Available online at www.giornaleitalianoendodonzia.it

ORIGINAL ARTICLE

# The outcome of root canal treatment with a calcium silicate-based sealer of necrotic teeth: a retrospective assessment


## ABSTRACT

***Aim:*** *This retrospective clinical assessment aimed to evaluate the healing effect of calcium silicate-based root canal sealers on necrotic teeth with periapical lesions.*
***Methodology:*** *An assessment of the outcome was carried out based on the patient's clinical records and radiographic data. The study involved 20 teeth in total: 9 of which were posterior and 11 anterior. Obturation was performing using either a single cone or a lateral compaction technique. The differences in sizes of lesions were characterized as large, medium, and small lesion sizes. Initial, final, and follow up periapical radiographs were taken and scored with the aid of periapical index scoring system.*
***Results:*** *The mean follow-up period was 15.8 months. Interobserver agreement was evaluated by Kappa test and categorical variables were evaluated by Fisher's Exact test. The overall success rate was 100%, with 70% of patients being fully healed and 30% assessed as healing. Variables did not differ statistically significant.*
***Conclusion:*** *Calcium silicate-based sealers have good healing capacity even in the presence of significant periapical lesions.*



**Ayşenur Kamacı Esen[1*]**
**Fahrettin Kalabalık[2]**

*[1]Sakarya University, Faculty of Dentistry Department of Endodontics, Turkey.*
*[2]Sakarya University Faculty of Dentistry Department of Oral Diagnosis and Radiology, Turkey.*



*Received 2023, May 26*
*Accepted 2023, August 17*

**KEYWORDS** *Non-surgical root canal treatment, calcium silicate-based sealer, outcome*



**Corresponding Author**
Ayşenur Kamacı Esen, Sakarya University Faculty of Dentistry Department of Endodontics, Sakarya, Türkey.
E-mail: a.kamaci@windowslive.com | Tel. 00905346137213



Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2023.37.01.19

## Introduction

In cases of apical periodontitis, root canal therapy aims to minimize the amount of bacteria in the root canal space and promote periapical healing (1). Hermetic root canal obturation is an essential step when attempting to initiate periapical healing. Historically, gutta-percha has been the most commonly used obturation material (2). However, it does not adhere to dentin walls and cannot fill root canal defects if thermoplastic gutta-percha techniques are not applied (3, 4). Gutta-percha is typically used with root canal sealers due to the unfavorable effects of the substance. Root canal sealers are a crucial component in hermetic root canal obturation as they adhere to root canal walls and gutta-percha, aid in tridimensional root canal obturation by filling in irregularities in the canal, eradicate germs, and stop bacteria from receiving nourishment (5). Resin-based root canal sealers have been the gold standard for many years due to their low solubility, adequate dimensional stability and strong bonding strength (6). However, due to their lack of bioactive characteristics, resin-based root canal sealers do not promote bone formation (6).

Calcium silicate-based root canal sealers have been introduced to the market with the ideal properties including; antimicrobial effect, hydrophilicity, biocompability, biomineralization, hydroxyapatite formation, adhesion, and bioactivity (7, 8). Calcium silicate-based sealers require dentinal tubule moisture for setting (9, 10). Due to the sealer's mechanism of setting, any residual moisture has no negative effects. Calcium silicate-based sealers that are extruded from the apex are also considered to be biocompatible (11). Due to their larger film thickness compared to resin-based root canal sealers (12), calcium silicate-based sealers have a lesser dentinal tubule penetration (13). Despite this drawback when compared to resin-based root canal sealers, they have been associated with an increase in root canal treatment success rates (14, 15) thanks to the bioactive features of the previously mentioned calcium silicate-based sealers. When calcium silicate-based sealers were first introduced to the market, their use in combination with thermoplastic gutta-percha systems was not recommended due to worries that high temperatures could have a negative influence on the sealer's characteristics (11). Nevertheless, the use of calcium silicate-based sealers in conjunction with cold gutta-percha in techniques like single cone and lateral compaction obturation appears to be favorable in terms of being simple to use, requiring no additional material or time, and being non-irritating when in contact with periapical tissue (16, 17).

The aim of the present study is to assess the success rate of calcium silicate-based root canal sealer in necrotic teeth with periapical bone destruction.

## Materials and Methods

*Case selection and treatment procedure*

The Non-Invasive Research Ethics Committee at Sakarya University granted approval (E-71522473-050.01.04-202820-353) for the study. The information was gathered from the records of the patients that were treated between September 2020 and February 2022 at the Sakarya University, School of Dentistry, Department of Endodontics. The following criteria were used for inclusion and exclusion:

*Inclusion criteria*

- Teeth with X-rays adequate quality for preoperative and postoperative evaluation,
- Teeth with fully developed root canals,
- Root canal therapy of radiologically acceptable quality (all canals adequately sealed within 2 mm of the radiological apex, no broken files, etc.),
- Satisfactory coronal restoration
- Patients who attended follow-up appointments.

*Exclusion criteria*

- MTA or resin-based root canal sealers that were used to complete the root canal filling.
- Teeth with open apices,
- Severe periodontal loss,

- Treatments which were carried out in a single session,
- Vital pulp root canal treatment,
- Patients that did not show up for their follow-up appointments,
- Teeth that were underwent periapical surgery following root canal therapy (Figure 1).

*Treatment protocol*

All root canal procedures and follow-ups were carried out by a single endodontic specialist with more than five years of experience. A standardized treatment protocol was utilized and performed in two sessions. A rubber dam was placed, and the access cavity was opened following the injection of local anesthetic (1,8 ml lidocaine with 1:100,000 epinephrine). Any coronary restorations and caries were removed. Working length was determined with an apex locator (Woodpex III, Woodpecker, Guilin, China) and a size 10 K file (Micro Mega, Besancon, France). Depending on the operator's instrumentation preference, either the crown-down approach or the step-back technique was used for root canal enlargement. ProTaper next (Dentsply Maillefer, Ballaigues, Switzerland) rotary files were used when crown down instrumentation was performed. The canals were irrigated with 3% NaOCl (Coltene/Whaledent, Switzerland) between each instrument using 30 G side-vented irrigation tips (Endo Eze Tip, Ultradent Products). During the first visit, root canal shaping and debriment was completed using either step-back or crown-down technique according to root canal anatomy, followed by temporization via calcium hydroxide paste (Cerkamed, Stalowa Wola, Poland). After application of calcium hydroxide, a teflon tape was used to cover root canal orifices and glass ionomer cement (Ionofil, VOCO, Cuxhaven, Germany) was used as a temporary restoration.

In the second session, the temporary restoration was removed while using a rubber dam to isolate the teeth under local anesthetic. The calcium hydroxide in the canals was then removed using irrigation and sonic activation (EDDY; VDW, Munich, Germany). Each root canal was irrigated with 2.5 mL of 5% EDTA, 5 mL of 3% NaOCl, 2.5 mL of distilled water, and 2.5 mL of 2% chlorhexidine during final irrigation. NaOCl was activated for 20 seconds with the EDDY sonic activation system during the final stage of irrigation. After drying with paper points, the root canals were filled with gutta-percha and calcium silicate-based sealer (Ceraseal, Meta Biomed Co., Cheongju, Korea) using either lateral compaction or single cone technique, depending on the technique used for root canal enlargement. Patients were advised to attend their follow-up appointments every six months. Bulk-fill resin SDR (Dentsply Sirona, Charlotte, NC, USA) and composite resin (Tokuyama Estelite Posterior, Tokyo, Japan), were used to fill the access cavity in cases where a permanent restoration was placed. If a prosthetic restoration was indicated, the access cavity was temporarily sealed with glass ionomer cement, and the patients referred to the Department of Prosthodontics as soon as possible. All procedures were performed under an operating microscope (Zumax OMS2350, Zumax Medical Co. Ltd, Jiangsu, China).

Recall appointments included clinical and radiographic examinations of the treated tooth, and the results were recorded and filled. The patient admissions system was used to retrieve retrospective radiographic data.

Radiographs were evaluated by two calibrated examiners. Teeth were all scored according to their healing process and periapical index (PAI) scoring system (18).

1. Healed: functional, asymptomatic teeth with no or minimal radiographic periradicular (apical) pathosis (radiolucency)
2. Unhealed: nonfunctional, symptomatic teeth with or without radiographic periradicular (apical) pathosis (radiolucency) or asymptomatic teeth with unchanged, new, or enlarged radiographic periradicular (apical) pathosis (radiolucency).
3. Healing: teeth that are asymptomatic and functional with a decreased size of radiographic periradicular (apical) pathosis (radiolucency).

**Table 1**
**Relationship between sociodemographic characteristics of patients and healing status**

| | Status | | p |
|---|---|---|---|
| | Healed | Healing | |
| **Age** | | | |
| 18-45 | 10 (76,9) | 3 (23,1) | 1,000 |
| 46-76 | 4 (66,7) | 2 (33,3) | |
| **Teeth** | | | |
| Anterior | 9 (81,8) | 2 (18,2) | 0,336 |
| Posterior | 5 (55,6) | 4 (44,4) | |
| **Lesion size** | | | |
| Large | 10 (71,4) | 4 (28,6) | 0,587 |
| Small | 2 (100) | 0 (0) | |
| Medium | 2 (50) | 2 (50) | |
| **Gender** | | | |
| Male | 8 (66,7) | 4 (33,3) | 1,000 |
| Female | 6 (75) | 2 (25) | |
| **Follow-up period** | | | |
| 18 months | 8 (66,7) | 4 (33,3) | 1,000 |
| >18 months | 6 (75) | 2 (25) | |
| **Restoration** | | | |
| Bridge | 3 (75) | 1 (25) | 0,380 |
| Crown | 1 (50) | 1 (50) | |
| Post+crown | 0 (0) | 1 (100) | |
| Sdr+composite | 10 (76,9) | 3 (23,1) | |
| **Apical sealer extrusion** | | | |
| Yes | 5 (62,5) | 3 (37,5) | 0,642 |
| No | 9 (75) | 3 (25) | |
| **Obturation Technique** | | | |
| Lateral compaction | 6 (85,7) | 1 (14,3) | 0,354 |
| Single cone | 8 (61,5) | 5 (38,5) | |

*Fisher's Exact Testi*

PAI 1: Normal periapical bone structure.
PAI 2: Small changes in bone structure, no demineralization.
PAI 3: Changes in bone structure with some diffuse mineral loss.
PAI 4: Apical periodontitis with well-defined radiolucent area.
PAI 5: Severe apical periodontitis, exacerbating features.
Both healed and healing cases were considered as successful and unhealed cases were considered as failure. Age, periapical lesion size, coronary restoration type, sealer extrusion, and follow-up time were among the patient- and tooth-related characteristics that were assessed. The age of the patients was divided into two categories; those under 45 and those older than 45. Small lesions (0-2 mm), medium lesions (2-5 mm), and large lesions (greater than 5 mm) were classified according to the size of the periapical lesion.

*Statistical Analysis*
The data was analyzed with SPSS (version 23; IBM Corp, Armonk, NY). Pearson Chi-square test and Fisher's Exact test were used to compare categorical variables according to healing status. Kappa test was used to evaluate the interobserver agreement.

## Results

A significantly high level of interobserver agreement was found between observer 1 and observer 2 in terms of healing evaluation ($\Re$=0,875; p<0,001). Nine posterior teeth and eleven anterior teeth out of the 20 total teeth were included in the study. The categorical variables are shown in Table 1.

*Clinical and radiographic evaluation*
Fourteen teeth with large lesions and 4 teeth with medium lesions were categorized as healed and healing while 2 teeth with small lesions were categorized as healed. There were no teeth identified as unhealed; all of the evaluated teeth were either healed or healing (Table 1, Figure 2, 4). No significant difference was found between any of the variables and the healing status evaluated in the study (p>0.05).

*Outcome assessment*
The majority of lesions were categorized as large lesions (Table 1). The mean follow-up period is 15.8 months, with the shortest follow-up period being 11 months and the longest being 24 months. To determine the influence of patient-related factors on healing status, patient ages were

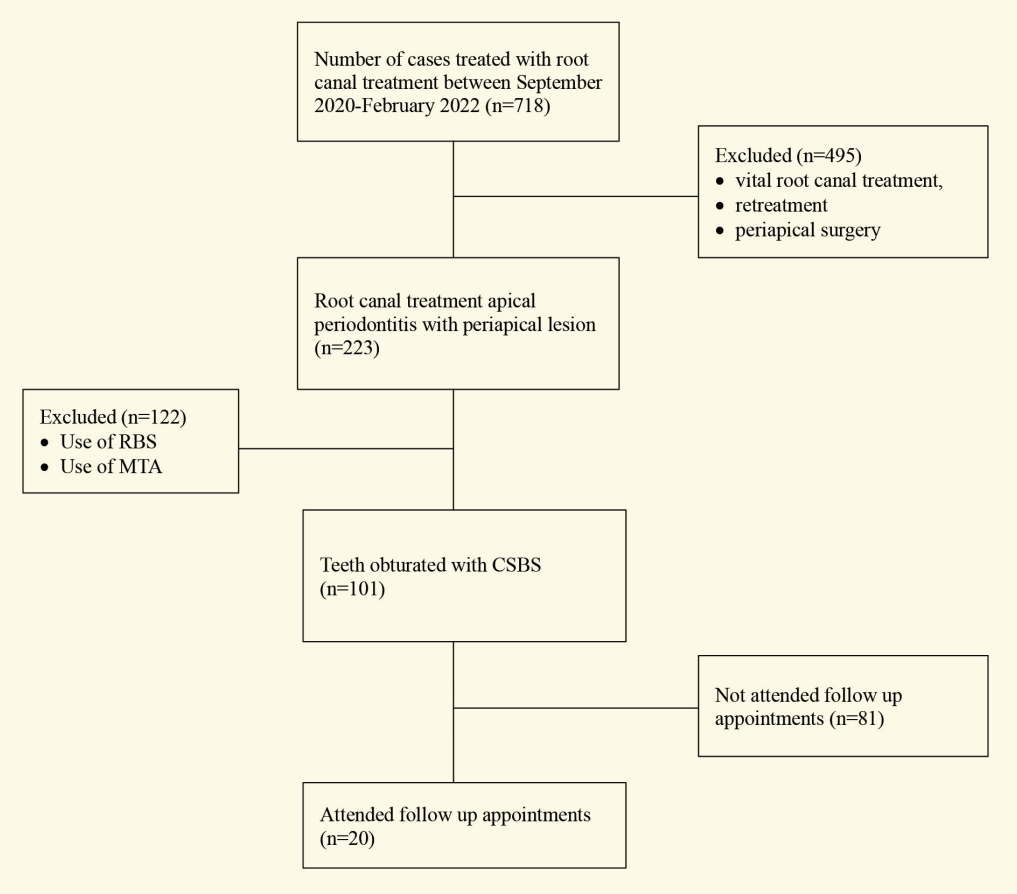


**Figure 1**
Flowchart allocation of patient inclusion to the study.

*n=Number of cases, RBS=Resin-based root canal sealers, MTA=Mineral trioxide aggregate, CSBS=Calcium silicate-based sealers.*

divided into groups of 18 to 45 and 46 to 76, lesion sizes into large, medium, and small, and follow-up times into longer than 18 months and less than 18 months. Patients' age, gender, restoration type, compaction technique, and presence of extruded sealer (Figure 3) were also evaluated. None of the variables showed statistical significance ($p>0.05$).

## Discussion

To enhance the effectiveness of root canal therapy, calcium silicate-based root canal sealers have been introduced into endodontic practice (19). Due to microbial involvement, the success rate of root canal therapy in necrotic teeth is lower than in vital teeth (20). There has been recent research have focused on different aspects of the effects of calcium silicate-based root canal sealers. There are some studies showing the effect of resin-based root canal sealers and calcium silicate-based sealers on postoperative pain (21, 22). Other studies have been published with a focus on the outcome of calcium silicate-based sealers. However, none of the previous studies were focused solely on the effects of calcium silicate-based root canal sealers on necrotic teeth with periapical lesion (8, 23-25). This study appears to be the first in that sense.

Endodontic treatments are performed as single or multiple sessions depending on the condition of the teeth requiring root canal treatment. Despite the fact that there are no conclusive studies demonstrating that single-session endodontic treatment is superior to multi-session therapy (26, 27), single-visit endodontic treatment is commonly preferred since it keeps the patient motivated and reduces the risk of bacterial leakage and the associated flare-ups (26, 28, 29). However, in the presence of infected root canal system with periapi-

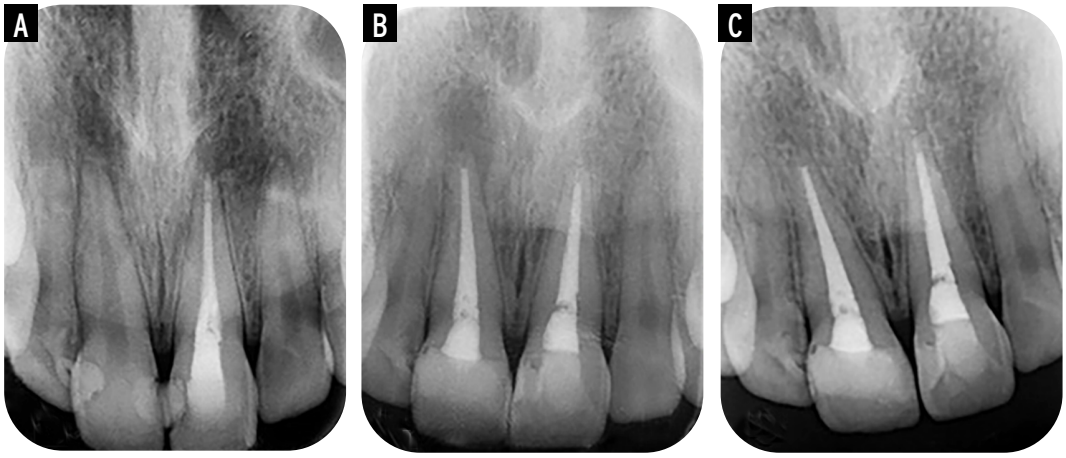


**Figure 2**
A clinical case of a healed lesion: **A)** preoperative radiograph of right central incisor **B)** postoperative radiograph **C)** 24 months follow up radiograph showing healing with no clinical signs and symptoms.

cal lesions intracanal medicament placement is advised in order to properly disinfect the root canal system (30). In the current study, multiple visit endodontic treatment was preferred due to the presence of periapical lesions in necrotic teeth. Unlike other studies (23-25), all cases were treated by the same endodontist. This is one of the advantages that sets our study apart from previous studies in terms of standardization. Different irrigation protocols were performed in previous studies, Salah et al. (8) used only 17% EDTA for final irrigation, Chybowski et al. (24) used the same concentration of EDTA along with passive ultrasonic irrigation, Coşar et al. (23) used 17% EDTA and 2.5% NaOCl for final irrigation. In the present study 5% EDTA, 3% NaOCl, distilled water, and 2% chlorhexidine was used as irrigation solution. Furthermore, NaOCl was activated with a sonic activation system. Due to its adequate ability to remove the smear layer and reduced the risk of dentinal erosion, 5% EDTA was selected over 17% EDTA (31). Chlorhexidine was utilized as a final irrigation solution, because of its impact on biofilm and endotoxins, as well as its beneficial effects on the durability of coronal restorations and the endodontic therapy (32).

Recent advancements in calcium silicate-based root canal sealers have rendered these sealers useable with warm obturation procedures (33). Nevertheless, cold obturation techniques are still frequently preferred due to their convenience of use. Vasconcelos et al. (34) reported that 41.3% of the endodontists and 95.7% of the academicians preferred to use cold obturation techniques for root canal obturation. In the present study, cold obturation techniques were used due to its ease of use and not requiring extra materials or time (16,

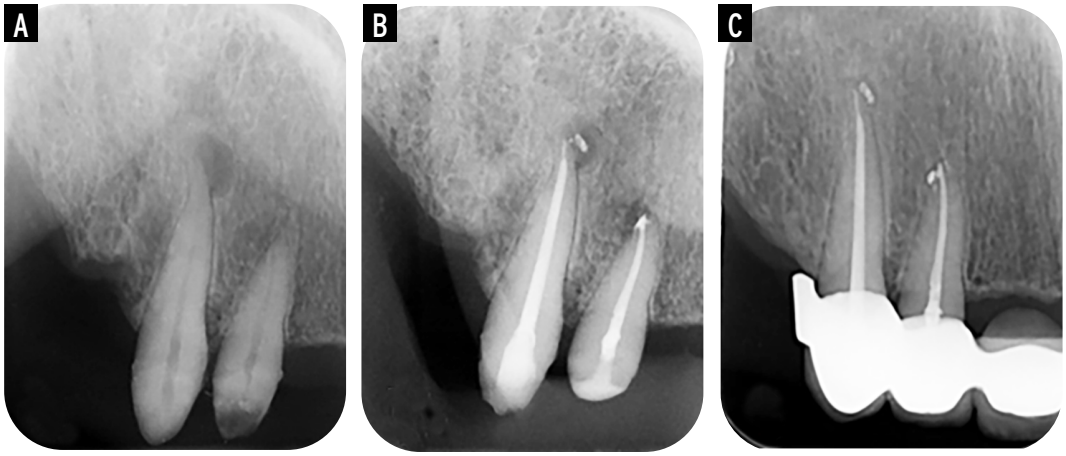


**Figure 3**
A clinical case of apically extruded sealer: **A)** preoperative radiograph of upper right lateral and canine teeth **B)** postoperative radiograph **C)** 13 months follow up radiograph showing significant level of healing with no clinical signs and symptoms.


**Figure 4**
A clinical case of a healing lesion: **A)** preoperative radiograph of right mandibular molar teeth; **B)** postoperative radiograph; **C)** 21 months follow up radiograph showing healing is still in process with no clinical signs and symptoms.

17). Root canal preparation technique was determined according to root canal anatomy; while stepback techinique was preferred for oval shaped and wide canals, crown down tecnique was pereferred for round shaped canals. The obturation choice was made according to root canal preparation technique. Same techniques were used in the majority of outcome studies involving the use of calcium silicate-based root canal sealers (24, 25, 35).
To the best of our knowledge, there currently are no studies which have investigated the effect of calcium silicate-based root canal sealers solely on necrotic teeth with periapical lesions. However, various results were achieved with different endodontic diagnoses in the outcome studies. Chybowski et al. (24) reported a success rate of 90.6% for initial treatment, 91.7% for retreatment with mean 18.6 months follow up while Coşar et. al (23) reported slightly a lesser success rate of 88.6% for initial treatment with the 24 months follow up. Zavattini et al. (14) reported 84% for necrotic and vital teeth for 12 months follow up but where they differed from current study they used cone beam computed tomography (CBCT) images to evaluate healing. Pontoriero et al. (36) reported a 99% success rate for the initial and retreatment groups but they used different brands of calcium silicate-based sealers with warm vertical compaction technique with mean a 18 months follow up period. In the current study, a mean follow-up period of 15.6 months showed a 100% success rate. Of all the cases, 75% had fully recovered. This finding seems compatible with the study of Pontoriero et. al. (36) but slightly higher than the rest of the previous studies (14, 23, 24). This increased success rate may be attributed to the use of calcium hydroxide as intracanal medicament, additional antimicrobial effect gained by chlorhexidine, or treatment of all cases by the same experienced endodontist. However, evaluation of cases was performed only according to periapical X-rays in the present study. Compared to periapical X-rays, the accuracy of lesion follow-up with CBCT images is higher. On the other hand, a CBCT examination performed for the follow-up of endodontic treatments results in a higher radiation dose compared to periapical radiographs (37). Therefore, due to the increased radiation dose associated with CBCT exams, periapical radiography is the most often utilized approach for the follow up of endodontic treatments (38).
In a previous study reported by AlBakhakh et al. (35), periapical lesions were divided into three subgroups; as small, medium, and large similar to the present study. They showed that small and medium lesions had a significantly higher success rate compared to large lesions. Another study performed by Pontoriero et. al. (36) divided periapical lesions as larger than 5 mm and smaller than 5 mm and they found that small lesions have faster healing capacity. Contrary to these studies, no significant difference was observed between lesions sizes in terms of healing capacity in the present study. However, it should be emphasized that the sample sizes of large, medium and small lesions are not equal. Since most of the lesions found in the study are categorized as large lesions, it will not be very accurate to compare them with other groups.

According to the results of the present study, as highlighted in a previous study (36), it was thought that operator knowledge and experience had a significant impact on the prognosis of endodontic treatment. However, it is also obvious that calcium silicate-based sealers have undeniable healing potential.
There are also some limitations that should be underlined in the present study. One of them is having a limited number of cases, the others include short follow up duration and uneven distribution of the lesion sizes.

## Conclusion

The findings of this study indicated that calcium silicate-based sealers should definitely be taken into consideration when choosing a material since they have good healing capability on necrotic teeth with periapical lesions. It would be good to do long-term clinical trials with more patients, different diagnoses, and alternative compaction techniques.

## Clinical Relevance

Calcium silicate-based sealers appear to be recommended due to their rapid healing time and high healing capability in necrotic cases with periapical lesions.

## Conflict of Interest

The authors deny any conflicts of interest related to this study.

## Acknowledgement

None.

## References


1 *Sjögren U, Figdor D, Persson S, Sundqvist G. Influence of infection at the time of root filling on the outcome of endodontic treatment of teeth with apical periodontitis. Int Endod J 1997;30:297-306.*
2 *Washio A, Morotomi T, Yoshii S, Kitamura C. Bioactive Glass-Based Endodontic Sealer as a Promising Root Canal Filling Material without Semisolid Core Materials. Materials (Basel) 2019;12.*
3 *Li GH, Niu LN, Zhang W, et al. Ability of new obturation materials to improve the seal of the root canal system: a review. Acta Biomater 2014;10:1050-63.*
4 *Bhandi S, Mashyakhy M, Abumelha AS, et al. Complete Obturation-Cold Lateral Condensation vs. Thermoplastic Techniques: A Systematic Review of Micro-CT Studies. Materials (Basel) 2021;14.*
5 *Komabayashi T, Colmenar D, Cvach N, et al. Comprehensive review of current endodontic sealers. Dent Mater J 2020;39:703-20.*
6 *Silva Almeida LH, Moraes RR, Morgental RD, Pappen FG. Are Premixed Calcium Silicate-based Endodontic Sealers Comparable to Conventional Materials? A Systematic Review of In Vitro Studies. J Endod 2017;43:527-35.*
7 *Aminoshariae A, Primus C, Kulild JC. Tricalcium silicate cement sealers: Do the potential benefits of bioactivity justify the drawbacks? J Am Dent Assoc 2022;153:750-60.*
8 *Bel Haj Salah K, Jaâfoura S, Tlili M, et al. Outcome of Root Canal Treatment of Necrotic Teeth with Apical Periodontitis Filled with a Bioceramic-Based Sealer. Int J Dent 2021;2021:8816628.*
9 *Xu HH, Carey LE, Simon CG, et al. Premixed calcium phosphate cements: synthesis, physical properties, and cell cytotoxicity. Dent Mater 2007;23:433-41.*
10 *Nagas E, Uyanik MO, Eymirli A, et al. Dentin moisture conditions affect the adhesion of root canal sealers. J Endod 2012;38:240-4.*
11 *Till D. Calcium silicate-based sealers: The end of thermoplastic obturation? Dtsch Zahnarztl Z 2021;3:71-9.*
12 *Sfeir G, Zogheib C, Patel S, et al. Calcium Silicate-Based Root Canal Sealers: A Narrative Review and Clinical Perspectives. Materials (Basel) 2021;14.*
13 *Lin GSS, Chan DZK, Leong JZ, et al. Dentinal tubule penetration of bioceramic-based versus epoxy resin-based root canal sealers: a systematic review and meta-analysis. Giornale Italiano Di Endodonzia 2022;36:108-18.*
14 *Zavattini A, Knight A, Foschi F, Mannocci F. Outcome of Root Canal Treatments Using a New Calcium Silicate Root Canal Sealer: A Non-Randomized Clinical Trial. J Clin Med 2020;9.*
15 *Donnermeyer D, Bürklein S, Dammaschke T, Schäfer E. Endodontic sealers based on calcium silicates: a systematic review. Odontology 2019;107:421-36.*
16 *Dummer PM, Lyle L, Rawle J, Kennedy JK. A laboratory study of root fillings in teeth obturated by lateral condensation of gutta-percha or Thermafil obturators. Int Endod J 1994;27:32-8.*
17 *Levitan ME, Himel VT, Luckey JB. The effect of insertion rates on fill length and adaptation of a thermoplasticized gutta-percha technique. J Endod 2003;29:505-8.*
18 *Orstavik D, Kerekes K, Eriksen HM. The periapical index: a scoring system for radiographic assessment of apical periodontitis. Endod Dent Traumatol 1986;2:20-34.*
19 *Jain P, Ranjan M. The rise of biocramics in endodontics: A review. Int J Pharm Bio Sci 2015;6:416-22.*
20 *Siqueira JF, Rôças IN. Clinical implications and microbiology of bacterial persistence after treatment procedures. J Endod 2008;34:1291-301.e3.*
21 *Shim K, Jang YE, Kim Y. Comparison of the Effects of a Bioceramic and Conventional Resin-Based Sealers on Postoperative Pain after Nonsurgical Root Canal Treatment: A Randomized Controlled*

*Clinical Study. Materials (Basel) 2021;14.*
22 *Ahmed YE, Emara RS, Sarhan SM, et al. Post-treatment endodontic pain following occlusal reduction in mandibular posterior teeth with symptomatic irreversible pulpitis and sensitivity to percussion: a single-centre randomized controlled trial. Int Endod J 2020;53:1170-80.*
23 *Coşar M, Kandemir Demirci G, Çalışkan MK. The effect of two different root canal sealers on treatment outcome and post-obturation pain in single-visit root canal treatment: A prospective randomized clinical trial. Int Endod J 2023;56:318-30.*
24 *Chybowski EA, Glickman GN, Patel Y, et al. Clinical Outcome of Non-Surgical Root Canal Treatment Using a Single-cone Technique with Endosequence Bioceramic Sealer: A Retrospective Analysis. J Endod 2018;44:941-5.*
25 *Li J, Chen L, Zeng C, et al. Clinical outcome of bioceramic sealer iRoot SP extrusion in root canal treatment: a retrospective analysis. Head Face Med 2022;18:28.*
26 *Moreira MS, Anuar ASN, Tedesco TK, et al. Endodontic Treatment in Single and Multiple Visits: An Overview of Systematic Reviews. J Endod 2017;43:864-70.*
27 *Sathorn C, Parashos P, Messer HH. Effectiveness of single- versus multiple-visit endodontic treatment of teeth with apical periodontitis: a systematic review and meta-analysis. Int Endod J 2005;38:347-55.*
28 *Naoum HJ, Chandler NP. Temporization for endodontics. Int Endod J 2002;35:964-78.*
29 *Onay EO, Ungor M, Yazici AC. The evaluation of endodontic flare-ups and their relationship to various risk factors. BMC Oral Health 2015;15:142.*
30 *Mohammadi Z, Farhad A, Tabrizizadeh M. One-visit versus multiple-visit endodontic therapy–a review. Int Dent J 2006;56:289-93.*
31 *Sen BH, Erturk O, Piskin B. The effect of different concentrations of EDTA on instrumented root canal walls. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108:622-7.*
32 *Gomes BP, Vianna ME, Zaia AA, et al. Chlorhexidine in endodontics. Braz Dent J 2013;24:89-102.*
33 *Aksel H, Makowka S, Bosaid F, et al. Effect of heat application on the physical properties and chemical structure of calcium silicate-based sealers. Clin Oral Investig 2021;25:2717-25.*
34 *Vasconcelos I, Manilha C, Ginjeira A. A survey on root canal obturation trends: warm versus cold obturation technique. Giornale Italiano Di Endodonzia 2022;36:17-28.*
35 *AlBakhakh B, Al-Saedi A, Al-Taee R, Nahidh M. Rapid Apical Healing with Simple Obturation Technique in Response to a Calcium Silicate-Based Filling Material. Int J Dent 2022;2022:6958135.*
36 *Pontoriero DIK, Ferrari Cagidiaco E, Maccagnola V, et al. Outcomes of Endodontic-Treated Teeth Obturated with Bioceramic Sealers in Combination with Warm Gutta-Percha Obturation Techniques: A Prospective Clinical Study. J Clin Med 2023;12.*
37 *Horner K. Cone beam CT for dental and maxillofacial radiology (evidence based guidelines). Radiation Protection Publication 2012:172.*
38 *Ramis-Alario A, Tarazona-Álvarez B, Peñarrocha-Diago M, et al. Is periapical surgery follow-up with only two-dimensional radiographs reliable? A retrospective cohort type sensitivity study. Medicina Oral, Patología Oral y Cirugía Bucal 2021;26:e711.*