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# Clinical outcome of root canal obturation using different based sealers: a retrospective cohort study

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## Abstract

**Background** This study aimed to assess and compare the performance of root canal treatment obturated either with calcium silicate-based or epoxy resin-based root canal sealers on retreatment cases with periapical lesions.

**Methods** Patients' radiographic data and clinical records were obtained retrospectively from the computerized patient record system. A total of 44 teeth, 28 teeth treated with calcium silicate-based sealer and 16 teeth treated with epoxy resin-based sealer, were included in the study. The mean follow-up period was 11.9 months for calcium silicate-based sealer and 23.6 months for epoxy resin based sealer groups. The outcome was evaluated based on radiographic findings and clinical records of the patients. Chi-square test and Fisher's Exact test were used to examine the differences between categorical variables. An independent samples t-test was used to compare the initial and final PAI differences based on sealer type.

**Results** The success rate was 100% for calcium silicate-based sealer and 93.75% for epoxy resin-based sealer. Calcium silicate-based sealer showed a faster healing capacity than epoxy resin-based sealer.

**Conclusions** Both sealers are viable options for retreatment cases, but calcium silicate-based sealer has a faster healing potential.

**Keywords** Calcium silicate-based sealer, Epoxy resin-based sealers, Non-surgical root canal treatment, Outcome

## Introduction

The purpose of root canal treatment of teeth with apical periodontitisis is to reduce number of bacteria in the root canal space and help to initiate periapical healing [1]. Although initial root canal treatment has been shown to have high success rate [2], still more than 15% failure might occur [3]. In those cases, non-surgical retreatment and periapical surgery are both viable options. The choice of treatment between non-surgical root canal treatment and periapical surgery should be based on the balance of benefits and risks between two treatments, considering factors related to the patient and operator [4]. Some studies reported no difference between the treatment outcomes of two treatment options. However, other studies indicated that periapical surgery has favorable initial success rates, while non-surgical root canal treatment provides long-term success [5, 6]. Besides all these conflicting results, it is a fact that non-surgical endodontic retreatment is the first treatment option for many cases [7].

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Relatively lower success rates have been reported in retreatment cases compared to primary endodontic treatments [8, 9]. Initiating periapical healing may be challenging, especially in retreatment cases, due to the presence of residual bacteria [10] and improper primer endodontic treatment [11]. Gutta-percha is the most commonly used obturation material [12]. However, its use alone is inadequate to seal the irregularities in the root canal system [13, 14]. Therefore, gutta-percha is used together with root canal sealers due to these negative aspects. Root canal sealers play an important role in achieving hermetic root canal obturation. They bind gutta-percha to root canal walls, help root canal obturation by filling root canal irregularities, kill bacteria, and prevent bacterial nourishment [15]. Resin-based root canal sealers have been considered as gold standard sealer for many years due to its low solubility, adequate dimensional stability, and good bond strength. However, they do not induce bone formation due to their lack of bioactive properties [16]. Calcium silicate-based sealers have been introduced to the market with the ideal properties such as antimicrobial effect, hydrophilicity, biocompatibility, biomineralization, hydroxyapatite formation, adhesion, and bioactivity [17, 18]. Calcium silicate-based sealers are also considered as biocompatible when they are extruded from the apex [19]. Therefore, calcium silicate-based sealers are associated with increased success rate [20, 21]. Due to concerns regarding high temperatures and its potential adverse effects, it is not recommended to use calcium silicate-based sealers with thermoplastic gutta-percha systems [19]. Nevertheless, using calcium silicate-based sealers in combination with cold gutta-percha techniques such as single cone and lateral compaction obturation appears to be advantageous in terms of ease of use, requiring no extra material and time, and being non-irritating to periapical tissue [22, 23].

To date, some studies have been performed on the outcome of calcium silicate-based endodontic sealers in vital and devital cases [24–27]. However, none of them have compared the success rates of epoxy resin-based sealers and calcium silicate-based sealers in retreatment cases with periapical lesions. Therefore, the aim of the present study is to evaluate the success rates of non-surgical root canal retreatment in cases with periapical bone destruction that were obturated either with calcium silicate-based sealers or epoxy resin-based sealers, along with gutta-percha.

## Materials and methods

### Case selection and treatment procedure

Ethical approval was obtained from our university, Faculty of Medicine, Clinical Research Ethics Committee (Approval number: E-71522473-50.01.04-202827-354). Furthermore, a written informed consent was obtained from all patient and legal guardian of minor regarding the use of their radiologic data for scientific research. The data were obtained retrospectively from the records of the teeth treated between September 2020 and February 2022 at our university, Faculty of Dentistry, Department of Endodontics. The study included retreatment cases with symptomatic or asymptomatic apical periodontitis with periapical lesions treated either with epoxy resin-based sealers or calcium silicate-based sealers.

### Inclusion and exclusion criteria

Inclusion criteria were as follows:

1. Teeth with sufficient quality preoperative and postoperative X-rays.
2. Teeth with complete root canal development.
3. Radiologically acceptable quality of the root canal treatment (all root canals obturated sufficiently within 2 mm from the radiological apex, absence of broken file etc.).
4. Acceptable coronal restoration.
5. Patients who came to follow-up sessions.

Exclusion criteria were as follows:

1. Internal or external root resorption cases.
2. Teeth with open apex.
3. Severe periodontal loss.
4. Treatments performed in one session.
5. Primary endodontic treatment.
6. Teeth that underwent periapical surgery after the root canal treatment.

All root canal treatments and follow-ups were performed by a single endodontic specialist with more than 5 years of experience. A standardized treatment protocol was carried out in two sessions. At the first session access cavity were opened and gutta-percha removed by the aid of rotary retreatment files (ProTaper Universal Retreatment System, Dentsply Maillefer, Ballaigues, Swizerland) and H type hand files (Mani, Tochigi, Japan). After removing old gutta-percha, root canal shaping completed either with ProTaper Next Rotary system (Dentsply Maillefer, Ballaigues, Swizerland) or conventional hand files according to root canal anatomy. Calcium hydroxide dressing (Cerkamed, Stalowa Wola, Poland) were inserted into the root canals between first and second sessions. The second session were scheduled a week after from the first session. At the second session, after removal of calcium hydroxide and radiographic confirmation of gutta-percha position, final irrigation performed with 2.5mL 5% EDTA, 5 mL 3% NaOCl, 2.5mL distilled water, 2.5mL and 2% chlorhexidine per root canal. The root canals

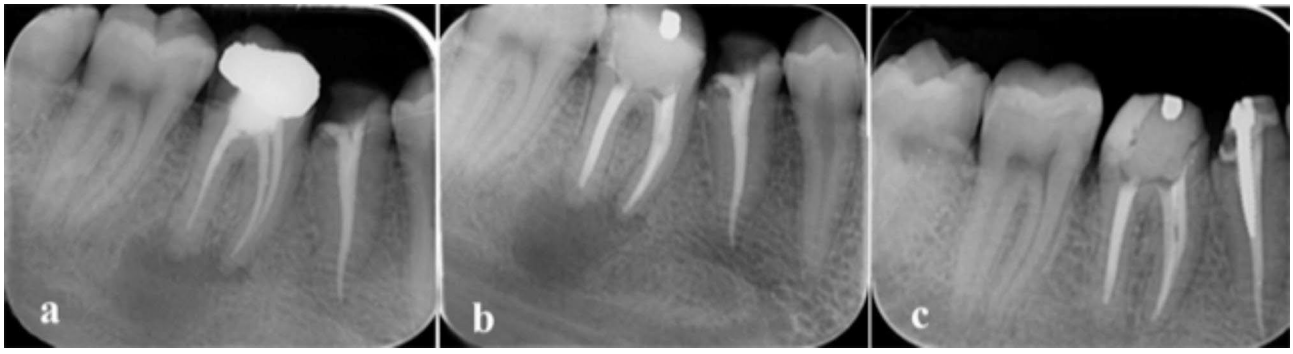


**Fig. 1** Calcium-silicate based sealer group: (**a**) preoperative radiograph of mandibular first molar, (**b**) post-operative radiograph, (**c**) 14 months follow-up radiograph showing complete healing

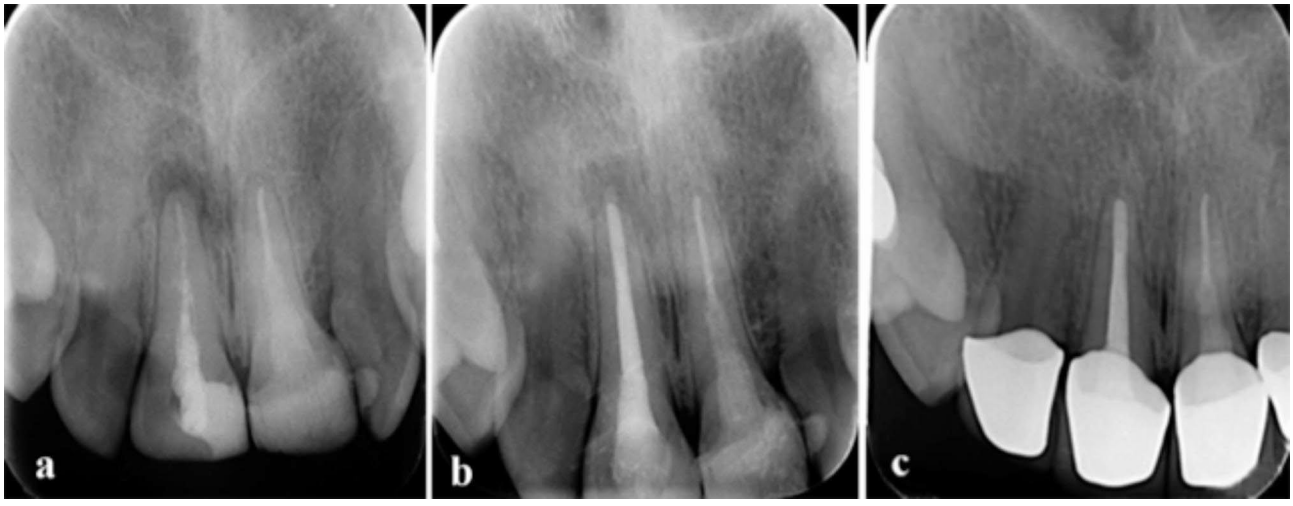


**Fig. 2** Epoxy resin-based sealer group (**a**) preoperative radiograph of maxillary right incisor, (**b**) post-operative radiograph, (**c**) 24 months follow-up radiograph showing complete healing

were then obturated either with calcium silicate-based root canal sealer (Ceraseal Meta Biomed Co., Cheongju, Korea) or epoxy resin-based root canal sealer (Ah Plus Dentsply DeTrey GmbH, Konstanz, Germany) and gutta-percha. All procedures were performed under an operating microscope (Zumax OMS2350, Zumax Medical Co. Ltd, Jiangsu, China). Patients were advised to attend their follow-up appointments every 6 months. In cases completed with a permanent restoration, the access cavity was filled with bulk-fill resin SDR (Dentsply Sirona, Charlotte, NC, USA) and composite resin (Tokuyama Estelite Posterior, Tokyo, Japan). If a prosthetic restoration was needed, the access cavity was filled with glass ionomer cement and patients were advised to apply to the department of prosthesis as soon as possible.

#### Clinical and radiographic evaluation

Recall appointments were archived including radiographic and clinical examination of the treated tooth. Radiographic data were obtained retrospectively from patient admission system (Figs. 1 and 2).

Radiographs were evaluated by two calibrated examiners. Teeth were all scored according to their healing process [25] and periapical index (PAI) scoring system [28].

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

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.

### Outcome assessment

Both healed and healing cases were considered as success and unhealed cases were considered as failure. Patient and tooth related factors such as sex, age, periapical lesion size, coronary restoration type, sealer extrusion and follow-up time were also evaluated. The age of the patients was divided into two categories; those under 45 and those older than 45. Periapical lesion size was evaluated into 3 groups; small lesions (0–2 mm), medium lesions (2–5 mm), and large lesions (more than 5 mm) [29, 30].

### Statistical analysis

The data were analyzed using IBM SPSS version 26.0 (SPSS Inc., Chicago, IL, USA). Normality of distribution was assessed using the Shapiro-Wilk test. Categorical variables were compared between groups using the Chi-square test and Fisher's Exact test. An independent samples t-test was used to compare the initial and final PAI differences based on sealer type. Statistical significance was considered at $p<0.05$. The level of inter-observer agreement was evaluated using Cohen's kappa statistics.

## Results

The study included retreatment cases of 44 patients, comprised of 20 males and 24 females, with ages ranging from 14 to 67 years (mean age: 32.68 ± 12.01 years). While 28 cases were in the calcium silicate-based sealer group, 16 cases were in the epoxy resin based-sealer group. The majority of cases were anterior teeth. Cohen's kappa score for inter-observer agreement ranged from 0.687 to 0.954 for healing and initial, final, and delta PAI, which indicates a good agreement between the observers. No significant differences were found between the two groups in terms of age, tooth type, gender, healing status, restoration type, and obturation technique ($p>0.05$). Sealer extrusion was observed only in the calcium silicate-based sealer group but did not affect the healing capacity. The median age of the epoxy resin-based sealer group (37.5) was slightly higher than that of the calcium silicate-based sealer group (31), but this difference was statistically insignificant ($p=0.065$). There were no significant differences in healing status based on gender, tooth type, and obturation technique ($p>0.05$). Both single-rooted and multi-rooted teeth showed similar healing responses ($p=0.382$). One case in the epoxy resin-based sealer group was considered as unhealed, whereas all cases in the calcium silicate-based sealer group were healing or healed. The mean follow-up duration was significantly shorter in the calcium silicate-based sealer group (11.9 months) compared to the epoxy resin-based sealer group (23.6 months) ($p<0.001$). Initial PAI status was significantly higher in the calcium silicate-based sealer group than in the epoxy resin-based sealer group ($p<0.05$), but there was no significant difference in final PAI status between the two groups ($p>0.05$) (Table 1). The mean Delta PAI values were significantly different between the two groups ($p=0.022$) (Table 2). The calcium silicate-based sealer group had a considerably faster healing rate than the epoxy resin-based sealer group ($p<0.05$), despite having a shorter mean follow-up period.

**Table 1** Comparison of the initial and final PAI scores according to sealer type

| | Sealer type | | |
|---|---|---|---|
| **Initial PAI score** | **Calcium silicate-based (Ceraseal) n (%)** | **Resin based (AH+) n (%)** | **p** |
| PAI 1 | 0[a] (0.0) | 1[a] (6.2) | **0.03*** |
| PAI 2 | 0[a] (0.0) | 1[a] (6.2) | |
| PAI 3 | 5[a] (17.9) | 4[a] (25.0) | |
| PAI 4 | 11[a] (39.3) | 9[a] (56.2) | |
| PAI 5 | 12[a] (42.9) | 1[b] (6.2) | |
| Final PAI score | | | |
| PAI 1 | 19 (67.9) | 8 (50.0) | 0.145 |
| PAI 2 | 3 (10.7) | 6 (37.5) | |
| PAI 3 | 5 (17,9) | 1 (6,2) | |
| PAI 4 | 1 (3,6) | 1 (6,2) | |
| PAI 5 | 0 (0) | 0 (0) | |

Fisher's Exact test

The significance level was set to $P<0.05$. *: $P<0.05$

Each superscript letter denotes a subset of sealer type categories whose column proportions do not differ significantly from each other at the 0.05 level

**Table 2** Comparison of the delta PAI scores according to sealer type

| **Sealer Type** | ***n*** | **DELTA PAI (Mean ± SD)** | ***p*** |
|---|---|---|---|
| Calcium silicate-based (Ceraseal) | 28 | 2.68 ± 1.09 | **0.022*** |
| Resin based (AH+) | 16 | 1.81 ± 1.27 | |

Independent samples t-test

The significance level was set to $P<0.05$. *: $P<0.05$

## Discussion

The use of single cone technique has been a matter of concern due to apical leakage and low dentinal tubule penetration [31, 32]. Macedo et al. [33] compared dentinal tubule penetration of single cone and thermoplastized gutta-percha obturation and found significantly less tubule penetration in single cone obturation group. However, it has been shown that use of matched gutta-percha increases dentinal tubule penetration of the sealer [34]. According to another study, cold root canal obturation methods are still quite popular [35]. Therefore, in the present study, single cone obturation and lateral compaction techniques were preferred due to being easy

to use and requiring no extra equipment [22, 23]. The lateral compaction method was employed when a single cone obturation was insufficient for hermetic obturation. Moreover, there is no single obturation method for every case.

In contrast to the study by Chybowski et al. [25] concentration of 3% NaOCl was preferred in the present study due to lower concentrations of NaOCl have same effect as high concentrations with longer contact period [36]. Similarly, lower concentrations of NaOCl was used in other outcome studies [8, 26, 27].

There are some studies about clinical outcome of non-surgical endodontic retreatment but many of those did not separate retreatment cases from primary endodontic treatment cases [25, 29, 37]. Only retreatment cases included in the present study to standardize inter group variations.

Contemporary single visit root canal treatment has gained popularity due to great patients' acceptance and reduced risk of temporary filling [38]. However, there is no evidence to support the superiority of single session root canal treatment over multiple visits root canal treatment [38, 39]. Furthermore, some studies claim that without calcium hydroxide dressing, proper bacterial elimination cannot be mentioned in root canal treatments, and that using calcium hydroxide may boost the likelihood of clinical success [40, 41]. Therefore, in the present study, root canal procedures were carried out multiple visits utilizing calcium hydroxide as an intracanal medication; procedures carried out in a single session were excluded from the study due to potential variations in the healing process. Same approach was preferred in different studies [24, 27].

Previous studies have used different sample sizes. Bel Haj Salah et al. [24] completed their study with 7 cases treated by a 3-year experienced endodontic resident. Chybowski et al. [25] reported a study that included 307 cases treated by 4 different endodontists, but they included both initial treatment and retreatment cases. Li et al. [27] evaluated 185 primary treatment and retreatment cases treated with same endodontist in their study. Coşar et al. [26] completed their study with 88 vital cases. In the present study, a total of 44 cases were included, 28 cases for calcium silicate-based sealer group and 16 cases for epoxy resin-based sealer group. Unlike previous studies, all cases were treated by the same operator and only the cases of retreatments with periapical lesions were included in the study to provide more standardized study design.

Different irrigation regimes were performed in different studies. Bel Haj Salah et al. [24] used 3.25% NaOCl during root canal enlargement and 17% EDTA for final irrigation. Chybowski et al. [25] used 5.25% NaOCl during root canal enlargement and 17% EDTA with passive ultrasonic activation as final irrigation. In a recent study, Coşar et al. [26] used 2.5% NaOCl during enlargement and 17% EDTA, 2.5% NaOCl, and distilled water as final irrigation. In the present study, 3% NaOCl was used during root canal enlargement, and final irrigation was performed with 5% EDTA, 3% NaOCl, distilled water, and 2% chlorhexidine. NaOCl was activated with a sonic activation device to increase its effectiveness and 5% EDTA was preferred to over 17% EDTA due to having no significant difference in terms of smear layer removal [42] and to minimalize the risk of dentinal erosion due to use of higher concentrations of EDTA [43]. Moreover, 2% chlorhexidine was used to obtain additional antimicrobial effect and increase bonding strength by inhibiting matrix metalloproteinase [11].

The age group was classified in general outcome studies based on potential influences on healing capacity. According to some studies in the literature, significantly better outcomes were observed in patients older than 45 years compared to younger patients [44, 45]. Therefore, patients were divided into two age groups as under 45 and those older than 45 in the present study. No significant difference was found between age and the healing capacity in the present study. Li et al. [27] established a 40-year-old threshold, and Coşar et al. [26] established a 35-year-old threshold. In both studies, no significant correlation was found between the healing capacity and age. Chybowski et al. [25] categorized the patients as being over 50 and those who were under 50 and they found that patients younger than 50 years tended to have a higher rate of success than older patients. This different finding may be related with the higher mean age value.

In some of the previous studies lesions were categorized as larger than 5 mm and smaller than 5 mm [25, 27], while others categorized lesions as small (0–2 mm), medium (2–5 mm) and large (more than 5 mm) lesions, as in our study [29, 30]. In order to evaluate the relationship between lesion size and healing capacity more accurately, this classification was preferred in the present study.

Since lesion healing can take four to five years, a minimum of four years of follow-up period is recommended [46]. On the other hand, due to the lengthy duration, patients become less motivated and reluctant to attend follow-up appointments [47]. With the exception of one case in which an epoxy resin-based sealer was applied, all cases showed a clear healing in the present study. An increase in lesion size was observed in the unhealed case. The lesion size did not remain stable in any of the cases. Therefore, the relatively short follow-up period in the present study no longer seems to be a limitation.

To the best of our knowledge, no previous studies have investigated the efficacy of epoxy resin-based root canal sealer and calcium silicate-based root canal sealer with

cold compaction techniques in the retreatment cases. Some studies have examined the success rate of cases with calcium silicate-based root canal sealers [18, 20, 25, 26, 29], but very limited of them investigated success rate of retreatment cases [25, 29]. Furthermore, none of them have compared the efficacy of epoxy resin-based sealers and calcium hydroxide-based sealers with cold compaction techniques. In this sense, this study appears to be the first. In the present study, the overall success rates for the calcium silicate-based root canal sealer and resin-based sealer were 100% and 93.75%, respectively. The success rate of the calcium silicate-based sealer group was higher than that of a previous study [25], but the mean follow-up time in the previous study was longer than in ours [29]. This lower success rate in the previous study could be related with lack of final irrigation regimen along with higher follow-up period. Differently from the previous studies [25, 29], retreatment in two visits may have increased the success rate along with the irrigation regimen due to antibacterial and antifungal effect of calcium hydroxide which utilized as an intracanal medicament [48]. The high success rate in our study, in addition to the variables previously mentioned, can be attributed to the fact that each case was handled by the same operator with more than five years of postdoctoral experience.

In the present study, healing rates among the groups were statistically insignificant. However, significant decrease was detected in the PAI status. While decrease of 2.68 points was observed in the calcium silicate-based root canal sealer group in the 11-month follow-up period in the PAI score, 1.81 points decrease was observed in the epoxy resin-based sealer group in 24 months. This finding indicates that calcium silicate-based sealer has better healing potential than epoxy resin-based sealer.

In a previous study, AlBakhakh et al. [29] divided periapical lesions into three subgroups as small, medium, and large as in the present study. They showed that small and medium lesions had a significant success rate compared to large lesions. Unlike this study, large lesions also healed as much as small and medium lesions and success rate is much higher in the present study. This difference could be related with the treatment protocol used and the operator's clinical experience.

To the authors' knowledge, this is the first clinical trial comparing the success rate of retreatment using calcium silicate-based sealer and epoxy resin-based sealer with single cone and lateral compaction technique. The limited number of cases evaluated and the difference in sample sizes between the groups may be the limitations of this study. Further studies could be performed with more cases and long term follow of period.

This study revealed that epoxy resin-based sealer and calcium silicate-based sealer had similar healing rates. Furthermore, there was no difference in the healing rates between single cone obturation and lateral compaction techniques. However, the calcium silicate-based sealer group showed a faster healing capacity than the epoxy resin-based sealer group. Further long-term clinical trials with different pulpal and periapical status and more cases could be beneficial.

#### Author contributions

A. K. E. and F. K. conceived the ideas; A.K.E carried out the treatments and collected the data; F. K. analyzed the data; A.K.E and F. K. wrote, reviewed, edited, and approved the final manuscript.

#### Funding

No funding was obtained for this study.

#### Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

#### Ethics approval and consent to participate

This study was approved by Sakarya University, Faculty of Medicine, Clinical Research Ethics Committee (Approval number: E-71522473-50.01.04-202827-354). The study was performed according to Helsinki Declaration. Informed consent was obtained from all patient and legal guardian of minor regarding the use of their radiologic data for scientific research.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare no competing interests.

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