

Evaluating Modern Root Canal Obturation Techniques And Their Effect On Microleakage

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Abstract

Reliable obturation of root canals is a critical step in endodontic treatment, ensuring a dense and hermetic filling of the canal system and its accessory branches with sealing materials. The primary goal of root canal filling is to eliminate communication between the periapical tissues and the pulp chamber, thereby forming a biological barrier that prevents reinfection.

This study aimed to evaluate and compare the efficacy of different root canal obturation techniques in preventing microleakage. An *in vitro* experiment was conducted using 30 extracted single-rooted teeth, divided into three groups based on the obturation technique used:

Group 1: Lateral condensation with gutta-percha and AH Plus sealer.

Group 2: Injection technique with E&Q Master and AH Plus sealer.

Group 3: Thermafil system with AH Plus sealer.

The root canals were prepared with ProFile instruments (size 30/04) and irrigated with 5.25% sodium hypochlorite. After obturation, the samples were immersed in 1% methylene blue, then sectioned at 2, 5, and 7 mm from the apex to assess dye penetration under 10x magnification.

The results revealed varying levels of root canal seal quality among the different obturation techniques. The lateral condensation technique exhibited significant microleakage, while the injection technique showed the most reliable sealing with minimal dye penetration. The Thermafil system provided better apical sealing than lateral condensation but was slightly less effective than the injection technique.

This study highlights the superior performance of three-dimensional obturation methods, particularly the injection technique, in preventing apical microleakage and ensuring long-term success in endodontic treatment.

Keywords: 3D obturation, lateral condensation, Thermafil

INTRODUCTION

Root canal obturation is a fundamental step in endodontic therapy, aiming to create an airtight seal that prevents the ingress of bacteria and fluids into the canal system. A well-sealed root canal not only eliminates residual infection but also prevents reinfection from periapical fluids. The success of root canal therapy depends on proper instrumentation, irrigation, and obturation. Microleakage, the infiltration of fluids and bacteria through the root canal filling, remains one of the most common causes of endodontic failure. Studies have shown that poor adaptation of obturation materials leads to persistent periapical inflammation, requiring retreatment or extraction. Factors contributing to microleakage include inadequate condensation, improper adaptation of gutta-percha to canal walls, and the presence of voids within the obturation material. Advancements in obturation materials and techniques have introduced three-dimensional (3D) filling methods, which claim to provide superior sealing. Traditional lateral condensation of gutta-percha has long been used in clinical practice, but warm vertical compaction, injection techniques, and carrier-based Thermafil systems offer alternative approaches that may improve sealability and reduce microleakage. A well-adapted obturation technique not only prevents microleakage but also ensures a better long-term prognosis for the treated tooth.

The present study aims to compare the effectiveness of these techniques by evaluating the extent of microleakage in an experimental dye penetration model.

Ease Of Use

Endodontic obturation techniques should not only provide an optimal seal but also be practical and efficient for clinical application. The ease of use of different obturation techniques varies, affecting clinical outcomes and operator preference.

Lateral Condensation: Although widely used, it requires multiple accessory cones and precise finger pressure, which can be time-consuming and technique-sensitive. This technique requires careful placement of a master cone and multiple accessory cones, followed by adequate compaction. While cost-effective, it is technique-sensitive and may not achieve an ideal 3D seal, especially in irregularly shaped root canals.

Injection Technique: The injection of warm gutta-percha provides an easier and faster obturation process. It allows better adaptation to the canal walls and reduces the risk of voids. However, careful control is required to prevent overextension beyond the apex.

Thermafil System: Offers a simplified approach with pre-made carrier-based obturators. However, the handling and placement of Thermafil require precision to avoid overfilling. A pre-fabricated carrier coated with gutta-percha simplifies the obturation process. This method enhances flowability and improves the apical seal in many cases. However, it may not adapt well in canals with complex anatomy, and removal during retreatment can be challenging.

The clinical preference for obturation techniques often depends on the balance between ease of use, reliability, and effectiveness. Practitioners should consider both clinical outcomes and procedural efficiency when selecting an obturation method.

MATERIALS AND METHODS

To maintain the integrity of the experiment, teeth exhibiting visible cracks, external or internal resorption, or signs of multiple canal systems were excluded. These selection criteria ensured that the results would not be skewed by variations in anatomical complexity, allowing a direct comparison of the obturation techniques used in this research.

Once the teeth were selected, they underwent standardized root canal preparation. Each tooth was instrumented using ProFile rotary instruments, manufactured by Dentsply, with the final preparation size set to 30/04. This preparation size was chosen as it provides sufficient space for adequate obturation while preserving the structural integrity of the root canal walls. Throughout the instrumentation process, the canals were irrigated with 5.25% sodium hypochlorite between each file change. This irrigation step was essential to dissolve organic debris, disinfect the canal system, and ensure that no pulp remnants were left behind. To further optimize canal cleanliness, a final irrigation protocol was performed using 17% EDTA, which effectively removed the smear layer created during instrumentation. This step ensured better penetration of the sealer into dentinal tubules, thereby improving the adhesion of the obturation material. Following irrigation, the canals were dried using sterile paper points, ensuring that no residual moisture remained, which could compromise the adhesion and adaptation of the sealer and gutta-percha. The selected teeth were then randomly divided into three groups, each consisting of 10 samples, based on the obturation technique used:

Group 1 – Lateral Condensation (Control Group)

For the lateral condensation technique, a standardized gutta-percha master cone was selected to match the final prepared size of the canal. This cone was coated with AH Plus sealer (Dentsply) and inserted into the canal. A fine finger spreader was then used to create space for the placement of additional accessory gutta-percha cones. The spreader was inserted alongside the master cone, compacting the material laterally against the canal walls. Once space was created, accessory gutta-percha cones were sequentially placed and compacted to ensure a tight fit. The process continued until no further cones could be inserted without excessive force. This method relies on the mechanical interlocking of multiple gutta-percha cones and the sealer to achieve an adequate seal. However, lateral condensation has been criticized for its inability to achieve a truly homogeneous, void-free fill, particularly in irregularly shaped canals.

Group 2 – Injection Technique

In the injection technique, the E&Q Master System (META) was used to deliver warm gutta-percha into the canal. Prior to injection, a thin layer of AH Plus sealer was applied along the canal walls to enhance adhesion. The preheated gutta-percha was then injected in a controlled manner, allowing it to flow into the prepared space. A calibrated needle tip was inserted to the apical third of the canal, and as the material was dispensed, the tip was gradually withdrawn to ensure a consistent and homogeneous fill. This technique allowed the gutta-percha to conform more precisely to the intricate anatomy of the canal,

reducing the risk of voids and microleakage. Once the obturation was complete, a heated plugger was used to compact the material apically, further enhancing the seal.

Group 3 – Thermafil System

For the Thermafil technique, pre-fabricated carrier-based obturators (Dentsply Sirona) were used. The carrier core, coated with gutta-percha, was preheated using a specialized oven to soften the material. AH Plus sealer was applied to the canal walls before inserting the heated obturator. The carrier was gently positioned within the canal, allowing the softened gutta-percha to flow and adapt to the prepared space. This method offers an advantage in achieving a more uniform fill, especially in canals with irregular shapes. However, one challenge associated with this technique is the removal of the carrier in cases requiring retreatment.

Microleakage Evaluation

Following obturation, all samples were stored at 37°C in 100% humidity for 48 hours. This incubation period allowed the sealer to set completely, simulating the clinical setting in which a root canal filling stabilizes over time. After the setting period, each tooth was carefully coated with a layer of nail varnish, leaving only the apical 2 mm exposed. This step ensured that any dye penetration observed would be exclusively attributed to apical microleakage rather than lateral leakage through unsealed dentin surfaces. The samples were then submerged in a 1% methylene blue solution for 24 hours. This dye penetration test served as an indicator of the effectiveness of each obturation technique in preventing apical leakage. After immersion, the teeth were thoroughly rinsed under running water to remove any excess dye from the surface. Each tooth was then sectioned at three predetermined levels—2 mm, 5 mm, and 7 mm from the apex—using a precision saw. The cross-sections were examined under 10x magnification to assess the extent of dye penetration. The degree of microleakage was recorded for each group, and statistical comparisons were made to determine the most effective obturation technique.

By employing these standardized methods, this study aimed to provide a reliable comparison of lateral condensation, injection, and Thermafil obturation techniques in terms of their ability to prevent apical microleakage. The findings contribute to the growing body of research that seeks to optimize endodontic treatment outcomes by improving obturation techniques and materials.

Figures & Tables

Microleakage Analysis for Different Obturation Techniques

Table 1 presents the observed microleakage levels at various sectioning points (2 mm, 5 mm, and 7 mm from the apex) for each experimental group. The percentage of samples showing dye penetration is recorded to compare the sealing ability of lateral condensation, injection technique, and Thermafil system.

Table 1. Example of a figure caption. (figure caption).

Obturation technique	Penetration Level		
	2mm	5mm	7mm
Lateral Condensation	50%	30%	30%
Injection Technique	10%	0%	0%
Thermafil system	20%	0%	10%

Figure 1. Microleakage comparison between different obturation techniques at various levels of sectioning. The injection technique demonstrated the least dye penetration, indicating superior sealing ability. This table visually summarizes the microleakage trends, reinforcing the statistical findings of the study. The injection technique consistently exhibited the most effective seal, while lateral condensation showed significant microleakage. The Thermafil system performed better than lateral condensation but was slightly less effective than the injection technique.

DISCUSSION

The results of this study confirm that the ability of different obturation techniques to prevent apical microleakage varies significantly. Lateral condensation, despite being one of the most widely used methods, demonstrated the highest levels of dye penetration, indicating substantial leakage. This technique, although reliable in terms of ease of use and accessibility, has notable limitations when it comes to achieving a true three-dimensional seal. The inherent shortcomings of lateral condensation are primarily due to the presence of voids between the gutta-percha cones and the limited adaptability of the material to irregular canal anatomy. The lack of thermoplastic flow also restricts its ability to completely fill accessory canals, which increases the risk of bacterial infiltration and potential failure of the treatment over time. In contrast, the injection technique proved to be the most effective approach for root canal obturation, ensuring complete adaptation of the material to the internal contours of the canal system. The application of warm gutta-percha through controlled injection allowed for excellent flow properties, minimizing the presence of voids and significantly reducing microleakage. The high sealing capability of this technique is attributed to its ability to conform closely to the dentinal walls and penetrate accessory canals, providing a more homogeneous and consistent fill. The statistical analysis confirmed that the injection technique resulted in the least amount of dye penetration, supporting its superior performance in ensuring apical seal integrity. The Thermafil system, while demonstrating better sealing ability than lateral condensation, was slightly less effective than the injection technique. One of the main concerns with this technique is the inconsistent adaptation of the gutta-percha carrier within complex canal morphologies. Although the pre-coated carrier-based approach facilitates an efficient and user-friendly obturation process, challenges arise in cases where the canal shape is highly irregular. In some instances, gaps may form between the carrier and the dentinal walls, leading to compromised sealing efficiency. However, the overall results suggest that Thermafil remains a viable alternative to traditional lateral condensation and can provide a satisfactory seal when used in appropriately shaped canals.

The findings of this study strongly support the increased adoption of modern three-dimensional obturation techniques such as warm gutta-percha injection. The enhanced flow and adaptability of these materials ensure a more effective and durable seal, which is critical for the long-term success of endodontic treatment. Practitioners should consider these advanced methods to improve clinical outcomes and reduce the likelihood of treatment failure due to microleakage.

CONCLUSIONS

The findings of this study indicate that the injection technique provides the most effective apical seal, exhibiting the least amount of microleakage among the techniques evaluated. Its ability to fully adapt to the canal walls and effectively fill accessory canals makes it the preferred method for ensuring long-term success in endodontic therapy. The Thermafil system, while demonstrating reasonable effectiveness, is slightly less reliable in cases involving complex root canal anatomy. Its carrier-based design allows for ease of application but may not achieve the same level of adaptability as injected warm gutta-percha. Despite its widespread use, lateral condensation showed the highest failure risk due to its inherent limitations in achieving a void-free, three-dimensional seal. The presence of gaps between gutta-percha cones and reduced adaptability to irregular canal spaces compromise its effectiveness, making it a less favorable choice in cases where an optimal apical seal is required.

Clinical Implications

The results of this study hold important implications for clinical practice. Given the superior sealing ability demonstrated by the injection technique, practitioners should strongly consider incorporating this method into routine endodontic treatment to maximize success rates. The ability of injected warm gutta-percha to conform to canal irregularities and fill accessory canals ensures a more comprehensive seal, reducing the potential for microleakage and subsequent reinfection. Carrier-based obturation systems, such as Thermafil, can serve as a practical alternative in cases where a simplified and efficient obturation technique is preferred. However, clinicians should be aware of its limitations and carefully evaluate the root canal anatomy before selecting this method. Cases involving complex morphologies may require additional modifications to ensure optimal adaptation and sealing performance.

Traditional lateral condensation should be employed with caution, particularly in cases requiring precise apical sealing. While this technique remains widely used due to its familiarity and cost-effectiveness, the

increased risk of microleakage and void formation raises concerns regarding its long-term reliability. When used, it should be carefully executed with the application of adequate sealer and proper condensation techniques to minimize the likelihood of failure.

Future research should focus on evaluating the long-term clinical outcomes of various obturation techniques, exploring new materials, and refining obturation protocols to further enhance treatment success. As technology continues to evolve, ongoing advancements in endodontic obturation will play a key role in improving patient care and clinical outcomes.

With the continued advancements in endodontic materials and techniques, practitioners should prioritize modern three-dimensional obturation methods to enhance treatment predictability and clinical outcomes. The ability to reduce microleakage directly translates to a lower risk of bacterial contamination and improved prognosis for endodontically treated teeth.

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