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Voids during obturation in primary teeth: Etiology, evaluation, prevention and management—A narrative review

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Abstract
Background: Pulpectomy is a widely performed procedure for preserving primary teeth affected by irreversible pulpitis or pulpal necrosis until their physiological exfoliation. The quality of obturation is a key determinant of treatment success, and the presence of voids within the obturating material or at the material–dentin interface can compromise the hermetic seal, leading to bacterial leakage and potential treatment failure.
Objective: To provide a comprehensive overview of the etiology, classification, evaluation, clinical significance, prevention, and management of obturation voids in primary teeth, while highlighting recent advances in obturation materials, techniques, and assessment methods.
Review: A narrative review of the literature was conducted using electronic databases, including PubMed, Scopus, Google Scholar, and Web of Science. Relevant studies on obturation quality, void formation, obturation materials, delivery techniques, and imaging modalities in primary teeth were reviewed. Current evidence indicates that void formation is influenced by root canal anatomy, operator technique, instrumentation, material properties, and obturation methods. Advances in syringe-based delivery systems, improved obturation materials, and three-dimensional imaging techniques such as cone-beam computed tomography (CBCT)[5-12] and micro-computed tomography (micro-CT) have enhanced obturation quality and the detection of voids. Comprehensive assessment systems, including the Coll and Sadrian criteria2, KEDOO Classification3, and the SS Radiographic Evaluation Checklist, have further improved the evaluation of obturation quality.
Conclusion: Although significant advances have been made in obturation materials, techniques, and evaluation methods, achieving a consistently void-free obturation in primary teeth remains challenging. Careful case selection, meticulous clinical technique, appropriate material selection, and standardized radiographic assessment are essential to minimize void formation and improve the long-term success of pulpectomy. Further well-designed clinical studies are needed to establish evidence-based protocols for optimal obturation in primary teeth.

Keywords: Primary teeth, pulpectomy, obturation, voids, endoflas, Micro-CT, CBCT, pediatric endodontics, root canal filling

Introduction

Pulpectomy is the treatment of choice for primary teeth with irreversible pulpitis or pulpal necrosis, aiming to preserve the tooth until its physiological exfoliation [1, 2]. The long-term success of pulpectomy depends on effective cleaning and shaping of the root canal system, followed by complete obturation with a resorbable material that provides a three-dimensional seal while allowing physiological root resorption.

Achieving an ideal obturation in primary teeth is challenging because of their complex root canal anatomy, including ribbon-shaped canals, accessory canals, irregular canal morphology, and physiological root resorption. These anatomical characteristics, along with operator technique and the physical properties of obturation materials, predispose to the formation of voids.

Various obturation materials and techniques have been developed to improve filling quality and minimize void formation. Despite these advancements, achieving a consistently dense and void-free obturation remains a clinical challenge.

Therefore, this narrative review aims to summarize the current evidence on the etiology, classification, evaluation, prevention, and management of obturation voids in primary teeth, while highlighting recent advances and future perspectives for improving the success of pediatric endodontic therapy.

Definition of voids

A void in endodontic treatment refers to an empty space or gap within the root canal filling material after obturation.

These voids can be located either inside the filling mass or at the interface between the filling material and the root canal walls.

They represent areas where the canal space is not completely filled or sealed, which compromises the hermetic seal intended to prevent bacterial leakage and reinfection

Classification

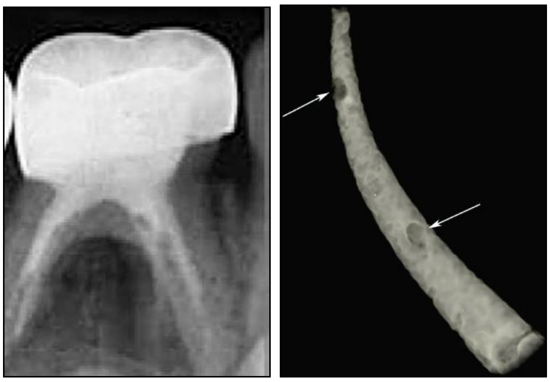
(based on their location and characteristics within the root canal filling)

- **Internal Voids:** These are voids located within the bulk of the filling material itself, meaning there are air pockets or gaps inside the gutta-percha or sealer mass.
- **External Voids:** These occur at the interface between the filling material and the root canal walls.
- **Closed Voids:** Voids completely enclosed within the filling material, not connected to the canal walls or external environment.
- **Open Voids:** Voids that communicate with the canal walls or external environment, posing a higher risk for leakage and reinfection.

Internal Voids

Internal voids are gaps or air pockets that occur within the bulk of the root canal filling material, such as gutta-percha or sealer, after obturation.

- Internal voids reduce the density of the filling and can compromise the overall seal
- Studies have shown that internal voids can occur in various parts of the root canal system, including the pulp chamber, root canal, and particularly in complex anatomical areas like isthmuses
- Internal voids are generally considered less critical than external voids because the filling material encapsulates them and do not directly communicate with the canal wall or the oral environment. And they are less likely to serve as pathways for bacterial leakage.



Internal voids may result from –

a. Incomplete condensation of the filling material during obturation

b. Entrapment of air bubbles during the mixing or placement of sealers, c. Inadequate adaptation of filling materials especially in irregular or complex canal anatomies

External Voids

External voids are gaps or spaces found at the interface between the root canal filling material (such as gutta-percha and sealer) and the root canal walls.

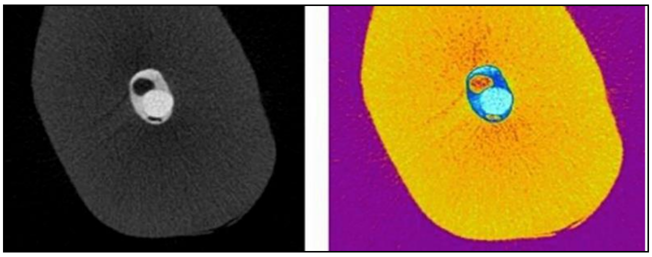
- External voids represent unfilled or poorly adapted areas along the canal walls where the filling material fails to contact the dentin surface properly
- External voids are particularly critical because they create potential pathways for microleakage, allowing bacteria and fluids to penetrate the root canal system. This leakage can lead to reinfection, persistent apical periodontitis, and ultimately, failure of the endodontic treatment.
- The presence of external voids indicates inadequate marginal adaptation of the filling, compromising the hermetic seal essential for long-term success

Causes of external voids

- Incomplete or inadequate condensation of the filling material during obturation.
- Complex or irregular root canal anatomy, such as oval-shaped canals or isthmuses, which are difficult to fill completely.
- Improper use or selection of obturation materials and techniques.
- Shrinkage or setting contraction of sealers, especially resin-based types, leading to gaps at the interface.
- Operator error or insufficient visualization during obturation

Closed Voids

Closed voids are defined as empty spaces or gaps that occur within the obturation material itself, completely enclosed by the filling mass and not in contact with the root canal walls or dentin surface.



- These voids are internal pockets of air or unfilled space trapped inside the gutta-percha or sealer material during root canal obturation.
- The clinical importance of closed voids lies in their potential to reduce the density and homogeneity of the filling mass, although they do not directly create a pathway for bacterial leakage since they are not connected to the canal walls.
- Therefore a high volume or number of closed voids can weaken the mechanical integrity of the filling and may indirectly affect the seal over time.

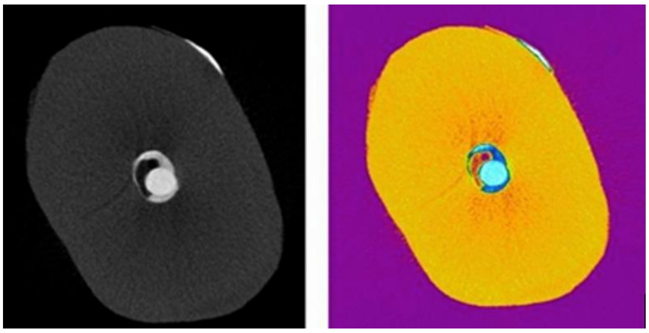
Micro-computed tomography (micro-CT) studies have been used in identifying and quantifying closed voids in root canal fillings. These studies show that closed voids can occur regardless of obturation technique, with a tendency for more voids in the cervical third of the canal, often related to canal geometry such as oval shapes

Open voids

Open voids in endodontic treatment are gaps or empty spaces within the root canal obturation that directly communicate with the canal wall or extend to the external environment.

Unlike closed voids, open voids are exposed to the dentin surface, making them critical sites for potential leakage and reinfection

Open voids are particularly significant because they compromise the seal between the obturation material and the canal wall. This allows oral fluids, bacteria, and their byproducts to penetrate the root canal system, increasing the risk of persistent infection and failure of endodontic therapy



Causes of open voids

a. Incomplete condensation of obturation materials
b. Complex or irregular canal anatomy
c. Presence of debris or tissue remnants that prevent proper adaptation of filling material
d. Technique-related errors during obturation

- Studies have shown that open voids can be more prevalent in cervical third, especially in teeth with oval canal geometry.
- They may also be found in anatomically complex areas like isthmuses, where irregular shapes and tissue remnants make complete filling difficult.

Type “I” And “S”VOIDS

Type I ("I") and Type S ("S") voids are specific classifications of voids observed within root canal obturations, particularly studied in primary teeth using cone-beam computed tomography (CBCT) [5-12].

Type I ("I") Voids

These voids are typically found in the apical area of the root canal and appear as linear or isolated voids along the canal filling.
They were most commonly observed in the apical third of canals obturated with certain techniques, such as disposable syringes.

Type S ("S") Voids

These voids are more common in the coronal or cervical third of the root canal and tend to be larger or more irregular in shape compared to I-type voids.
They were frequently found in the coronal third of canals, with eight canals showing S-type voids when using disposable syringes.

Voids by location in root canal

Apical Third

Generally shows fewer voids compared to coronal and middle thirds but remains critical for sealing success.
Voids here often occur between the sealer and canal wall, depending on the obturation method.
Studies report void percentages around 3.6–4.2% in the apical area, with some variation between mesial and distal canals.
The apical area is considered more clinically relevant for treatment success due to its role in preventing periapical leakage

Middle/Coronal Third

Exhibits a higher percentage of voids, especially in the coronal third of distal canals.
Voids in this region are often related to inadequate condensation or backfilling pressure not reaching the full canal length.
The coronal third may have void percentages ranging from about 5.1% to over 10%.
Voids here are often located between the filling material and canal walls, increasing the risk of leakage

Etioloy for voids

Complex Root Canal Anatomy

Anatomical complexities such as isthmuses (narrow connections between canals), accessory canals, and oval or irregularly shaped canals make it difficult to achieve complete filling, increasing the risk of voids.

a. **Isthmuses:** Narrow connections between main canals, common in mandibular molars, that are difficult to clean, disinfect, and obturate. These areas often harbor microorganisms and debris, leading to void formation.

b. **Accessory Canals:** Small lateral or furcation canals that branch off the main canal. Their small size and location make them hard to reach and fill, increasing the potential for voids.

c. **Oval or Irregularly Shaped Canals:** Canals that deviate from a round cross-section, preventing complete adaptation of standard filling materials. This shape makes it difficult to ensure the filling material contacts all canal walls, leading to voids.

To minimize voids in complex canal anatomies:

- Utilize flexible instruments for shaping and cleaning.
- Use bioceramic sealers that expand slightly upon setting to fill irregularities.
- Consider advanced imaging for detailed anatomical assessment.

2. Inadequate Cleaning and Shaping: Residual debris, dentin chips, or calcifications left in the canal after cleaning can obstruct filling material placement, leading to voids or incomplete obturation.

a. **Physical Obstruction:** Debris and calcifications block filling material from reaching all areas of the canal, creating voids.

b. **Poor Adaptation:** Filling materials cannot properly adapt to canal walls when debris is present, leaving gaps.

c. **Reduced Disinfection:** Residual debris harbors bacteria, preventing effective disinfection and increasing the risk of treatment failure.

Material Properties: Some sealers, especially resin-based ones, may shrink during setting, creating gaps within the filling material. Also, mixing errors or air bubbles introduced during preparation of the sealer or paste contribute to voids.

a. **Polymerization Shrinkage:** During the setting process, resin monomers convert into a polymer network. This conversion reduces volume because the monomers are more closely packed in the polymer structure than they were as individual molecules.

b. **Stress Development:** As the resin shrinks, it generates internal stresses within the material. If the bond to the canal walls is not strong enough to resist these stresses, the resin pulls away from the dentin, creating voids or gaps

Clinical Significance of Voids

- Voids are important because they can allow residual microorganisms to survive or recolonize the root canal system, potentially leading to treatment failure and apical periodontitis.
- Bacterial Leakage and Reinfection: Voids allow oral fluids and bacteria to penetrate the root canal system, increasing the risk of persistent or recurrent infection and apical periodontitis.
- Compromised Treatment Success: Inadequate obturation, including the presence of voids, is a leading cause of endodontic failure, accounting for a significant proportion of unsuccessful cases.
- Persistent Symptoms: Failure to completely fill and seal the canal space can result in ongoing or recurring symptoms for the patient, such as pain or swelling.

Evaluation of Obturation Quality

Evaluation of obturation quality serves several important purposes. It enables clinicians to assess the adaptation of the filling material to the canal walls, identify procedural errors such as underfilling, overfilling, and void formation, compare different obturation techniques and materials, and predict the long-term prognosis of endodontically treated primary teeth.

Over the years, various imaging modalities have been employed to assess obturation quality, ranging from conventional intraoral radiographs to advanced three-dimensional imaging techniques such as cone-beam computed tomography (CBCT) [5-12] and micro-computed tomography (micro-CT). Each technique differs in its ability to detect voids and evaluate the homogeneity of the root canal filling.

Conventional Intraoral Radiography

Conventional periapical radiographs have long been considered the standard clinical method for evaluating obturation quality following pulpectomy. They are inexpensive, readily available, and expose patients to relatively low radiation doses. Radiographs allow clinicians to determine whether the obturating material has reached the desired working length and whether overfilling or underfilling has occurred.

Despite these advantages, conventional radiographs have important limitations. As they provide only a two-dimensional representation of a three-dimensional structure, voids located on the buccal or lingual aspects of the canal may not be detected because of superimposition of anatomical structures. Small internal voids and defects within the filling material often remain undetected, leading to an overestimation of obturation quality. Furthermore, radiographic interpretation is subjective and depends on the observer's experience.

Nevertheless, intraoral radiographs continue to be the most widely used method in routine pediatric dental practice because of their accessibility and simplicity.

Cone-Beam Computed Tomography (CBCT)

Cone-beam computed tomography has significantly improved the evaluation of obturation quality by providing three-dimensional visualization of the root canal system. Unlike conventional radiographs, CBCT eliminates the problem of anatomical superimposition and enables assessment of the obturation from multiple planes.

CBCT allows clinicians and researchers to evaluate the location, size, and distribution of voids within the obturation material, detect underfilled or overfilled canals, and assess adaptation of the filling material to canal walls. It is particularly useful in teeth with complex canal morphology where two-dimensional imaging may underestimate procedural errors.

Several clinical studies comparing obturation techniques in primary teeth have used CBCT because of its ability to provide volumetric information while maintaining acceptable radiation exposure for research purposes. Studies have demonstrated that CBCT identifies significantly more voids than conventional radiographs and provides a more accurate assessment of obturation quality.

However, CBCT has limitations including higher radiation exposure than intraoral radiography, greater cost, limited accessibility, and lower spatial resolution compared with micro-CT. Consequently, its routine use solely for evaluating pulpectomy quality is not recommended, particularly in children, unless clinically justified.

Micro-Computed Tomography (Micro-CT)

Micro-computed tomography is currently regarded as the gold standard for evaluating obturation quality in endodontic research. It provides high-resolution, non-destructive, three-dimensional images that enable precise quantitative analysis of the obturation.

Unlike conventional radiographs or CBCT, micro-CT can accurately measure the total volume of obturation material, quantify internal and external voids, determine the percentage of canal space occupied by the filling material, and assess adaptation to the canal walls throughout the entire root canal system. The technique allows differentiation between open and closed voids and identifies void distribution within the coronal, middle, and apical thirds of the canal.

Micro-CT studies have substantially improved understanding of void formation in primary teeth and have been widely used to compare obturation materials, instrumentation systems, and delivery techniques. Recent investigations have demonstrated that rotary instrumentation combined with syringe-based delivery systems often produces fewer voids than conventional manual techniques.

Despite these advantages, micro-CT is limited to laboratory and ex *vivo* research because of its high radiation dose, long scanning time, high cost, and inability to be used clinically in patients. Therefore, although micro-CT provides the highest level of accuracy, its application remains restricted to research settings.

Evaluation Criteria and Classification Systems

Several criteria have been proposed to standardize the assessment of obturation quality in primary teeth. Traditionally, obturations have been classified according to the extent of canal filling as optimal filling, underfilling, or overfilling based on the distance between the obturation material and the radiographic apex. Another is The KEDOO Classification [3], evaluates obturation quality based on obturation length, density, homogeneity, and void formation.

Recognizing the limitations of conventional radiographic assessment systems that primarily evaluate the apical extent of obturation, Dr. Savitha Sathyaprasad [4] proposed the SS criteria for Obturation of Primary Teeth, a comprehensive radiographic assessment tool designed to evaluate the overall technical quality of pulpectomy procedures. Unlike earlier classifications that focus only on the length of the obturation, the SS checklist systematically assesses each procedural step that may influence the final quality of obturation and the occurrence of endodontic mishaps.

Management of voids

Prevention of Void Formation

The most effective management of voids is prevention. Successful prevention begins with meticulous biomechanical preparation. Complete removal of pulp tissue, adequate irrigation, and proper canal shaping create sufficient space for the obturating material to flow and adapt to the canal walls. Accurate determination of the working length is equally important, as underprepared canals or inaccurate working lengths may result in under-obturation and void formation.

Proper canal drying before obturation is another critical factor. Residual moisture or blood interferes with the adaptation of obturating materials, particularly zinc oxide eugenol- and calcium hydroxide-based pastes, increasing the likelihood of void formation. The obturating material should be mixed according to the manufacturer's recommendations to achieve optimal viscosity and flow. Incorporation of air bubbles during mixing should be minimized because entrapped air can produce internal voids within the filling mass.

The choice of obturation technique also plays a significant role in minimizing void formation. Incremental placement of the obturating material, slow withdrawal of the delivery needle while expressing the material, and gentle condensation reduce air entrapment and improve adaptation to canal walls. Recent clinical studies have demonstrated that syringe-based delivery systems, particularly the NaviTip double side-port system and endodontic pressure syringe, produce more homogeneous obturations with fewer voids than conventional lentulo spirals or disposable syringes.

Intraoperative Management of Voids

Radiographic evaluation immediately after obturation is essential to identify voids before the tooth is permanently restored. When a radiograph reveals large voids, multiple voids, or voids extending to the canal wall, the obturation should ideally be removed and repeated during the same appointment, provided that adequate isolation can be maintained.

If the void is confined to the coronal portion of the canal and the apical seal is satisfactory, additional obturating material may occasionally be condensed into the defect before placing the coronal restoration. However, this approach should only be attempted when the clinician is confident that the newly added material will integrate with the existing filling without creating additional voids.

In contrast, voids extending through the middle or apical thirds of the canal usually require complete removal of the obturation material followed by thorough irrigation, canal drying, and re-obturation to establish a homogeneous seal.

Selection of Materials and Techniques to Reduce Voids

Materials with superior flow characteristics and dimensional stability demonstrate better adaptation to irregular canal anatomy. Bioceramic sealers have shown promising results because of their excellent flow, slight setting expansion, and bioactivity, although their routine use in primary teeth requires further clinical evidence.

Among conventional obturation materials, Endoflas and calcium hydroxide–iodoform pastes demonstrate better flow characteristics than zinc oxide eugenol in many studies. Ultrasonic activation has also been reported to improve penetration of calcium hydroxide–iodoform pastes into irregular canal spaces and reduce void formation.

Similarly, rotary instrumentation has been shown to produce more uniformly shaped canals than manual instrumentation, facilitating improved adaptation of obturating materials.

Contemporary evidence also favors syringe-based delivery systems such as NaviTip and endodontic pressure syringes, which consistently demonstrate fewer voids compared with disposable syringes and lentulo spirals.

Recent advances have explored the incorporation of antimicrobial agents into obturating materials to enhance both sealing ability and antibacterial efficacy. The combination of clindamycin gel with Endoflas [23] has shown enhanced sealing ability and a significant reduction in void formation, indicating superior adaptability to the complex root canal morphology of primary teeth. In addition to improving obturation homogeneity, the sustained antimicrobial effect of clindamycin may help eliminate residual microorganisms and reduce the risk of reinfection.

Conclusion

successful management of obturation voids depends on a combination of meticulous biomechanical preparation, accurate working length determination, appropriate material selection, careful obturation technique, and thorough radiographic evaluation. As advances in biomaterials, three-dimensional imaging, artificial intelligence-assisted diagnostics, and standardized assessment criteria continue to evolve, future pediatric endodontic practice is expected to achieve more predictable, biologically acceptable, and clinically successful obturation outcomes. A comprehensive understanding of the etiology, detection, prevention, evaluation, and management of obturation voids will enable clinicians to optimize pulpectomy procedures and improve the long-term prognosis of primary teeth.

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