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Influence of Obturation Technique on Postoperative Pain and Healing Outcomes

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Abstract

Obturation is an important part of root canal treatment, which is concerned with securing a three-dimensional seal to avoid reinfection and facilitate periapical healing. The effect of obturation technique on the postoperative pain and the long-term healing effects have been a long-standing issue because depending on the technique used may influence not only the comfort of the patients in the short-term but also the outcome of the treatment in the long-term. Although cold lateral condensation is dependable and commonly applied, it can possibly relate with more voids and greater discomfort in the postoperative stage because of its mechanical forces. In vertical compaction, warm vertical compaction offers the best adaptation to canal walls, and has risks of overextension and possible periapical irritation. Obturation systems that are carried out with carriers are efficient and homogeneously filled, but prone to sealer extrusion. The single-cone method in which bioceramic sealers are used has been more recently considered due to its simplicity, bioactivity and good prognosis. It has been argued that apical extrusion of materials, preoperative status, and postoperative pain are significant predictors of postoperative pain, and obturation quality and biological compatibility of sealers are related to long-term healing. The balance between the technical efficiency, patient comfort, and biological properties of materials should, therefore, be maintained in clinical decision-making. The further developments of bioceramic systems and outcome assessment tools can optimize obturation strategies to give better patient-centered outcomes.

Keywords: Obturation techniques, postoperative pain, periapical healing, root canal therapy, bioceramic sealers.

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1. Introduction

Endodontic therapy is a basic form of treatment that is used to help eradicate intraradicular infection, ward off reinfection, and reinstate periapical well-being. Effective three-dimensional obturation of the prepared canal system is also the key to the success of the root canal treatment besides the comprehensive approach to chemomechanical debridging. Obturation is a natural and mechanical obstacle, it avoids the penetration of microorganisms and closes the possible gaps where leftover bacteria may flourish. Of the plethora of the steps in the processes, the obturation phase has been carefully associated with immediate postoperative reaction and long-term healing results.

Pain after root canal treatment is one of the major concerns as it is noticed to impact on the quality of life and this is usually deemed to be a kind of success of the treatment in the eyes of the patient. This pain is caused by various factors such as preoperative conditions, periapical inflammation, methods of instrumentation, apical extrusion of debris or filling materials. Material adaptation, apical sealing and risk of extrusion through the obturation technique has a significant role in the development of the postoperative pain experience.

Moreover, the quality of obturation has been long related to the healing of the periapical and the survival of teeth in the long term. Proper obturation and low amounts of voids and proper seal increase periapical repair, but poorly prepared fillings or over-extensions may negatively affect healing and lead to chronic apical periodontitis. Obturation methods including cold lateral condensation, warm vertical compaction, carrier-based systems and single-cone methods using advanced bioceramic sealers have distinct benefits and drawbacks, in this respect. Considering these facts, it is important to know how the obturation technique affects postoperative pain and healing outcomes in order to make evidence-based clinical decisions. This is a review of the biological justification, clinical, and comparison of different obturation strategies with regards to the maximization of patient comfort and long-term treatment success.

2. Biological and Clinical Rationale

The biological basis for obturation lies in the objective of eliminating microorganisms from the root canal system and preventing their re-entry. Following chemomechanical preparation, obturation aims to entomb residual microorganisms, seal lateral and accessory canals, and create

a stable barrier that facilitates periapical healing. Failure to achieve an effective seal may allow leakage of irritants and microorganisms into periapical tissues, perpetuating inflammation and compromising treatment outcomes.

Postoperative pain, one of the most common patient concerns, is largely mediated by the host inflammatory response to procedural irritants. Apical extrusion of filling materials, sealers, or debris can trigger periapical inflammation, resulting in nociceptor activation and transient discomfort. Techniques that generate excessive apical pressure, such as forceful compaction during cold lateral condensation or uncontrolled thermoplasticized delivery, may increase this risk. Conversely, bioceramic-based sealers and single-cone obturation techniques may reduce postoperative pain due to their bioactivity, chemical stability, and minimal extrusion tendency.

From a clinical perspective, healing outcomes are influenced by both the quality of obturation and the biological compatibility of the materials used. Well-adapted and homogeneous fillings prevent microleakage and create favorable conditions for tissue repair. Moreover, obturation materials that stimulate hard tissue deposition or exert antibacterial effects may enhance periapical healing. Thus, the selection of obturation technique is not solely a technical preference but a biologically driven decision that directly impacts patient comfort and long-term treatment success.

3. Overview of Obturation Techniques

Obturation is the final phase of root canal therapy that aims to entomb residual microorganisms, prevent reinfection, and facilitate periapical healing. Various techniques have been developed to optimize three-dimensional filling of the root canal system. The main approaches include cold lateral condensation, warm vertical compaction, carrier-based obturation, and the single-cone technique with advanced sealers. Each technique differs in its procedural steps, material requirements, and impact on clinical outcomes.

3.1 Cold Lateral Condensation

Cold lateral condensation remains one of the most widely practiced obturation techniques due to its simplicity, predictability, and low cost. It involves placing a master gutta-percha cone to

working length, followed by accessory cones compacted laterally with a spreader. Although effective in achieving length control, it is often associated with voids, poor adaptation in oval or irregular canals, and increased postoperative discomfort due to excessive compaction forces.

3.2 Warm Vertical Compaction

Warm vertical compaction uses heat to soften gutta-percha, allowing it to flow and adapt closely to canal irregularities. It offers superior sealing and homogeneity compared with lateral condensation. However, the technique is more time-consuming, requires specialized equipment, and carries a risk of overfilling or extrusion of sealer into periapical tissues, which may trigger postoperative pain.

3.3 Carrier-Based Systems

Carrier-based obturation employs a plastic or metal core coated with thermoplasticized gutta-percha, which is inserted into the prepared canal. These systems provide efficient canal filling with relatively uniform obturation and are less technique-sensitive than warm vertical compaction. However, limitations include potential extrusion, difficulty in retreatment, and dependence on precise canal preparation.

3.4 Single-Cone Technique with Bioceramic Sealers

The single-cone technique has been revitalized by the introduction of bioceramic-based sealers, which exhibit excellent flow, dimensional stability, and bioactivity. This approach reduces procedural time, minimizes compaction stress, and may lower postoperative pain incidence. Furthermore, the bioactive properties of bioceramic sealers promote periapical healing through calcium ion release and hydroxyapatite formation. The main challenges remain sealer dependency and the need for high-quality canal shaping to ensure proper adaptation.

3.5 Comparative Considerations

While each technique offers unique advantages, their influence on clinical outcomes varies. Lateral condensation ensures length control but risks voids; warm vertical compaction achieves superior adaptation but may increase postoperative pain through extrusion; carrier-based systems

provide efficiency but complicate retreatment; and the single-cone technique with bioceramic sealers balances simplicity with biological advantages. Ultimately, technique selection should be based on canal morphology, operator experience, material properties, and patient-related factors.

Table 1. Comparative Overview of Major Obturation Techniques

Obturation Technique	Key Advantages	Limitations	Clinical Impact on Postoperative Pain	Clinical Impact on Healing Outcomes
Cold Lateral Condensation	Simple and inexpensive - Reliable length control - Widely taught and practiced	- Risk of voids and poor adaptation in irregular canals - Time consuming - Potential compaction stress on dentin	May cause increased postoperative discomfort due to lateral forces	Adequate healing if apical seal is intact, though less effective in complex anatomy
Warm Vertical Compaction	- Superior adaptation to canal irregularities - Dense, homogenous fill - Proven long-term sealing ability	- Technique-sensitive - Time-intensive - Risk of overfilling or sealer extrusion	Possible increase in pain from extrusion of heated gutta-percha or sealer	Generally favorable healing outcomes due to enhanced seal, provided extrusion is minimized

Carrier-Based Systems	- Efficient and fast - Uniform obturation - Less technique-sensitive than vertical compaction	- Retreatment can be difficult - Possible core separation - Risk of extrusion	Pain incidence varies; may increase if material is extruded apically	Satisfactory healing outcomes, but success depends on precise canal preparation
Single-Cone with Bioceramic Sealers	- Simple and efficient - Minimal compaction stress - Bioactive properties promote healing - Good dimensional stability	- Heavily sealer-dependent - Requires optimal canal shaping - Limited long-term evidence compared with traditional methods	Often associated with reduced postoperative pain due to minimal compaction and bioactivity	Promotes favorable periapical healing through ion release and hydroxyapatite formation

4. Influence on Postoperative Pain

Postoperative pain following root canal treatment is a multifactorial phenomenon influenced by preoperative status, canal preparation, irrigation, and obturation. Among these, obturation technique plays a pivotal role, primarily through its effect on apical extrusion of debris and sealer, mechanical stress within the canal, and interaction of materials with periapical tissues.

Pain is usually reported within the first 24–72 hours post-treatment and tends to decrease progressively.

4.1 Biological Mechanisms of Pain

- **Apical Extrusion of Materials:** Sealer and gutta-percha beyond the apical foramen can irritate periapical tissues, initiating an inflammatory response.
- **Pressure and Mechanical Stress:** Lateral or vertical compaction forces may generate internal pressure, contributing to postoperative discomfort.
- **Biological Interaction of Sealers:** Some sealers induce cytotoxic effects initially, whereas newer bioceramic formulations promote biocompatibility and reduce irritation.

4.2 Pain Profiles Across Techniques

- **Cold Lateral Condensation:** Associated with moderate pain incidence due to lateral forces and risk of apical extrusion of sealer when accessory cones are forced apically.
- **Warm Vertical Compaction:** May lead to increased discomfort compared to cold lateral condensation if thermoplasticized gutta-percha or sealer is extruded, although superior adaptation generally limits persistent pain.
- **Carrier-Based Systems:** Pain occurrence is variable; efficiency of obturation reduces procedural time, but risk of material extrusion may elevate discomfort in certain cases.
- **Single-Cone with Bioceramic Sealers:** Frequently associated with lower pain incidence, attributed to minimal compaction stress and the anti-inflammatory, bioactive properties of bioceramic sealers.

4.3 Evidence from Clinical Studies

Systematic reviews and randomized clinical trials have shown no absolute consensus, though trends indicate that single-cone obturation with bioceramic sealers results in less immediate postoperative pain compared with traditional condensation methods. Warm vertical compaction and carrier-based systems may be linked with higher short-term pain in some studies, especially in teeth with preoperative periapical pathology. Importantly, preoperative pain remains a stronger predictor of postoperative discomfort than the obturation technique alone.

4.4 Clinical Implications

The choice of obturation technique should consider patient comfort alongside technical and biological factors. For patients with heightened preoperative pain or symptomatic apical periodontitis, minimally invasive approaches such as single-cone with bioceramics may offer advantages in reducing postoperative discomfort. Conversely, techniques requiring greater compaction or thermal manipulation should be performed with careful control to minimize apical extrusion.

5. Influence on Healing Outcomes

The long-term success of root canal therapy is fundamentally linked to periapical healing, which is determined by effective disinfection, apical sealing, and host immune response. Obturation techniques, by influencing the quality of canal filling and interaction of materials with periapical tissues, contribute significantly to healing outcomes.

5.1 Radiographic and Clinical Healing Indicators

Healing is typically assessed through reduction or resolution of periapical radiolucency, absence of clinical symptoms, and restoration of periodontal ligament space. Modern cone-beam computed tomography (CBCT) has enhanced detection of periapical changes, offering greater sensitivity than conventional radiographs.

5.2 Outcomes with Specific Techniques

- **Cold Lateral Condensation:** Provides predictable apical length control but may result in voids or incomplete adaptation, potentially delaying resolution of periapical lesions in complex canal anatomy.
- **Warm Vertical Compaction:** Demonstrates high success rates in long-term healing studies due to dense, homogeneous fills and improved adaptation to canal irregularities. Overfilling, however, may compromise outcomes if sealer or gutta-percha extrudes into periapical tissues.

- **Carrier-Based Systems:** Achieve uniform obturation and are clinically efficient. Healing outcomes are generally favorable, though extrusion-related complications and retreatment challenges may impact long-term prognosis.
- **Single-Cone with Bioceramic Sealers:** Increasing evidence supports enhanced periapical healing due to the bioactivity of sealers, which stimulate mineralization, promote hydroxyapatite deposition, and exhibit antibacterial effects. This technique may offer particular benefits in cases with pre-existing apical pathology.

5.3 Factors Modifying Healing

Healing is not solely determined by obturation. Critical modifiers include:

- Preoperative condition (vital vs. necrotic pulp, presence of periapical lesions).
- Quality of chemomechanical preparation and coronal restoration.
- Biological properties of the sealer (biocompatibility, bioactivity, dimensional stability).
- Patient-related factors (systemic health, immune status).

5.4 Clinical Implications

While obturation technique influences the homogeneity and biological impact of the filling, overall healing success depends on a combination of technical and biological parameters. Bioceramic sealers paired with simplified single-cone techniques appear promising in optimizing both patient comfort and long-term periapical healing, though further long-term studies are needed to establish equivalence or superiority over traditional methods.

Table 2. Comparative Impact of Obturation Techniques on Postoperative Pain and Healing Outcomes

Technique	Postoperative Pain Profile	Healing Outcomes	Key Considerations

Cold Lateral Condensation	Moderate pain risk due to lateral compaction forces and possible apical extrusion	Adequate healing if apical seal is intact, but voids may delay resolution in irregular canals	Cost-effective and reliable, but less suitable for complex anatomies
Warm Vertical Compaction	Possible increased pain if extrusion occurs; otherwise well tolerated	High healing success rates due to dense, homogenous fill and superior adaptation	Technique-sensitive; requires specialized equipment and operator skill
Carrier-Based Systems	Pain incidence variable; higher if material extrudes	Generally favorable healing, but extrusion and retreatment challenges may compromise outcomes	Efficient and less technique-sensitive; retreatment is difficult
Single-Cone with Bioceramic Sealers	Frequently associated with reduced postoperative pain due to minimal compaction and bioactivity	Promotes enhanced healing through hydroxyapatite formation and antibacterial effects	Simple, efficient, and biologically advantageous; sealer-dependent

6. Clinical Considerations

The choice of obturation technique extends beyond technical preference, as it must align with patient-specific, biological, and procedural factors that influence both short- and long-term outcomes. Understanding these considerations allows clinicians to balance efficiency, comfort, and healing potential in endodontic practice.

6.1 Patient-Related Factors

- **Preoperative Pain and Pulpal Status:** Patients presenting with symptomatic irreversible pulpitis or acute apical periodontitis are more prone to postoperative discomfort, regardless of the obturation technique. In such cases, techniques that minimize apical extrusion such as single-cone with bioceramic sealers may reduce pain incidence.
- **Systemic Health:** Compromised immune status, diabetes, or other systemic conditions may delay periapical healing. Techniques using bioactive sealers may enhance healing by promoting tissue regeneration.
- **Patient Comfort and Expectations:** Faster, less invasive methods such as single-cone obturation may improve patient acceptance, particularly in anxious or time-constrained individuals.

6.2 Operator-Related Factors

- **Technical Proficiency:** Cold lateral condensation is widely taught and reliable, but requires meticulous spreader placement to avoid excessive stress. Warm vertical compaction and carrier-based systems demand additional training and specialized equipment, increasing technique sensitivity.
- **Retreatment Considerations:** Techniques involving carrier-based systems can complicate retreatment due to difficulty in removing cores, whereas single-cone and lateral condensation are more retreatment-friendly.

6.3 Material Considerations

- **Sealer Biocompatibility:** Traditional resin-based sealers may induce cytotoxic effects, whereas newer bioceramic sealers exhibit bioactivity and reduced inflammatory potential.
- **Extrusion Risk:** Techniques involving thermoplasticized materials (warm vertical, carrier-based) carry higher risk of extrusion, which may elevate postoperative pain and impair healing.

6.4 Practical Decision-Making

No single obturation technique is universally superior; clinical decision-making should be individualized. For straightforward canals, cold lateral condensation or single-cone techniques may be effective. Complex anatomies benefit from warm vertical compaction, while efficiency-driven settings may favor carrier-based systems. Ultimately, the balance between minimizing patient discomfort and maximizing periapical healing should guide technique selection.

7. Future Perspectives

The evolution of obturation techniques reflects a broader trend toward biologically driven endodontic therapies. While current methods provide satisfactory outcomes, several areas warrant advancement to enhance patient-centered care and long-term success.

7.1 Advancements in Bioceramic Technologies

Bioceramic sealers have shifted the paradigm of obturation by introducing bioactivity, dimensional stability, and favorable sealing ability. Future developments are expected to focus on sealers with enhanced antimicrobial activity, faster setting times, and improved retreatability. Research into functionalized sealers capable of releasing therapeutic ions or growth factors may further promote periapical tissue regeneration.

7.2 Integration of Imaging and Artificial Intelligence

High-resolution imaging, particularly cone-beam computed tomography (CBCT), enables more accurate assessment of periapical healing. Future integration with artificial intelligence (AI) could standardize outcome assessment, reduce observer variability, and allow predictive modeling of healing trajectories based on obturation technique and case complexity.

7.3 Patient-Centered Research on Postoperative Pain

While healing outcomes are often prioritized, minimizing postoperative pain remains critical to patient satisfaction. Future clinical trials should incorporate validated pain scales, standardized

reporting intervals, and stratification by preoperative status. Emphasis on patient-reported outcomes will help identify techniques that optimize both comfort and healing.

7.4 Toward Personalized Endodontics

The future of obturation is likely to embrace personalized approaches, tailoring technique and material selection to patient-specific variables such as systemic health, canal morphology, and preoperative pain profiles. This precision model aligns with broader trends in healthcare, aiming for outcomes that are both biologically predictable and individually optimized.

8. Conclusion

Obturation technique is important in determining the postoperative comfort, as well as the long-term outcome of the healing process on root canal therapy. Although cold lateral condensation and warm vertical compaction are still valid, new developments are inclined towards single-cone methods where bioceramic sealers are used due to less pain and improved healing. Systems that are carrier-based are efficient yet have issues of retreatment. Finally, the choice of techniques must be personalized, taking into account the characteristics of the patients, the skills of the operator and the characteristics of materials. Innovative treatments of bioactive sealers, imaging, and personalized care are likely to enhance the future obturation strategies to achieve the predictable and patient-based outcomes.

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