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Best intracanal medicament in re-root canal treatment: A comprehensive review

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Abstract

Re-root canal treatment is a challenging procedure necessitated by the failure of initial root canal therapy, often due to persistent infections or inadequate debridement. A key determinant of success in these cases is the effective use of intracanal medicaments to eradicate resistant microorganisms, such as *Enterococcus faecalis*, and to promote periapical healing. This review evaluates the efficacy of various intracanal medicaments, including calcium hydroxide, chlorhexidine, triple antibiotic paste, and natural products, in retreatment cases. Additionally, it explores emerging trends like nanotechnology, combination therapies, and regenerative endodontics. While calcium hydroxide remains a widely used and cost-effective option, its limitations against resistant bacteria highlight the need for alternative agents and advanced formulations. The comparative analysis underscores the importance of tailored medicament selection based on case complexity and microbial challenges to optimize clinical outcomes.

Keywords: Re-root canal treatment, intracanal medicaments, calcium hydroxide, chlorhexidine, triple antibiotic paste, *Enterococcus faecalis*, biofilms, antimicrobial efficacy, regenerative endodontics, nanotechnology in endodontics

1. Introduction

1.1 Background of Re-root Canal Treatment

Re-root canal treatment (retreatment) is indicated when the initial root canal therapy fails due to factors like persistent infections, inadequate debridement, or improper sealing of the root canal system (Chong & Ford, 1992) [12]. Persistent microorganisms, particularly *Enterococcus faecalis*, are frequently associated with endodontic failures due to their ability to survive in previously treated canals (Kim & Kim, 2015) [11]. These bacteria are difficult to eradicate because of their ability to penetrate dentinal tubules, resist high pH environments, and form biofilms (Siqueira Jr., 2001) [11]. Consequently, the use of effective intracanal medicaments is critical in retreatment procedures.

1.2 Purpose of Intracanal Medicaments

Intracanal medicaments are used between treatment appointments to disinfect the root canal system and eliminate bacteria that remain after mechanical debridement (Law & Messer, 2004) [4]. The primary goals of using medicaments are to reduce bacterial loads, neutralize bacterial endotoxins, and dissolve necrotic tissue, which promotes a favourable environment for healing (Savitha *et al.*, 2019) [2]. These medicaments become essential in retreatment cases where persistent infections, such as *E. faecalis*, complicate the treatment.

1.3 Objective of the Review

This review aims to evaluate the efficacy of various intracanal medicaments used in re-root canal treatments. Specifically, it examines their antimicrobial properties, tissue compatibility, and clinical outcomes in terms of healing and symptom resolution. Furthermore, the review will highlight emerging alternatives and potential improvements in intracanal medicament protocols for enhanced treatment success (Ordinola-Zapata *et al.*, 2022) [6].

2. Microbial Challenges in Re-root Canal Treatments

2.1 Resistant Bacteria in Failed Root Canals

One of the main challenges in re-root canal treatments is the presence of resistant bacteria such as *Enterococcus faecalis* and *Candida albicans* (Kawashima *et al.*, 2009) ^[9]. These microorganisms are resilient to many traditional disinfectants and have the ability to survive in nutrient-deprived environments. Studies have shown that *E. faecalis* can endure calcium hydroxide (CaOH) treatments, as it can adapt to alkaline environments and penetrate deeply into dentinal tubules. This makes it a persistent challenge in failed root canal cases.

2.2 Biofilm Formation

Biofilms are another significant obstacle in root canal retreatment. Biofilms are communities of microorganisms that adhere to canal surfaces and are encased in a protective extracellular matrix (Estrela *et al.*, 1995) ^[14]. These structures protect bacteria from both the host's immune system and antimicrobial agents, making them difficult to eliminate. Research indicates that biofilm-forming bacteria are highly resistant to both calcium hydroxide and chlorhexidine, necessitating the use of more potent medicaments or combination therapies for effective eradication (Morsy & Nageh, 2022) ^[3].

3. Criteria for an Ideal Intracanal Medicament

3.1 Antimicrobial Efficacy

The primary requirement for any intracanal medicament is its ability to effectively eliminate a broad spectrum of microorganisms, including both aerobic and anaerobic bacteria (Silveira *et al.*, 2007) ^[8]. Medicaments should also target resistant species like *E. faecalis*, which are often implicated in re-root canal cases (Mohammadi & Abbott, 2009) ^[10]. Studies have shown that medicaments like chlorhexidine and triple antibiotic paste (TAP) provide superior antimicrobial activity compared to calcium hydroxide (Savitha *et al.*, 2019) ^[2].

3.2 Biocompatibility

Intracanal medicaments must be biocompatible, meaning they should not cause irritation or inflammation in the surrounding periapical tissues (Law & Messer, 2004) ^[4]. Biocompatible medicaments, such as calcium hydroxide, promote tissue healing and reduce postoperative pain. Newer agents, including natural products like propolis, also show promise due to their excellent tissue compatibility (Geetha *et al.*, 2014) ^[7].

3.3 Solubility and Tissue Dissolution

An ideal medicament should have tissue-dissolving properties to help clear necrotic debris from the canal system. While calcium hydroxide has limited tissue-dissolving capabilities, agents like sodium hypochlorite (often used as an irritant) are combined with medicaments to enhance their effectiveness (Kim & Kim, 2015) ^[1]. The ability of a medicament to penetrate biofilms and dissolve necrotic tissue is essential for successful retreatment.

3.4 Ease of Application and Cost-effectiveness

Intracanal medicaments must be easy to apply, cost-effective, and widely available. Calcium hydroxide, for example, is affordable and easy to manipulate, which makes

it one of the most commonly used agents in endodontics (Estrela *et al.*, 1995) ^[14]

¹. However, newer medicaments, such as TAP or natural alternatives, may be more expensive or less accessible in some regions, limiting their use in routine practice (Silveira *et al.*, 2007) ^[8].

4. Types of Intracanal Medicaments

4.1 Calcium Hydroxide (CaOH)

Calcium hydroxide has been the gold standard for intracanal medicaments due to its high pH (approximately 12.5), which inhibits bacterial growth by creating an alkaline environment that is unfavorable for most microorganisms (Orstavik, 1987) ^[18]. Its tissue-dissolving properties make it useful for clearing necrotic tissue, but studies have shown that *E. faecalis* can survive in the presence of CaOH. Furthermore, calcium hydroxide's inability to penetrate biofilms limits its effectiveness in complex re-root canal cases (Silveira *et al.*, 2007) ^[8].

4.2 Chlorhexidine (CHX)

Chlorhexidine is a broad-spectrum antimicrobial agent that is often used in endodontics due to its substantivity, meaning it continues to exert antimicrobial activity over time (Mohammadi & Abbott, 2009) ^[10]. Studies by Savitha *et al.* (2019) have shown that chlorhexidine is more effective against *E. faecalis* than calcium hydroxide, making it a preferred choice in cases where resistant bacteria are present. However, chlorhexidine's inability to dissolve necrotic tissue and its cytotoxic effects on periapical tissues limit its use as a standalone medicament (Law & Messer, 2004) ^[4].

4.3 Triple Antibiotic Paste (TAP)

Triple antibiotic paste, a combination of ciprofloxacin, metronidazole, and minocycline, has been shown to be highly effective in eliminating resistant bacteria, particularly in cases involving *E. faecalis* (Morsy & Nageh, 2022) ^[3]. However, the use of TAP is not without challenges, as prolonged application can lead to tooth discoloration due to minocycline, and concerns about antibiotic resistance have been raised (Geetha *et al.*, 2014) ^[7]. Despite these drawbacks, TAP remains a valuable option in difficult retreatment cases where traditional medicaments have failed.

4.4 Calcium Hydroxide with Additives

Recent studies have explored combining calcium hydroxide with other agents, such as chlorhexidine or corticosteroids, to enhance its antimicrobial properties and reduce postoperative pain. Calcium hydroxide with dexamethasone, for example, has been shown to significantly reduce inflammation while maintaining the antimicrobial efficacy of the calcium hydroxide base (Silveira *et al.*, 2007) ^[8]. These combinations offer a more comprehensive approach to root canal disinfection and symptom relief.

4.5 Natural Products

Natural products like propolis, aloe vera, and essential oils are gaining attention as alternative intracanal medicaments due to their biocompatibility and antimicrobial properties (Geetha *et al.*, 2014) ^[7]. Propolis, in particular, has been shown to be effective against resistant bacteria like *E. faecalis* and *Candida albicans*, while also promoting tissue

healing (Mohammadi & Abbott, 2009) ^[10]. While still in the experimental stage, these natural products offer a promising alternative to synthetic medicaments in re-root canal treatments.

5. Efficacy of Intracanal Medicaments in Re-root Canal Treatment

5.1 Calcium Hydroxide

Calcium hydroxide remains a widely used intracanal medicament, but its effectiveness in re-root canal treatment is often questioned due to its limited efficacy against resistant bacteria like *E. faecalis* (Kim & Kim, 2015) ^[11]. Studies have shown that while calcium hydroxide can reduce bacterial populations, it is less effective in eliminating biofilms and may require additional agents to achieve full disinfection (Wang *et al.*, 2006) ^[5].

5.2 Chlorhexidine

Chlorhexidine is often considered superior to calcium hydroxide in terms of antimicrobial efficacy, particularly against resistant microorganisms (Savitha *et al.*, 2019) ^[2]. Chlorhexidine's substantivity allows it to continue killing bacteria over an extended period, making it effective in retreatment scenarios. However, it is not as effective in dissolving necrotic tissue, which limits its use as a sole medicament (Mohammadi & Abbott, 2009) ^[10].

5.3 Antibiotic-based Pastes

Triple antibiotic paste has been shown to be highly effective in eliminating bacteria from re-root canal systems, especially in retreatment cases where *E. faecalis* is present (Morsy & Nageh, 2022) ^[3]. Its broad-spectrum activity targets multiple bacterial species, making it a comprehensive disinfection option. However, the risk of antibiotic resistance and potential tooth discoloration from minocycline limit its routine use (Geetha *et al.*, 2014) ^[7].

5.4 Combination Therapies

Combining calcium hydroxide with other agents, such as chlorhexidine or antibiotics, enhances its antimicrobial efficacy. These combination therapies have been shown to improve treatment outcomes, particularly in retreatment cases where resistant bacteria and biofilms are present (Silveira *et al.*, 2007) ^[8].

6. Comparative Analysis of Medicaments

6.1 Head-to-Head Comparisons

Studies comparing calcium hydroxide with chlorhexidine and TAP have shown that TAP outperforms both in terms of bacterial elimination, particularly against resistant strains like *E. faecalis* (Morsy & Nageh, 2022) ^[3]. Chlorhexidine has been shown to be more effective than calcium hydroxide in retreatment scenarios, but TAP remains the most potent agent for difficult cases (Kim & Kim, 2015) ^[11].

6.2 Success Rates and Healing Times

Calcium hydroxide has been shown to promote periapical healing, but its slower action compared to chlorhexidine and TAP may delay the resolution of symptoms (Savitha *et al.*, 2019) ^[2]. Combination therapies using calcium hydroxide and chlorhexidine have demonstrated higher success rates and faster healing times in retreatment cases (Ordinola-Zapata *et al.*, 2022) ^[6].

6.3 Pain Management

The addition of corticosteroids to calcium hydroxide has been shown to reduce postoperative pain significantly. Chlorhexidine, on the other hand, has minimal impact on pain reduction, while TAP, though effective in infection control, can cause discomfort due to its antibiotic components (Geetha *et al.*, 2014) ^[7].

6.4 Cost-effectiveness and Accessibility

Calcium hydroxide is the most cost-effective and widely available intracanal medicament, making it a practical choice for many clinicians (Orstavik, 1987) ^[18]. Chlorhexidine is slightly more expensive but offers better antimicrobial coverage, especially in resistant cases. TAP, while effective, is the most expensive option and is less commonly available due to concerns about antibiotic resistance (Morsy & Nageh, 2022) ^[3].

7. Emerging Trends in Intracanal Medicaments

7.1 Nanotechnology in Endodontics

Nanoparticles, such as silver and zinc oxide nanoparticles, are being explored as alternatives to traditional intracanal medicaments due to their antimicrobial properties and ability to penetrate biofilms (Ordinola-Zapata *et al.*, 2022) ^[6]. These nanoparticles offer enhanced disinfection and have the potential to revolutionize intracanal therapy by providing sustained antimicrobial effects (Kim & Kim, 2015) ^[11].

7.2 Regenerative Endodontics

Intracanal medicaments are playing a growing role in regenerative endodontic treatments, where the goal is to eliminate infection while promoting the regeneration of pulp tissues (Ordinola-Zapata *et al.*, 2022) ^[6]. Calcium hydroxide and antibiotic pastes have been used in revascularization protocols to support tissue healing and regeneration (Geetha *et al.*, 2014) ^[7].

7.3 Customized Medicament Formulations

With advances in diagnostic tools, it is now possible to tailor intracanal medicament formulations to the specific microbial profiles of individual patients (Kim & Kim, 2015) ^[11]. Customized treatments that address specific bacterial species offer a promising future for improved treatment outcomes in re-root canal therapy (Wang *et al.*, 2006) ^[5].

8. Clinical Recommendations

8.1 Best Practices for Selecting Medicaments

Clinicians should base their selection of intracanal medicaments on the specific needs of the case, considering factors like bacterial resistance, biofilm formation, and patient sensitivities (Kim & Kim, 2015) ^[11]. For cases involving resistant bacteria, chlorhexidine or antibiotic-based medicaments may be preferable over calcium hydroxide.

8.2 When to Use Combinations vs. Single Medicaments

Combination therapies offer enhanced disinfection in complex re-root canal cases, particularly when dealing with resistant microorganisms or biofilms (Silveira *et al.*, 2007) ^[8]. Single medicaments like calcium hydroxide may still be effective in less complicated cases, but combinations of CaOH with chlorhexidine or antibiotics should be

considered for more challenging infections (Savitha *et al.*, 2019)^[2].

8.3 Recommendations Based on Current Evidence

Based on current evidence, calcium hydroxide remains a reliable option for routine cases, while chlorhexidine and TAP should be reserved for more complex retreatments involving resistant infections (Ordinola-Zapata *et al.*, 2022)^[6]. Combination therapies show promise for achieving better outcomes in difficult cases (Morsy & Nageh, 2022)^[3].

9. Future Directions

9.1 Gaps in Current Research

While there has been extensive research on the efficacy of various intracanal medicaments, there is still a need for long-term clinical trials comparing the outcomes of different combinations and formulations (Geetha *et al.*, 2014)^[7]. More studies are needed to understand the full potential of newer agents like nanomedicines and natural products (Ordinola-Zapata *et al.*, 2022)^[6].

9.2 Innovations on the Horizon

Advances in nanotechnology and biologically active materials offer exciting possibilities for the future of intracanal therapy. Customized drug delivery systems that provide sustained antimicrobial effects could revolutionize the way we approach disinfection in root canal treatments (Kim & Kim, 2015)^[1].

10. Conclusion

In re-root canal treatments, calcium hydroxide remains a widely used and cost-effective intracanal medicament. However, its limitations, particularly against resistant bacteria, have led to the development and use of alternative agents like chlorhexidine and antibiotic-based pastes. Combination therapies show promise for improving treatment outcomes in difficult cases. Emerging trends in nanotechnology and regenerative endodontics offer new opportunities for enhanced disinfection and tissue healing in root canal treatments.

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