

Review

Managing Pulpal Necrosis and Long-Term Tooth Preservation

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Abstract

Pulpal necrosis, the irreversible death of the dental pulp, often results from untreated dental caries or trauma. It poses significant challenges in clinical practice due to its potential to cause severe complications, including periapical abscesses, infection, and tooth loss. Effective management of pulpal necrosis focuses on eliminating infection, preserving the natural tooth, and preventing reinfection through a multidisciplinary approach. Diagnostic tools such as pulp vitality testing, radiographic imaging, and clinical examination are essential for identifying necrotic tissue and determining the extent of periapical involvement. Treatment typically involves root canal therapy, a widely used method that emphasizes thorough cleaning, disinfection, and sealing of the root canal system to eliminate bacterial presence and promote healing. Restorative procedures, particularly the placement of full-coverage crowns, are crucial for protecting the treated tooth from fracture and ensuring its longevity. In more complex cases, surgical endodontic procedures like apicoectomy may be necessary. Advances in endodontic materials and techniques, including regenerative therapies, offer new possibilities for promoting tissue regeneration and healing within the root canal system. Long-term success relies on effective post-treatment monitoring through regular clinical and radiographic evaluations to detect any signs of reinfection or failure early. The role of patient education is also critical in ensuring compliance with follow-up appointments and maintaining good oral hygiene, which are key to preventing future complications. By combining innovative techniques with careful monitoring and patient engagement, clinicians can achieve long-term preservation of teeth affected by pulpal necrosis, maintaining their function and structural integrity for years. This comprehensive approach enhances the overall success rate of endodontic treatments, contributing to better outcomes in dental practice and improved patient satisfaction.

Keywords: *pulpal necrosis, root canal therapy, tooth preservation, endodontic treatment, post-treatment monitoring*

Introduction

Pulpal necrosis, a condition resulting from the death of the dental pulp, is often a consequence of untreated dental caries, trauma, or other pathological conditions affecting the tooth structure. It is a progressive condition, where the loss of vitality within the tooth's pulp tissue can lead to severe complications such as periapical abscesses, chronic pain, and eventual tooth loss if not addressed in a timely manner. The management of pulpal necrosis requires a comprehensive understanding of endodontic principles, diagnostic approaches, and long-term strategies aimed at tooth preservation. With advancements in dental treatment, there has been a shift towards conservative approaches that emphasize saving natural teeth whenever possible, as opposed to extraction (1). Consequently, managing pulpal necrosis has become a critical component of contemporary dental practice, focusing on maintaining the structural integrity and function of teeth affected by this condition.

The primary cause of pulpal necrosis is the bacterial invasion of the pulp chamber, typically due to caries or traumatic injury. Once the pulp is infected, the body's immune response can result in the destruction of the pulp tissue, leading to necrosis. Symptoms often include discoloration of the affected tooth, pain on biting, and swelling, though some cases may be asymptomatic until the infection spreads to the surrounding tissues (2). Early diagnosis and intervention are essential in preventing further complications, such as the spread of infection to the periapical tissues or systemic involvement.

Various treatment options are available for managing pulpal necrosis, with root canal therapy being the most widely employed approach. The success of root canal treatment depends on proper debridement, disinfection, and sealing of the root canal system. In cases where root canal treatment is not feasible or has failed, surgical interventions such as apicoectomy may be required (3). Long-term tooth preservation, following pulpal necrosis, is contingent on adequate restoration after treatment

and regular follow-up care to monitor the health of the tooth and surrounding tissues. Recent developments in biomaterials and regenerative endodontics offer new possibilities for enhancing treatment outcomes and preserving natural teeth in the long term (4). This review aims to explore the current approaches to managing pulpal necrosis, focusing on the clinical decision-making process and strategies for ensuring the long-term preservation of affected teeth.

Review

The management of pulpal necrosis requires a multi-faceted approach that integrates clinical expertise, patient-specific factors, and advancements in dental technologies. Root canal therapy remains the gold standard for treating pulpal necrosis, offering a predictable means of preserving the affected tooth. However, the success of root canal treatment is highly dependent on thorough cleaning and shaping of the root canal system, as well as effective disinfection to eliminate bacterial pathogens (5). Failure to properly disinfect the root canal can result in persistent infection, leading to treatment failure or the need for retreatment. Advances in irrigation techniques and materials, such as the use of biocompatible sealers, have improved the long-term outcomes of endodontic procedures (6).

Recent developments in regenerative endodontics also present promising alternatives for managing necrotic teeth, particularly in cases where conventional treatment options may not be viable. Regenerative techniques aim to restore vitality to the tooth by promoting tissue repair and regeneration within the pulp chamber. This approach has shown potential in preserving natural teeth in younger patients and those with immature apices, where traditional root canal therapy may be challenging (6).

Diagnosis and Clinical Assessment of Pulpal Necrosis

Accurate diagnosis and clinical assessment are crucial in managing pulpal necrosis to determine the most appropriate course of treatment. Diagnosis

typically begins with a detailed patient history and examination of symptoms. Pulpal necrosis can be associated with a variety of symptoms, including prolonged tooth sensitivity, pain upon biting, or even asymptomatic presentations. Clinically, these symptoms must be correlated with radiographic findings and diagnostic tests to confirm the extent of pulp damage and periapical involvement. One of the key diagnostic tools used in this process is pulp vitality testing, which includes both thermal and electric pulp tests. These tests help differentiate between reversible and irreversible pulp conditions, aiding in the identification of necrotic pulp tissue (7).

Additionally, periapical radiographs remain an essential component of diagnosing pulpal necrosis. Radiographs can reveal periapical radiolucencies, indicating the spread of infection to surrounding tissues, which is often a sign of advanced pulpal necrosis. In some cases, cone-beam computed tomography (CBCT) is employed to provide three-dimensional imaging, offering a more precise evaluation of periapical pathologies, root morphology, and extent of bone destruction. CBCT is particularly beneficial in cases of complex root canal systems, where standard radiographs may not provide sufficient detail (8).

Another important aspect of clinical assessment is identifying etiological factors contributing to necrosis, such as trauma, extensive caries, or previous dental procedures. Traumatic injuries often lead to compromised blood supply to the pulp, resulting in its eventual necrosis. Furthermore, deep carious lesions that penetrate the dentin-pulp complex are significant contributors to pulpal inflammation and necrosis. Identifying these underlying causes aids in planning treatment, especially in cases where prevention of further pulpal damage is crucial (9).

Palpation and percussion tests are also performed during clinical assessment to check for tenderness or pain in the periapical region, indicating inflammation or infection of the surrounding tissues. Sensitivity to pressure during these tests often points to periapical involvement secondary to

pulpal necrosis. Moreover, discoloration of the tooth is another clinical indicator, especially in cases where necrosis has been longstanding. Discoloration occurs due to the breakdown of blood components within the pulp chamber, which can seep into dentinal tubules, giving the tooth a greyish appearance.

Treatment Modalities for Pulpal Necrosis

Managing pulpal necrosis involves several treatment options, with the primary objective of eliminating infection and preserving the affected tooth. Root canal therapy (RCT) is the most common treatment modality for pulpal necrosis, and it remains a reliable option in cases where the tooth can be restored and maintained in the oral cavity. The procedure involves removing the necrotic pulp, disinfecting the root canal system, and sealing it to prevent future microbial infiltration. Advances in endodontic instrumentation, such as rotary files and advanced irrigation techniques, have significantly enhanced the effectiveness and efficiency of RCT (10). These advancements allow for more thorough debridement of complex root canal systems, improving overall treatment outcomes. In some cases, nonsurgical retreatment may be required if the initial RCT fails due to incomplete disinfection or inadequate sealing. Nonsurgical retreatment involves re-entering the root canal system, removing the previous filling material, and re-cleaning and sealing the canals. This approach is often preferred over extraction as it allows for the preservation of the natural tooth structure. However, the success of retreatment depends heavily on the extent of the initial damage and the complexity of the root canal anatomy (11).

For cases where nonsurgical options are not viable, surgical endodontic procedures, such as apicoectomy, may be considered. Apicoectomy involves the removal of the apex of the root, along with the infected periapical tissue, followed by sealing of the root end. This procedure is typically performed when conventional RCT or retreatment has failed, and infection persists in the periapical region. Although surgical intervention can be more invasive, it offers a viable solution for saving the tooth in cases where nonsurgical methods are

insufficient. Modern microsurgical techniques and the use of biocompatible materials, such as mineral trioxide aggregate (MTA), have improved the success rates of apicoectomy procedures (12). In more recent years, regenerative endodontic therapy has emerged as a promising alternative for treating necrotic teeth, particularly in younger patients with immature root development. This treatment approach focuses on inducing the regeneration of pulp-like tissue within the root canal system, potentially restoring the vitality of the tooth. Techniques such as stem cell therapy, platelet-rich plasma, and growth factor delivery are being explored to facilitate tissue regeneration and healing. While regenerative endodontics is still in its early stages of development, it offers a novel approach for cases where traditional treatments may not provide long-term success or are not feasible.

Strategies for Enhancing Long-Term Tooth Preservation

Long-term tooth preservation following the treatment of pulpal necrosis relies on multiple factors, including effective restoration, maintenance of tooth function, and prevention of reinfection. A critical aspect of enhancing tooth preservation is the proper restoration of the tooth after root canal therapy. The use of full-coverage restorations, such as crowns, is often recommended to protect the tooth from fracture, which is a common risk due to the loss of structural integrity following endodontic treatment. Studies have shown that teeth restored with crowns after root canal therapy have a significantly higher survival rate compared to those without full coverage restorations (13). The role of restorative techniques cannot be overstated in ensuring the longevity of endodontically treated teeth. Another important factor in long-term preservation is the quality of the coronal seal. A compromised seal can allow for bacterial leakage into the root canal system, leading to reinfection and failure of the treatment. Ensuring that the coronal restoration is well-sealed and does not allow for microleakage is essential for maintaining the sterility of the root canal. Modern adhesive materials and techniques have improved the ability to achieve a tight seal, reducing the risk of

contamination over time (14). This highlights the importance of a multidisciplinary approach, where both the endodontist and the restorative dentist collaborate to ensure optimal outcomes.

Post-treatment maintenance through regular follow-up and monitoring is key to long-term success. Regular dental check-ups allow for the early detection of any signs of reinfection or complications, such as periapical pathology or restoration failure. Clinical studies emphasize the importance of monitoring the periapical area through radiographs to assess the healing of the surrounding bone and tissues. Periapical healing can take time, and regular imaging helps clinicians evaluate whether the treatment has been successful and if any further intervention is necessary (15). Finally, patient education plays a vital role in ensuring long-term tooth preservation. Educating patients about the importance of maintaining good oral hygiene, attending follow-up appointments, and addressing any dental concerns promptly can significantly impact the longevity of the treated tooth. Patients should also be made aware of the risks associated with delayed treatment or failure to follow recommended restorative protocols, which could jeopardize the success of the treatment.

Post-Treatment Monitoring and Success Indicators

Post-treatment monitoring is a crucial component in ensuring the long-term success of teeth treated for pulpal necrosis. Effective monitoring involves regular clinical evaluations and radiographic assessments to detect any signs of failure or complications early. Clinical follow-up typically includes checking for symptoms such as tenderness, swelling, or changes in tooth color, which may indicate reinfection or persistent periapical inflammation. In addition, the evaluation of the functional integrity of the tooth, such as its ability to withstand normal masticatory forces without discomfort or fracture, is an essential success indicator (16).

Radiographic follow-up, particularly with periapical radiographs, is the gold standard for assessing healing of the periapical tissues. Healing of

periapical lesions may take months to years, and regular radiographs allow clinicians to monitor bone regeneration around the root apex. A decrease in the size of radiolucent lesions on subsequent radiographs is a positive indicator of healing. In cases where lesions persist or increase in size, further investigation and possible retreatment may be necessary. CBCT can also provide more detailed three-dimensional imaging when standard radiographs are inconclusive, particularly in complex cases with apical pathology (8).

Success in post-treatment monitoring is not limited to the absence of symptoms or radiographic healing; it also includes the long-term survival of the tooth. The concept of "functional success" focuses on the tooth's ability to maintain its role in the dental arch without significant complications over time. Teeth that remain symptom-free, demonstrate radiographic healing, and retain functionality without further intervention are considered successful. Monitoring these factors regularly helps guide clinicians in determining whether the treatment has achieved its objectives or if additional procedures are needed. Coronal microleakage remains a leading cause of failure in endodontically treated teeth. Ensuring that the restoration remains intact and does not permit bacterial ingress is crucial to long-term success. Regular check-ups to evaluate the quality of the coronal seal and restoration integrity can prevent reinfection and significantly improve the prognosis of the treated tooth (17). This highlights the importance of continuous communication between the endodontist and the restorative dentist, ensuring that the restoration is monitored and maintained properly.

Conclusion

A combination of accurate diagnosis, effective treatment, and thorough post-treatment monitoring is essential for long-term tooth preservation. Advances in endodontic techniques and materials, along with careful restoration and regular follow-up, significantly improve treatment outcomes. By integrating modern approaches such as regenerative therapy and ensuring robust patient education, clinicians can achieve both functional and aesthetic

success. Ultimately, the goal is to maintain the natural tooth for as long as possible while minimizing the risk of complications.

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Data availability

Data that support the findings of this study are embedded within the manuscript.

Author Contribution

The authors contributed to conceptualizing, data drafting, collection and final writing of the manuscript.

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