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Research Article

Clinical and radiological assessment of periapical wound healing of endodontically treated teeth using two different root canal filling materials

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Abstract. The aim of this study was the 12-month radiological assessment of the results obtained following endodontic treatments performed using two conventional and widely used root canal filling materials. Material and method. There were 22 patients included in the study, undergoing treatment for 24 teeth with one or more roots, teeth with gangrene and periapical pathology. Periapical lesions were assessed using digital radiography at baseline, after 6 months and after 12 months, using the periapical index (Periapical Index Score, PAI). The group of patients was randomly divided into two groups, with 12 teeth subjected to root canal treatment using AH Plus (DentsplyDeTrey GmbH, Konstanz, Germany) and 12 teeth subjected to root canal treatment using RealSeal SE (SybronEndo, Orange, CA, USA). Results. The changes observed in the apical region were not statistically different when considering the two root canal filling materials used for treatment. However, the comparison between the periapical index values recorded for every time interval revealed a statistically significant difference compared with baseline in both groups. **Conclusion.** A proper therapeutic conduct, closely following the rigorous isolation, mechanical and antiseptic preparation and root canal filling stages, is urgently required for a successful therapy.

Key Words: apical periodontitis, periapical index, periapical healing, root canal treatment

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Introduction

The role of bacteria in the development and persistence of apical periodontitis is well established (Siqueira 2002). Mechanical instrumentation, including proper apical preparation, as well as the use of antimicrobial irrigants, are the two key elements that lead to a reduction of intracanal microbial load (Card et al 2002). Root canal treatment is mainly aimed at preventing or treating inflamed periapical tissues. Clinical signs of pulp or periapical inflammation vary and there are few signs indicating these diseases, which occur with unknown frequency. On the other hand, there are currently no saliva or blood tests indicating periapical inflammation. Therefore, for the time being, radiological investigation has become the only method used for assessing periapical inflammation.

Although modern endodontics emphasizes the biocompatibility and the sealing capacity of root canal sealers, there are several root canal filling materials containing antibacterial or therapeutic agents, such as corticosteroids or calcium hydroxide. There is a delicate boundary between cytotoxicity and antibacterial properties when it comes to these root canal sealers. It should be noted, however, that the variations in clinical procedures and the lack of objective criteria in assessing the outcome made it difficult to compare results from different studies. Thus, the periapical index (PAI) was imagined in order to overcome this obstacle (Orstavik et al 1986).

The presence of periapical lesions before root canal treatment increases the risk of treatment failure. The success of root canal treatment of teeth with normal periapical structures is significantly higher compared with teeth with periapical disorders (Chugal et al 2001). Most studies are based on the success/failure ratio, and lesion follow-up occurred until obtaining normal radiological images of periapical structures. This follow-up can be carried out for many years and in some cases it might last up to 10 years or even more (Fristad et al 2001). The European Society of Endodontology (2006) recommends a 4-year follow-up period.

When establishing a root canal procedure following a diagnosis of chronic apical periodontitis, its purpose is to determine apical wound healing. In this situation, it is important that the root canal filling material supports or at least does not slow down periapical bone tissue regeneration processes. Therefore, the aim of this study is to investigate the effect of two root canal filling materials on periapical wound healing using the periapical index scoring system (PAI).

Materials and methods

The periapical index (PAI)

This index is a simple radiographic assessment method that consists of 5 categories numbered 1 to 5. Radiographs shown in Figure 1 (Brynolf 1967) were used as a reference and the following steps were carried out:

1. We found the reference radiograph that most resembles the periapical area studied. We gave a score from 1 to 5.
2. Where there was doubt, we granted the highest score.
3. Teeth with more roots were given the highest score identified in any of the roots.
4. All teeth were given a score.

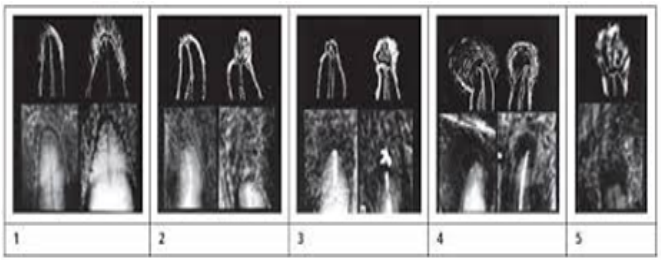

Figure 1. Reference radiographs, simplified, drawn images and PAI scores

In other words, scores were given in accordance with the criteria presented in Table 1.

Table 1. The PAI scoring criteria

PAI score	Radiograph interpretation
1	Normal periapical structures
2	Small changes in bone structure
3	Changes in bone structure accompanied by mineral loss
4	Periodontitis with well-defined radiolucent area
5	Severe periodontitis with exacerbating features and bone expansion

Patient Selection

The study consisted of a total of 22 patients aged between 20 and 45 years, undergoing treatment for 24 teeth with one or more roots, teeth with gangrene and periapical pathology, PAI >3. Each tooth was given a PAI score before treatment. The study was reviewed and approved by the Ethics Committee of "Iuliu Hatieganu" University of Medicine and Pharmacy, Cluj-Napoca (no. 131/2015). The informed consent on inclusion in the study was obtained from all subjects included in the study. The following patients were not included in the study: patients with systemic diseases, pregnant women, patients who took antibiotics, NSAIDs or corticosteroids one month before treatment. Patients with calcified canals, canals with apparent curvature, inaccessible and waterproof canals were also excluded. The group of patients was randomly divided into two groups, A and B, with 12 teeth subjected to root canal treatment using AH Plus (Dentsply DeTrey GmbH, Konstanz, Germany), and 12 teeth subjected to root canal treatment using RealSeal SE (Sybron Endo, Orange, CA, USA).

Root canal treatment

Root canal treatment was performed in two stages, at a one-week interval, with intracanal calcium hydroxide - Calxyd (Spofa Dental, Czech Republic) being applied between the two sessions.

Mechanical and antiseptic preparation of root canals

After isolation with rubber dam system and access cavity preparation, we determined the working length using a ZX apex locator (J. Morita, Japan) and checked it using the radiograph.

Teeth were prepared to working length using ProTaper® system (Dentsply Maillefer) in continuous rotation to instrument F2, according to the manufacturer's protocol.

S1- F2 instrumental sequence was used with X-SmartTM Endodontic Motor® (Dentsply, UK), at a speed of 250 rpm, according to the manufacturer's instructions.

Catheterization was performed manually using a 15/100 mm K-file tool in the presence of EDTA chelating gel (MM EDTA®, Micromega, France), performing watch - winding movements.

Apical patency was maintained throughout the preparation of the root canal by using a manual tool with a 10/100 mm diameter.

The apical diameter of the final preparation was confirmed by the use of an ISO hand tool with a diameter of 25/100 mm.

Mechanical and antiseptic treatment assumed the use of a chelating gel - MM EDTA® (Micromega, France), applied on each of the instruments used for root canal preparation, and the continuous irrigation using sodium hypochlorite at a concentration of 2.5. At the end of the preparation, the canal was irrigated with 1 ml EDTA at a concentration of 8% and maintained for 3 minutes in order to remove the smear layer, further performing a final wash with sodium hypochlorite. After aspiration, root canals were dried with paper points and prepared for sealing.

At the end of the first session, calcium hydroxide was applied inside the root canal and coronal sealing was performed using glass-ionomer cement - Kavitan Plus (SpofaDental, Czech Republic).

In the second session, after isolation, the coronal filling and calcium hydroxide were removed and root canal filling was performed.

Radicular sealing

In order to achieve this phase, the following materials were used:

- AH Plus endodontic sealing cement (DeTrey Dentsply GmbH, Konstanz, Germany) and RealSeal SE (Sybron Endo, Orange, CA, USA)
- Gutta-percha points size F2 (Dia-ProT®, DiaDent)
- System B plugger and manual pluggers for warm vertical condensation of gutta-percha
- System B and backfill for warm vertical condensation technique

Patient follow-up

First, bone changes in apical structures were examined after a period of 6 or 12 months, depending on the material used for root canal filling. This step was performed using the periapical index (PAI).

Secondly, we examined the presence of abnormal clinical signs over 12 months: spontaneous pain, abscesses, mobility, sensitivity to percussion and palpation. All these data were collected and compared with data obtained during the treatment.

Statistical analysis

Statistical analysis was performed using MedCalc software version 15.2.1 (MedCalc Software BVBA, Ostend, Belgium). The Mann-Whitney test was used to assess differences between groups at baseline and after 12 months. After the quantification of periapical lesions (giving PAI scores), the results were analyzed using the Wilcoxon test. Data were distributed as parameters, and differences in the group of patients treated with AH Plus (group A) and the group of patients treated with RealSeal SE (group B) were analyzed using the chi-square test. Statistical significance threshold was established at a p value of <0.05.

Results

At the end of 12-month period, only 20 patients presented themselves for check-up. Therefore, only 22 teeth could be assessed, 11 treated with AH Plus (group A) and 11 with RealSeal SE (group B).

Data regarding clinical signs and symptoms related were collected and recorded, compared with baseline values, but they were not subjected to statistical analysis.

The following results were obtained at the end of 12-month period: group A - 82% of the teeth were healed or were still undergoing healing, 18% were unchanged; group B - 73% teeth were healed or were still undergoing healing, 18% were unchanged, 9% were worse (Table 2). Representative radiological aspects are shown in Figure 2, Figure 3, Figure 4, Figure 5, and Figure 6. Following statistical analysis, there was no significant difference between the two groups (p = 0.12).

The changes observed in the apical region did not differ significantly between the two root canal filling materials (p=0.12). On the other hand, the comparison between the values of the periapical index recorded for each time interval revealed a statistically significant difference versus baseline situation, for both groups (p=0.04) (Table 3, Figure 7).

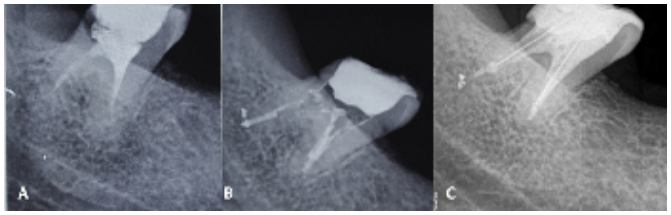

Figure 2. Radiographs of root canal treatment performed with AH Plus at level 4.7. A-baseline B-6 months C-12 months

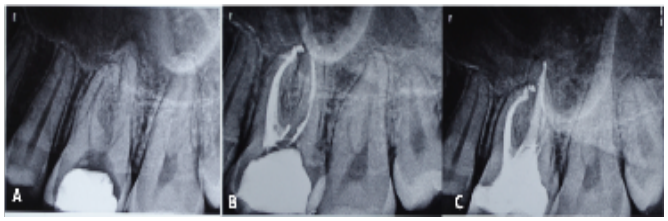

Figure 3. Radiographs of root canal treatment performed with AH Plus at level 2.6. A-baseline B-6 months C-12 months

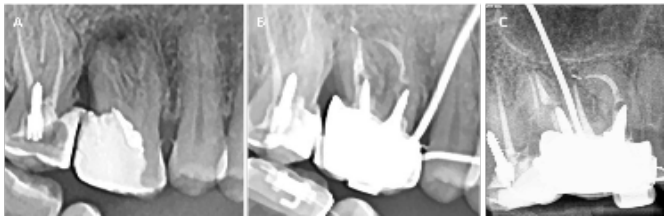

Figure 4. Radiographs of root canal treatment performed with RealSeal SE at level 1.6. A-baseline B-6 months C-12 months

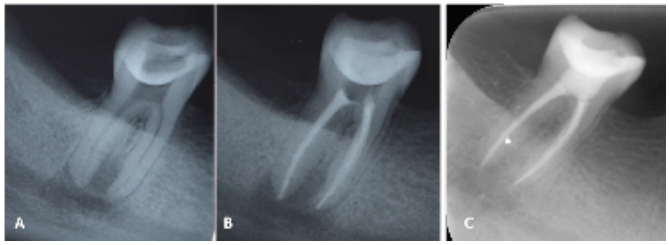

Figure 5.Radiographs of root canal treatment performed with RealSeal SE at level 4.7. A-baseline B-6 months C-12 months

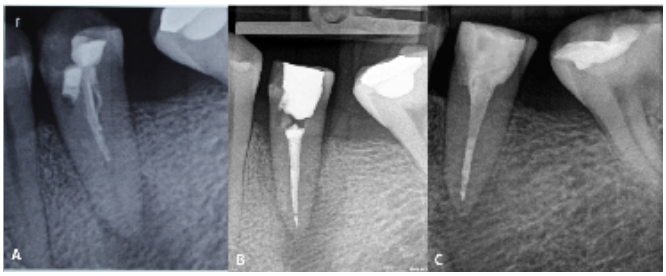

Figure 6. Radiographs of root canal treatment performed with AH Plus at level 3.5. A-baseline B-6 months C-12 months

Table 2. Healed/Unhealed tooth ratio after 12 months; n – number of teeth

	Healed/Undergoing healing	Unchanged	Worse
Group A	82%	18%	0%
n=11	n=9	n=2	n=0
Group B	73%	18%	9%
n=11	n=8	n=2	n=1

Table 3. Mean periapical index values at different times; SD - standard deviation

	Group A PAI mean ± SD	Group B PAI mean ± SD
baseline	3.72±0.51	3.67±0.57
6 months	2.87±0.72	2.82±0.70
12 months	2.21±0.93	2.31±0.99

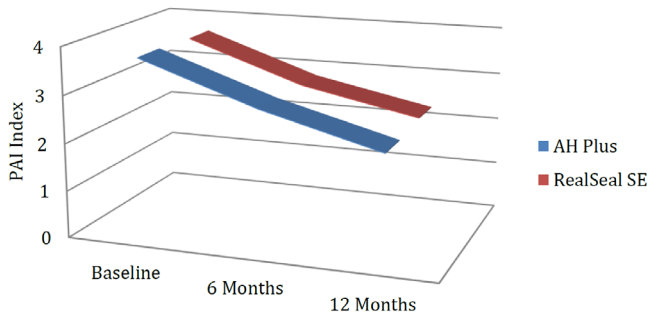

Figure 7.The evolution of periapical index values for the two materials studied

Discussion

Reference radiological images for PAI scores 3, 4 and 5 show clear lesions of the periapical tissue, as first described by Brynolf (1967). Therefore, we can say that all teeth in this study with a PAI score ≥ 3 showed clear periapical lesions.

Calcium hydroxide was used as temporary treatment for a period of 7 days, in accordance with the study carried out by Sjogren et al (1991), showing that the use of calcium hydroxide as intracanal medicine for one week is sufficient to reduce the bacterial count to undetectable levels in cell cultures.

Although longer post-treatment follow-up periods are ideal, evidence of periapical bone changes associated with healing should occur after 12 months, when using the PAI score, and longer follow-up periods are no longer required (Penesis et al 2008, Molander et al 2007). According to Bystrom et al (1987), as long as there is a reduction in the size of the lesion, follow-up is not necessary anymore.

Clinical symptoms were absent, so the results were assessed using radiographs and the PAI.

Periapical healing was visible in the 12 months following treatment in most cases, which is consistent with previous studies (Huumonen et al 2003). In addition, the present study demonstrated clear healing from the very first check-up, 6 months after treatment.

The results of this study demonstrated that mechanical instrumentation, irrigation and root filling play an important role in the healing of periapical lesions. The size of periapical lesions was also considered to be a risk factor, a larger lesion being associated with a lower healing rate when compared to smaller lesions, for the same time interval.

However, the results may be influenced by factors that cannot be controlled. Therefore, diabetic patients were excluded due to possible impaired healing, but smokers were not excluded, although there are studies demonstrating that they may also present delayed healing (Doyle et al 2007). Moreover, an equal number of teeth with one or more roots were excluded from the study in both groups, although the chances of healing for a single-rooted tooth outweigh those of a multi-rooted tooth (Marquis et al 2006). Fortunately, the difference was not too big, so we did not consider it as an influential factor.

A drawback of this study is represented by the small number of patients, which does not allow the identification of a cause-effect relationship between study variables and results. Therefore, it was not possible to correlate the age of patients, their gender, the treated tooth and the root canal filling material used. All these variables could contribute to differences in periapical healing.

While the success of root canal therapy is reported as ranging between 68 and 95%, most studies that have followed the evolution of root canal treatments over time consider that the success rate varies between 85 and 90% (Cvek 1992). It was also observed that the treatment of teeth with periapical lesions has a lower success rate than that of teeth without periapical lesions.

In a clinical trial where calcium hydroxide was used as temporary sealer, Cvek (1992) reported the healing of periapical lesionsin 50 out of 55 cases. In this context, the study conducted by Kerekes and Tronstad (1979) should also be mentioned, as the authors reported an 85% success rate with complete healing and 6% still undergoing healing in the treatment of teeth with apical periodontitis, without using calcium hydroxide. Bystrom et al (1987) indicated that the treatment cannot be considered a failure as long as periapical lesion decrease is recorded, regardless of the time elapsed after treatment.

The healing process is known to be quicker and the recovery complete in young people compared to older people. Similar studies to the present one indicated that age is an important factor in the healing of periapical lesions in patients aged between 11 and 24 years (Gesi et al 2006).

It is assumed that periapical lesions occur due to the immune response to antigens from the root canal. Their interaction with antibodies causes immunological reactions in periapical tissues. Immunological reactions involve the removal of invasive antigenic substances. The healing of periapical structures depends on their ability to develop an immune response to the action of various antigens. The presence of immunocompetent cells, especially T cells, in periapical lesions indicates the presence of humoral immune responses in that area. These complex immune responses play an important role in periapical lesions. However, immune functions are weakened when reaching sexual maturity due to changes in the number and proliferation of immunocompetent cells. The decrease in T-cell proliferation in response to antigens, together with the poor reaction of mature T cells to antigens, are the main factors associated with lower immune responses associated with increased age (Matsuo et al 1994, Kurashima & Utsuyama 1997).

In contrast, in a study that included patients aged between 19 and 86 years, Peters and Wesselink (2002) reported that there is no connection between patient age and periapical healing. In their study, they obtained a 71% success rate of root canal therapy performed in two sessions, after a period of 4½ years. These observations are consistent with studies showing no significant difference in periapical tissue response when T cell functions have been suppressed (Peters & Wesselink 2002), similar to elderly patients. According to this conclusion, we can say that immunodeficiency is not a significant factor in the healing of periapical lesions in the elderly. Due to the controversy over the influence of age on periodontal healing, there is a need for more comparative studies.

Khabbaz and Papadopoulos (1999) have determined that periapical wound healing is not affected by the presence of root canal filling material in the periapical tissue. They also concluded that healing is due to infection control during root canal preparation and, equally, during root canal filling. Katebzadeh et al (2000) also mention the importance of root canal filling in the healing of apical periodontitis. Failure due to overfilling is actually caused by infected dentin and debris pushed beyond the apex during instrumentation. Augsberger and Peters (1990) stressed that periapical would healing takes place even if the root canal sealer reaches the periapical tissue, and possible failure is due to other factors, such as improper handling. Lin et al. (1992) stressed that root canal filling material has a much lower irritant effect than microbial factors.

Huang et al (2002) have concluded that the biocompatibility of the root canal sealer is extremely important as it stimulates the reorganization of the affected periapical tissue that it comes into contact with. Tanomaru et al (1998) stated that in case of teeth with chronic periapical infection, root canal filling materials with antibacterial properties that do not irritate the periapical or periradicular tissues can stimulate apexification and

therefore healing. Leonardo et al (2003) showed that periapical tissue reaction is excellent in the presence of AH Plus. In their study, they observed the presence of mineralized tissue apposition in the apical zone of the root and, in many cases, soft tissue mineralization processes around the apex.

Azar et al (2000) have found that freshly mixed AH Plus has mutagenic and cytotoxic properties, which disappear when filling is completed. Dartar et al (2003) reported the lack of AH Plus cytotoxicity in vitro and the promotion of bone healing.

Other studies have shown that the type and amount of root canal filling material used, its resorption capability and especially its toxicity are all important factors in the healing of periapical lesions.

Another interesting aspect of periapical healing is the link between the healing process and the position of the tooth in the dental arch. There are few studies on the subject and neither does the present study assess this due to the low number of patients. It seems that maxillary second premolars as well as maxillary and mandibular canines have a better prognosis than other teeth. The first maxillary molars often have two middle-vestibular root canals, and one of them could remain unspotted, untreated and unfilled, thus maintaining the infection active. Maxillary lateral incisors present anatomical variations, such as pronounced curvature in the apical area and very thin roots, aggravating the correct mechanicaland antiseptic treatment as well as the root canal filling process. However, other studies suggest that there is no connection between periapical healing and tooth position in the dental arch (Orstavik & Horsted-Bindslev 1993).

Conclusion

Root canal filling materials used in this study had different chemical composition and biological properties. The results were favorable and similar. This indicates that a correct therapeutic conduct, closely following the isolation, mechanical and antiseptic preparation and filling stages, is urgently required in order to achieve therapeutic success.

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