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Review Article

3D Fill: Mastering the modern techniques in endodontic obturation

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Abstract

Advancements in endodontics have introduced innovative obturation techniques that aim to improve the sealing ability, biocompatibility, and long-term success of root canal treatments. Traditional methods, such as lateral condensation, have been supplemented or replaced by contemporary approaches, including thermoplasticized gutta-percha, carrier-based systems, and bioceramic-based sealers. These newer techniques emphasize superior adaptability to canal morphology, reduced microleakage, and enhanced antimicrobial properties. This review highlights the principles, materials, and clinical outcomes associated with modern obturation techniques, emphasizing their role in achieving predictable and durable root canal therapy outcomes.

Keywords: 3D obturation, current concepts, Newer obturation techniques, Concept of monoblock.

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1. Introduction

The primary aim of root canal treatment is to achieve a comprehensive three-dimensional filling of the root canal system after it has been properly cleaned and shaped. The purpose of this filling, or obturation, is to seal the main root canal along with all potential entry and exit points, preventing future interaction between the endodontium and periodontium. Ensuring a complete seal is crucial to block microorganisms from accessing and infecting the periradicular tissues.[1]

The primary goal of endodontic science is to achieve a monoblock effect within the root canal. Various materials and techniques are available to obturate the root canal system to accomplish this. Gutta-percha, used in combination with root canal sealers, remains the gold standard for root canal fillings due to its biocompatibility, non-toxic and non-allergenic properties, and ease of removal when necessary.[2]

2. Discussion

2.1. Concept of monoblock in obturation

In endodontic obturation, the term "monoblock" refers to the goal of achieving a root filling material that bonds to the dentin, creating a uniform, cohesive mass within the root canal.

In a review by Tay and Pashley, monoblocks formed within root canal spaces were categorized as primary, secondary, or tertiary based on the number of interfaces between the bonding substrate and the core material.[4]

1. Primary: In this obturation is completely done with corematerial, for example, use of MTA for obturation in cases of apexfication
2. Secondary: In this bond is there between etched dentin ofcanal wall impregnated with resin tags which are attached to resin cement that is bonded to core layer, e.g. resilon based system.
3. Tertiary: In this conventional gutta-percha surface is coated with resin which bond with the sealer, which further bond tocanal walls, e.g. Endo Rez and Activ GP system.[3]

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The primary objective of obturation is to prevent the re-infection of root canals that have been cleaned, shaped, and disinfected through biomechanical preparation and irrigation. Effective obturation relies on materials and techniques that can densely fill the entire root canal system (RCS) and establish a fluid-tight seal from the apical end to the canal orifice, thereby preventing re-infection.[5]

The aim of three-dimensional obturation is to create an impermeable, fluid-tight seal throughout the entire root canal system (RCS), effectively preventing both oral and apical microleakage.[5]

Since Schilder introduced thermoplastic obturation techniques in 1967, various devices and systems using thermoplasticized gutta-percha as a root canal filling material have been developed. One such method is the sectional backfill technique, which uses a device to heat and inject thermoplasticized gutta-percha into the root canal. This technique offers improved adaptation to the canal walls compared to lateral condensation and achieves successful filling of simulated lateral canals. This review article gives insight about newer obturation techniques

2.2. Smart seal: Newer obturation system

The latest advancement in endodontic obturation materials involves the use of a hydrophilic polymer within the root canal, exemplified by the SmartSeal system (Prosmart - DRFP Ltd., Stamford, UK). This system includes obturation points (ProPoints) made of a polyamide core coated with a bonded hydrophilic polymer, along with a specialized sealer containing polymer powder that is incorporated during its preparation.[6]

ProPoints, commonly referred to as "C Points," are obturation points composed of two main components: the central core and the outer layer.

The central core is composed of a blend of two proprietary nylon polymers, Trogamid T and Trogamid CX. This design provides the obturation point with the necessary elasticity to navigate smoothly around curvatures in the biomechanically prepared canal, while maintaining sufficient rigidity to easily reach the full length of narrow canals.[7]

The outer polymer layer consists of a cross-linked copolymer of acrylonitrile and vinyl pyrrolidone, cross-linked with allyl-methacrylate and a thermal initiator. This hydrophilic layer, featuring a hydrogel coating, enables the points to swell and adapt to the complexities of the root canal system.[7]

It is available in following sizes:
6% taper - ISO tip sizes 25 to 45
4% taper - ISO tip sizes 25 to 45
ProTaper™ - F1, F2, F3, F4 & F5
Sendoline™ S5 - S2, S3, S4.

SmartPaste is a resin-based sealer containing an active polymer that expands to fill any gaps or voids within the root canal system. It is supplied in a syringe to ensure consistent and precise ratios of sealer components with each use, and mixing or dispensing trays are included to facilitate application.[7]

Smartpaste Bio: This resin-based sealer is designed to swell with the addition of ground polymer. According to the manufacturer, the inclusion of bioceramics provides exceptional dimensional stability, making the sealer non-resorbable within the root canal. During the setting reaction of the bio-paste, calcium hydroxide and hydroxyapatite are produced as byproducts, rendering the material antibacterial during setting and highly biocompatible once set.[8]

The sealant is present in a pre-mixed syringe and can be applied directly into the canal using an intra-canal tip which minimizes its wastage. The cement absorbs water from within the canal and once set smartpaste bio produces a radiopaque biocompatible cement.[8,9]

Farge *et al*. showed that lateral condensation technique results in more leakage than thermomechanical compaction technique.

In a study conducted by Arora and Shashank on comparing sealing abiliy of novel smartseal obturation system and other obturation techniques an invitro cbct study demonstrates that polyamide polymer occupies a larger area and exhibits greater linear extension within the root canal space compared to obturation techniques utilizing Gutta-percha.[6]

2.2.1. Advantages

1. The hydrophilic nature of the obturating points allows them to absorb surrounding moisture and expand, effectively filling voids and spaces within the root canal system.[7]
2. Has versatile nature, allows for the creation of points compatible with various file systems, enhancing its adaptability in clinical practice.[8]
3. The Smart Seal system's properties enable a simplified obturation process, potentially reducing chair time compared to traditional methods.[8]

2.2.2. Disadvantages

1. Limited Retreatment Options. The polymer-based material can be challenging to remove.[7]
2. Higher Cost
3. Technique Sensitive
4. Uncontrolled expansion in some cases may lead to overfilling or extrusion beyond the apex, potentially causing complications.[7]

2.3. Woodpecker obturation pen system

The Woodpecker Obturation Pen System is designed to heat the working tip, cut the gutta-percha point, and soften and pressurize the gutta-percha. It is utilized for warm vertical compaction during root canal treatment, allowing the softened gutta-percha to flow and thoroughly fill the entire root canal system

The Woodpecker Obturation Pen System is utilized during root canal treatments to achieve warm vertical compaction. By thermo softening and pressurizing the gutta-percha, it ensures thorough filling of the root canal system, including lateral canals and the apical region, thereby enhancing the quality and longevity of the obturation. The device is cordless and ergonomically designed, providing clinicians with comfortable handling and precise control during procedures. Its high-capacity battery supports up to 1,500 operations on a full charge, enhancing clinical efficiency. While these features are promising, there is limited availability of peer-reviewed in vitro studies specifically evaluating the performance and outcomes of the Woodpecker Obturation Pen System.

2.3.1. Advantages

1. Reaches operating temperature in approximately 0.2 seconds, allowing for efficient workflow.
2. Offers four preset temperatures (150°C, 180°C, 200°C, 230°C) for better adaptability to different obturation needs.
3. Provides ease of use, reducing hand fatigue during procedures.
4. Ensures proper softening and sealing of the root canal system.
5. Long Battery Life
6. Precision and Control

2.3.2. Disadvantages

1. There is a lack of extensive research evaluating its long-term performance and effectiveness.
2. Higher Cost
3. If not handled properly, excessive heat may damage periapical tissues.
4. Technique Sensitivity
5. Device Maintenance: Regular care is needed to ensure consistent performance

3. Calamus Dual 3D Obturation System

The Calamus Dual 3D Obturation System, developed by Dentsply Maillefer, integrates both "Pack" and "Flow" handpieces into a single, ergonomic unit designed to enhance the efficiency and effectiveness of root canal obturation procedures.

3.1. System components

1. Calamus Pack Handpiece: This serves as the heat source, used in conjunction with Electric Heat Pluggers (EHPs) of varying sizes, to thermosoften, remove, and condense gutta-percha during the downpacking phase of obturation. The appropriate EHP is selected based on the apical size, taper, and curvature of the prepared canal.[10]
2. Calamus Flow Handpiece: Utilized for the backfilling phase, it delivers thermoplasticized gutta-percha into the canal system. The system offers cartridges with integrated cannulas in 20 and 23 gauge sizes, allowing for precise delivery of the obturation material.[10]

3.1.1. Clinical application

The Calamus Dual 3D system is employed in warm vertical compaction techniques during root canal treatments. The Pack handpiece thermosoftens and compacts the gutta-percha to create a dense apical plug, while the Flow handpiece delivers additional material to fill the canal system completely. This method ensures that the softened gutta-percha flows into intricate canal anatomies, providing a hermetic seal that is crucial for the long-term success of endodontic therapy.

Studies conducted have demonstrated the effectiveness of the Calamus Dual 3D system in achieving high-quality obturation with minimal voids. For instance, a comparative evaluation found that the Calamus technique resulted in superior filling quality compared to lateral compaction and Thermafil techniques.[11]

The Calamus Dual 3D Obturation System offers a comprehensive solution for endodontic obturation, combining advanced technology with user-friendly features to enhance clinical outcomes in root canal treatments.

3.1.2. Advantages

1. Has efficient 3D Filling the system facilitates warm vertical compaction and backfill techniques, ensuring a well-adapted and dense root canal filling.[10]
2. It allows controlled extrusion of gutta-percha, improving adaptation to canal irregularities.[10]
3. The lightweight and user-friendly design reduces hand fatigue during procedures.
4. Fast Heating.[10]
5. The system provides stable and adjustable temperature settings for optimal gutta-percha flow.[10]
6. Reliable Seal.It helps achieve a hermetic seal, reducing the risk of microleakage and reinfection.[10]
7. Compatibility with Various Techniques.

3.1.3. Disadvantages

1. High Cost.
2. Proper training is required to master the system and achieve optimal results.

3. Potential Overfilling Risk. Excessive gutta-percha flow can lead to overextrusion beyond the apex if not controlled properly.[10]
4. Unlike cordless systems, the Calamus 3D requires a power connection, which may restrict mobility in clinical settings.[10]

3.2. Bee fill obturation system

The BeeFill 2in1 Obturation System, developed by VDW, is a comprehensive device designed for three-dimensional root canal obturation. It combines downpack and backfill capabilities, enabling efficient and reliable filling of the entire root canal system.

3.2.1. Clinical application

The BeeFill 2in1 is utilized for warm vertical condensation, achieving a homogeneous and dense filling of the root canal system, including oval canals, isthmi, ramifications, and lateral canals. This method ensures a reliable seal, which is crucial for the long-term success of endodontic treatment.[13]

A study comparing the sealing efficiency of the BeeFill 2in1 with other obturation techniques found that, after two weeks, the BeeFill group exhibited greater leakage compared to single-cone and cold lateral compaction methods. However, all test groups showed a significant decrease in fluid conductance over time, indicating improved sealing with prolonged use.[12]

The BeeFill 2in1 Obturation System offers a versatile and efficient solution for endodontic obturation, combining advanced technology with user-friendly features to enhance clinical outcomes in root canal treatments.[13]

3.2.2. Advantages

1. Efficient 3D Filling: The system facilitates dense, three-dimensional obturation, enhancing the seal of the root canal system.[16]
2. Combined Functionality: By integrating downpack and backfilling capabilities, the BeeFill 2in1 streamlines the obturation process, potentially reducing chairside time.[16]
3. Thermoplasticized Gutta-Percha Delivery: The device delivers warm gutta-percha, which can adapt better to canal irregularities, potentially improving the seal and reducing voids.[16]

3.2.3. Disadvantages

1. Technique Sensitivity: Proper training is required to effectively use the system and achieve optimal results.[12]
2. Risk of Overfilling: The use of thermoplasticized gutta-percha can lead to overfilling beyond the apex if not carefully controlled.[12]
3. Equipment Maintenance**:** Regular maintenance is necessary to ensure consistent performance and longevity of the device.[12]
4. Cost Considerations**:** The initial investment for the BeeFill 2in1 system may be higher compared to traditional obturation methods, which could be a factor for some dental practices.[16]

3.3. NeoSEALER® Flo obturation system

NeoSEALER® Flo is a state-of-the-art bioactive bioceramic sealer developed by Avalon Biomed. It is specifically designed to enhance the obturation process during root canal treatments by providing an effective seal that promotes healing and reduces bacterial contamination.[14]

3.4. Clinical Applications

1. Ideal for use in obturating complex canal systems, including those with lateral canals or isthmi.
2. Works well with the provided Flex Flo Tips™**,** allowing accurate application with minimal waste.
3. Effective for primary endodontic treatments and retreatment procedures.[14]

3.4.1. Advantages

1. Bioactivity
   a. The bioceramic formulation promotes the formation of hydroxyapatite, aiding in natural healing.
   b. The release of calcium and hydroxide ions supports bone and tissue regeneration.
2. Versatility
   a. Compatible with various obturation techniques, including:
      i. Warm Vertical Compaction
      ii. Single-Cone Techniques
   b. Offers flexibility for a wide range of clinical scenarios.
3. Resin-free composition
   a. Avoids the risks associated with resin-based sealers.
   b. Enhances bioactivity and biocompatibility.
4. Flowable consistency
   a. Provides easy and precise delivery into the root canal.
   b. Optimized flow ensures thorough adaptation to canal walls and irregularities.
5. Non-staining
   a. Maintains tooth aesthetics by preventing discoloration.
6. Dimensional stability
   a. Unlike some sealers, it remains stable over time, ensuring a lasting seal.
7. Antimicrobial properties
   a. Its high pH (alkaline) environment reduces residual bacteria, contributing to a sterile canal environment.
8. Retreatability
   a. Allows for effective retreatment, offering flexibility in cases requiring additional procedures.

3.4.2. Disadvantages

1. Technique Sensitivity: Achieving optimal results with NeoSEALER™ Flo requires precise technique and adequate training.
2. Retreatment Challenges: Removing bioceramic sealers during retreatment procedures can be more difficult compared to traditional sealers.
3. Cost Considerations: Bioceramic sealers like NeoSEALER™ Flo may be more expensive than conventional sealers, which could impact their widespread adoption

3.5. Clinical applications

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3.6. Elements™ IC obturation system

The Elements™ IC Obturation System by Kerr Endodontics is a cordless, comprehensive solution designed to enhance the efficiency and effectiveness of root canal obturation procedures. Combining a Downpack heat source with a Backfill extruder, it facilitates the Continuous Wave warm vertical condensation technique, ensuring precise and predictable results.[15]

3.6.1. Key features

1. Cordless Design: Offers unrestricted movement, enhancing ergonomics and ease of use during procedures.[15]
2. Downpack Handpiece: Provides rapid heating with precise digital temperature control, allowing for efficient compaction of gutta-percha in the apical portion of the canal.
3. Backfill Handpiece: Features motorized extrusion with built-in finger grips and effective aerogel insulation, protecting against heat while delivering gutta-percha into the canal.
4. Inductive Charging: Equipped with a longer-lasting battery and inductive charging, ensuring the system is always ready for use without the constraints of cords.
5. Ergonomic Design: Designed for comfort, reducing hand fatigue during extended procedures.[15]

3.6.2. Advantages

1. Efficient Workflow: The combination of Downpack and Backfill devices streamlines the obturation process, reducing chair time and improving procedural efficiency. [15]
2. Enhanced Precision: Precise temperature control and motorized extrusion contribute to a more accurate and homogenous fill of the root canal system. [15]
3. Versatility: Suitable for various obturation techniques, accommodating diverse clinical preferences and patient needs. [15]

3.6.3. Disadvantages

1. Automatic Shut-Off: Some users have reported that the unit's automatic shut-off feature activates sooner than desired, potentially interrupting procedures. [15]
2. Plunger Engagement Delay: There is a noted delay in the plunger's engagement with the cartridges, which could affect the workflow. [15]
3. Learning Curve. Transitioning from traditional obturation systems to the Elements™ IC may require a period of adjustment and training. [15]
4. High cost

Conducting in vitro studies is crucial to better evaluate the efficiency of the Elements IC Obturation System and compare it with other obturation techniques. Further research is required in newer obturation techniques.[17]

4. Conclusion

Newer obturation techniques and materials have transformed endodontic practice by addressing the limitations of traditional methods and offering solutions tailored to modern clinical challenges. While each technique has its own advantages and limitations, the selection should be based on individual case requirements, clinician expertise, and evidence-based recommendations. As research continues to refine these technologies, the future of obturation lies in further improving materials and delivery systems to achieve even higher standards of clinical efficacy and patient outcomes.

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6. Conflict of Interest

None.

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