ORIGINAL RESEARCH

Radiographical Assessment of Periapical Lesion Resolution Following Nonsurgical Root Canal Treatment with Different Irrigation Protocols and Intracanal Medicaments

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Abstract

Aim: To evaluate healing following nonsurgical treatment of periapical lesions using different intracanal medicaments and irrigation protocols.

Materials and methods: Seventy-eight patients having periapical lesion were selected and randomly allocated into six equal groups based on the irrigation protocol followed and the intracanal medicament administered. The groups allocated were: positive pressure irrigation group (group I) and negative pressure irrigation group (group II). The subgroups were modified triple antibiotic paste (group Ia/IIa), photoactivated disinfection (group Ib/IIb), and calcium hydroxide (group Ic/IIc) subgroups. The patients were assessed radiographically based on the designated parameters at intervals of 3, 6, and 12 months. The data obtained were analyzed using one-way ANOVA with GPower software version 3.0. Kruskal Wallis test and Friedman test were used for intergroup comparison. An alpha level of 5% (p-value was <0.05) was considered significant.

Results: Group II showed significantly better results than group I at 6 and 12 months ($p = 0.042, 0.029$). Group IIb showed the best healing at all time frames. Groups Ia and IIa showed better healing than group Ic and IIc at 6 and 12 months. Groups Ic & IIc showed the least amount of healing.

Conclusion: The use of photoactivated disinfection (PAD) as an intracanal medicament and negative pressure irrigation for canal disinfection resulted in superior healing of periapical lesions.

Clinical significance: Photoactivated disinfection resulted in superior canal disinfection followed by triple antibiotic paste and with negative pressure irrigation eventualized in better healing of periapical lesions. Calcium hydroxide was the least effective in canal disinfection and periapical lesion healing.

Keywords: Calcium hydroxide, Modified triple antibiotic paste, Periapical diseases, Photoactivated disinfection.

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Introduction

Studies have reported a success rate of up to 85% incomplete healing of large periapical lesions after nonsurgical endodontic treatment.[1] The success largely depends on the eradication of microorganisms from root canals, as they are crucial for pulpo periapical pathosis.[2] Literature states that 35% or more of the canal system remains untouched during biomechanical preparation due to anatomical complexities.[3] This finding addresses the importance of the use of supplemental means of canal disinfection by various irrigating solutions.[4] Sodium hypochlorite is considered as the gold standard amongst all available root canal disinfecting agents.[4]

In conventional/positive pressure irrigation, there is the possibility of periapical extrusion of irrigants, which may cause periapical tissue injury in the form of periapical tissue necrosis, pain, swelling, periapical bleeding, and delay in the repair process.[3–6] The negative pressure irrigation system [Endovac (SybronEndo, Orange, CA)] was thus introduced to address this issue. Here, the irrigant from the access cavity is drawn apically and is finally removed *via* suction.[4] Studies using Endovac have shown increased efficacy of irrigation at working length, increased sealer penetration, and no periapical extrusion of irrigants with its associated complications.[3,7]

There are studies advocating the use of antimicrobial intracanal medicaments in combination with mechanical cleansing for improving the outcome of nonsurgical root canal therapy.[2] These medicaments favor the elimination of bacterial flora and simultaneously decrease the ingress of pathogenic microorganisms into the canals.[6,8] Calcium hydroxide and triple antibiotic paste (TAP) are the most commonly used medicaments and can eliminate root canal pathogens due to their alkalinity and broad-spectrum activity, respectively.[2,9–12] Minocycline in TAP has a major drawback of inducing tooth discoloration, to counteract this cefaclor is substituted to form modified triple antibiotic paste (MTAP).[13]

The success of endodontic therapy has been reported to have increased dramatically with the introduction of lasers.[14] They provide better access to unreachable parts of the root canal system.[15] Recently, low power laser along with dyes or photosensitizers (PSs) such as toluidine blue, methylene blue, chlorine p6, etc., has been used as a medicament for root canal disinfection, which is known as photoactivated

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disinfection (PAD). Various studies on PAD have stated that the use of PAD resulted in maximum elimination of microorganisms, especially E. Faecalis.[4]

Although the antibacterial efficacy of TAP, calcium hydroxide, and PAD has been studied, but there is only one *in vivo* study evaluating the nonsurgical healing of large periapical lesions using TAP, calcium hydroxide, and PAD. There are no *in vivo* studies evaluating the nonsurgical healing of large periapical lesions using MTAP nor are there any clinical studies evaluating the effect of positive or negative irrigation on the healing of periapical lesions. Thus, the aim of this study was to evaluate the healing following nonsurgical treatment of periapical lesions using different intracanal disinfectants in combination with two different irrigation protocols.

Subjects and Methods

This *in vivo* study [KIMS/KIIT/IEC/184/2018] was conducted on patients who reported to the Department of Conservative Dentistry and Endodontics, KIDS, Bhubaneswar.

G power software (version 3.0) was used for sample size determination. A total sample size of 78 teeth was chosen (39 in each group and 13 in each subgroup), which was sufficient for an alpha of 0.05, 80% power with a 10% drop-out anticipation. After obtaining informed consent from the patients and excluding those who did not meet the inclusion criteria, they were assigned to different intervention groups randomly by a blinded nurse.

A simple randomization technique using computer software (www.random.org) was employed to allocate patients to different groups. The type of intervention to be instituted was concealed in an envelope that was later opened by the operator at the time of intervention (Fig. 1).

Inclusion Criteria

Patients:

- Age: 18–30 years.
- Single rooted maxillary/mandibular anterior teeth.
- Periapical lesion in the maxillary/mandibular anterior region (PAI score: 3–5).

Exclusion Criteria

Patients with:

- Positive response to allergic patch test.
- Previously endodontically treated teeth.
- History of any systemic disease.
- Pregnancy or lactating.
- Vertical root fracture.
- Calcific degeneration/external or internal root resorption.

Clinical Procedure

After anesthesia and isolation, access opening was performed and working length determined using an electronic apex locator (Dentsply Maillefer) and confirmed radiographically. In cases

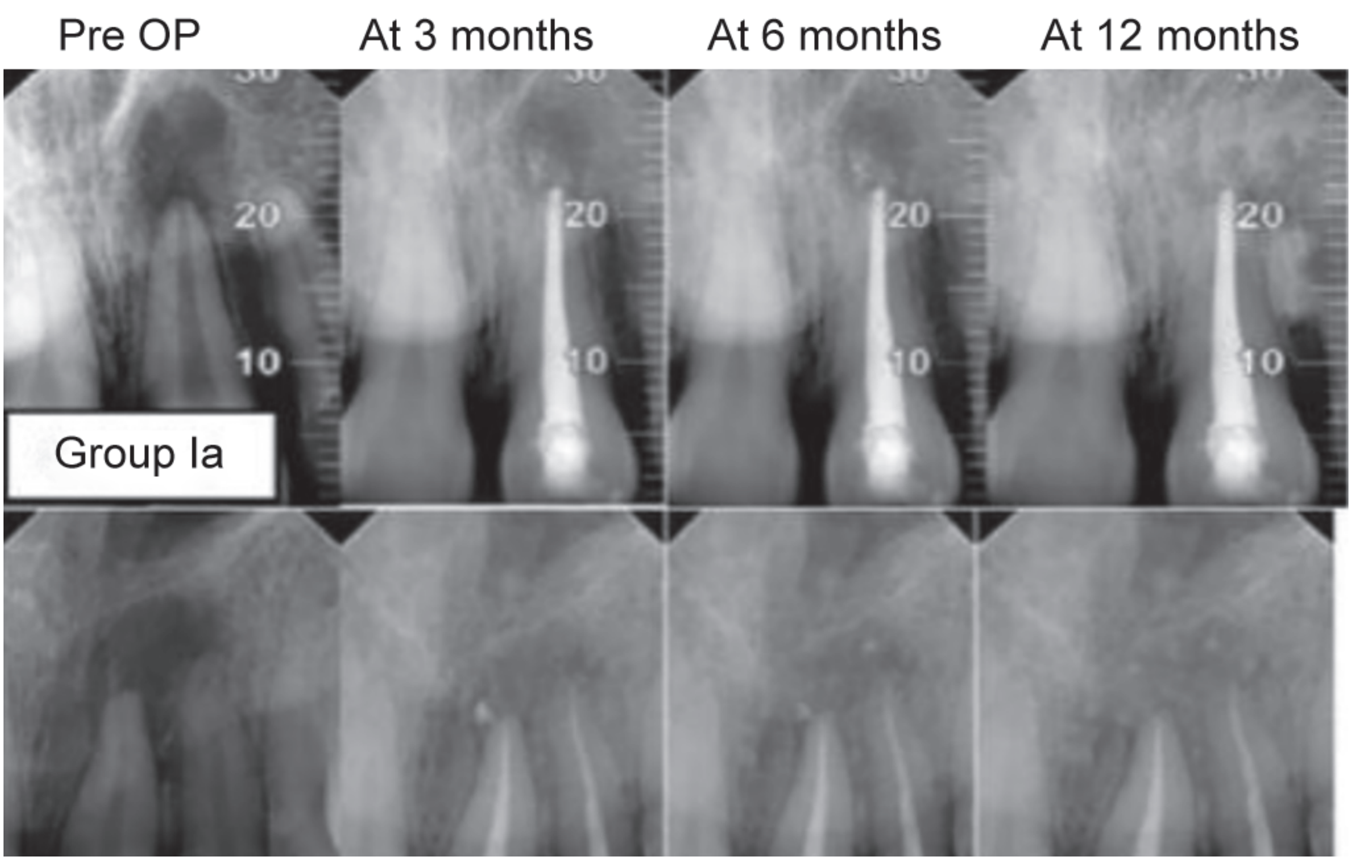

Fig. 1: Consolidated standards of reporting clinical studies

where drainage was observed, the canals were left open to drain before biomechanical preparation was initiated or intracanal medicament placed. After the discharge ceased, biomechanical preparation was done (step back technique) with intermittent irrigation using three mL of 3% sodium hypochlorite and normal saline subsequent to each file used. Final apical preparation was done to a size 40 K file.

Based on the group that the patient belonged to, the following disinfection protocol groups were formed:

Sl. no. Groups

I. **Positive pressure irrigation group** [27 gauge side vented irrigation needle (Hua En, China)]
   - Ia. modified triple antibiotic paste subgroup
   - Ib. photoactivated disinfection subgroup
   - Ic. calcium hydroxide subgroup.

II. **Negative pressure irrigation group** [Endovac system (Kerr Dental)]
   - IIa. triple antibiotic paste subgroup
   - IIb. photoactivated disinfection subgroup
   - IIc. calcium hydroxide subgroup.

Canal Medication Protocol

Modified triple antibiotic paste subgroup: Equal parts of ciprofloxacin (Cipla Ltd, India), metronidazole (Abbott India, India), and cefaclor (Health Biotech, India) were mixed with distilled water (3:1 P/L ratio) to form a slurry and filled in the canal (#4 lentulo spiral in slow-speed handpiece) passively 1 mm short of the working length.[13] Patient was recalled once every week for 4 weeks to change the medicament dressing.

Photoactivated disinfection subgroup: The root canals were filled with a photosensitizer (tolonium chloride 0.01% w/v in aq. solution) and were activated using 940 nm diode laser (Biolase) with an output power of 2.5 W. The canals were irradiated for 2 minutes then rinsed with normal saline to remove the dye.[16] Patient was recalled once every week for 4 weeks for the same.

Calcium hydroxide subgroup: Calcium hydroxide paste (prime dental) was introduced in the canal (#4 lentulo spiral in slow-speed handpiece) passively one mm short of the working length. The medicament dressing was changed every week for up to 4 weeks.

At 4th week final recall: The canals were rinsed with normal saline to remove the medicament present, then with three mL of 17% aq. EDTA (Prime Dental), after which they were finally rinsed with 10 mL of sterile saline solution and dried with corresponding paper points (Dentsply). The tooth was obturated (cold lateral condensation) using 2% gutta percha (Dentsply) and AH plus sealer (Dentsply) and permanently restored with composite resin (Dentsply Spectrum).

Post endodontic evaluation was done at 3, 6, and 12 months intervals by taking radiographs for recording the PAI scores and for periapical healing assessment.

Scoring Criteria for PAI Index

Periapical radiographs were taken using the bisecting angle technique by radiovisiography (60 KVP, 2.5 mA, 0.12 sec). The preoperative periapical status was assessed by using the periapical index (PAI) by Ostravik et al.[17] The patients were assessed radiographically at intervals of 3, 6, and 12 months postoperatively. The treatment was considered to be successful or failed, based on the following criteria.[16]

- Favorable
  healed: 3, 4, 5 at IPO [initial pre-operative]- >1–2 at follow-up or 1–2 at IPO- >1–2 at follow-up.
  healing: 3, 4, 5 at IPO improves but isn't- >1–2 at follow-up.
- Unfavorable not healed/healing
  5–3 at IPO stays- >5–3 at follow-up.
  or 1–2 at IPO- >3, 4, 5 at follow-up.

Results

GPower software (version 3.0) using ANOVA one-way analysis was used. The mean and Standard Deviation are compared across the groups using the Kruskal Wallis test and Friedman's test.

Individual groups were compared over a period of 12 months (3, 6 and 12 months) and statistically, significant healing was noted for all the groups over 12 months (p-value = 0.0) as depicted in (Table 1). The test scores show a statistically significant difference between the positive pressure group (group I) and negative pressure group (group II) at 2nd and 3rd follow-up (p-value = 0.022 and 0.01 at 2nd and 3rd follow-up, respectively). But no significant difference was seen among the groups at first follow-up (p-value = 0.339) (Table 2).

At 2nd follow-up, improvement in the PAI scores was noted for all the groups. A statistically significant difference (p = 0.042) was noted among all the subgroups in the negative pressure irrigation group (group II) showing greater healing than group I. The most visible improvement was seen for the group that used the photoactivated disinfection method (group IIb). Calcium hydroxide subgroups in both groups reflected a poorer healing rate.

Table 1: Friedman test statistics for comparison of the scores over the follow-up period

		Comparison over the period	
Positive (Group I)	Triple antibiotic paste (Group Ia)	N	13
		Chi-square	34.009
		df	3
		p-value	.000
	Photoactivated disinfection (Group Ib)	N	13
		Chi-square	30.052
		df	3
		p-value	.000
	Calcium hydroxide (Group Ic)	N	13
		Chi-square	30.446
		df	3
		p-value	.000
Negative (Group II)	Triple antibiotic paste (Group IIa)	N	13
		Chi-square	29.227
		df	3
		p-value	.000
	Photoactivated disinfection (Group IIb)	N	13
		Chi-square	34.718
		df	3
		p-value	.000
	Calcium hydroxide (Group IIc)	N	13
		Chi-square	31.647
		df	3
		p-value	.000

Table 2: Kruskal Wallis scores among the groups for individual follow-ups

	Kruskal Wallis test statistics			
	Baseline	*1st follow-up*	*2nd follow-up*	*3rd follow-up*
Kruskal-Wallis H	0.097	0.916	5.268	0.273
df	1	1	1	1
p-value	0.756	0.339	0.022*	0.01*
a. Kruskal Wallis test				
b. Grouping variable: POSI Neg				

At the 3rd follow-up, an improvement was noted in the PAI scores of all the groups. A statistically significant difference ($p = 0.029$) was noted among all the subgroups for the negative pressure irrigation group (group II) showing greater healing than group I. The most visible improvement was seen for the photoactivated disinfection subgroup (group IIb). The modified triple antibiotic paste subgroup (group IIb) in the negative pressure irrigation group (group II) showed better healing than the positive pressure irrigation group. The calcium hydroxide subgroups (group IIc) in both negative and positive pressure irrigation groups (group I & II) showed similar healing.

The assessment of periapical healing, radiographically, in all the test groups at 3, 6, and 12 months is depicted in Figure 2.

Discussion

Numerous clinical studies have demonstrated that nonsurgical root canal treatment with thorough debridement and disinfection and of the root canal system with appropriate intracanal medication protocol can promote healing of large periapical lesions.[18]

Calcium hydroxide is a routinely used intracanal medicament with effective bactericidal properties and has demonstrated a periapical healing success of 73.8–80.4%. Its major drawback is that on prolonged use, the bacteria present in the root canal can buffer its high alkalinity, rendering it ineffective.[19]

TAP is another such medicament that is considered a gold standard to combat the polymicrobial nature of the root canal microflora. Its antibiotic mixture shows effective bactericidal properties without developing bacterial resistance. It has been shown to heal large periapical lesions nonsurgically. The demerit with TAP is that in prolonged use, metronidazole can cause tooth discoloration thus the effectiveness in replacing it with other antibiotics is being explored.

The disadvantage with routinely used intracanal medicaments is that, for it to be effective, it mandates close proximity with bacteria and none of the medicaments have the potential to reach the entire root canal system, especially the recesses and the apical region. PAD utilizes a low-power laser with a dye, which on photochemical activation releases singlet oxygen that damages the bacterial DNA and cell wall membrane. It has shown effective disinfection of the entire root canal system without developing bacterial resistance.

The routine irrigation protocol used is positive pressure irrigation which employs a 27–30 gauge needle to deliver the irrigating solution. The disadvantage with this technique is that the irrigant may not go up to the working length due to canal morphology or it may extrude beyond the apex causing periapical irritation, both of which impede periapical healing. The use of negative pressure irrigation (endovac) addresses both the issues thus favoring periapical healing with better canal cleaning and no periapical irritation.[3,20]

As there are no *in vivo* studies evaluating the nonsurgical healing of large periapical lesion using MTAP neither are there any clinical studies evaluating the effect of positive or negative irrigation on the healing of periapical lesions. Thus, this *in vivo* study was undertaken to address these lacunae in the literature.

In this study, at the first follow-up a reduction in the overall PAI scores was noted for all the groups. The rationalization of this finding is synonymous with what was observed by Fish in 1939, namely, removal of the nidus of infection will result in infection resolution.[21] Thus, when nonsurgical root canal treatment was initiated in teeth with thorough mechanical and chemical debridement along with intracanal medication, there was the elimination of foci of infection from the root canal which prevented the metastasis of microorganisms from the root canal to the periapical region thus leading to lesion resolution in this study.[4] On comparison, the periapical healing was found to be better in group II (negative pressure irrigation) than in group I (positive pressure irrigation) although the difference was not statistically significant ($p = 0.492$). This is in accordance with the previous studies conducted.[22,23] The negative pressure irrigation system (Endovac) promotes better cleaning of main, lateral canals and the other inaccessible areas of the root canal system by maintaining a constant flow of irrigants from the coronal portion of the canal to the apex and back by negative pressure. This helps in reducing bacterial contamination and also curbing down the risk of irrigant extrusion thus promoting healing of the periapical lesions.[22,23]

The difference in periapical healing between group I and group II was not statistically significant at the end of 3 months because periapical healing is a slow process. The extended time of healing of periapical lesions is related to the persistence of an activated state of macrophages and lymphocytes within the lesion which is responsible for the osteoclastic activity and delayed healing. The lesion heals when the osteoclastic activity subsides.[24] As a response to healing, there might be woven bone formation in the periapical region, which is radiolucent and hence cannot be appreciated radiographically at 3 months.[25]

At the 2nd follow-up, further improvement in the PAI Scores was noted for all the groups which are suggestive of progressive healing of the periapical lesion. A statistically significant difference ($p = 0.042$) was noted amongst all the subgroups in group II. The most visible improvement was seen for the subgroup that used the photoactivated disinfection method (group IIb). This is due to the better penetration of the laser beam even in anatomically complex root canal systems and the release of singlet oxygen species from the dye on light activation which causes cell membrane and DNA damage of the micro-organisms, thus, rendering its antimicrobial action.[16] The success is further accentuated by the use of a negative pressure irrigation system for reasons mentioned previously.

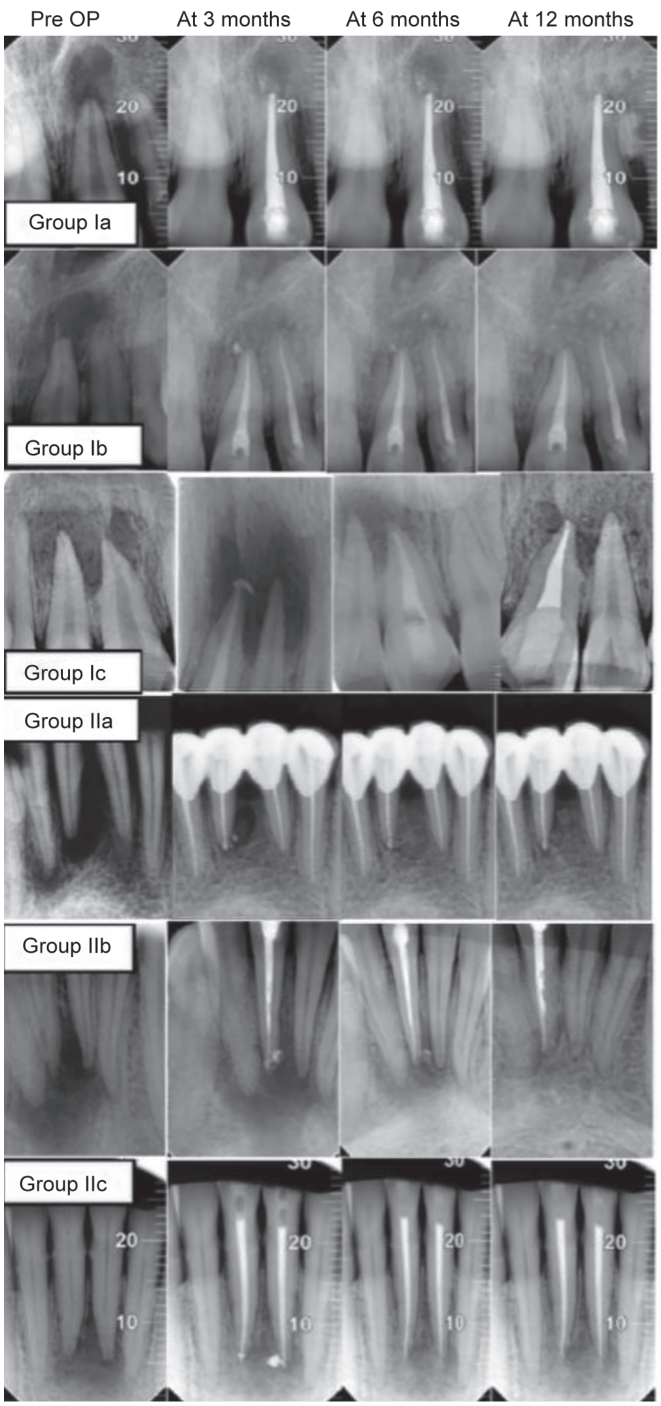

Fig. 2: Representative radiographic healing assessment of test groups at 3, 6, and 12 months

The calcium hydroxide subgroups in both groups (group I and II) reflected a poorer healing rate (53.8%). This may be due to buffering of the high pH by the microorganisms as well as dentin, thereby compromising its disinfection ability.[16]

At the 3rd follow-up, a significant improvement was noted in the PAI scores of all the groups which represent healing. A statistically significant difference ($p = 0.029$) was noted amongst all the subgroups for the negative pressure irrigation group (group II) showing greater healing than group I. The most visible improvement was seen for the photoactivated disinfection subgroup (group IIb).

The modified triple antibiotic paste subgroups showed better healing than the calcium hydroxide subgroups. There is enough literature available that demonstrates that triple antibiotic paste has better antimicrobial efficacy than calcium hydroxide. The bacteria in the deeper layers of root canal walls are obligate anaerobes. Metronidazole is the first choice of drug because it has been reported to penetrate the deep layers of carious lesions and disinfect the lesions *in vivo*. In root canal systems, the bacterial flora is polymicrobial in nature. Thus, ciprofloxacin and cefaclor added to metronidazole provide a broad-spectrum antibacterial activity to sterilize infected root dentine and minimize the risk of antimicrobial resistance.[11–13,16,26,27]

Radiographically, better healing is observed at 6 and 12 months follow-up. This might be due to the maturation of the woven bone to compact bone which is well appreciated radiographically (Fig. 2).[22] In this study, a follow-up period of 1 year was chosen, as in other studies, it was seen that this time frame appeared adequate for periapical healing assessment and for evaluation of the efficacy of intracanal medicaments a timeline of 2 weeks to 6 months was considered adequate.[28,29]

Conclusion

Within the limitations of the study, it can thus be concluded that superior healing was achieved when negative pressure irrigation in combination with PAD was used for canal disinfection. Triple antibiotic paste showed better healing than calcium hydroxide when used with both positive and negative pressure irrigation groups. calcium hydroxide showed the poorest results.

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