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Review Artic;e

Controversies in endodontics

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ABSTRACT

In light of the contagious nature of pulpal lesions, it is imperative for clinicians to adopt specific precautions to forestall infections in the root canal system of teeth. Comparable to diverse dental disciplines, the initial evolution of endodontic treatments relied on empirical observations, with scientific methodologies only recently being incorporated to bolster clinical approaches. The delineation between medical practitioners and other specialties is exacerbated by their proclivity to seek internal rather than external consultation. This trend has persisted largely unchanged over three decades, with the amassed biological knowledge having limited practical influence in endodontic practice, thus engendering divergent viewpoints in this dental domain.

The review's methodology encompassed sourcing studies from databases such as PubMed, Embase, Health InterNetwork Access to Research Initiative, Cochrane Library, and Google Scholar searches. This review casts a spotlight on the contentious dimensions inherent in root canal therapy, particularly focusing on the debates surrounding techniques like attaining a hermetic seal, as well as other commonly employed methodologies in daily endodontic practices. These controversies mirror the dynamic landscape of the field, where traditional practices intersect with emergent scientific insights, sparking divergent perspectives and ongoing dialogues. By elucidating these disputes, the review underscores the imperative of a comprehensive grasp of diverse viewpoints to foster informed decisions and advances in the realm of endodontics.

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1. Introduction

Diseases affecting the dental pulp often stem from infections, and treatments are aimed at managing infections within the root canal system. The principles of endodontic treatment initially developed through trial and error, and only in recent decades have scientific approaches been embraced to support clinical strategies. Nevertheless, there is a scarcity of pertinent research within the endodontic literature concerning disease processes, their diagnoses, and effective treatment methods. Consequently, the integration of biologically grounded knowledge into clinical endodontics has progressed sluggishly. As a result, numerous divergent viewpoints persist in this dental domain.

This review brings into focus and examines the underlying aspects of some of the more heavily disputed topics in recent times. Specifically, it delves into disagreements surrounding the clinical handling of exposed pulps due to cavities in adult teeth, the definitions outlining the success and failure of endodontic therapy, as well as the causes and strategies for managing infections within the root canal system.

Evidently, a pronounced void within the published endodontic literature is the absence of randomized clinical trials addressing the weightier controversial matters pertaining to the management of pulp injuries, medication usage, and the optimal number of appointments necessary

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for treating infected root canals. However, conducting trials in the field of endodontics requires exceedingly lengthy follow-up periods to yield valid conclusions. Therefore, the rapid resolution of these issues in the foreseeable future is not to be anticipated.

2. Data Source and Source Approach

The databases PubMed, Embase, Health InterNetwork Access to Research Initiative, and Cochrane Library, as well as past prevalence lists from Google searches, were used to search for the studies. The following keywords were searched for individually or in combination with keywords & MeSH terms (in the case of PubMed) and Boolean operators (AND and OR): endodontic, controversies, endodontics, conservative dentistry, hermetic seal, operational techniques, compaction, condensation, smear layer, visits, obturation, materials, solvents, aluminium cones etc.

2.1. Hermetic seal: A fallacy or misunderstanding

The main objective of obturation is to completely remove any chance of leakage into the intra-radicular space. Any irritants that cannot be completely removed during the cleaning and shaping processes should be sealed inside the system. The goal of obturating the root canal is to replace the destroyed or removed pulp with an inert hermetic sealing material in order to stop further infection. The obturating material should restore normalcy to the periapical tissues with which it comes into direct touch in addition to strengthening or repairing the affected tooth.[1] Obturation's primary goal is to replace the pulp tissue gap with an inert substance that stops bacteria percolating either coronally or apically. Therefore, any discrepancy in this process would result in the endodontic treatment's failure. Obturation of the canal space is essential to the effectiveness of root canal therapy.[2] The majority of root canal treatment failures are brought on by fluid percolating into inadequately obturated channels from inflammatory periapical tissue. One of the key goals of root canal therapy is to completely seal the coronal and apical surfaces in three dimensions.

Hermetic seal is regarded as the most crucial outcome of root canal therapy. By fusion or sealing, an airtight seal is created that prevents air from escaping or entering. By fusion or sealing, an airtight seal is created that prevents air from escaping or entering. Given the potential for fluids to percolate into the canal coronally and apically, a fluid-tight closure is preferable. A tight seal for the entire root canal system is one of the main causes of long-term treatment failures.[3]

2.2. Compaction vs. Condensation

The conventional term for the common techniques of obturation are lateral and vertical condensation. Condensation is the term used to describe the transformation of a substance's physical condition when it is compressed or condensed into a smaller mass with a higher density. Additionally, gutta-percha cannot be concentrated, decreased, or compressed. On the other hand, the gutta-percha is stacked one on top of the other, with the interspersed sealer in the voids. Consequently, the word COMPACTION is preferred. But lateral condensation does not actually result in the production of a dense mass of gutta-percha; rather, the individual cones merely hang in a sea of cement.[4]

2.3. Vertical vs. Lateral techniques

Numerous experiments[5–8] have been done to determine how much stress the instrumentation techniques cause during cleaning, shaping, and obturation. A complicated pattern of stresses and force vectors that are not solely vertical or lateral can be seen in obturations, which include both vertical and lateral compaction techniques. As a result, a composite stress pattern is created, mostly along the lateral canal walls. The strains created by either of the two procedures are comparable. The doctor should understand that success can be achieved by using either strategy.

2.4. Solid versus soft materials

Obturation procedures and materials have experienced a significant transition; from the usage of gold as a root canal filler material before 1800 to the materials of the present. Hill (1847) had created the original gutta-percha root canal filling substance known as "Hills stopping". The ideal material is softened and malleable. Gutta-percha has shown to be the best material for successfully sealing canals over the past 100 years. It complies with the most of Grossman's requirements for an optimal root filling substance, despite not being the perfect filling material. The alpha form of gutta-percha, which is formed by phase transformation at temperatures of around 42°-49°, is more flexible and flowable when thermo-plasticized, while the beta-phased form of gutta-percha, which is typically available for obturation, is rigid and less flexible at room temperature. Alpha-phased thermoplasticized gutta-percha is becoming more and more well-known even if beta-phased gutta-percha is still the preferred material. Gutta-percha's effectiveness as an obturating material with a three-dimensional sealing property and the effectiveness of using a solid core obturating material in curved canals led to development of a carrier technique in which thermoplasticized gutta-percha was coated over a stainless-steel carrier.[9] Thermafil Endodontic Obturators (Tulsa Dental Products, Tulsa, OK) are flexible metal (stainless steel/titanium) that are covered with an alpha-phased gutta-percha. The firm that manufactures and markets this product was founded in 1989. It is advantageous for the material to soften in order for the material to move into the canal's intricate details, including the dentinal tubules.[10] As long as a sealer was applied, Thermafil obturators produced seals similar to lateral compaction under the conditions of this study.[11] However, the incidence of material ejection outside of the canal has increased with the use of softened gutta-percha procedures. Therefore, a treatment strategy utilising both solid and softened gutta-percha is preferable, meaning that in the event of an open apex, the apical third is filled with beta phase gutta-percha and the remaining canal is back filled with thermoplasticized gutta-percha.

2.5. *Utilizing solvents to modify materials*

For almost a century, chemical solvents have been employed to soften gutta-percha. The gutta-percha was either utilised after being dipped in a solvent or after being formed into a thin paste. Even while a softened gutta-percha would flow more easily, the solvent's presence would change its characteristics, making it unable to provide a sufficient apical seal. Chloroform, methylchloroformate, halothane, rectified white turpentine, and eucalyptol are some of the common solvents. Typically, solvents are employed to create gutta-percha cones that are specifically sized for uneven canals or open apices. The use of these solvents has diminished with the introduction of thermoplasticized gutta-percha.[12]

3. Smear Layer

After instrumentation, the root canal walls have an accumulation of organic and inorganic detritus known as a "smear layer." The smear layer appears amorphous, uneven, and granular under a scanning electron microscope, representing dentinal shavings, tissue debris, odontoblastic processes, and microbial components. For many years, there has been debate concerning the removal of smear layer. The smear layer must be entirely eliminated from the root canal system because it contains bacteria and bacterial byproducts. According to Haapasalo et al.[13] (1987), the removal of the smear layer may make it easier for intracanal medications to reach the diseased root canals' dentinal tubules and, as a result, improve the cleaning process. Root canal filling materials may not fully lock and attach to the dentinal tubules.[14] Smear layer, on the other hand, can stop undesired bacterial activities by sealing the bacteria within the dentinal tubules. It also prevents bacteria from entering the dentinal tubules from contaminated canals, acting as a barrier to the free movement of bacteria into or out of the dentinal tubules. The maintained smear layer affects the flow of fluids in dentinal tubules, hinders the entry of microorganisms, and lessens the susceptibility of dentine to oral bacterial toxins. Dentinal tubule exudate is prevented from wetting the dentine surface further by the smear layer. Before any considerable dentine removal, the smear layer would be primarily organic in origin during the early stages of canal preparation or in irregular anatomic variations of the canal.[15]

3.1. *Smear Layer*

1. Permits for the growth of microorganisms inside the dentinal tubules and harbours them.
2. Restricts or hinders the irrigants' ability to kill microorganisms
3. If left in place, would melt and damage the apical seal, especially in the apical third.
4. Interfere with the adherence and penetration of the sealers into the dentinal tubules, as well as the penetration of the gutta-percha into the tubules.

3.2. *Smear layer's impact on obturation*

In both AH26 and RoekoSeal root canal sealers, removal of the smear layer has a beneficial effect in minimising apical and coronal leakage. The degree of microleakage in obturated root canals is significantly impacted by the removal of the smear layer. Roth 811's capacity to seal is unaffected significantly by the presence or absence of a smear layer.[16]

3.3. *Irrigants for smear layer removal*

Doxycycline solution may be utilised as an irrigant due to its antibacterial activity, smear layer removal capacity, and improvement of apical seal. Lactic acid successfully cleans and smoothens the dentin walls of endodontically prepared teeth's root canals. The smear layer is totally eliminated by both EGTA and EDTA, whereas EGTA successfully removes the smear layer without causing any erosion. Thus, EGTA can be utilised successfully as a substitute chelator for the elimination of the smear layer. The best irrigation method for removing smears was 15 percent EDTA irrigation with a syringe after instrumenting with a 5 percent NaOCl solution.[17] Regardless of the irrigant employed, ultrasonic irrigation is the most efficient irrigation approach for clearing debris. Syringe irrigation of the OPW after instrumentation with 5 percent NaOCl has a similar result to irrigation with 15 percent EDTA for the removal of debris and the smear layer. A new intracanal irrigant to rival EDTA is MTAD. It consists of doxycycline, an isomer of tetracycline, citric acid, and detergent (Tween 80). The MTAD clinical procedure calls for 20 minutes of 1.3 percent NaOCl and then 5 minutes of MTAD. Tween 80 is a member of the Polysorbates group of food additives. It is a water-soluble, somewhat yellowish liquid that is used to combine oil and water as a dispersant. On pulp and dentin, MTAD has solubilizing effects that are relatively comparable to those of EDTA. The main distinction between these solutions' effects is the doxycycline found in MTAD's strong affinity for dentin. MTAD is substantially more effective than EDTA and as effective as NaOCl at 5.25 percent. Additionally, when the solutions are diluted, MTAD kills E. faecalis far more efficiently than NaOCl. At a 200x dilution, MTAD is still effective at killing E. faecalis, whereas NaOCl loses its effectiveness. In a 2003 study, Shabahang et al.[18] compared the effectiveness of MTAD and NaOCl at cleaning human root canals that had become infected with entire saliva. Of the sixty teeth that received NaOCl treatment, 23 still had infections. Out of sixty teeth treated with MTAD, just one had an infection. The most common techniques for removing the smear layer prior to obturation involve alternately using a chelating agent (di sodium ethylenediaminetetraacetic acid (EDTA)] or a weak acid (ten percent citric acid), followed by a thorough canal rinse with three to five percent sodium hypochlorite (NaOCl).[19]

3.4. *Instrument insertion depth during obturation*

Compacting the gutta-percha and the sealer at the apex is crucial for the effectiveness of the endodontic therapy. When thermoplasticized gutta-percha is being vertically compacted, the compacting tool is positioned just below the apex, and the softened filler is compacted into the apical preparation in a three-dimensional way. The master cone is anticipated to fit tightly at the preparation's apical end when using the lateral condensation procedure. The spreader should provide an apically directed vector that strengthens the apical seal. The spreader should therefore be positioned as precisely as possible. The master cone must fit into the apical preparation with the least amount of sealer feasible. When the spreader is positioned at the working length unnecessary apical stresses may be applied, leading to root fracture.[20] Additionally, it can cause the obturating material to protrude outside of the root canal space. Therefore, the canal's form at the apex is crucial. Modern canal configurations that encourage funnel-type preparations from the apical matrix to the coronal orifice enable correct insertion of the compacting device and modification of the master gutta-percha cone. Position of the obturation material at the apex. Although the primary goal of obturation is to fill the entire root canal, there is still considerable debate in the endodontic community over the apical extension of root canal instrumentation and root filling. The cementodentinal junction or apical constriction is the optimal location to stop the cleaning and shaping of the canals as well as the location where the filling material should be applied. The cementodentinal junction, however, is not usually the most restricted part of the root canal system because it is a histology position rather than a clinical position.[21] Age, trauma, orthodontic treatments (cemental deposition), and any pathologic process (resorption) all affect how far the radiographic apex is from the constriction. Understanding the prerequisites for tissue repair in the apical region of the root canal is crucial to comprehending the biological basis for apical termination in a case of viable but inflamed pulp. Hard tissue closure, which permanently isolates the root canal content (the root filling) from the periapical tissues and avoids persistent irritation and responses from foreign bodies by material components, is the most ideal end result of an endodontic procedure.[22] Clinical studies have shown that the natural healing process occurs after an aseptic partial pulpectomy in which a few millimeters of the apical pulp tissue are left.[13] Healing will take place with the development of cementum-like tissue if the proper filling material is utilized and/or dentinal filings have been packed against the pulp stump. Due to the potential presence of microorganisms near the apical foramen, the necrotic infected pulp provides a distinct difficulty as compared to the vital pulp since the entire length of the infected tissue needs to be cleaned and disinfected, the length of the instrumentation is therefore be crucial. The best success rate for vital pulpectomy has been noted when the treatment was stopped 2 to 3 mm short of the radiographic apex. Bacteria and their metabolites, together with diseased dentinal debris, may stay in the most apical part of the canal with pulpal necrosis; these irritants could endanger apical healing. Better results were obtained in these situations when the procedures ended at or within 2 mm of the radiographic apex (0 to 2 mm). The success rate for infected canals was almost 20 percent lower when the treatment procedures ended at less than 2 mm from or past the radiographic apex than when they did so from 0 to 2 mm. When treatment involves obturation short of the apex, success rates are higher.[23]

4. Apical Obstacles

Before canal obturation, dentin chips or other artificial barriers (such as calcium hydroxide, demineralized dentin, lyophilized bone, tricalcium phosphate, hydroxyapatite, or collagen) are frequently placed to provide an apical stop or matrix. Dentin chips have been utilized for 60 years and have been demonstrated to have positive outcomes. These chips not only provided a biologic seal but also stop irrigants from entering the periapical space and from overfilling.[24] However, Adams (1979)[25] and Yee et al. (1984)[26] have demonstrated that the apical seal that is offered is insufficient. The use of the barrier materials promoted healing, apical cement deposition, and the peri-radicular tissue response with little inflammation.

4.1. *Endodontics: Single vs. Multiple Visits*

The use of a calcium hydroxide dressing helps provide superior effects, than the treatment in one session. Before the insertion of a permanent filling, therapy has traditionally been separated into two or more appointments. This has allowed the dentist to improve root canal cleaning, promote patient comfort, and monitor the healing process. Between

107 and 108 bacterial cells are thought to be present in the pulpal space and it is not yet known whether instrumentation and antimicrobial irrigation can predictably reduce the bacterial count to zero during a single treatment session.[27] However, there are differing views on whether the pulpal region needs to be thoroughly cleaned before the root filling is inserted. Despite the existence of residual microorganisms, Peters and Wesselink[28] (2002) reported no change in treatment outcomes when root canals were filled. In a randomised clinical trial, Weiger et al.[29] (2000) found no differences in outcomes between teeth treated in a single session versus teeth filled after calcium hydroxide therapy.

4.2. Pastes vs Gutta-percha as materials for root canals

In endodontics, the use of paste-type obturation procedures is not recommended because.

Paste components may seep into the peri-radicular area. Due to the porosities in the paste fills, the pastes eventually resorb, causing leakage or fluid percolation. Blood samples and several key organs have been shown to contain components of some paste materials systemically. The pastes' chemical components have been demonstrated to be antigenic and to trigger immune reactions. When there is no apical matrix, the apical control of the paste fills is extremely impossible.[30]

Gutta-percha's drawback was that it couldn't adequately seal the curved, narrow canals because of how elastic and non-rigid it was in thinner areas, which prompted dentists to adopt solid-core filling materials. Thus, silver cones became quite well known. In the 1930s, silver cones were first used in endodontic procedures. These were widely employed; however, it was later discovered that they may corrode. Numerous investigations have demonstrated that a significant portion of the corrosion was caused by the sealer's breakdown.[31]

Galvanic response and microleakage with infection are two potential explanations for the silver point's deterioration. Another major drawback was the requirement that the canal be prepared for silver cone obturation to be completely circular in order for the cone to readily fit into the canal with no space between it and the canal walls. Such accuracy, however, is challenging to accomplish. Because this issue is overlooked, the usage of silver cones unintentionally results in microleakage and eventual failure.[32]

4.3. Aluminum cones

Experiments with various metals were encouraged in the hunt for a superior solid core obturating material, and this effort resulted in the employment of titanium and its alloy titanium-aluminum-vanadium, which displayed properties that were particularly conducive to their use as obturating materials. The success these materials had as implants, which showed extremely strong tissue response, bio compatibility, and non-corrosiveness, gave them a very bright future in endodontics. Titanium is less harmful than silver cone.Titanium possesses all the characteristics of a perfect solid core material, but its flexibility in small canals can be questioned, especially when there hasn't been much preparation. Nickel-Titanium, which is more flexible and still possesses Titanium's biocompatibility and non-corrosiveness, has become increasingly popular as a result.[33]

5. Discussion

The intrinsic significance of this review becomes increasingly evident as it delves deeply into the fundamental aspects of root canal therapy. Its exploration of pivotal subjects resonates remarkably with the multifaceted challenges and dynamic advancements encountered in today's intricate landscape of dental care. By steadfastly underlining the pivotal goal of achieving a hermetic seal, the review implicitly underscores a foundational element critical for the triumph of treatment endeavors. This emphasis not only highlights the paramount importance of thwarting bacterial ingress and curbing potential leakage but also underscores the overarching objective of ensuring enduring and gratifying treatment outcomes.[3] As dental practices progressively metamorphose in the face of contemporary advancements, the establishment of a robust edifice rooted in evidence-based methodologies emerges as an unequivocal requisite for elevating treatment efficacy and optimizing the holistic well-being of patients. This historical backdrop not only serves as a testament to the discipline's resilience but also reaffirms the pressing need for perpetual adaptation and well-informed decision-making in light of the rapid strides witnessed in dental science.[34] Simultaneously, the review astutely captures the evolving emphasis on infection control within contemporary endodontic practice through its exploration of smear layer management. In an era increasingly sensitive to microbial dynamics, the discussion surrounding the repercussions of smear layer removal on treatment outcomes attests to the intricate interplay between meticulous cleaning and the realization of successful root canal interventions. This aspect finds particular resonance as practitioners navigate the intricate landscape of microbial control to augment overall patient well-being.[17,21] The review's analysis of the dichotomy between single and multiple visit treatments illuminates the multifaceted considerations that practitioners weigh in their clinical decisions. As the ethos of personalized patient care gains prominence, the analysis of these distinct treatment trajectories underscores the underlying principle of tailoring therapeutic approaches to individual cases, infection severities, patient comfort, and the ultimate ambit of treatment goals.[29]

Lastly, the review's spotlight on the dynamic realm of materials within endodontics accentuates the discipline's relentless pursuit of efficacy and innovation. The narrative's transition from traditional to contemporary materials, exemplified by the shift towards gutta-percha and titanium alloys, reverberates with the overarching spirit of progress. As material science continues to unfurl new horizons, the ability to adeptly integrate these evolving materials into the clinical paradigm assumes paramount importance, significantly impacting treatment longevity and overall success.[35]

6. Conclusion

The data presented here reveals that, in order to reconcile many of the differing perspectives in the endodontic sector, there is a significant need for adequately planned clinical investigations. The most obvious gap in the published literature is the lack of randomised clinical trials, which are required to clarify questions concerning correct management of pulpal wounds, proper medication, and the number of appointments required for treatment of infected root canals. Such studies must not only include a significant number of cases, but also take into account confounding factors. Endodontic trials also necessitate extremely extended follow-up periods in order to provide accurate conclusions. Molecular biology tools for the study of microbiology have evolved dramatically in recent years, allowing the identification of numerous novel microorganisms. In many cases, genotypic identification has supplanted classic phenotypic identification. This has resulted in fresh findings that will be useful for future research. Thus, in addition to identifying new microorganisms in the pulp area, credible information about their prevalence has been established.

This advancement in endodontic microbiology is promising, and molecular biology approaches may play an important role in creating a better understanding of the still-complex pathological process associated with apical periodontitis tissue repair in the future. However, research in this area is still in its infancy, and more work need to be done.

7. Conflicts of Interest

The authors declare no conflicts of interest.

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