Original Research

Radiological Outcome of Calcium Hydroxide as A Root Canal Sealer Constituent

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Abstract

Background: *The effectiveness of root canal sealers plays a crucial role in the success of endodontic treatments by preventing microbial leakage and promoting periapical healing. This study aimed to compare the radiological outcomes of calcium hydroxide-based sealers and zinc oxide eugenol sealers in treating teeth with periradicular pathosis.*

Methods: *This cross-sectional observational study was conducted at different private clinics, Dhaka, Bangladesh during the period from January 2019 to December 2019. A total of 60 permanent teeth with periradicular pathosis were randomly assigned into two groups: Group 1 (n=30), treated with zinc oxide eugenol sealer, and Group 2 (n=30), treated with calcium hydroxide-based sealer. Clinical evaluations were conducted on days 2 and 7 post-treatment, and radiological evaluations were performed at 3, 6, and 12 months. Data were analyzed using SPSS version 22.*

Results: *The majority of participants were aged 11-30 years, with a higher proportion of males in both groups. Trauma was the leading etiological factor, with maxillary teeth being more frequently affected. Group 2 showed significantly better radiological outcomes, with 80.00% exhibiting reduced periapical pathosis size at 3 months, compared to 26.67% in Group 1 ($p < 0.001$). At 6 months, 93.33% of Group 2 showed reduced pathosis size, compared to 60.00% in Group 1 ($p = 0.002$). At 12 months, 96.67% of Group 2 and 83.33% of Group 1 showed reduced pathosis size ($p = 0.194$). The final success rate was 96.67% in Group 2 and 86.67% in Group 1, with no statistically significant difference ($p = 0.353$).*

Conclusion: *Calcium hydroxide-based sealers provide superior radiological outcomes compared to zinc oxide eugenol sealers in the treatment of teeth with periradicular pathosis. These findings support the use of calcium hydroxide sealers for enhanced endodontic treatment outcomes.*

Introduction

Endodontic treatments are pivotal in preserving teeth that have been compromised by infection or decay. The primary goal of these treatments is to eliminate pathogenic microorganisms from the root canal system and to prevent reinfection by sealing the canal effectively. This sealing process is crucial for the success of endodontic therapy, as it prevents microbial leakage, which can lead to periapical inflammation and treatment failure[1]. Root canal sealers play a significant role in achieving this seal, acting as a filler between the core filling material and the canal walls, thus enhancing the hermetic seal and promoting healing[2]. Historically, various materials have been employed as root canal sealers, each with unique properties that influence their performance. Among these, calcium hydroxide has been extensively studied and used in endodontics due to its therapeutic properties. Introduced by Herman in 1920, calcium hydroxide is renowned for its high pH, which imparts potent antibacterial effects and the ability to promote the formation of hard tissue[3].

These properties make calcium hydroxide a valuable constituent in root canal sealers, contributing to its continued use in contemporary endodontic practices[4]. Different types of root canal sealers are available, each with distinct physical and biological properties. These include zinc oxide-eugenol-based, resin-based, glass ionomer-based, and calcium hydroxide-based sealers. Zinc oxide-eugenol sealers, such as Tubliseal, are known for their antimicrobial properties and ease of use but may cause irritation and discoloration[5]. Resin-based sealers, like AH Plus, offer strong adhesion and durability but can be cytotoxic[6]. Glass ionomer-based sealers, such as Ketac Endo, provide good biocompatibility and fluoride release but have limited sealing ability[7]. Calcium hydroxide-based sealers, exemplified by Sealapex, combine high pH and calcium ion release to enhance healing and provide an alkaline environment conducive to tissue repair[8]. Radiological evaluation plays a critical role in endodontics, from diagnosis to treatment planning and follow-up. The significance of radiopacity in root canal sealers cannot be overstated, as it allows for the visualization of the sealer within the canal on radiographs, facilitating the assessment of the quality of the seal and the detection of voids or overextensions[9]. Traditional periapical radiography has been the mainstay of radiographic evaluation in endodontics. However, it presents limitations such as geometric distortion and the inability to visualize three-dimensional structures accurately[10]. Cone-beam computed tomography (CBCT) has emerged as a superior diagnostic tool, providing detailed three-dimensional images that overcome the limitations of periapical radiographs and offer enhanced diagnostic accuracy for complex cases[11]. The importance of radiological follow-up in assessing the success of root canal treatments cannot be underestimated. Regular radiographic evaluations allow clinicians to monitor the healing process and identify any complications early. Studies have shown that CBCT is particularly effective in detecting periapical pathologies, missed canals, and root fractures that may not be visible on conventional radiographs[12]. The therapeutic benefits of calcium hydroxide in root canal sealers are well-documented. Its high pH creates an unfavorable environment for bacterial growth, while its calcium ion release promotes the formation of a mineralized barrier, facilitating the healing of periapical tissues[6]. Studies comparing different sealers have found that calcium hydroxide-based sealers exhibit superior biocompatibility and sealing ability compared to traditional zinc oxide-eugenol and resin-based sealers. For example, Huang et al. (2001) and Rajesh et al. (2000) reported that Sealapex, a calcium hydroxide-based sealer, showed minimal cytotoxicity and excellent sealing properties, making it a preferred choice in endodontic therapy[5,7]. Despite these advantages, there are limitations to the use of calcium hydroxide-based sealers. They may not provide the same level of radiopacity as other sealers, which can complicate radiographic evaluation. Additionally, their solubility in tissue fluids can lead to degradation over time, potentially compromising the seal[9]. Therefore, ongoing research is essential to optimize the formulation of calcium hydroxide-based sealers and enhance their radiological and clinical performance.

Methods

This cross-sectional observational study was conducted at different private clinics, Dhaka, Bangladesh during the period from January 2019 to December 2019. A total of 60 permanent teeth were selected from patients purposively chosen from the outpatient department. These patients had teeth with periradicular pathosis and were randomly assigned into two groups, with 30 patients in each group. Group 1 (ZOE group) consisted of patients treated with single-visit root canal therapy and obturated with a zinc oxide eugenol sealer. Group 2 ($Ca(OH)_2$ group) included patients treated with single-visit root canal therapy and obturated with a calcium hydroxide-containing sealer (Sealapex). All patients were recalled for clinical evaluation on days 2 and 7 after the completion of treatment. Radiological evaluations of periapical pathosis were conducted at 3 months, 6 months, and 12 months post-treatment. Patient complaints were recorded in a data sheet during these follow-up visits. The collected data were analyzed using standard statistical methods with SPSS version 22 software and Microsoft Excel.

Results

Table 1: Distribution of demographic characteristics among the participants (N=60)

Baseline	Group 1 (n=30)		Group 2 (n=30)	
	n	%	n	%
Age				
11-20	8	26.67%	12	40.00%
21-30	14	46.67%	11	36.67%
31-40	5	16.67%	5	16.67%
41-50	3	10.00%	1	3.33%
51-60	0	0.00%	1	3.33%
Gender				
Male	20	66.67%	17	56.67%
Female	10	33.33%	13	43.33%

In terms of age distribution, Group 1 had 26.67% (n=8) of participants aged 11-20 years, 46.67% (n=14) aged 21-30 years, 16.67% (n=5) aged 31-40 years, 10.00% (n=3) aged 41-50 years, and none aged 51-60 years. Group 2 had 40.00% (n=12) of participants aged 11-20 years, 36.67% (n=11) aged 21-30 years, 16.67% (n=5) aged 31-40 years, 3.33% (n=1) aged 41-50 years, and 3.33% (n=1) aged 51-60 years. Regarding gender distribution, Group 1 consisted of 66.67% (n=20) male participants and 33.33% (n=10) female participants. In Group 2, 56.67% (n=17) were male and 43.33% (n=13) were female.

Table 2: Distribution of etiological factors among the participants (N=60)

Etiological factors	Group 1 (n=30)		Group 2 (n=30)	
	n	%	n	%
Trauma	21	70.00%	18	60.00%
Leaking restoration	3	10.00%	4	13.33%
Caries	4	13.33%	6	20.00%
Occlusal trauma	1	3.33%	1	3.33%
Others	1	3.33%	1	3.33%

In Group 1, the predominant etiological factor was trauma, affecting 70.00% (n=21) of participants. This was followed by caries, which affected 13.33% (n=4) of participants. Leaking restorations were identified in 10.00% (n=3) of participants, while occlusal trauma and other factors each affected 3.33% (n=1) of participants. In Group 2, trauma was also the most common etiological factor, affecting 60.00% (n=18) of participants. Caries was identified in 20.00% (n=6) of participants, and leaking restorations were found in 13.33% (n=4). Both occlusal trauma and other factors affected 3.33% (n=1) of participants.

Table 3: Distribution of type of tooth affected among the participants (N=60)

Type of tooth	Group 1 (n=30)		Group 2 (n=30)	
	n	%	n	%
Maxillary	17	56.67%	19	63.33%
Mandibular	13	43.33%	11	36.67%

In Group 1, 56.67% (n=17) of the affected teeth were maxillary, while 43.33% (n=13) were mandibular. In Group 2, the distribution was similar, with 63.33% (n=19) of the affected teeth being maxillary and 36.67% (n=11) being mandibular.

Table 4: Distribution of patients by pre-operative signs and symptoms (n=60)

Signs and Symptoms	Group 1 (n=30)		Group 2 (n=30)	
	n	%	n	%
Pain	23	76.67%	27	90.00%
Swelling	4	13.33%	8	26.67%
Tenderness on percussion	25	83.33%	23	76.67%
Discharging sinus	1	3.33%	16	53.33%

In Group 1, the most common pre-operative symptom was pain, reported by 76.67% (n=23) of participants. Tenderness on percussion was observed in 83.33% (n=25) of participants, swelling was noted in 13.33% (n=4), and a discharging sinus was present in 3.33% (n=1). In Group 2, pain was the most prevalent symptom, affecting 90.00% (n=27) of participants. Tenderness on percussion was observed in 76.67% (n=23), swelling in 26.67% (n=8), and a discharging sinus in 53.33% (n=16).

Table 5: Distribution of participants by radiological evaluation at different follow-ups (N=60)

Radiological Evaluation	Group 1 (n=30)		Group 2 (n=30)		p-value
	n	%	n	%	
At 3 months					
Static	22	73.33%	6	20.00%	<0.001
Reduced size	8	26.67%	24	80.00%	
Increased size	0	0.00%	0	0.00%	
At 6 months					
Static	12	40.00%	2	6.67%	0.002
Reduced size	18	60.00%	28	93.33%	
Increased size	0	0.00%	0	0.00%	
At 12 months					
Static	5	16.67%	1	3.33%	0.194
Reduced size	25	83.33%	29	96.67%	
Increased size	0	0.00%	0	0.00%	

At the 3-month follow-up, 73.33% (n=22) of participants in Group 1 showed static radiological findings, while 26.67% (n=8) exhibited a reduced size of periapical pathosis. In Group 2, 20.00% (n=6) of participants had static findings, and a significant 80.00% (n=24) demonstrated a reduced size of periapical pathosis. No participants in either group showed an increase in the size of periapical pathosis. The difference between the groups was statistically significant with a p-value of <0.001. At the 6-month follow-up, 40.00% (n=12) of participants in Group 1 had static radiological findings, while 60.00% (n=18) showed a reduced size of periapical pathosis. In Group 2, only 6.67% (n=2) of participants had static findings, whereas a substantial 93.33% (n=28) exhibited a reduced size of periapical pathosis. Again, no participants in either group showed an increase in the size of periapical pathosis. The difference between the groups was statistically significant with a p-value of 0.002. At the 12-month follow-up, 16.67% (n=5) of participants in Group 1 had static radiological findings, while 83.33% (n=25) showed a reduced size of periapical pathosis. In Group 2, 3.33% (n=1) of participants had static findings, and 96.67% (n=29) demonstrated a reduced size of periapical pathosis. No participants in either group showed an increase in the size of periapical pathosis. The difference between the groups was not statistically significant with a p-value of 0.194.

Table 6: Distribution of patients by final radiological outcome (N=60)

Final Outcome	Group 1 (n=30)		Group 2 (n=30)		p-value
	n	%	n	%	
Success	26	86.67%	29	96.67%	0.353
Doubtful	4	13.33%	1	3.33%	
Failure	0	0.00%	0	0.00%	

In Group 1, 86.67% (n=26) of participants achieved a successful radiological outcome, while 13.33% (n=4) had a doubtful outcome. There were no cases of failure in this group. In Group 2, a higher success rate was observed, with 96.67% (n=29) of participants achieving a successful radiological outcome, and only 3.33% (n=1) having a doubtful outcome. Similarly, there were no cases of failure in this group. The difference in the final radiological outcomes between Group 1 and Group 2 was not statistically significant, with a p-value of 0.353.

Discussion

The present study aimed to evaluate the radiological outcomes of using calcium hydroxide ($Ca(OH)_2$) as a root canal sealer constituent compared to zinc oxide eugenol (ZOE) in the treatment of teeth with periradicular pathosis. Our findings indicated that calcium hydroxide-based sealers demonstrated superior radiological outcomes at various follow-up intervals, which aligns with the established literature. The age distribution in our study showed that the majority of participants were aged 11-30 years, with a higher proportion of males in both groups. This demographic trend is consistent with previous studies that have reported a higher prevalence of

endodontic treatments among younger adults and a slightly higher incidence in males[13,14]. Trauma was identified as the leading etiological factor in both groups, affecting 70.00% in Group 1 and 60.00% in Group 2, which is supported by the literature emphasizing trauma as a common cause of endodontic treatment needs, especially in younger populations[15,16]. In terms of tooth type, maxillary teeth were more frequently affected in both groups, with 56.67% in Group 1 and 63.33% in Group 2. This finding corroborates with studies indicating a higher incidence of trauma and endodontic treatment needs in maxillary teeth due to their prominence and exposure to injury[17,18]. Pre-operative signs and symptoms such as pain, tenderness on percussion, swelling, and discharging sinus were prevalent, with pain being the most common symptom, particularly in Group 2. This aligns with the findings of studies highlighting the significance of these clinical signs in diagnosing periradicular pathosis and the need for endodontic intervention[5,19]. At the 3-month follow-up, Group 2 ($Ca(OH)_2$) demonstrated a significantly higher percentage of reduced periapical pathosis size (80.00%) compared to Group 1 (ZOE) at 26.67% ($p < 0.001$). This trend continued at the 6-month follow-up, where 93.33% of Group 2 showed reduced pathosis size compared to 60.00% in Group 1 ($p = 0.002$), and at the 12-month follow-up, with 96.67% in Group 2 versus 83.33% in Group 1 ($p = 0.194$). These findings are consistent with the literature, which highlights the enhanced healing properties of calcium hydroxide due to its high pH, antibacterial effects, and ability to promote hard tissue formation[3,4]. Studies have demonstrated that calcium hydroxide-based sealers are effective in reducing periapical lesions and enhancing radiological outcomes[2,20]. The final radiological outcome revealed a success rate of 86.67% in Group 1 and 96.67% in Group 2, with no statistically significant difference ($p = 0.353$). The success rates in our study are comparable to other studies reporting high success rates for both calcium hydroxide and zinc oxide eugenol sealers, albeit with a slight advantage for calcium hydroxide[21,22]. Previous research has shown that calcium hydroxide sealers result in higher success rates due to their superior antibacterial properties and biocompatibility, which facilitate better healing and reduced recurrence of periapical lesions[23,24]. In conclusion, the findings of this study indicate that calcium hydroxide-based sealers provide superior radiological outcomes compared to zinc oxide eugenol sealers in the treatment of teeth with periradicular pathosis. These results are consistent with existing literature and support the use of calcium hydroxide as a preferred root canal sealer constituent for enhancing endodontic treatment outcomes. Future studies should continue to explore the long-term benefits and potential improvements in formulation and application techniques for calcium hydroxide-based sealers to further optimize endodontic success rates.

Limitations of The Study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

Conclusion

This study demonstrates that calcium hydroxide-based sealers provide superior radiological outcomes compared to zinc oxide eugenol sealers in the treatment of teeth with periradicular pathosis. The findings indicate a higher success rate and greater reduction in periapical pathosis size with calcium hydroxide sealers, supporting their use as a preferred constituent in root canal treatments. These results align with existing literature, emphasizing the efficacy and biocompatibility of calcium hydroxide-based sealers. Future research should focus on optimizing these sealers and exploring their long-term benefits to further enhance endodontic treatment outcomes.

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