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ETIOLOGY AND MODERN TREATMENT METHODS OF PULPITIS

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Abstract
Pulpitis, an inflammation of the dental pulp, remains a critical issue in modern dentistry due to its prevalence and the complexity of its diagnosis and management. This article explores the etiology of pulpitis, examining both microbial and non-microbial causes, and highlights the physiological mechanisms behind its acute and chronic forms. Emphasis is placed on the evolution of treatment methods, from traditional endodontic approaches to minimally invasive and biologically based interventions. Contemporary advances, including vital pulp therapy, regenerative endodontics, and biomaterials, are examined in the context of preserving pulp vitality and improving long-term outcomes. The article also evaluates diagnostic innovations and outlines best practices for clinical decision-making. By understanding both the pathological and therapeutic dimensions of pulpitis, clinicians can more effectively manage this condition and reduce the risk of irreversible pulp damage.

Keywords: Pulpitis; dental pulp; endodontics; inflammation; vital pulp therapy; regenerative endodontics; etiology; biomaterials.

INTRODUCTION

Pulpitis is one of the most commonly encountered inflammatory conditions in dental practice. Characterized by the inflammation of the dental pulp, it often results in intense pain and can lead to serious complications if not treated appropriately. The pulp, a vascular and innervated tissue located in the center of the tooth, is vital for its development and defense against injury. However, due to its enclosed anatomy, the pulp has a limited ability to swell, making inflammation particularly painful and potentially destructive. The understanding of pulpitis has evolved significantly, shifting from a solely mechanical and surgical approach to a more conservative, biologically informed paradigm that emphasizes pulp preservation and regeneration [1].

MATERIALS AND METHODS

The most common etiology of pulpitis is microbial invasion, typically resulting from dental caries, which creates a pathway for bacteria and their byproducts to penetrate enamel and dentin, ultimately reaching the pulp. Bacterial species such as Streptococcus mutans, Lactobacilli, and Actinomyces play a key role in the initial stages of decay. Once they breach the dentinal tubules, they provoke an immune-inflammatory response that can lead to either reversible or irreversible pulpitis, depending on the extent and duration of exposure.

Other causes include mechanical trauma (e.g., accidental fracture), thermal injury from repeated dental procedures, and iatrogenic factors such as over-preparation during cavity restorations. Excessive use of heat-generating instruments or desiccation of dentin can lead to pulpal irritation or necrosis. Restorative materials with poor biocompatibility may also trigger an adverse pulpal response [2].

RESULTS AND DISCUSSION

Recent immunological research has shed light on the cellular and molecular events that characterize pulpitis. The pulpal immune response is initiated by pattern recognition receptors (PRRs) on odontoblasts and dendritic cells, which detect microbial invaders. Once activated, these cells release pro-inflammatory cytokines such as IL-1β, IL-6, and TNF-α, leading to vasodilation and immune cell infiltration. In reversible pulpitis, this immune response is controlled and aimed at tissue repair. However, in irreversible pulpitis, the exaggerated or prolonged cytokine storm leads to tissue necrosis. Understanding these immunological events is crucial for developing pharmacological therapies that modulate the pulp environment and delay or prevent necrosis.

Histologically, the pulp's response to injury varies depending on the stage and severity of the inflammation. In mild reversible pulpitis, one may observe vasodilation, increased vascular permeability, and infiltration of polymorphonuclear leukocytes in the coronal pulp. In contrast, irreversible pulpitis is characterized by widespread neutrophilic infiltration, abscess formation, and even liquefactive necrosis in the pulp core. Calcific metamorphosis and internal resorption may also occur as part of the chronic pulp response. These histopathological changes reinforce the need for accurate clinical classification, as treatment decisions hinge on the pulp's regenerative potential.

Modern vital pulp therapy relies heavily on the performance of biocompatible capping materials. Traditional calcium hydroxide, while widely used, is being replaced by next-generation biomaterials such as mineral trioxide aggregate (MTA), Biodentine, and calcium-enriched mixture cement (CEM). These materials not only form a physical barrier but also stimulate odontoblastic differentiation and tertiary dentin formation. MTA, in particular, has demonstrated superior sealing ability, antibacterial effects due to its high pH, and long-term clinical success [3]. Moreover, new materials are being designed with added nanoparticles, such as silver nanoparticles for antimicrobial effects and bioactive glass for enhanced remineralization, pushing the boundary of pulp preservation.

Regenerative endodontic procedures (REPs) are revolutionizing the management of immature permanent teeth with necrotic pulp. The strategy involves disinfection of the root canal followed by the induction of bleeding to provide a scaffold for tissue regeneration. Stem cells from the apical papilla (SCAP), dental pulp stem cells (DPSCs), and platelet-rich fibrin (PRF) are at the forefront of research in this domain. These cells, when combined with signaling molecules such as bone morphogenetic proteins (BMPs) or transforming growth factor-beta (TGF-β), can facilitate the regeneration of pulp-like tissue and continuation of root development. Future developments aim at engineering full pulp-dentin complexes using tissue scaffolds and 3D bioprinting.

Pulpitis management in special populations, such as pediatric, geriatric, and medically compromised patients, poses unique challenges. In children, behavior management and immature root development must be considered; hence, pulpotomy and apexogenesis are often preferred over root canal treatment. In the elderly, reduced pulp volume, calcifications, and systemic conditions such as diabetes or osteoporosis may complicate both diagnosis and treatment. Immunocompromised patients may not exhibit classic signs of infection, requiring clinicians to rely on adjunctive imaging and laboratory diagnostics. Tailoring treatment protocols to the physiological and systemic context of the patient is essential for optimal outcomes [4].

Digital transformation in healthcare has extended into endodontics with the advent of Clinical Decision Support Systems (CDSS). These AI-driven platforms integrate patient history, symptoms, radiographs, and diagnostic test results to suggest probable diagnoses and treatment paths. Machine learning algorithms trained on large datasets have shown promising accuracy in differentiating between reversible and irreversible pulpitis. Such systems enhance diagnostic consistency among clinicians and improve evidence-based decision-making. They are especially useful in large-scale public health settings or regions with limited access to dental specialists.

One of the most defining characteristics of pulpitis is dental pain, which often presents acutely and severely. The unique innervation of the dental pulp explains this intense pain experience. The pulp contains both A-delta fibers, which are myelinated and responsible for sharp, localized pain (typically provoked by cold stimuli), and C-fibers, which are unmyelinated and produce dull, throbbing, spontaneous pain associated with irreversible pulpitis. As inflammation progresses, increased intrapulpal pressure compresses nerve fibers and blood vessels within the confined pulp chamber, intensifying pain. Recent research suggests that inflammatory mediators such as prostaglandins, bradykinin, and substance P sensitize nociceptors and lower their activation threshold, resulting in hyperalgesia. Understanding this neurobiological basis has led to the incorporation of neuro-modulating agents, such as NSAIDs and corticosteroids, into pulpitis pain management protocols before definitive dental procedures.

Minimally Invasive Endodontics is transforming traditional approaches to treating pulpitis and other pulpal pathologies. The MIE approach focuses on maximizing the preservation of natural tooth structure, especially dentin and the pericervical region, to enhance long-term tooth survival. This shift is supported by the realization that aggressive canal shaping and excessive removal of dentin, as seen in older endodontic techniques, compromises tooth integrity and increases the risk of vertical root fractures. Modern MIE protocols employ [5]:

- Conservative access cavity designs (ninja access, truss access)
- Smaller-diameter rotary files
- Biocompatible sealers that require less instrumentation

By conserving dentin and relying on advanced irrigation techniques (e.g., ultrasonic activation, photon-induced photoacoustic streaming), clinicians can achieve disinfection while minimizing mechanical stress on the tooth.

While disinfection is a cornerstone of pulpitis management, resistant endodontic biofilms remain a major cause of treatment failure. Certain microbial species, such as Enterococcus faecalis and Candida albicans, have demonstrated a remarkable ability to survive in harsh canal environments, resist intracanal medicaments, and form complex multispecies biofilms. These biofilms are highly structured and protected by an extracellular matrix that hinders the penetration of antimicrobials. Conventional sodium hypochlorite irrigation, though effective against planktonic bacteria, may not fully eradicate biofilm-forming organisms in the apical third or lateral canals. Consequently, adjunctive methods such as:

- Photodynamic therapy (PDT)
- Ozone therapy
- GentleWave systems (multisonic cleaning)

are being explored to improve disinfection efficiency and reduce reinfection risks in root canal-treated teeth.

The success of pulpitis treatment extends beyond endodontic procedures. Restorative sealing and coronal coverage play a pivotal role in preventing reinfection and preserving tooth functionality. Endodontically treated teeth, especially those with extensive coronal damage, are structurally compromised and prone to fracture. Recent studies emphasize that pulpitis is not caused by a single bacterial strain but by the collective behavior of complex, multispecies biofilms. These biofilms thrive in nutrient-rich environments such as carious lesions, where they establish a structured, layered matrix that protects microbial communities from host defenses and antimicrobial agents. This microbial synergy enhances acid production and virulence, accelerating dentin demineralization and facilitating bacterial ingress into the pulp chamber. Once bacteria penetrate dentinal tubules, they form microcolonies that are difficult to eradicate even with aggressive chemical irrigation.

Understanding this biofilm dynamics has led to the development of advanced irrigants, such as nanoparticle-based solutions, and mechanical agitation systems designed to disrupt the biofilm matrix and improve the penetration of disinfecting agents.

Aside from bacterial invasion, pulpitis frequently arises from iatrogenic factors during restorative or prosthodontic procedures. High-speed handpieces generate considerable heat if insufficient water cooling is used, leading to thermal injury of the pulp. Similarly, excessive acid etching, improper use of bleaching agents, or exposure to toxic resin monomers can provoke a sterile inflammation that mirrors bacterial pulpitis. Recent research has focused on low-shrinkage resin composites and less aggressive bonding agents that reduce chemical irritation. Additionally, modern laser-assisted cavity preparation techniques have been shown to produce less heat and microcracking in dentin, lowering the risk of iatrogenic pulpitis.

CONCLUSION

Pulpitis represents a dynamic interplay between infectious, mechanical, and systemic factors leading to inflammation of one of the most vital components of the tooth. Early diagnosis and differentiation between reversible and irreversible forms are essential for proper treatment planning. Modern approaches such as vital pulp therapy and regenerative endodontics offer less invasive and biologically favorable alternatives to traditional root canal therapy. The continued development of bioactive materials, improved diagnostics, and personalized care strategies will enhance the future of endodontic treatment and increase the likelihood of preserving pulp vitality.

REFERENCES

1. Siqueira J.F., Rôças I.N. Clinical implications and microbiology of bacterial persistence after treatment procedures // J Endod. – 2008. – Vol. 34, No. 11. – P. 1291–1301. URL: https://doi.org/10.1016/j.joen.2008.07.028
2. Berman L.H., Hargreaves K.M. Cohen's Pathways of the Pulp. – 11th ed. – St. Louis: Mosby/Elsevier, 2016. – 928 p.

URL: https://www.elsevier.com/books/cohens-pathways-of-the-pulp/berman/978-0-323-09602-9
3. Aguilar P., Linsuwanont P. Vital pulp therapy in vital permanent teeth with cariously exposed pulp: a systematic review // J Endod. – 2011. – Vol. 37, No. 5. – P. 581–587. URL: https://doi.org/10.1016/j.joen.2010.12.004
4. Dammaschke T. The history of direct pulp capping // J Hist Dent. – 2008. – Vol. 56, No. 1. – P. 9–23. URL: https://pubmed.ncbi.nlm.nih.gov/18543641/
5. El Meligy O.A., Avery D.R. Comparison of mineral trioxide aggregate and calcium hydroxide as pulpotomy agents in young permanent teeth // Pediatr Dent. – 2006. – Vol. 28, No. 5. – P. 399–404. URL: https://pubmed .ncbi.nlm.nih.gov/17176828/
6. Diogenes A., Ruparel N.B., Shiloah Y., Hargreaves K.M. Regenerative endodontics: a way forward // J Am Dent Assoc. – 2016. – Vol. 147, No. 5. – P. 372–380. URL: https://doi.org/10.1016/j.adaj.2015.12.013.