

## Research Article



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### Conflict of Interest

No potential conflict of interest relevant to this  
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# Incidence of interappointment emergencies in multiple-visit root canal treatments performed with or without intracanal medicament by undergraduate students

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## ABSTRACT

**Objectives:** This retrospective cohort study examined the incidence of interappointment emergencies during multiple-visit molar root canal treatments conducted by undergraduate students. Treatments performed without the use of intracanal medicament were compared to treatments that incorporated calcium hydroxide as an intracanal medicament.

**Materials and Methods:** Interappointment emergencies, defined as instances of pain or swelling that required the patient to make an unscheduled follow-up visit, were recorded for up to 2 months after the intervention. To avoid the influence of obturation on the observed incidence of emergency visits, only unscheduled visits occurring between the start and end of the root canal treatment were included.

**Results:** Of the 719 patients included in this study, 77 (10.7%) were recorded as experiencing interappointment emergencies. Of these emergencies, 62% occurred within 2 weeks following the most recent intervention. In the group of patients who did not receive intracanal medicament, the incidence of interappointment emergencies was 11.9% (46 of 385 patients). In comparison, this rate was 9.3% (31 of 334 patients) among those who received calcium hydroxide as an intracanal medicament (odds ratio, 1.33; 95% confidence interval, 0.82–2.15;  $p = 0.249$ ).





**Conclusions:** Interappointment emergencies may arise at any point during root canal treatment, but they most commonly occur within the first 2 weeks following intervention. The omission of intracanal medicament in multiple-visit molar root canal treatments, performed by undergraduate students, did not significantly increase the incidence of these emergencies.

**Keywords:** Clinical outcomes; Dental education; Endodontics; Pain; Patient outcomes; Prevention

**Author Contributions**

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**INTRODUCTION**

Root canal treatments are frequently conducted over multiple visits. Patients may return to the clinic between these scheduled appointments due to pain or swelling, a situation referred to as an interappointment emergency [1,2]. Such emergencies are not only unpleasant for both the patient and the dentist, but they also demand additional resources and expenses, while contributing to the carbon footprint [3].

During the initial visit for a root canal treatment, the root canals may not be thoroughly prepared and irrigated. This can leave behind tissue remnants or a persisting infection, potentially triggering an interappointment emergency [4]. While incomplete preparation alone is not necessarily related to a higher incidence of interappointment emergencies, it may be pertinent to consider the use of an intracanal medicament in such scenarios [5].

The utilization of calcium hydroxide as an intracanal medicament has become common practice in root canal treatment [6]. Calcium hydroxide is believed to play a key role in disinfecting the root canal system and inhibiting the regrowth of microorganisms [7,8]. The healing of apical periodontitis after a root canal treatment has been attributed in part to the use of calcium hydroxide [9]. However, the purported benefits of calcium hydroxide as an intracanal medicament in root canal treatments are still under scrutiny. The healing of apical periodontitis following a single-visit root canal treatment appears comparable to the healing observed after multiple-visit root canal treatments with calcium hydroxide as an intracanal medicament, as well as the healing after a 2-visit root canal treatment without the use of an intracanal medicament [10,11]. Microorganisms can regrow between visits, even when calcium hydroxide is used as an intracanal medicament [11]. For calcium hydroxide to effectively disinfect, it must come into direct contact with the microorganisms, which is not always feasible in all areas of the root canal system or within the dentinal tubules [12]. Moreover, most microorganisms inhabiting the root canal system exist in biofilms, which make them more resistant to alkaline stress and, consequently, less susceptible to the effects of calcium hydroxide [13]. Calcium hydroxide may even facilitate the proliferation of opportunistic microorganisms, leading to a shift in biofilm composition towards more resilient species [14]. It may also contribute to an increase in biofilm mass production [15].

Based on the available scientific evidence, calcium hydroxide cannot be definitively concluded to have a therapeutic effect in root canal treatment [16]. Moreover, it is extremely challenging, if not impossible, to completely remove calcium hydroxide from the root canal system [17]. The remnants of calcium hydroxide left in the root canal system can negatively impact the sealing ability of the root filling [18]. Additionally, exposure to calcium hydroxide has been found to not only decrease the flexural strength and fracture resistance of the dentin, but also cause irreversible changes such as paresthesia and necrosis in cases of extrusion into periradicular tissues [19-21].

The application of calcium hydroxide as an intracanal medicament is not risk-free, and undergraduate students may struggle with its placement into the root canals [22]. In undergraduate clinics, root canal treatments typically span multiple visits, with an average of 4 [23]. The relevance of calcium hydroxide used as an intracanal medicament may be higher in these clinics compared to others. Patients in undergraduate clinics who experience an interappointment emergency are less likely to complete root canal treatment than patients who do not, and an incomplete treatment could potentially jeopardize their overall health

[23]. However, insufficient scientific evidence exists to determine whether calcium hydroxide used as an intracanal medicament can reduce the risk of interappointment emergencies. Within the first 2 days post-intervention, the use of calcium hydroxide does not decrease the incidence or intensity of pain [24]. That said, pain or swelling that requires an emergency visit may occur later.

The efficacy of calcium hydroxide as an intracanal medicament in reducing the risk of interappointment emergencies in undergraduate clinics has not yet been confirmed. Therefore, this retrospective cohort study was conducted to analyze the incidence of such emergencies during molar root canal treatments performed by undergraduate students across multiple visits. Molar root canal treatments were specifically chosen for this study due to the greater number of visits required to complete the treatment, as well as the increased incidence of interappointment emergencies associated with molars [1,23,25]. This study compared treatments performed without an intracanal medicament to those conducted with calcium hydroxide used as the intracanal medicament.

## MATERIALS AND METHODS

The ethics committee of the Academic Centre for Dentistry Amsterdam independently reviewed and approved the research protocol of this study (nr. 2017013). As this was a retrospective cohort study, written informed consent was not required. The protection of participants' rights was ensured throughout the study. Additionally, this study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology checklist for cohort studies.

### Design

An interappointment emergency was defined as an instance of pain or swelling that occurs during the course of root canal treatment, necessitating an unscheduled visit to the institution by the patient. To avoid the influence of obturation on the observed incidence of emergency visits, only unscheduled visits that occurred between the beginning and end of the root canal treatment (interappointment emergency visits) were included in this study. The time between the interappointment emergency and the preceding intervention was documented. While the period between consecutive appointments can exceed 2 months, the occurrence of interappointment emergencies was evaluated only up to 2 months post-intervention, as this was deemed most relevant for our undergraduate clinic.

The primary independent variable in this study was the application of intracanal medicament between visits. Multiple-visit treatments without intracanal medicament were compared to those with calcium hydroxide used as an intracanal medicament. Additionally, other variables potentially related to the incidence of interappointment emergencies were evaluated. **Table 1** shows the additional variables assessed. The patient's sex, which was based on the patient's identification, was retrieved from the patient chart in the dental record system. Medically compromised patients—that is, patients with primary immunodeficiency diseases or taking immunosuppressive medication—were identified based on recorded information from the medical anamneses and using the classification criteria of the International Union of Immunological Societies Expert Committee for Primary Immunodeficiency and the Dutch Pharmacotherapeutic Compass (National Health Care Institute, Diemen, The Netherlands), respectively [26]. At our dental school, 5 diagnoses are used to differentiate between various pulpal and/or periapical pathoses: reversible pulpitis, irreversible pulpitis, irreversible

**Table 1.** Distribution of variables across the 2 patient cohorts receiving multiple-visit molar root canal treatment

Variables	No.	No intracanal medicament (n = 385)	Calcium hydroxide (n = 334)	p value
Sex				0.775
Male	392	208 (54.0)	184 (55.1)	
Female	327	177 (46.0)	150 (44.9)	
Pain (preoperative)				0.644
Present	565	300 (77.9)	265 (79.3)	
Absent	154	85 (22.1)	69 (20.7)	
Diagnosis (preoperative)				0.139
Irreversible pulpitis	282	149 (38.7)	133 (39.8)	
Irreversible pulpitis with apical periodontitis	112	51 (13.2)	61 (18.3)	
Symptomatic apical periodontitis	215	118 (30.6)	97 (29.0)	
Asymptomatic apical periodontitis	110	67 (17.4)	43 (12.9)	
Abscess (preoperative)				0.332
Present	55	26 (6.8)	29 (8.7)	
Absent	664	359 (93.2)	305 (91.3)	
Sinus tract (preoperative)				0.024*
Present	71	47 (12.2)	24 (7.2)	
Absent	648	338 (87.8)	310 (92.8)	
Location of treated molar				0.181
Upper jaw	321	163 (42.3)	158 (47.3)	
Lower jaw	398	222 (57.7)	176 (52.7)	
Diabetes				0.540
Yes	37	18 (4.7)	19 (5.7)	
No	682	367 (95.3)	315 (94.3)	
Medically compromised				< 0.001*
Yes	24	4 (1.0)	20 (6.0)	
No	695	381 (99.0)	314 (94.0)	
Treatment follow-up				0.029*
Root canal treatment completed	613	316 (82.1)	297 (88.9)	
Extraction following initial treatment	33	20 (5.2)	13 (3.9)	
Quit treatment following initial treatment	73	49 (12.7)	24 (7.2)	
Complications†				0.415
None	616	336 (87.3)	280 (83.8)	
Calcifications	51	22 (5.7)	29 (8.7)	
Fracture	18	11 (2.9)	7 (2.1)	
Perforation	17	9 (2.3)	8 (2.4)	
Separated instrument	17	7 (1.8)	10 (3.0)	
Age (yr)				0.282
≤ 30	159	78 (20.3)	81 (24.3)	
31–40	158	78 (20.3)	80 (24.0)	
41–50	180	100 (26.0)	80 (24.0)	
51–60	127	78 (20.3)	49 (14.7)	
61–70	75	39 (10.1)	36 (10.8)	
> 70	20	12 (3.1)	8 (2.4)	
Antibiotics (preoperative)				0.510
Yes	25	15 (3.9)	10 (3.0)	
No	694	370 (96.1)	324 (97.0)	

Data are presented as number (%).

\*Variables that were not evenly distributed across the 2 cohorts are indicated with an asterisk. Sub-variables that were not evenly distributed across cohorts are presented in italic typeface. The p values ≤ 0.05 were considered to indicate statistical significance.

†The number of complications observed in this study was low, and as a result, they were excluded from further analyses.

pulpitis with apical periodontitis, symptomatic apical periodontitis, and asymptomatic apical periodontitis. Root canal treatment is not performed on teeth diagnosed with reversible pulpitis. Additionally, if a root canal treatment was not completed within a year of its initiation, it was categorized as “quitting treatment following initial treatment,” indicating incomplete root canal treatment.

All data used in this study were extracted from the information recorded in the patients' charts.

### Sample

Patients who underwent primary root canal treatment on a molar across 2 or more visits at our institution's undergraduate clinic were included. If a patient received root canal treatment on more than 1 molar, only the treatment of a single molar was included in this study. Random tables generated at <https://www.random.org> (RANDOM.ORG, Dublin, Ireland) were used to select the molar for inclusion. Any root canal treatments that had been initiated outside of the undergraduate clinic were excluded.

The patient cohort that received calcium hydroxide as an intracanal medicament during molar root canal treatment consisted of individuals treated between September 2010 and September 2011 ( $n = 334$ ). The data collection period for this sample could not be extended without introducing a risk of bias. This was because the root canal preparation method was revised in September 2010, and the use of calcium hydroxide as an intracanal medicament during root canal treatment was discontinued from the protocol in September 2011. However, calcium hydroxide remained available in the undergraduate clinic for several more months. Therefore, the patient cohort that did not receive intracanal medicament during molar root canal treatment included those treated between September 2012 and September 2014 ( $n = 385$ ). A sample size calculation was performed using G\*Power 3.1.9.7 for Windows (Heinrich Heine University, Düsseldorf, Germany). This calculation was based on the estimated incidence of interappointment emergencies according to the literature, which ranged from 1.5% to 5.5% with a tendency towards 1.5% [1,2,4,27]. Consequently, for the sample size calculation, the lower and upper limits of the reported range of interappointment emergencies were used for proportions 1 and 2, respectively. The sample size calculation indicated that each group required at least 290 patients ( $\alpha$  type error = 0.05, power = 0.8).

The treatments included in this study were performed by dental students in their final years of undergraduate training. All procedures were performed under isolation with a rubber dam. Prior to initiation of the root canal treatment, any existing caries were excavated. When indicated for proper isolation or temporary restoration, the walls of the tooth were restored before proceeding with the root canal treatment. Throughout the preparation process, the root canal system was irrigated with 2% sodium hypochlorite using 10-cc luer lock-tip syringes (Terumo Medical Corporation, Somerset, NY, USA) and irrigation needles (NaviTip, Ultradent Products Inc., South Jordan, UT, USA) until 1–2 mm short of the working length. The root canals were prepared using rotary instruments (Mtwo, VDW, Munich, Germany) in a modified crown-down sequence: after enlarging the coronal part of the canal with a size 20.06 rotary instrument, the entire Mtwo sequence from size 10.04 to size 40.04 was used to reach the full working length. The working length was consistently confirmed via periapical radiography before the rotary preparation was conducted to this length. Electronic length measurement devices were also available to determine the working length. Upon completion of the preparation, irrigation was finished using ultrasonic-activated irrigation. This involved three 20-second cycles, using an ultrasound needle (IrriSafe; ACTEON Group, Merignac, France) and 2% sodium hypochlorite.

In the patient cohort that received intracanal medicament, the canals were dried using paper points. Subsequently, a calcium hydroxide paste (UltraCal XS 30%–35%, Ultradent Products Inc.) was applied using a capillary tip (Ultradent Products Inc.) prior to creating the temporary restoration. Regardless of whether they were treated with intracanal medicament,

teeth were temporarily restored using a temporary filling material (Cavit W, 3M, St. Paul, MN, USA) and glass ionomer cement (Ketac, 3M) between visits. Care was taken to ensure that the tooth undergoing treatment was free from occlusal contacts.

### Data acquisition

Data were obtained from the dental record system using spreadsheets with drop-down lists to prevent typographical errors. Two observers were responsible for retrieving the data. To ensure proper data collection, a third observer randomly checked the data. All observers signed confidentiality agreements, and the data were processed anonymously.

### Statistical analyses

Data were analyzed using SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA). Pearson chi-square and, when indicated, Fisher exact tests were performed to examine the distribution of variables across the 2 cohorts. These tests were also used to investigate the relationship between these variables and the occurrence of interappointment emergencies. For cross tables larger than  $2 \times 2$ , adjusted standardized residual values were utilized to determine which sub-variables deviated from the expected count. To investigate whether the omission of calcium hydroxide intracanal medicament during multiple-visit root canal treatment was associated with the incidence of interappointment emergencies, binary logistic regression analyses were conducted. Corrections were made for variables that were related to interappointment emergencies and could potentially influence their incidence. The significance level was set at 0.05.

## RESULTS

**Table 1** illustrates the distribution of variables, excluding the dependent variable, across the 2 cohorts. The associations between these variables and the occurrence of interappointment emergencies are depicted in **Table 2**.

In this study, 77 of the 719 patients (10.7%) experienced interappointment emergencies. Most of these emergencies occurred within 2 weeks after the intervention (**Table 3**). The incidence of interappointment emergencies was 11.9% (46 of 385 patients) in the cohort of patients who received no intracanal medicament, compared to 9.3% (31 of 334 patients) in the group receiving calcium hydroxide intracanal medicament (odds ratio, 1.33; 95% confidence interval, 0.82–2.15;  $p = 0.249$ ). After correction for the variables that were related to interappointment emergencies and may have influenced the findings, no association was found between the omission of calcium hydroxide intracanal medicament and the occurrence of interappointment emergencies (**Table 4**).

## DISCUSSION

In the dental record system of our institution, all patient communications are recorded. This allowed for a reliable assessment of the incidence of interappointment emergencies in the retrospective study design employed for this research [28]. Given that the undergraduate dental students adhered to uniform protocols for all included root canal treatments, and considering the similar distribution of variables influencing the incidence of interappointment emergencies across both cohorts (**Tables 1 and 2**), the 2 cohorts were highly comparable.



**Table 2.** Relationships between variables and the incidence of interappointment emergencies

Variables	Interappointment emergencies			p value
	Incidence	Present	Absent	
Sex				0.996
Male	10.7	42 (54.5)	350 (54.5)	
Female	10.7	35 (45.5)	292 (45.5)	
Pain (preoperative)				0.002*
Present	12.6	71 (92.2)	494 (76.9)	
Absent	3.9	6 (7.8)	148 (23.1)	
Diagnosis (preoperative)				0.006*
Irreversible pulpitis	9.6	27 (35.1)	255 (39.7)	
Irreversible pulpitis with apical periodontitis	14.3	16 (20.8)	96 (15.0)	
<i>Symptomatic apical periodontitis</i>	14.4	31 (40.3)	184 (28.7)	
<i>Asymptomatic apical periodontitis</i>	2.7	3 (3.9)	107 (16.7)	
Abscess (preoperative)				< 0.001*
Present	43.6	24 (31.2)	31 (4.8)	
Absent	8.0	53 (68.8)	611 (95.2)	
Sinus tract (preoperative)				0.572
Present	12.7	9 (11.7)	62 (9.7)	
Absent	10.5	68 (88.3)	580 (90.3)	
Location of treated molar				0.564
Upper jaw	10.0	32 (41.6)	289 (45.0)	
Lower jaw	11.3	45 (58.4)	353 (55.0)	
Diabetes				0.582
Yes	13.5	5 (6.5)	32 (5.0)	
No	10.6	72 (93.5)	610 (95.0)	
Medically compromised				0.313
Yes	16.7	4 (5.2)	20 (3.1)	
No	10.5	73 (94.8)	622 (96.9)	
Treatment follow-up				< 0.001*
Root canal treatment completed	9.1	56 (72.7)	557 (86.8)	
Extraction following initial treatment	39.4	13 (16.9)	20 (3.1)	
Quit treatment following initial treatment	11.0	8 (10.4)	65 (10.1)	
Age (yr)				0.053
≤ 30	8.2	13 (16.9)	146 (22.7)	
31–40	15.2	24 (31.2)	134 (20.9)	
41–50	12.2	22 (28.6)	158 (24.6)	
51–60	11.8	15 (19.5)	112 (17.4)	
61–70	4.0	3 (3.9)	72 (11.2)	
> 70	0.0	0 (0.0)	20 (3.1)	
Antibiotics (preoperative)				0.003*
Yes	32.0	8 (10.4)	17 (2.6)	
No	9.9	69 (89.6)	625 (97.4)	

Data are presented as number (%).

\*Variables related to interappointment emergencies are denoted with an asterisk. Sub-variables associated with these emergencies are italicized. The *p* values ≤ 0.05 were considered to indicate statistical significance.

**Table 3.** Time elapsed between the most recent intervention and the interappointment emergency

Period	Interappointment emergencies	
	Cumulative percentage (%)	Cumulative incidence (%)
1 day	14.9	1.6
2 days	23.0	2.5
4 days	31.1	3.3
1 week	43.2	4.6
2 weeks	62.2	6.7
1 month	78.4	8.4
2 months	100.0	10.7

The incidence of interappointment emergencies was assessed for up to 2 months after the intervention. The cumulative incidence refers to the number of interappointment emergencies that occurred up to the indicated point in time. The cumulative percentage represents the proportion of the total number of interappointment emergencies that happened up to the indicated point during the 2-month follow-up period.

**Table 4.** Association between the omission of calcium hydroxide as an intracanal medicament and the incidence of interappointment emergencies, as determined with binary logistic regression analysis

Incidence of interappointment emergencies	Odds ratio	95% confidence interval	Regression coefficient
No intracanal medicament compared to calcium hydroxide	1.33	0.82–2.15	0.28
Corrected for preoperative			
Pain	1.35	0.83–2.19	0.30
Diagnosis	1.32	0.81–2.13	0.28
Abscess	1.48	0.89–2.47	0.40
Antibiotics	1.31	0.80–2.12	0.27

The results of this study align with prior research involving root canal treatments performed by undergraduate students, general dental practitioners, postgraduate students, and endodontists. Those studies revealed that the incidence of interappointment emergencies is not related to the patient's sex, age, or potential for compromised healing due to medical conditions, or whether a maxillary or mandibular molar was involved; however, the incidence is associated with the preoperative diagnosis of the tooth and the presence of preoperative pain or abscess [1,2,5,25,29].

The relationship between the incidence of interappointment emergencies and the use of antibiotics, as shown in the present study, should be interpreted with caution. Our sample did not always include information on the reasons for antibiotic prescriptions. According to institutional protocols regarding endodontic pathology, antibiotics should be prescribed only in cases of spreading cellulitis. However, we cannot rule out other reasons for antibiotic prescriptions, as patients may receive them outside of the undergraduate clinic. Other than reasons unrelated to endodontic pathology, antibiotics could have been used due to a preoperative periapical abscess, severe pain, or swelling. All of these factors are intrinsically linked to the incidence of interappointment emergencies [5,29].

In undergraduate clinics, the likelihood of completing a root canal treatment is greater when no emergency visits are necessary between appointments [23]. This finding was also reflected in the current study (**Table 2**), suggesting that an emergency visit between appointments could potentially lead a patient to decline further treatment. However, the results of this study did not confirm such an explanation; the decision to discontinue root canal treatment—resulting in incomplete treatment for the endodontic pathology—appeared unrelated to interappointment emergencies (**Table 2**). The findings did indicate, however, that an interappointment emergency could be a reason for a patient to opt for tooth extraction rather than completing the root canal treatment. The incidence of interappointment emergencies was 4 times higher in the group of patients who chose tooth extraction compared to those who completed root canal treatment (**Table 2**).

The percentage of patients who had the tooth extracted after initial treatment was similarly distributed across both cohorts (**Table 1**). This suggests that the decision to extract the tooth midway through root canal treatment is not influenced by the omission of an intracanal medicament. However, the completion rate of root canal treatments was higher in the cohort that received intracanal medicament (**Table 1**). Interestingly, the number of root canal treatments initiated during the 2010–2011 period (representing the cohort receiving intracanal medicament) was twice as high as the number of treatments initiated during the 2012–2013 or 2013–2014 periods (representing the cohort that did not receive intracanal medicament). The reasons for both the decrease in the number of root canal treatments initiated and the increase in the number of incomplete treatments remain unclear. Potentially, changes in financial



circumstances over time may have played a role. If so, it raises the question of whether this also influenced the number of interappointment emergencies. However, these additional visits were always free of charge for patients, and they were aware of this fact.

The incidence of interappointment emergencies observed in this study may appear high. However, this could be attributed to the extended follow-up interval. Up to 11 days post-intervention, the incidence observed in this study fell within the previously reported range of 1.5% to 5.5% (**Table 3**). In most prior studies, the incidence was evaluated over only a few days following the intervention. A recent study, similar to the present research, reported an incidence of 2.3% over a 3-day interval [2]. This closely align with the incidence observed over the same time period in this study (2.9%).

The extended follow-up period utilized in the present research allowed us to observe that interappointment emergencies could occur not only in the immediate aftermath of an intervention, but also considerably later. An interappointment emergency is defined as a case of pain or swelling severe enough to disrupt a patient's normal routine, necessitating an unplanned visit to the dental clinic [5]. The term “flare-up” is used in most studies to describe similar emergency situations involving pain or swelling [1,2,5]. The American Association of Endodontists defines a flare-up as “an acute exacerbation of an asymptomatic pulpal and/or periradicular pathosis after the initiation or continuation of root canal treatment”, the onset of which typically occurs within a few days following intervention [5,30]. In the present study, we included both asymptomatic and symptomatic teeth and extended the follow-up period to 2 months. This is why we chose to use the term “interappointment emergency” instead of “flare-up”. Interappointment emergencies, as defined in this study, are clinically relevant given that the interval between appointments for root canal treatment at an undergraduate clinic can span weeks or even months. At our clinic, students provide general dental care 2 days a week. Root canal treatments are scheduled alongside other care services provided as part of their undergraduate training. Additionally, it is not uncommon for patients to reschedule appointments, which can result in root canal treatment appointments being spaced far apart. The observed lack of increased risk of interappointment emergencies when no intracanal medicament is used in multiple-visit root canal treatment provides valuable information. This finding seemingly contradicts the prevailing opinions of practitioners and educators.

## CONCLUSIONS

Interappointment emergencies can arise at any point during root canal treatment, not only in the days immediately following the procedure, but also in the weeks thereafter. However, the majority of these emergencies tend to occur within the first 2 weeks post-procedure. Omitting the use of intracanal medicament in multiple-visit root canal treatment did not significantly increase the incidence of interappointment emergencies.

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