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Comparative study of calcium hydroxide versus triple antibiotic paste as intracanal medicaments

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Abstract:

Persistent microorganisms, particularly *Enterococcus faecalis*, may survive chemomechanical preparation and compromise root canal disinfection, necessitating effective intracanal medicaments. Therefore, it is of interest to evaluate the 100 patients with necrotic single-rooted teeth, randomly allocated to calcium hydroxide (n=50) or triple antibiotic paste (n=50), assessing postoperative pain and microbial reduction. Triple antibiotic paste produced significantly greater pain reduction at 24, 48 and 72 hours ($p=0.01$, 0.002 and 0.01) and greater microbial reduction (99.1% vs. 96.8%; $p=0.001$) than calcium hydroxide. Both medicaments were effective, but triple antibiotic paste provided superior antimicrobial activity and faster pain relief against persistent endodontic infection. Thus, data shows triple antibiotic paste as an effective intracanal medicament while emphasizing individualized selection based on clinical needs and potential risks such as tooth discoloration and antibiotic resistance.

Keywords: Calcium hydroxide; triple antibiotic paste (TAP); intracanal medicament; root canal disinfection; *Enterococcus faecalis*; endodontics

Background:

Endodontic infections are mostly polymicrobial and they entail intricate biofilm communities that exist in the root canal system. Removal of these microorganisms and prevention of reinfection is the key to the success of root canal therapy. Although there has been an improvement in instrumentation methods and irrigating solutions, the root canal system is not fully disinfected because of the complexities of the anatomy like lateral canals, isthmuses and dentinal tubules [1]. Research has established that despite rigorous chemo mechanical treatment, a substantial percentage of canal walls is not destroyed, leaving behind any remaining bacteria [2]. *Enterococcus faecalis* is the most commonly isolated microorganism among the many microorganisms implicated in persistent endodontic infections. It is a significant cause of endodontic treatment failure due to its capacity to enter dentinal tubules, endure in the most adverse conditions and withstand intracanal medicaments [3]. Thus, intracanal medicaments are necessary to promote the removal of microbes between treatment sessions. Calcium hydroxide (Ca(OH)₂) has traditionally been regarded as the gold standard intracanal medicament because of its high alkalinity (pH 12.5), antimicrobial effect and periapical healing-promoting effect. It works by releasing hydroxyl ions, which damage the cell membranes of bacteria, denature proteins and disrupt DNA replication. Calcium hydroxide also promotes the growth of hard tissue and is commonly employed in apexification. Nonetheless, it is not effective against some resistant microorganism's especially *E. faecalis* because the organism can

withstand alkaline conditions [4]. In order to address these shortcomings, intracanal medicaments based on antibiotics have been proposed. Of these, triple antibiotic paste (TAP) which is a combination of ciprofloxacin, metronidazole and minocycline has become very popular. TAP offers a wide range of antimicrobial protection against aerobic and anaerobic microorganisms. Metronidazole is active against obligate anaerobes, ciprofloxacin against gram-negative and minocycline against gram-positive. Such a combination guarantees a thorough disinfection of the root canal system [5]. A number of studies have shown better antimicrobial activity of TAP over calcium hydroxide especially in *E. faecalis* biofilms [6]. In a meta-analysis, it was reported that antibiotic pastes such as TAP had a much higher antibacterial activity compared to calcium hydroxide in *ex vivo* tests [7]. Likewise, *in vivo* experiments have shown that TAP can lead to improved clinical outcomes, such as decreased post-operative pain and increased healing rates [8]. Nevertheless, in other studies, it is proposed that both medicaments can have similar efficacy in some clinical conditions, especially regarding periapical healing [9]. Although TAP has its benefits, it is not devoid of limitations. Minocycline may lead to tooth discoloration and its long-term use could lead to antibiotic resistance. Also, TAP has been linked to decreased dentin microhardness, which could impact tooth strength [10]. Therefore, it is of interest to compare and contrast calcium hydroxide and triple antibiotic paste regarding antimicrobial effectiveness, pain relief and clinical outcomes of patients receiving root canal therapy.

Materials and Methodology:**Study design:**

This study was designed as a prospective, randomized comparative clinical study conducted in the Department of Conservative Dentistry and Endodontics at a tertiary care dental institution.

Study population:

A total of 100 patients requiring root canal treatment were selected based on predefined inclusion and exclusion criteria.

Inclusion criteria:

- [1] Patients aged between 18–60 years
- [2] Teeth diagnosed with necrotic pulp with or without periapical pathology
- [3] Single-rooted teeth indicated for primary endodontic treatment
- [4] Patients providing informed consent

Exclusion criteria:

- [1] Patients with systemic diseases affecting healing (*e.g.*, uncontrolled diabetes)
- [2] Teeth with previous endodontic treatment
- [3] Pregnant or lactating women
- [4] Teeth with root resorption or fractures
- [5] Patients allergic to antibiotics

Sample size and grouping:

The total sample size of 100 patients was randomly divided into two equal groups:

- [1] **Group I (n = 50):** Calcium hydroxide as intracanal medicament
- [2] **Group II (n = 50):** Triple antibiotic paste as intracanal medicament

Randomization was performed using a computer-generated random number table.

Clinical procedure:**Pre-operative assessment:**

- [1] Detailed history and clinical examination
- [2] Radiographic evaluation using intraoral periapical radiographs
- [3] Baseline pain recorded using Visual Analog Scale (VAS)

Access opening and cleaning:

- [1] Local anesthesia administered
- [2] Rubber dam isolation achieved
- [3] Access cavity prepared using sterile burs
- [4] Working length determined using apex locator and radiograph

Biomechanical preparation:

- [1] Cleaning and shaping performed using rotary instruments
- [2] Irrigation with 2.5% sodium hypochlorite and saline
- [3] Final rinse with EDTA to remove smear layer

Preparation of intracanal medicaments:

- [1] **Calcium Hydroxide:** Prepared by mixing calcium hydroxide powder with saline or propylene glycol to form a paste and introduced into the canal using a lentulo spiral.
- [2] **Triple Antibiotic Paste (TAP):** Prepared by mixing powdered forms of ciprofloxacin, metronidazole and minocycline in appropriate proportions to achieve a paste-like consistency, which was then placed into the canal.

Placement and sealing:

The intracanal medicament was placed in the canal and the access cavity was sealed with a temporary restorative material. Patients were recalled after 7 days.

Outcome measures:**[1] Pain assessment:**

Evaluated using VAS at 24, 48 and 72 hours

[2] Microbial reduction:

Microbial samples collected before and after medicament placement

Colony-forming units (CFU) counted

[3] Clinical and radiographic healing:

Assessed at follow-up visits

Statistical analysis:

Data were analyzed using SPSS software.

- [1] Continuous variables expressed as mean $\pm$ standard deviation
- [2] Comparison between groups done using Student's t-test
- [3] Categorical variables analyzed using Chi-square test
- [4] p-value < 0.05 considered statistically significant

Results:

A total of 100 patients were included in the study and equally divided into two groups: Group I (Calcium Hydroxide, n = 50) and Group II (Triple Antibiotic Paste, n = 50). The data were analyzed for pain reduction, microbial load reduction and clinical healing outcomes. The mean age of patients in both groups was comparable, with no statistically significant difference ($p = 0.72$). Gender distribution showed a slight male predominance (54%) compared to females (46%), but this difference was not statistically significant ($p = 0.68$). This indicates that both groups were demographically comparable, eliminating selection bias (**Table 1**). At baseline, both groups showed similar pain levels ($p = 0.81$). However, at 24 hours, patients treated with TAP demonstrated a significantly greater reduction in pain (mean VAS 4.1) compared to calcium hydroxide (mean VAS 5.2), with $p = 0.01$. At 48 and 72 hours, this difference became more pronounced, with TAP showing faster pain relief ($p = 0.002$ and $p = 0.01$ respectively). Overall, TAP achieved approximately 85% reduction in pain by 72 hours, compared to 76% in the calcium hydroxide group, indicating superior analgesic and antimicrobial action (**Table 2**). Both groups showed a substantial reduction in microbial load after intracanal medicament placement. However, TAP showed

significantly greater antimicrobial efficacy, reducing bacterial count by 99.1%, compared to 96.8% with calcium hydroxide ($p = 0.001$). This indicates that TAP is more effective in eliminating resistant microorganisms such as *E. faecalis* (Table 3).

Table 1: Demographic distribution of study population

Parameter	Calcium (n=50)	Hydroxide	TAP (n=50)	Total (%)	p-value
Mean Age (years)	38.6 ± 10.2		37.9 ± 9.8	—	0.72
Male	28 (56%)		26 (52%)	54%	0.68
Female	22 (44%)		24 (48%)	46%	

Table 2: Comparison of Pain Scores (VAS) between groups

Time Interval	Calcium Hydroxide (Mean ± SD)	TAP (Mean ± SD)	p-value
Baseline	7.6 ± 1.2	7.5 ± 1.3	0.81
24 hours	5.2 ± 1.4	4.1 ± 1.2	0.01*
48 hours	3.4 ± 1.1	2.2 ± 1.0	0.002*
72 hours	1.8 ± 0.9	1.1 ± 0.7	0.01*

(*Statistically significant)

Table 3: Comparison of microbial reduction (CFU Count)

Parameter	Calcium Hydroxide	TAP	p-value
Pre-treatment CFU	1.2×10^5	1.3×10^5	0.64
Post-treatment CFU	3.8×10^3	1.2×10^3	0.001*
% Reduction	96.8%	99.1%	

(*Statistically significant)

Discussion:

The current research was carried out to compare clinical and antimicrobial efficacy of calcium hydroxide and triple antibiotic paste (TAP) as intracanal medicaments in endodontic treatment. The results showed that both medicaments were effective in alleviating pain and microbial load, but TAP showed better results in the majority of clinical parameters. The demographic analysis revealed that there was no statistically significant difference in the age and gender distribution of the two groups and this guarantees comparability and reduction of confounding factors. The same has been observed in other clinical trials that have been conducted in the past and it is found that the demographics of patients do not have a significant impact on the efficacy of intracanal medicaments [2]. The decrease in pain is an important sign of the effectiveness of treatment and patient comfort. In the current research, the two groups showed a slow reduction in pain scores with time, but the TAP group showed quicker pain relief at all the post-treatment periods. This observation aligns with the studies that have indicated that TAP is effective in offering fast symptomatic relief because it has a wide-range of antimicrobial activity [11]. The synergy of antibiotics in TAP covers a broad spectrum of microorganisms, resulting in faster healing of inflammation and related pain. Calcium hydroxide, which is commonly employed, is not very effective against some of the resistant bacteria like *Enterococcus faecalis*. This organism can survive in high PH conditions, lowering the effectiveness of calcium hydroxide [6]. TAP, on the other hand, is a combination of ciprofloxacin, metronidazole and minocycline, which attack different bacterial populations. This synergistic effect increases the eradication of bacteria and leads to better clinical outcomes [7]. Microbial analysis in this study showed that there was a significant reduction in colony-forming

units (CFU) in the TAP group than the calcium hydroxide group. These findings are consistent with those of systematic reviews and meta-analyses that have repeatedly showed that antibiotic-based medicaments have a better antimicrobial effect than calcium hydroxide [9]. A research by Hoshino *et al.* has highlighted that the polymicrobial character of endodontic infections requires combination antibiotic therapy to be used in order to achieve effective disinfection [10]. Although TAP has its benefits, it has some limitations that should be taken into account. Tooth discoloration due to minocycline is one of the greatest concerns. A number of studies have proposed the use of alternative antibiotics like clindamycin to mitigate this side effect of minocycline [11]. Moreover, the long-term use of antibiotic pastes can also lead to the emergence of antimicrobial resistance, which is an increasingly significant problem worldwide [12, 13]. Thus, the TAP should be used judiciously. Instead, calcium hydroxide is an effective and inexpensive intracanal medicament. Its capacity to stimulate the formation of hard tissue and periapical healing makes it especially valuable in certain clinical conditions like apexification [14]. Nevertheless, its lower antimicrobial activity, as seen in this study, limits its usefulness in situations involving resistant bacterial strains. The other significant conclusion of this research was that both medicaments showed high microbial reduction (>95%), which suggests that intracanal medicaments are important in supplementing mechanical preparation in improving root canal disinfection. This promotes the idea that the endodontic therapy should be performed using a combination of chemo mechanical preparation and intracanal medication [8, 15]. This study finding are consistent with the current literature, which indicates that although calcium hydroxide is still a common intracanal agent, TAP has better antimicrobial effect and clinical outcome. Nevertheless, the selection of medicament must be made according to the needs of the particular case, taking into account such factors as the severity of the infection, the condition of the patient and the possibility of adverse reactions. The drawbacks of the current study are a relatively short follow-up and the lack of long-term radiographic assessment. It is suggested that future research involving larger sample sizes and longer follow-ups should be conducted to confirm these results and determine long-term outcomes.

Conclusion:

Calcium hydroxide and triple antibiotic paste were both effective intracanal medicaments, with triple antibiotic paste demonstrating greater antimicrobial activity and faster pain reduction. Despite these advantages, the potential for tooth discoloration and antibiotic resistance should be considered, while calcium hydroxide remains a feasible and cost-effective option where hard tissue formation is desired. These findings support individualized selection of intracanal medicaments based on clinical requirements and patient considerations.

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