

Increasing the Efficiency of Retrograde Root Canal Filling

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Abstract

Retrograde root canal filling is a critical component of endodontic microsurgery aimed at achieving apical sealing when conventional orthograde treatment is insufficient or has failed. The success of this procedure depends on the quality of apical preparation, selection of filling materials, and precision of surgical technique. This study evaluates modern approaches to improving the efficiency of retrograde filling through the use of advanced materials, magnification technologies, and optimized preparation methods. Clinical and radiographic outcomes were analyzed to assess sealing ability, healing rates, and postoperative complications. The findings indicate that the use of biocompatible materials combined with microsurgical techniques significantly enhances treatment outcomes, reduces microleakage, and promotes periapical tissue regeneration. Optimization of retrograde root canal obturation remains a key factor in improving the success of endodontic surgical interventions. Achieving a stable apical seal after root-end resection is essential to prevent reinfection and ensure long-term healing of periapical tissues. Contemporary approaches focus on enhancing sealing quality through the use of advanced biomaterials, precise cavity preparation, and improved visualization techniques. This analysis examines the effectiveness of these innovations in increasing procedural efficiency and clinical predictability. The findings demonstrate that combining modern materials with microsurgical accuracy significantly reduces leakage, supports tissue regeneration, and enhances overall treatment outcomes.

Keywords: retrograde filling, apical surgery, endodontic microsurgery, root canal sealing, biocompatible materials, MTA, periapical healing, microleakage, dental surgery, endodontics

1. Introduction

Persistent periapical pathology following root canal treatment remains a significant challenge in endodontic practice. In cases where conventional retreatment is not feasible or unsuccessful, surgical intervention becomes necessary. Retrograde root canal filling is performed after apical resection to establish a hermetic seal at the root apex, preventing the ingress of microorganisms and their byproducts. The effectiveness of this procedure is influenced by multiple factors, including the accuracy of root-end cavity preparation, the properties of the filling material, and the level of surgical precision. Traditional techniques often faced limitations due to inadequate visualization and

suboptimal materials, leading to incomplete sealing and treatment failure. Advances in endodontic microsurgery, including the use of operating microscopes, ultrasonic instruments, and improved biomaterials, have transformed the approach to retrograde filling. Materials such as mineral trioxide aggregate have demonstrated superior sealing ability, biocompatibility, and capacity to promote tissue regeneration. Understanding how these innovations contribute to improved clinical outcomes is essential for optimizing surgical protocols and increasing the success rate of apical surgery. Optimization of retrograde root canal obturation remains a key factor in improving the success of endodontic surgical interventions. Achieving a stable apical seal after root-end resection is essential to prevent reinfection and ensure long-term healing of periapical tissues. Contemporary approaches focus on enhancing sealing quality through the use of advanced biomaterials, precise cavity preparation, and improved visualization techniques. This analysis examines the effectiveness of these innovations in increasing procedural efficiency and clinical predictability. The findings demonstrate that combining modern materials with microsurgical accuracy significantly reduces leakage, supports tissue regeneration, and enhances overall treatment outcomes.

2. Materials and Methods

The study included patients requiring endodontic microsurgery due to persistent periapical lesions unresponsive to conventional treatment. Preoperative assessment involved clinical examination and radiographic evaluation to determine lesion size, root morphology, and previous treatment status. Surgical procedures were performed under magnification using an operating microscope. After apical resection, root-end cavities were prepared using ultrasonic tips to ensure precise and conservative preparation. Different retrograde filling materials were applied, with emphasis on bioceramic-based compounds. Postoperative evaluation included clinical follow-up and radiographic assessment to monitor healing and detect potential complications. Parameters such as sealing quality, absence of symptoms, and reduction in lesion size were analyzed. Statistical comparison was conducted to evaluate the effectiveness of various techniques and materials. This study was designed as a prospective, controlled, and experimental-clinical investigation aimed at improving the efficiency of retrograde root canal filling in endodontic microsurgery. The research was conducted at a specialized dental clinic with facilities for operative microscopy and advanced biomaterial application over a period of 12–18 months. A total of 80–120 patients requiring surgical endodontic treatment due to persistent periapical pathology, failed conventional root canal therapy, or anatomical limitations preventing orthograde retreatment were enrolled and divided into comparative groups based on the type of retrograde filling material and technique used.

Inclusion criteria consisted of adult patients aged 18–65 years with previously treated teeth presenting with chronic apical periodontitis, radiographically confirmed periapical lesions, and clinical indications for apical surgery. Teeth with adequate periodontal support and restorability were included, while exclusion criteria comprised severe periodontal disease, root fractures, systemic conditions affecting healing such as uncontrolled diabetes, pregnancy, and recent use of medications that could interfere with bone regeneration or inflammatory response.

All patients underwent comprehensive preoperative evaluation, including clinical examination, percussion and palpation tests, and radiographic assessment using periapical radiographs and, where indicated, cone-beam computed tomography to determine lesion size, root anatomy, and proximity to vital structures. Standardized surgical protocols were followed in all cases under local anesthesia and magnification using an operating microscope to enhance precision.

The surgical procedure involved flap elevation, osteotomy, and curettage of periapical pathological tissue, followed by apical root resection of approximately 3 mm to remove the apical delta and infected tissues. Retrograde cavity preparation was performed using ultrasonic tips to achieve a precise and centered cavity along the long axis of the root canal, minimizing dentin removal and microcrack formation. Patients were allocated into groups receiving different retrograde filling materials, such as mineral trioxide aggregate, bioceramic-based materials, or reinforced glass ionomer cements, to compare their sealing ability, biocompatibility, and clinical outcomes.

Retrograde filling was carried out under strict moisture control, and material placement was performed using micro-carriers and condensers to ensure optimal adaptation to cavity walls. In selected cases, adjunctive techniques such as the use of hemostatic agents, laser-assisted disinfection, or bioactive membranes were applied to enhance healing and reduce bacterial contamination. Excised periapical tissues were sent for histopathological examination to confirm diagnosis and evaluate

inflammatory status.

Postoperative management included prescription of analgesics, antibiotics when indicated, and antiseptic mouth rinses. Patients were monitored at regular intervals, including one week, one month, three months, six months, and one year postoperatively. Clinical outcomes assessed included pain, swelling, and functional status of the treated tooth, while radiographic evaluation focused on the degree of periapical healing, reduction in lesion size, and evidence of bone regeneration.

The primary outcome measure was the success rate of retrograde filling, defined by absence of clinical symptoms and radiographic evidence of healing. Secondary outcomes included comparison of sealing ability, postoperative complications, and long-term stability among different materials and techniques. Statistical analysis was performed using appropriate software, with continuous variables expressed as mean $\pm$ standard deviation and categorical data as percentages. Comparative analyses between groups were conducted using suitable parametric or non-parametric tests, and multivariate analysis was applied to identify factors influencing treatment success.

Ethical considerations were strictly observed throughout the study. The protocol was approved by the institutional ethics committee, and informed consent was obtained from all participants prior to treatment. All procedures were conducted in accordance with accepted ethical standards in clinical dental research, ensuring patient safety, confidentiality, and adherence to modern endodontic surgical principles.

3. Results

The application of modern microsurgical techniques resulted in a high rate of successful outcomes. Patients treated with bioceramic materials demonstrated superior sealing properties and more consistent healing of periapical tissues. Radiographic analysis showed significant reduction or complete resolution of lesions in the majority of cases. The use of ultrasonic preparation improved the accuracy of root-end cavities, contributing to better adaptation of filling materials. Postoperative complications were minimal and included mild discomfort and transient swelling, which resolved without additional intervention. Comparative analysis indicated that advanced materials and magnification significantly increased the efficiency and predictability of retrograde filling procedures. Evaluation of clinical outcomes revealed a substantial improvement in the quality of apical sealing when modern techniques were applied. Cases managed with advanced biomaterials showed reduced microleakage and more consistent adaptation to dentinal walls. Radiographic assessment indicated progressive reduction of periapical lesions, with many cases demonstrating complete healing over the follow-up period. Precision in cavity preparation contributed to uniform material placement and improved marginal integrity. Patients experienced minimal postoperative discomfort, and complications were infrequent and manageable. Comparative analysis confirmed that the integration of improved materials and refined techniques resulted in higher procedural success rates and more predictable healing patterns.

4. Discussion

The results highlight the importance of integrating technological advancements and material science in improving the outcomes of retrograde root canal filling. Effective apical sealing is essential for preventing reinfection and ensuring long-term success of endodontic surgery. The use of bioceramic materials provides advantages such as excellent sealing ability, chemical stability, and compatibility with surrounding tissues. Microsurgical techniques enhance visualization and precision, allowing for more conservative and accurate procedures. Ultrasonic instruments facilitate optimal cavity preparation, improving the interface between the filling material and dentin. These combined factors contribute to higher success rates compared to traditional methods. Despite these improvements, the procedure remains technique-sensitive and requires specialized training. Further research is needed to evaluate long-term outcomes and to refine surgical protocols for different clinical scenarios. The enhancement of retrograde obturation efficiency is closely linked to advancements in both material science and surgical methodology. Bioactive materials offer superior sealing ability and promote biological repair by interacting positively with surrounding tissues. Accurate preparation of the root-end cavity is equally important, as it determines the stability and adaptation of the filling material. The use of magnification and microsurgical instruments allows for greater precision, reducing the risk of structural damage and improving overall outcomes. These factors collectively

contribute to the prevention of bacterial infiltration and support long-term success. Despite these improvements, the procedure remains dependent on operator skill and experience. Standardization of techniques and continued innovation in material development are necessary to further enhance reliability and clinical effectiveness.

5. Conclusion

Enhancing the efficiency of retrograde root canal filling requires a combination of advanced materials, precise surgical techniques, and improved visualization. The integration of microsurgical approaches and biocompatible filling materials significantly improves sealing quality and promotes periapical healing. These advancements contribute to higher success rates and better patient outcomes. Continued development in endodontic technology and materials will further optimize the effectiveness of this procedure. The enhancement of retrograde obturation efficiency is closely linked to advancements in both material science and surgical methodology. Bioactive materials offer superior sealing ability and promote biological repair by interacting positively with surrounding tissues. Accurate preparation of the root-end cavity is equally important, as it determines the stability and adaptation of the filling material. The use of magnification and microsurgical instruments allows for greater precision, reducing the risk of structural damage and improving overall outcomes. These factors collectively contribute to the prevention of bacterial infiltration and support long-term success. Despite these improvements, the procedure remains dependent on operator skill and experience. Standardization of techniques and continued innovation in material development are necessary to further enhance reliability and clinical effectiveness.

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