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CONTROVERSIES AND POTENTIAL MEDICAL LIABILITY OF UNINTENTIONAL CANAL OVERFILLING OF ROOT CANAL TREATMENTS AND RETREATMENTS IN TEETH WITH PERIAPICAL RADIOLUCENCY

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Abstract: *Aim.* To determine the risk of unintentional root canal overfilling on long term radiographic outcome of root canal treatments and re-treatments in teeth with periapical radiolucency.

Methodology. Fifty-eight patients who presented seventy-nine teeth with periapical radiolucency (24 primary/ 55 retreatments) were treated by 2 endodontists. The teeth were rotary prepared and filled using AH Plus (Dentsply-Sirona, Germany) and warm vertically compacted gutta-percha. All the teeth presented unintentional canal overfilling, recorded on postoperative radiography. The patients were monitored clinically and radiographically for at least 1 year and up to 9 years in some cases. Two independent observers assessed the radiographs and determined the outcome according to PAI score pooled in a 3-category scale (1 or 2 - health, 3 - uncertain, 4 or 5 - diseased). The persistence or resorption of the extruded material and the final coronal restoration were registered. Also, the Kappa coefficient (K) was calculated. Wilcoxon, Friedman, Mann Whitney U and chi-square tests were used for group comparisons. Statistical significance was set at $p<0.05$.

Results. The level of inter-observer agreement K was 59.1%. The average recall time was 2.96 years. Initial PAI score and tooth location were the factors that significantly affected the outcome. Initial PAI score was statistically significant lower in favorable than in unfavorable/uncertain outcomes ($p<0.001$). Also a more favorable outcome was observed to the maxillary teeth (93.1%) compared to the mandibular teeth (64%) ($p<0.001$). At 1 year recall, mean PAI score decreased from 3.32 to 1.45 ($p<0.001$) and a favorable outcome was observed in 59 (74.68%) teeth. Moreover, mean PAI score decreased from the initial value of 3.5 to 1.58 in the first two years, to 1.17 in the following years ($p<0.001$), this suggesting healing was more pronounced in this period. Persistence of extruded material was present in 87.2% of cases with recalls at 2 years and in 96.8% of the cases with recalls between 2 and 9 years. However, The type of extruded material, its persistence or resorption did not affect the outcomes.

Conclusions. The outcome of root canal treatment with unintentional canal overfilling registered the best results in the first two years, especially in teeth with lower initial PAI score. Gross overfilling may involve medical liability, while a "puff" of sealer is becoming the standard of care, particularly with warm condensation techniques.

Keywords: periapical radiolucency, endodontic outcome, unintentional overfilling, sealer resorption.

INTRODUCTION

The aims of root canal treatment are to shaping, cleaning and filling the root canal system in order to seal the canal system and to prevent periradicular exudate and gingival exudate into the radicular space (Kirkevang *et al.*, 2000) [1]. Endodontic therapy wants to prevent and treat the diseases of the pulp and periradicular region. When pulp tooth suffered a pathological necrosis, this process creates an ideal environment for the growth of microorganisms which release toxins into the periapical tisuues, inducing the formation of an inflammatory reaction and subsequent a periapical lesion (Saatchi M, 2007) [2].

The endodontic standards of care are those standards set by the board-certified endodontists. A

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major standard of care controversy was over the issue of overfilling or overextending the root canal filling. As everybody can see, the today's patients became more sophisticated about their dental wants and more aware of their legal rights, so the dentists can no longer consider immune to malpractice litigation. Often specialists are called in court to assess the cases when patients think they have been treated below the standard of care. In our country, the National College of Dentists has developed a guide of national standard of endodontic care to which the practitioners must conform.

According to this guide, treatment on teeth with periapical lesions has as its objective the drastic reduction of microorganisms, removal of infected pulp and dentin, cleaning and shaping the root canal for proper root canal obturation. The root canal obturation must fill the entire space created after the instrumentation of root canals. So one might argue that any overfilling would be an error and may jeopardize the outcome of root canal treatment [3].

The root canal filling should end at the corect apical position. One of the major controversies is the apical limit of preparation and obturation. Many authors have considered the apical constriction and the cementum-dentinal junction the apical limit of root canal therapy (Ricucci &Langeland, 1998) [4].

However, other specialists have suggested that the apical foramen is the limit of root canal treatment. The apical foramen may have different position in the root (apical or lateral) and many portals of exit. For many years the shape of apical foramen was considered round, but Marroquin *et al.*, 2004 [5] have found in their study that the most common shape is oval, making root canal filling using sealer and standardized gutta-percha cones very difficult. In cases when the establishment of apical limit is very difficult, the apical extrusion is common and can occur through apical foramina and lateral or accessory canals as well. Also, in teeth with non-vital pulp associate with apical pathosis or apical resorbtion, the apical extrusion is very frequent.

Warm vertical condensation seems to produce more overfilled cases than other obturation techniques, especially when associated with epoxy-resin sealers like AH Plus (Dentsply-Sirona, Germany) (Goldberg *et al.*, 2001) [6]. The ability of sealer to flow and enter unininstrumented lateral canals is important. However, the sealer should flow into accessory canals and between gutta-percha cones, without risk of periapical extrusion [7].

It has also been shown that microorganisms persist and grow in dentinal tubules, lateral canals and apical ramifications (Love & Jenkinson 2002, Torabinejad *et al.,* 2002) [8,9]. For eradication of the remaining microorganisms, particularly when pulpal necrosis and apical periodontitis are present, the choice of a sealer which has a substantial antimicrobial activity can play an important role (Spangberg *et al.*, 1973) [10]. In case of overfilling a small amount of filling material went through apical foramina, while a correct, homogeneous root canal obturation fill the entire root canal space. The controversy lies in the fact that these overfilling might affect the long term outcome of root canal treatment. A lot of studies have associated overfilling with poor results in time (Bergenholz *et al.,* 1979, Sjogren *et al.,* 1990, Schaffer *et al.,* 2005) [11-13], while other consider it has no relationship with bad prognosis of root canal treatment or retreatment (Lin *et al.,* 1992, Farzaneh *et al.,* 2004, Ricucci *et al.,* 2016) [14-16]. Although these small amounts of extruded materials could remain for years in the apical area, "it is highly improbable" to produce and maintain a periapical inflammation [16].

The aim of this study was to evaluate the risk of unintentional overfilling on long-term radiographic outcome of root canal treatments and retreatments after warm vertical condensation, at teeth with periapical radiolucency, performed by two endodontists.

MATERIALS AND METHODS

A total seventy nine teeth with periapical radiolucency that exhibiting postoperative unintentional canal overfilling, from 58 patients, were included in this study. Two experienced endodontists performed all these treatments to sixty nine adult patients with ages ranging from 20 to 70 years, during 10 years of their private practice. Twenty-four of these treatments were primary treatments, while 55 were re-treatments. Access cavities were performed using round high speed burs, under rubber dam isolation. Teeth that needed primary treatments were rotary prepared and irrigated using 2 mL 5.25% sodium hypoclorite after each rotary instrument used. Working lenght was determined using apex locators and confirmed radiographically. Final irrigation consisted of 5 ml 5.25% sodium hypoclorite, ultrasonically agitated for 60 minutes using Irrisafe (Satelec, Acteon, Switzerland), followed by EDTA 17% solution for 1 minute and distilled water.

Retreatment cases were approached using retreatment rotary instruments without solvents, after that canal walls were rotary refined for old filling remnants removal. The same irrigation protocol was

used during instrumentation, while the final irrigation consisted, beside sodium hypoclorite ultrasonically agitated and EDTA, a rinse with saline, followed by 5 mL clorhexidine 2% and distilled water.

All teeth were filled using AH Plus (Dentsply-Sirona, Germany) and warm vertically compacted gutta-percha, recording the overfilling on postoperative radiography. A temporary coronar filling was placed (Ketac Molar, 3M ESPE, Germany) and the patient was referred for a final restoration.

Most of the root canal treatments were performed in a single visit. Only some complicated cases, with flare-ups were postponed, applying calcium hydroxide for 7 days.

Patients were informed about the importance of the follow-up examination and the first recall was scheduled at 1 year post-operatively. A direct phone call with the patient was made one day prior to the recall appointment to confirm the arrival and the patient was informed that there will be not additional charges for this examination.

Clinical examination included signs and symptoms, tenderness to percution, pain to palpation, presence of synus tract, loss of function or bite-discomfort, mobility, periodontal pockets and the quality of coronal restoration.

Periapical radiographs were obtained with a digital imaging system, using parallel technique. In multi-rooted teeth 2 periapical radiographs in mesial and distal incidence were taken in some difficult cases. Only those patients who presented for minimum 1 year of clinical and radiographic follow-up were included in the study.

The pre-operative, post-operative and follow-ups radiographs were evaluated by two experienced endodontic specialists (S.A.S.&S.M.). The persistence or resorption of the extruded material and the final coronal restoration were registered. The observers determined the outcome according to PAI score pooled in a 3-category scale. Scores 1 and 2 were considered health, score 3 was considered uncertain, while 4 or 5 were considered diseased (Ørstavik *et al.,* 1986) [17]. For multi-rooted teeth, the outcome was determined according to the root with the poorest outcome. The Kappa coefficient (K) was calculated and a consensus was attained by a second evaluation with both observers in cases of disagreement.

Also, a lot of prognostic factors were recorded

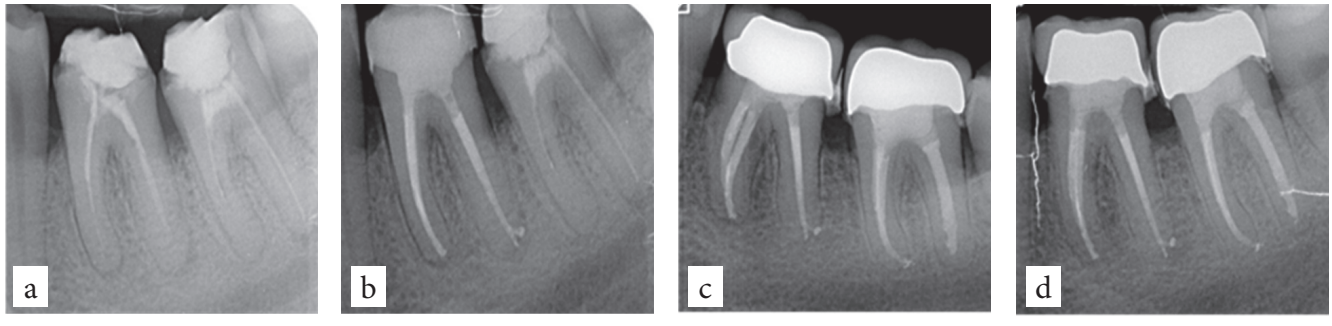

Figure 1. Example of retreatment of mandibular molars with incipient periodontitis (PAI 3). After root canal retreatment, one can see a small overfilling („puff"). After 1 year of root canal retreatment and filling, the lesion has already healed and the 2 years follow-up confirms the result. The overfilling with sealer persists; a – preoperative, PAI 3; b – postoperative radiograph; c – follow-up at 1 year, health; d – follow-up at 2 yrs, health.

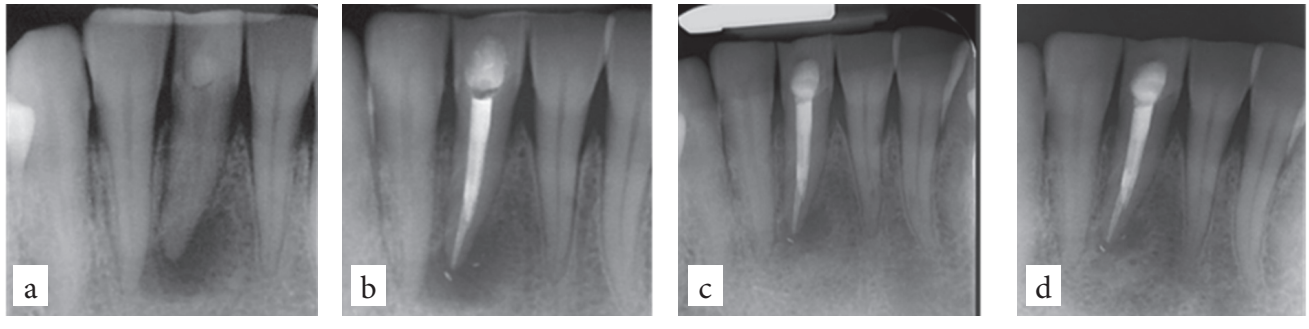

Figure 2. Example of mandibular incisor with well defined radio-transparent periodontitis (PAI 4). After root canal treatment and filling with a very small overfilling, the lesion decreased to PAI 3, the clinical symptoms disappeared, the tooth is functional, but lesion persists at 1 and even 3 years follow-ups as well as overfilling, suggesting an extended period of time for monitoring; a – preoperative radiograph, PAI 4; b – postoperative radiograph; c – follow-up at 1 year, uncertain; d – follow-up at 2 yrs, uncertain.

(gender, age, tooth location, arch, presence or absence of periapical lesions, type of treatment – primary/re-treatment, type of extruded material – sealer, gutappercha or both, type of coronal restoration. Cases in which there was not seen a resorption of extruded materials on periapical follow-ups radiographs were recorded as persistence of the filling material.

Statistical analysis

A logistic regression analysis was used to assess the factors that impact the treatment outcome. Wilcoxon, Friedman, Mann Whitney U and chi-square tests were used for group comparisons. Statistical significance was set at $p<0.05$.

RESULTS

Seventy nine teeth with periapical radiolucency (24 primary treatments/55 re-treatments) with postoperative unintentional canal overfilling performed by 2 endodontists during 10 years were selected. The range of recall time varied from at least 1 to 9 years in some cases, with an average recall time of 2.96 years. The Kappa coefficient (K) was 0.591.

The factors that significantly affected the outcome of root canal treatment were the initial PAI score and the maxillary arch.

We observed that initial PAI score was statistically significant lower in favorable than in

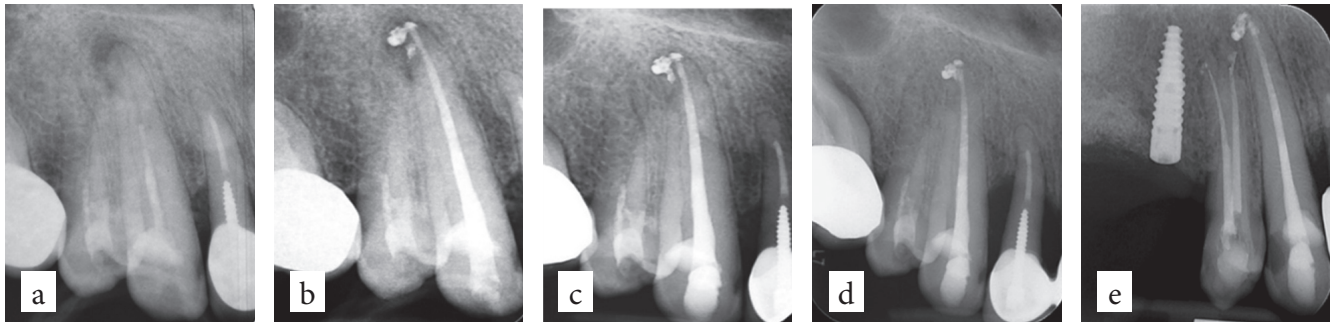

Figure 3. Example of retreatment of mandibular molars with incipient periodontitis (PAI 3). After root canal retreatment, one can see a small overfilling („puff"). After 1 year of root canal retreatment and filling, the lesion has already healed and the 2 years follow-up confirms the result. The overfilling with sealer persists; a – preoperative, PAI 3; b – postoperative radiograph; c – follow-up at 1 year, health; d – follow-up at 2 yrs, health; a – preoperative radiograph, PAI 3; b – postoperative radiograph; c – follow-up at 1 year, uncertain; d – follow-up at 5 yrs, healed; e – follow-up at 7 yrs, healed.

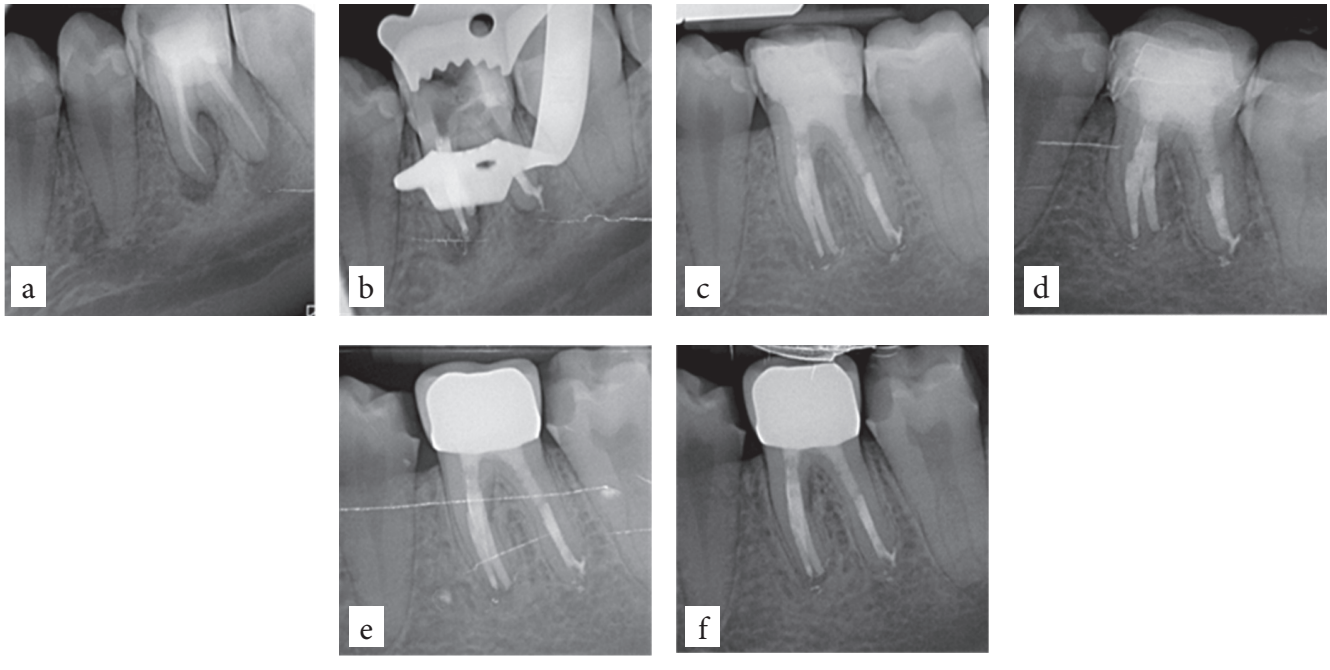

Figure 4. Example of retreatment of a mandibular molar with severe periodontitis (PAI 5). At 1 and 2 years recalls, PAI score dramatically decreased, there are still some bone changes with mineral loss, but at 4 years recall the tooth is healed. The 6 years recall confirms the healing, but the overfilling with sealer is still there; a – preoperative radiograph, PAI 5; b – postoperative radiograph; c – follow-up at 1 year, uncertain; d – follow-up at 2 yrs, uncertain; e – follow-up at 4 yrs, health; f – follow-up at 6 yrs, health.

unfavorable/uncertain outcomes (p<0.001) (Fig. 1 a-d and Fig. 2 a-d).

Healing occurred more frequently in the maxillary teeth (p<0.001). This is the reason why a more favorable outcome was observed to the maxillary teeth (93.1%) compared to the mandibular teeth (64%) (Fig. 3 a-e).

As shown in Table 1, the factors that affected the outcome (group of teeth, arch, size of periapical lesion, initial PAI score, recall time, type of treatment, persistence or resorption of the sealer) were recorded.

At 1 year recall, mean PAI score decreased (from 3.32 to 1.45; p<0.001), a favorable outcome was observed in 59 (74.68%) teeth, and absence of extrusion material was observed in 7 (11.86%) teeth.

Moreover, mean PAI score decreased from the initial value of 3.5 to 1.58 in the first two years, to 1.17 in the following years (p<0.001), this suggesting healing was more pronounced in this period (Fig. 4 a-f).

The majority of teeth (88.14%) presented a persistence of extrusion material represented by AH Plus. Also a more favorable outcome was observed when overfilling was only with sealer (77.6%) and restoration was performed without post (81.3%), but differences were not statistically significant.

Persistence of extruded material was present in 87.2% of cases with recalls at 2 years and in 96.8% of the cases with recalls between 2 and 9 years. The type of extruded material, its persistence or resorption did not affect the healing outcomes.

DISCUSSION

The issue of overfilling created large debates on standards of endodontic care. The apical extent of root canal fillings has been classified as follows: a. more than 2 mm short of radiographic apex (short); b. 0-2 mm within the radiographic apex (flush); c. extended beyond the radiographic apex (long) (Ng *et al.,* 2011) [18]. Flush root fillings were considered having the highest success rate of treatment, whilst long root fillings were found having the lowest success rate.

Overfilling means a three dimensional obturation in which a small portion of material extrudes

Table 1. Data for all teeth included in the study, with favourable, uncertain or unfavourable outcomes and persistence or resorption of the extruded material as well

	Outcomes			Resorption of sealer	
	Favourable	Uncertain	Unfavourable	Persistence	Resorbtion
Group of teeth					
Anterior					
Max.	18	0	0	17	1
Mand.	3	4	0	6	1
Posterior					
Max.	7	1	0	7	1
Mand.	32	11	3	42	4
Arch					
Maxillary	21	5	0	24	2
Mandibular	37	12	4	49	4
Size of periapical lesion					
5 mm^2 or less	44	6	0	47	3
More than 5 mm^2	16	10	3	25	4
Initial PAI					
3 or less	41	1	0	40	2
More than 3	18	16	3	32	5
Recall time					
≤2 years	40	4	3	41	6
>2-9 years	27	5	0	31	1
Type of treatment					
Primary	19	4	1	20	4
Retreatment	39	13	3	52	3
Type of restoration					
Restoration without post	39	6	3	35	4
Restoration with post	18	12	1	29	2
Resorption of sealer					
Persistence	51	16	4		
Complete resorption	5	1	1		

beyond the foramen apicale. It is not advisable to use a great deal of sealer or to place it deeply, because the gutta-percha cone should act as a true piston and cause overfilling. It seems overfilling appears more frequently in cases where patency is confirmed. Although patency concept is controversial, some authors claim that is preferable to extend the root canal filling to the radiographic terminus of the canal, having obturated the entire root canal system, even if this leads to small unwanted overfilling beyond the apex. It seems that patency has a direct influence on outcome of root canal treatment [18].

The quantity of overfilled material is very important. Gross overfilling, sometimes even to the point of filling in the mandibular canal involves medical liability. When overfills are small (a "puff" of cement out the apical constriction), the healing may be delayed but not impaired (Fig. 3 a-d and Fig.4 a-d). In some cases the overfilled material is fully absorbed over time, while in others it remains embedded in the tissues without jeopardize the treatment success. During re-treatments, fragments of gutta-percha can extrude beyond apex and may provoke a foreign body reaction, but when the recall periods are extended for a longer period of time, one can observe that the fragments disappeared and were resorbed in time.

Overfilling in teeth with periapical radiolucency are more frequent because of the destruction of the apex and the alveolar bone as well, but they produce much less pain or no pain at all, due to the disappearance of apical nerve fibers.

All the teeth involved in the study underwent rotary preparation and they were filled using only warm vertical condensation – the continuous wave technique. It was used only one sealer – AH Plus. Moreover, only the teeth that showed extended filling beyond the radiographic apex on the postoperative radiographs were included in the study.

As expected, warm vertical condensation led to a greater number of canals in which material extrusion occured (Farzaneh *et al.,* 2004a) [19], (Peng *et al.,* 2007) [20]. The sealer exceeded the apex in the large majority of cases because the flow rate of AH Plus increases with increasing temperature, which makes it very suitable for the cases in which warm vertical condensation is applied (Scarlatescu 2011, Venturi *et al.,* 2002, Venturi 2008) [7, 21, 22].

The ability of sealer to flow plays an important role and it reflects its capacity to penetrate into small canals and ramifications of root canal system (Siqueira *et al.,* 1995, Weis *et al.,* 2004) [23, 24]. AH Plus proved that it has such qualities and a very good sealing ability (Timpawat *et al.,* 2001, Kopper *et al.,* 2003, Carvalho-Junior *et al.,* 2007, Saleh *et al.,* 2008) [25-28]. AH Plus sealer showed also a great antimicrobial activity (Cobankara *et al.,* (2004, Kayaoglu *et al.,* 2005, Eldeniz *et al.,* 2006) [29-31]. This effect may be related to bisphenol diglycidyl ether which was previously identified as a mutagenic component of the resin-based sealer (Heil *et al.,* 1996) [32].

The ability of AH Plus to flow and to have antimicrobial efficacy as well reflects its capacity to penetrate into irregularities and ramifications of root canal systems and may aid in the elimination of remaining microorganisms from the canal (Siqueira *et al.,* 2000) [33].

In contrast to some authors who claimed that overfilling could negatively affect the outcome (Sjogren, 1990) [34], Bergenholtz *et al.,* 1979) [11], in this study neither the type of extruded material nor its resorption or persistence were related to the outcome. This is in agreement with previous studies – Ricucci *et al.,* 2016, Ng *et al.*, 2011a and Sari & Duruturk, 2007 [16, 18, 35]. In a small number of cases we observed the resorption of sealer on long term recall visits, but the „disappearance" might be due to the resorption of barium sulfate from the AH Plus composition.

In this study, the majority of teeth (88.14%) presented a persistence of extrusion material represented by AH Plus. Similarly, Ricucci *et al.,* 2016 [16] described the persistence of AH plus after long-term follow-up, while Schafer & Zandbiglari, 2003 [36] also observed low rate of solubilization, disintegration and phagocytosis of AH Plus and Diaket.

Most of the cases were re-treatments and in some teeth, the pre-existent gutta-percha was infected and it was perhaps extruded accidentally. Despite this fact, it did not seem to jeopardize the treatment outcome. According to some opinions, it seems that extrusions do not lead necessarily to failure as long as the cleaning, disinfection and filling the root canal system is adequate.

Primary root canal treatment had a greater success rate (79.16%) compared to re-treatments (70. 9%). These rates are smaller than those reported by Imura *et al.,* 2007 [37], in an article about treatments and re-treatments with correct length of root canal filling performed by specialists, but in that study the number of cases was much bigger (2000 teeth). The difference in success rate does not seem to relate to the presence or absence of extruded material (Goldberg *et al.,* 2020) [38].

Although the risk of infection is direct linked to the number of roots, maxillary teeth healed better both in treatment and retreatment. These are in agreement with Strindberg, 1956 [39] and different from Chevighy *et al.,* 2008 [40], Friedman *et al.,* 2003 [41].

The patients treated in this study presented chronic apical periodontitis, assessed by means of the periapical index (PAI) developed by Ørstavik *et al.,* 1986 [17]. Despite PAI has been used in studies to radiographically evaluate teeth with apical periodontitis, this index is relatively subjective due to its potential variability depending on the type of radiographic projection involved. It has a scale of 1 – 5 which ranges from "healthy" to "severe" periodontitis: 1 = normal structures, 2 = minor bone changes, 3 = some bone changes with mineral loss, 4 = periodontitis with well defined radio-transparent areas, and 5 = severe periodontitis with exacerbated features (Mendoza-Mendoza *et al.,* 2015) [42]. However, it remains the most used index for the analysis of bone changes in apical periodontitis.

The initial PAI score that reflects the size of periapical lesion was a statistically significant factor for a favourable outcome. 88% of lesions smaller than 5 mm had a favourable outcome compared to 61.5% of lesions with diameter over 5 mm. Moreover, the greatest results were obtained in the first 2 years after the treatment or retreatment (85.10% teeth healed) and less after this period ($p<0.001$). This can be explained because in these cases there is a great microbial diversity which penetrate the dentinal tubules over long distances and treatment is often ineffective or its action is difficult (Ng *et al.,* 2011a) [18].

The lowest percentage of healing was registered in teeth restored by post and crown (58%). The presence of post was associated with poor outcome due to the directions of action of occlusal forces and overloads (Boucher *et al.,* 2002) [43], (Ng *et al.,* 2011b) [44]. This study showed that restoration did not influence statistically significant the outcome, being in agreement with Chugal *et al.,* 2007 [45], Ng *et al.,* 2011b [44] and in disagreement with Chu *et al.,* 2005 [46], Farzaneh *et al.,* 2004 [15].

In some cases we think that asymptomatic persistent periapical lesions in teeth with short recall time may not be considered as failure, because many of them can heal after an extended period of time (Molven *et al.,* 2002) [47]. Also, the results of this study depend on the skills of the endodontic practitioners and may differ from other similar studies.

In conclusion, within the limitation of this study, the persistence or resorption of extruded material after root canal treatments or re-treatments of periapical lesions with unintentional canal overfilling did not associate with a favorable or unfavorable outcome. The best outcome of teeth with periapical lesions can be achieved in the first two years and much less in the following years, especially in teeth with lower initial PAI score. Maxillary teeth had a greater rate of complete healing than mandibular teeth, whilst AH Plus presented very low resorption rates, but it does not relate to a favorable or unfavorable outcome.

Conflict of interest

The authors declare that they have no conflict of interest.

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