of a homogeneous mineralized bridge over the exposure site.

## Case Selection

Appropriate diagnosis remains the single most important predictor of successful direct pulp capping.

Ideal candidates include:

- Mechanical pulp exposures
- Small traumatic exposures
- Carious exposures with reversible pulpitis
- Teeth exhibiting normal vitality
- Immature permanent teeth
- Patients without spontaneous lingering pain

Contraindications include:

- Irreversible pulpitis
- Pulp necrosis
- Purulent exudate
- Uncontrolled hemorrhage
- Extensive pulpal degeneration
- Vertical root fractures
- Inability to obtain an adequate coronal seal

The clinician should evaluate symptoms, pulp sensibility testing, radiographic findings, caries removal, and intraoperative hemorrhage before selecting direct pulp capping.

## Contemporary Pulp-Capping Materials

Modern calcium silicate biomaterials have transformed vital pulp therapy.

### Calcium Hydroxide

Advantages:

- Antibacterial activity
- Long clinical history
- Low cost

Disadvantages:

- Dissolution over time
- Weak mechanical properties
- Tunnel defects
- Inferior long-term sealing ability

### Mineral Trioxide Aggregate (MTA)

Advantages:

- Excellent biocompatibility
- Superior sealing ability
- Predictable dentin bridge formation
- Excellent long-term success

Disadvantages:

- Extended setting time

- Difficult handling
- Higher cost
- Potential tooth discoloration

#### Newer Bioceramics

Recent materials including premixed calcium silicate cements have demonstrated:

- Improved handling
- Faster setting
- Reduced discoloration
- High compressive strength
- Excellent sealing
- Sustained calcium ion release
- Bioactivity comparable to MTA

These materials continue to expand treatment options for clinicians seeking predictable vital pulp preservation.

#### Clinical Protocol

Successful direct pulp capping requires meticulous clinical technique.

Recommended protocol includes:

1. Accurate pulpal diagnosis.
2. Rubber dam isolation.
3. Complete removal of infected dentin.
4. Gentle irrigation.
5. Hemorrhage control within several minutes.
6. Placement of a bioactive pulp-capping material.
7. Immediate placement of a bacteria-tight restoration.
8. Periodic clinical and radiographic follow-up.

Failure to achieve hemorrhage control often suggests irreversible inflammation and should prompt reconsideration of the treatment plan.

#### Clinical Outcomes

Recent systematic reviews and randomized clinical trials have reported success rates exceeding 80–95% in carefully selected cases treated with modern calcium silicate materials.

Clinical success is associated with:

- Maintenance of pulp vitality
- Absence of spontaneous pain
- Continued root development in immature teeth
- Normal percussion findings
- Absence of periapical pathology
- Formation of reparative dentin
- Functional tooth retention

Long-term success depends not only upon the pulp-capping material but also upon the quality of the definitive coronal restoration.

#### Future Directions

Vital pulp therapy continues to evolve with advances in regenerative medicine. Current research is investigating:

- Bioactive growth factors
- Stem cell therapies
- Injectable hydrogels
- Biomimetic scaffolds
- Nanotechnology-based materials
- Controlled drug delivery systems
- Tissue engineering approaches

These emerging technologies may further enhance pulp regeneration and reduce the need for conventional endodontic treatment.

#### Conclusion

Direct pulp capping, now Vital Pulp Therapy, has undergone a renaissance in modern dentistry. Advances in diagnostic criteria, aseptic clinical protocols, and calcium silicate-based biomaterials have transformed a once unpredictable procedure into a reliable treatment option for preserving pulp vitality. Appropriate case selection remains paramount, but contemporary evidence demonstrates that many teeth previously destined for root canal therapy can now be successfully managed through conservative vital pulp therapy. As regenerative technologies continue to mature, direct pulp capping is likely to become an increasingly important component of minimally invasive, biologically based dental care aimed at preserving the natural dentition for the lifetime of the patient [1-6].

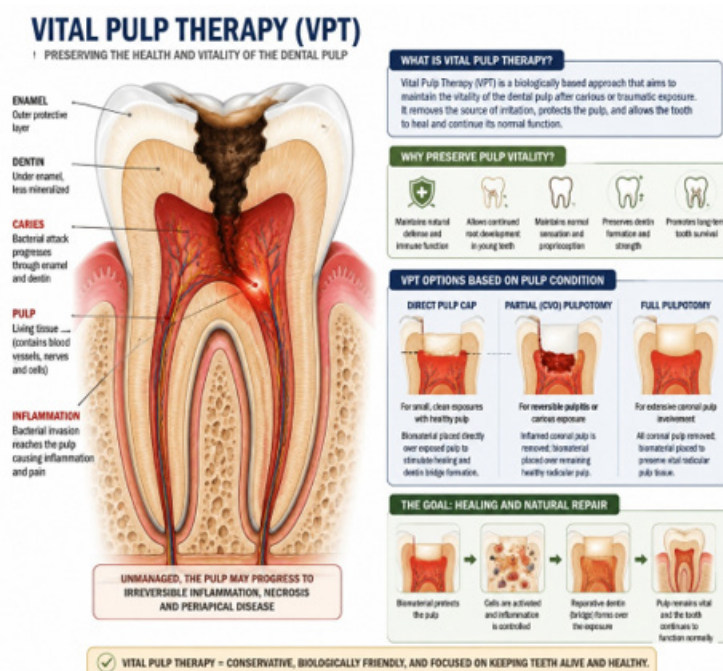


Figure 1

## Acknowledgement

None.

## Conflicts of Interest

No conflicts of interest.

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