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THE USE OF DENTAL MICROSCOPES IN ENDODONTIC TREATMENT: CLINICAL OPPORTUNITIES AND LIMITATIONS

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Abstract: The complex anatomy of the root canal system and limited visualization of the operative field during endodontic treatment may affect treatment accuracy and clinical outcomes. The aim of this article was to evaluate the clinical applications of dental operating microscopes in endodontic treatment, their impact on treatment effectiveness, and the main limitations associated with their use in clinical practice. The study was conducted as a literature review, analyzing data from recent scientific articles, systematic reviews, and meta-analyses. The findings indicate that dental microscopes facilitate the identification of additional root canals, management of calcified or complex canals, retrieval of fractured instruments, management of perforations, and improved operative control during endodontic microsurgery. Some meta-analyses have reported higher success rates for endodontic microsurgery performed under high magnification compared with conventional approaches. At the same time, the clinical effectiveness of dental microscopes depends on factors such as operator experience, technical equipment, tooth anatomy, and adherence to treatment protocols. In conclusion, dental microscopes are an important technology for improving visualization and treatment precision in complex endodontic cases, and their use in combination with clinical expertise and other modern endodontic techniques is recommended.

Keywords: endodontic treatment, dental operating microscope, endodontic microsurgery, root canal anatomy, magnification, additional root canals, calcified canals, endodontic treatment effectiveness, visualization, clinical limitations.

Introduction

The success of endodontic treatment depends on accurate identification of the anatomical characteristics of the root canal system, proper localization of canal orifices, complete removal of infected tissues, and precise mechanical and chemical preparation. The narrowness of root canals, additional canals, calcifications, isthmuses, and other anatomical variations may limit clinical visualization and make diagnosis and treatment more challenging in complex endodontic cases. Therefore, dental operating microscopes, which provide high magnification and enhanced illumination, are considered an important technology in modern endodontic practice [[1]].

[1] Liu B, Zhou X, Yue L, et al. *Experts consensus on the procedure of dental operative microscope in endodontics and operative dentistry*. International Journal of Oral Science. 2023.

Dental operating microscopes enable improved visualization of additional canal orifices, microstructural changes, and complex anatomical details by magnifying the operative field. An expert consensus published in 2023 described the use of dental operating microscopes in endodontics and operative dentistry as a valuable tool for improving diagnostic accuracy, facilitating minimally invasive preparation, and enhancing the precision of complex clinical procedures.

However, the clinical benefits of dental operating microscopes cannot be evaluated solely on the basis of magnification. A retrospective study published in 2025 reported that microscope-assisted endodontic treatment, particularly in complex posterior teeth, was associated with higher treatment success rates. At the same time, other prognostic factors, including the presence of apical lesions, root canal anatomy, and retreatment, also had a significant influence on treatment outcomes [2].

From this perspective, it is important to evaluate the actual clinical applications of dental operating microscopes in endodontic treatment together with their technical and practical limitations. This article analyzes the use of dental operating microscopes in endodontic diagnosis and treatment, their clinical effectiveness, and the limitations associated with their use based on current scientific literature.

1. Clinical Role of Dental Microscopes in Endodontic Treatment

Dental operating microscopes differ from other visualization tools used in endodontic practice by simultaneously improving the magnification and illumination of the operative field. The ability to visualize small anatomical details of the root canal system, accurately identify canal orifices, and prevent unnecessary removal of healthy dentin are among the main clinical advantages of dental microscopes. Particularly in molar teeth with complex canal anatomy, high magnification provides a more precisely oriented and conservative approach to the root canal system. Modern expert consensus describes the dental operating microscope as an important tool that can be used at various stages of endodontic diagnosis, nonsurgical treatment, retreatment, and microsurgery [3].

2. Identification and Treatment of Complex Root Canals

The presence of calcified, narrow, curved, or additional canals increases the technical difficulty of endodontic treatment. In such cases, inaccurate identification of the canal trajectory may lead to complications such as perforation, excessive removal of dentin, or instrument separation. Magnification improves visualization of canal orifices and anatomical landmarks within the dentin, while also facilitating the controlled use of ultrasonic instruments and minimally

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[2] *Effectiveness of microscope-assisted root canal treatment in permanent posterior teeth: A retrospective cohort study*. Journal of Dentistry. 2025.

[3] Liang J, et al. *Experts consensus on the procedure of dental operative microscope in endodontics and operative dentistry.* International Journal of Oral Science. 2023.

invasive preparation. A retrospective cohort study published in 2025 compared 337 posterior teeth treated with the aid of a microscope with 298 teeth treated without a microscope and found that the probability of treatment success was 2.91 times higher according to strict criteria and 3.25 times higher according to less stringent criteria in the microscope-assisted treatment group.

3. Importance of Dental Microscopes in Endodontic Retreatment

Endodontic retreatment requires the identification of altered anatomy resulting from previous preparation, root canal filling materials, posts, separated instruments, and missed canals. These structures may be difficult to identify under conventional visualization. The microscope provides high-resolution visualization of the operative field, facilitating the selective removal of previous filling materials, identification of missed canals, and management of procedural complications. At the same time, the final outcome of microscope-assisted retreatment depends not only on visualization but also on factors such as the presence of periapical pathology, root canal anatomy, and the quality of the initial treatment [4].

4. The Role of Microscopes in Endodontic Microsurgery

The clinical significance of dental microscopes is particularly evident in endodontic microsurgery. High magnification allows more precise visualization of the anatomical structures of the root apex, microcanals, isthmuses, cracks, and the resected root surface. Meta-analyses have reported an overall success rate of 94% for endodontic microsurgery performed under high magnification, which was higher than the 88% success rate reported for conventional surgical approaches, and this difference was considered statistically significant ($P<0.0005$). Therefore, the microscope is considered not only a visualization aid in endodontic microsurgery but also an important component of precise and minimally invasive surgical techniques [5].

5. The Impact of Microscope Use on Accuracy and Operator Performance

Magnified visualization can improve the accuracy of endodontic procedures while also enhancing the operator's technical control. In an in vitro study conducted in 2024, the group using magnification demonstrated more conservative removal of tooth structure during access cavity preparation, better identification of canal orifices, greater accuracy in canal shaping and obturation, and fewer procedural errors. These findings indicate that the main benefit of a dental microscope is

[4] *Effectiveness of microscope-assisted root canal treatment in permanent posterior teeth: A retrospective cohort study.* Journal of Dentistry. 2025;157:105771.

[5] Setzer FC, Shah SB, Kohli MR, Karabucak B, Kim S. *Outcome of endodontic surgery: a meta-analysis of the literature—Part 2: comparison of endodontic microsurgical techniques with and without the use of higher magnification.* Journal of Endodontics.

not merely to provide an enlarged view, but also to enable the operator to perform clinical decisions and procedures with greater precision [6].

6. Clinical Limitations of Dental Microscopes

Despite the advantages of dental microscopes, their availability alone does not guarantee successful endodontic treatment. The high cost of the equipment, the need for a specially adapted working environment, and the time and training required for the operator to develop adequate skills in microscope use are among its practical limitations. Furthermore, evidence regarding the extent to which magnification significantly improves treatment outcomes is not consistent across all clinical situations. A review published in 2025 reported the advantages of dental operating microscopes in diagnosis and treatment, while emphasizing that the optimal level of magnification and its limitations in different clinical situations should still be assessed on an individual basis [7].

Thus, a dental microscope is a technology with broader clinical significance in endodontic practice than simply being an optical device that improves visualization. It can provide significant advantages in identifying complex root canal anatomy, retreatment, microsurgery, and minimally invasive preparation. However, its clinical value should be evaluated in conjunction with operator experience, appropriate protocols, tooth anatomy, and the patient's periapical condition.

Discussion

The analyzed scientific data indicate that dental microscopes improve the visualization of the operative field and facilitate the identification of complex anatomical structures during endodontic treatment. Magnification is particularly valuable for identifying additional root canals, calcified or narrow canals, isthmuses, and anatomical variations encountered during retreatment. A retrospective study published in 2025 reported a higher probability of successful treatment in posterior teeth treated with the aid of a microscope compared with those treated without a microscope [4]. At the same time, it would not be appropriate to attribute this difference solely to the use of the microscope, as root canal anatomy, periapical status, and operator experience are also important factors influencing treatment outcomes.

The advantages of microscopes are particularly evident in endodontic microsurgery. High magnification enables better visualization of anatomical details and microstructures at the root apex, providing conditions for more precise and minimally invasive procedures. Meta-analysis data have demonstrated that the success rate of microsurgery performed under high magnification is higher than that of conventional approaches [5]. These findings support the consideration of dental microscopes as a useful technology, particularly in complex clinical cases.

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6 *Enhancing Precision in Endodontic Procedures: An In vitro Investigation of Magnification and Enhanced Visualization.* 2024.

7 *Magnification: The game changer in dentistry.* 2025.

At the same time, the available literature does not consistently demonstrate the same degree of advantage associated with microscope use in all clinical situations. Although some studies have shown that magnification devices improve clinical accuracy, the final success of endodontic treatment depends on many other factors. The high cost of microscopes, specialized working conditions, ergonomic requirements, and the need for adequate operator training may limit their widespread use [7]. Therefore, dental microscopes should not be regarded as a "guarantee of treatment success," but rather as a tool that enhances appropriate clinical decision-making and technical skills.

Overall, dental microscopes are important technologies in modern endodontics that can improve precision in identifying complex root canal anatomy, performing endodontic retreatment, and conducting microsurgical procedures. However, their clinical effectiveness depends not only on the microscope itself but also on the conditions in which it is used, operator competence, and the overall endodontic treatment protocol. Therefore, future studies should evaluate treatment outcomes associated with microscope-assisted procedures through long-term follow-up and standardized clinical criteria.

Conclusion

The use of dental microscopes in endodontic treatment improves the visualization of the operative field, facilitating the identification of complex anatomical structures within the root canal system and enabling more precise clinical procedures. Their clinical significance is particularly high in the detection of additional canals, management of calcified canals, endodontic retreatment, and microsurgical procedures. Scientific evidence indicates that microscope-assisted endodontic procedures may improve treatment outcomes in certain clinical situations.

However, the effectiveness of dental microscopes depends not only on the device itself but also on operator experience, root canal anatomy, periapical status, and the endodontic treatment protocol used. The high cost of the equipment, the need for appropriate technical infrastructure, and the requirement for specialized skills are among its main practical limitations. Therefore, the use of dental microscopes should be selected according to the individual clinical situation.

Overall, dental microscopes are effective tools for improving treatment precision and clinical control in modern endodontics. Their integration with accurate diagnosis and standardized endodontic protocols can contribute to improved treatment quality, particularly in complex clinical cases.

References

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