

Revolutionizing Calcified Tooth Treatment: A Review on Guided Endodontics

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Abstract—Calcified teeth pose significant challenges in endodontic treatment due to the partial or complete obliteration of root canals, often leading to complications such as treatment failure, instrument fracture, and patient discomfort. Traditional methods relying on tactile sensation and radiographs are frequently inadequate, particularly in managing severely calcified teeth. The advent of guided endodontics, which integrates cone-beam computed tomography (CBCT) and computer-aided design/computer-aided manufacturing (CAD/CAM) technology, has revolutionized treatment approaches. This review explores the evolution of endodontic treatment for calcified teeth, emphasizing the benefits of guided endodontics. By providing precise, minimally invasive access to calcified canals, guided endodontics improves clinical outcomes, reduces chair time, and enhances patient comfort. Despite challenges such as high costs, limited availability, and the need for technical expertise, the advantages, including enhanced precision, higher success rates, and decreased instrument fracture risk, make guided endodontics a superior choice for managing calcified teeth. Technological innovations, such as ultrasonic instruments and bioceramic sealers, further contribute to successful treatment outcomes. Guided endodontics is transforming endodontic care, offering a safer, faster, and more effective solution for tooth preservation, especially in complex cases where conventional techniques fall short.

Index Terms—Calcified teeth, Guided endodontics, CBCT

I. INTRODUCTION

Calcified teeth present significant challenges in endodontic treatment due to the partial or complete obliteration of the root canal system, typically caused by aging, trauma, or dental pathology.(1) The narrowing or closure of root canals complicates the access and cleaning required for successful treatment, often leading to treatment failure or the need for

surgical interventions.(2) Traditional endodontic approaches, which rely on tactile sensation and radiographic interpretation, are often inadequate when dealing with heavily calcified canals, increasing the risk of instrument fracture, perforation, and patient discomfort.(3) Additionally, locating the canal entrance becomes a time-consuming and technically demanding process, even for experienced clinicians. As a result, patients may face prolonged treatment periods or tooth extraction. Addressing these challenges requires more advanced, precision-guided techniques that allow for the accurate navigation of calcified canals while minimizing procedural risks. Guided endodontics has emerged as a promising solution, offering enhanced accuracy and patient outcomes in managing calcified teeth. (4)

II. THE EVOLUTION OF ENDODONTIC TREATMENT FOR CALCIFIED TEETH

Endodontic treatment for calcified teeth has evolved significantly over the decades, transitioning from conventional methods to more advanced, technology-driven approaches. Initially, the treatment of calcified teeth relied solely on traditional techniques, where clinicians used tactile sensation and basic radiographs to locate and navigate the root canals. This often proved challenging due to the unpredictable and complex anatomy of calcified canals, leading to higher rates of treatment failure, instrument fracture, or even perforation. (5)

With the advent of magnification tools, such as dental operating microscopes, practitioners gained enhanced visualization, improving their ability to locate calcified canals. These microscopes, combined with ultrasonics, helped clinicians overcome some limitations, allowing for more precise removal of calcifications. (6)

In recent years, the introduction of cone-beam computed tomography (CBCT) revolutionized endodontic treatment by providing three-dimensional imaging of the root canal system. CBCT enables clinicians to accurately assess the canal's anatomy and plan treatment with greater precision. The latest development, guided endodontics, incorporates CBCT data and computer-aided design/computer-aided manufacturing (CAD/CAM) technology to create custom-made guides that facilitate accurate access to the root canal. This technique drastically reduces the risk of procedural errors and has emerged as a game-changing approach for treating calcified teeth with improved success rates and patient outcomes. (7)

Guided Endodontics: Concept and Technology

Guided endodontics is a modern, precision-based approach to managing complex root canal treatments, particularly in cases involving calcified teeth. This technique integrates advanced imaging modalities and computer-aided technology to improve the accuracy and efficiency of endodontic procedures. The core concept of guided endodontics revolves around using three-dimensional (3D) imaging from cone-beam computed tomography (CBCT) and digital impressions of the patient's teeth to create a detailed virtual model of the tooth and surrounding structures. (8)

With this digital model, a custom-made guide is designed using computer-aided design/computer-aided manufacturing (CAD/CAM) technology. The guide, similar to those used in guided implant surgery, ensures precise drilling and access to the calcified root canal while minimizing errors such as perforation or instrument fracture. This approach allows clinicians to bypass the traditional trial-and-error method of locating calcified canals, significantly reducing the time and complexity of the procedure. (9)

Additionally, guided endodontics is particularly beneficial for anatomically challenging cases, as it enhances visibility and allows for more predictable outcomes. By leveraging 3D visualization, minimally invasive techniques, and real-time precision, guided endodontics provides patients with safer, faster, and more effective treatment for calcified teeth, representing a breakthrough in endodontic care. (10)

Clinical Applications of Guided Endodontics in Calcified Teeth (5,7,8)

The clinical applications of guided endodontics in the treatment of calcified teeth are diverse and have significantly improved patient outcomes.

Here are the key applications:

1. Precise Canal Location:

Guided endodontics facilitates the accurate location of calcified or obliterated root canals, which is often challenging with traditional techniques. By using a pre-designed guide, clinicians can access the root canal precisely without relying solely on tactile sensation or visual cues.

2. Minimally Invasive Access:

The use of a custom-made guide allows for minimally invasive access to the root canal, reducing unnecessary removal of tooth structure. This conserves the natural tooth anatomy and helps maintain its structural integrity, improving long-term prognosis.

3. Complex Anterior Teeth

Calcification is more prevalent in anterior teeth, which are difficult to treat due to their narrow canals. Guided endodontics provides accurate access to these calcified anterior teeth, ensuring that treatment is effective while minimizing the risk of procedural errors such as perforation.

4. Re-Treatment of Failed Root Canals:

For teeth that have undergone previous endodontic treatments and are now calcified, guided endodontics offers a reliable solution. The precision provided by 3D imaging and the use of guides allows clinicians to safely navigate the altered canal anatomy and achieve successful re-treatment.

5. Avoidance of Instrument Fracture:

Traditional methods in calcified teeth carry a higher risk of instrument fracture due to the difficulty in accessing and cleaning the root canals. Guided endodontics reduces this risk by providing an accurate and controlled pathway for endodontic instruments.

6. Surgical Endodontics:

In cases where calcified teeth require apical surgery, guided endodontics can be applied to plan and execute precise apicoectomy procedures. This reduces the likelihood of complications and enhances the precision of surgical outcomes.

7. Enhanced Treatment of Multiple Canals:

Multirrooted and calcified posterior teeth are difficult to navigate using conventional methods. Guided endodontics ensures proper access to all root canals,

even in complex cases involving multiple calcified canals.

8. Reduced Chair Time:

By eliminating the trial-and-error process of locating calcified canals, guided endodontics significantly reduces chair time for both the clinician and the patient, improving efficiency and patient comfort.

III. ADVANTAGES OF GUIDED ENDODONTICS OVER TRADITIONAL APPROACHE

:(10,11,12,13)

Here are the key advantages of guided endodontics over traditional approaches, outlined:

1. Enhanced Precision:

Guided endodontics uses 3D imaging and custom-made guides to precisely locate and access the root canal, reducing the risk of errors such as perforation or missed canals, common in traditional methods.

2. Minimally Invasive:

The technology allows for targeted access to the calcified canal, preserving more tooth structure compared to traditional techniques that may require extensive drilling to locate the canal.

3. Improved Success Rates:

By offering more accurate navigation and minimizing procedural risks, guided endodontics increases the overall success rate of endodontic treatments, particularly in challenging cases like calcified canals.

4. Reduction in Instrument Fracture:

Traditional techniques, which rely on tactile sensation, increase the risk of instrument fracture when navigating through calcified canals. Guided endodontics minimizes this risk by ensuring a more controlled and direct path for instruments.

5. Decreased Chair Time:

Guided endodontics streamlines the procedure by eliminating the trial-and-error approach of finding calcified canals, significantly reducing chair time for both clinicians and patients.

6. Increased Patient Comfort:

With faster procedures, fewer errors, and a minimally invasive approach, guided endodontics enhances patient comfort and reduces the need for multiple appointments or re-treatment.

7. Application in Complex Cases:

Guided endodontics is particularly beneficial in cases with challenging anatomy, such as multirooted teeth or severely calcified canals, where traditional

techniques may fail. It provides reliable solutions for complex cases.

8. Integration with Modern Technology:

By utilizing advanced imaging like CBCT and CAD/CAM, guided endodontics integrates modern digital technology into clinical practice, providing a more predictable and effective treatment outcome compared to conventional methods.

Guided endodontics offers significant advantages in terms of precision, safety, efficiency, and patient experience, making it a superior choice for managing calcified teeth over traditional techniques.

IV. LIMITATIONS AND CHALLENGES IN GUIDED ENDODONTICS: (5,7, 11,12,13)

Here are the key limitations and challenges of guided endodontics, outlined pointwise:

1. High Cost:

The use of advanced technology such as CBCT imaging and CAD/CAM-guided templates increases the overall cost of the procedure, making it less accessible to patients compared to traditional techniques.

2. Limited Availability:

Not all dental clinics are equipped with the necessary technology and expertise to perform guided endodontics, limiting its widespread use, especially in rural or resource-limited settings.

3. Technical Expertise Required:

Guided endodontics demands specialized training and familiarity with the use of 3D imaging software, designing custom guides, and operating advanced equipment, making it challenging for clinicians without experience in these technologies.

4. Time-Consuming Pre-Procedure Planning:

The process of obtaining CBCT scans, designing the guide, and fabricating it can be time-consuming, potentially delaying the start of treatment compared to traditional approaches.

5. Radiation Exposure:

CBCT imaging involves radiation exposure, which may not be suitable for all patients, especially those concerned about cumulative radiation doses from multiple diagnostic imaging sessions.

6. Limited Application for Complex Anatomies:

In cases with severely distorted or irregular tooth anatomy, guided endodontics may still face

challenges, as it relies heavily on accurate imaging and modeling.

7. Potential for Guide Misalignment:

If the guide is not properly aligned during the procedure, it can lead to inaccuracies in canal access, which may compromise treatment outcomes.

These challenges highlight the need for careful consideration when choosing guided endodontics for specific cases.

V. INNOVATIONS IN ENDODONTIC TECHNOLOGY

Innovations in endodontic technology have significantly transformed the field, improving precision, efficiency, and patient outcomes. (14) Key advancements include the integration of cone-beam computed tomography (CBCT), which provides 3D imaging for detailed visualization of root canal anatomy. This has been further enhanced by computer-aided design/computer-aided manufacturing (CAD/CAM) systems, allowing the creation of custom guides for procedures like guided endodontics, ensuring precise canal location and minimally invasive access. (15) The development of ultrasonic instruments has improved the removal of calcifications and enhanced the ability to clean intricate canal systems effectively. Additionally, bioceramic sealers and advanced irrigation techniques, such as laser-assisted irrigation, have optimized the disinfection and sealing of root canals, reducing post-treatment infections. Digital workflows, from diagnosis to treatment planning, have streamlined endodontic procedures, making them faster and more predictable. These innovations are revolutionizing endodontics by enhancing clinical accuracy, reducing procedural risks, and improving long-term success rates. (16)

VI. CONCLUSION

Guided endodontics has made a profound impact on tooth preservation, particularly in challenging cases involving calcified canals. By combining advanced imaging techniques, such as CBCT, with custom-made guides, this approach allows for precise and minimally invasive access to complex root canal systems. This accuracy reduces the risk of errors like canal perforation or missed canals, which are

common in traditional methods, and significantly increases the success rate of endodontic treatments. Additionally, guided endodontics conserves more natural tooth structure, promoting long-term tooth health and reducing the need for more invasive procedures like extractions or apicoectomies. The enhanced precision and reduced treatment time also improve patient comfort and satisfaction. As a result, guided endodontics is revolutionizing endodontic care, offering a more predictable, efficient, and successful solution for tooth preservation, particularly in cases where traditional techniques are insufficient.

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