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Relationship between unintentional canal overfilling and the long-term outcome of primary root canal treatments and nonsurgical retreatments: a retrospective radiographic assessment

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Abstract

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Aim To determine retrospectively the long-term radiographic outcome of root canal treatments and root canal retreatments with unintentional root canal overfilling.

Methodology A total of 220 root canal treatments (143 primary/77 retreatments) with postoperative unintentional canal overfilling and performed by two endodontists during their 45 years of private practice were included in the study. Lateral condensation techniques and nine different sealers were used. Overfilling was confirmed with a postoperative periapical radiograph and patients were scheduled regularly for recall visits. Average recall time was 4.86 years (maximum = 30 years). Two calibrated observers evaluated the radiographs and determined the long-term outcome using the PAI score pooled in a 3-category scale. The persistence or resorption of the extruded material was registered. The Kappa coefficient (K) was calculated and a logistic regression was used for further analysis. Odds ratios and their 95% CI were estimated.

Results The level of inter-observer agreement was 66.1%. Primary root canal treatments had a significantly ($P = 0.015$) greater rate of success (91.6%) than retreatments (81.8%). Tooth location ($P = 0.019$) was the only other factor that significantly affected the outcome. The type of extruded material, and its resorption or persistence did not relate to the outcome. Persistence of extruded material was significantly affected by tooth location and recall time after treatment.

Conclusion The outcome of root canal treatment with unintentional canal overfilling was not associated with the type of extruded material or its resorption or persistence. The persistence of extruded material did not relate to a favourable or unfavourable outcome.

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

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Introduction

One of the major objectives of root canal treatment is the filling of the root canal system with the intention of establishing a tight seal against bacteria recontamination (Ørstavik 2005). A basic requirement during shaping, cleaning and canal filling is to maintain the intra-canal procedures at the correct apical position,

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except for the use of patency files. For many decades, the apical constriction and the cementum-dentinal-canal (CDC) junction were considered the apical limit of root canal treatment; however, several authors have described those limits a clinical utopia, very irregular and difficult to identify clinically (Dummer *et al.* 1984, Ricucci & Langeland 1998, Ponce & Vilar Fernández 2003, Olson *et al.* 2008, Meder-Cowherd *et al.* 2011). Others have suggested the apical foramen as the apical limit, although portals of exit such as apical and/or lateral foramina can result in significant variations in their number, shape, position and size (Gutierrez & Aguayo 1995). In addition, oval apical foramina have also been described (Marroquin *et al.* 2004), making standardized gutta-percha cones more difficult to fit without unintended sealer extrusion (Ricucci & Langeland 1998, Marroquin *et al.* 2004).

Apical extrusion of canal filling materials occurs for a variety of reasons, including difficulty in establishing a precise apical limit of canal preparation. Material extrusion can occur both via apical foramina and via lateral canals. Overfilled cases seem to be more frequent with the use of thermoplastic techniques and the increase in the flow properties of endodontic sealers (Goldberg *et al.* 2001), although apical resorption may also favour extrusion, for example in cases with apical pathosis. Nevertheless, depending on the type of sealer and the mass and consistency of the extruded material, the overfilling can either be maintained for many years in the periapical area or disappear by the action of physical, chemical and biological phenomena (Ricucci *et al.* 2016).

At the same time, Siqueira (2001) suggested that 'it is highly improbable' that contemporary endodontic materials could maintain a periapical inflammatory response as long as endodontic infection has been controlled. In fact, the relative importance of overfilling has been thoroughly debated in the literature. Several authors have associated overfilling with root canal treatment or retreatment failure (Bergenholtz *et al.* 1979, Sjögren *et al.* 1990, Ricucci & Langeland 1998, Ricucci *et al.* 2011); but others consider it has no relationship with the long-term outcome (Halse & Molven 1987, Augsburger & Peters 1990, Lin *et al.* 1992, Farzaneh *et al.* 2004a,b, Ricucci *et al.* 2016). Schaeffer *et al.* (2005) concluded in a meta-analysis that filling materials extruded beyond the radiographic apex correlated with a poorer prognosis.

Therefore, the purpose of this study was to determine retrospectively the long-term radiographic outcome of root canal treatments and root canal retreatments with unintentional overfilling, performed by experienced endodontists.

Materials and methods

This study was performed with the approval of the Ethics Committee of the Department of Coordination of General Research of the Argentinian Dental Association (resolution number 0119/2019). The STROBE (strengthening the reporting of observational studies in Epidemiology) checklist and statement was followed.

A total of 220 root canal treatments performed in teeth with negative pulp response or teeth that had been referred for root canal retreatment, and exhibiting unintentional overfilling in the postoperative periapical radiograph, with at least a 2-year follow-up (in which the final restoration did not have clinical signs of coronal leakage) were included. From the 220 root canal treatments, 143 were primary root canal treatments and 77 retreatments. All treatments were performed by two experienced endodontists during 45 years of private practice.

In general, all treatments were performed under rubber dam isolation and with conventional access cavities. Gates-Glidden burs were used to pre-flare the coronal two-thirds of the root canals and canals prepared either with stainless-steel files using a step back technique or more recently nickel-titanium rotary instruments. Working length was established 1 mm short of the radiographic apex at first; however, from 1992 onwards, several apex locators were incorporated to determine working length, which was confirmed radiographically. Copious amounts of 2.5% sodium hypochlorite were used for irrigation during the shaping procedure with a 25G needle that was inserted to the apical third. At some point in time, a final irrigation with 17% EDTAC (Farmadental, Buenos Aires, Argentina) was incorporated in the irrigation protocol. Root canals were filled with a lateral condensation technique and eight different endodontic sealers depending on the period of time when the root canal was performed [Grossman's Sealer (Farmadental), Pulp Canal Sealer EWT (SybronEndo, Orange, CA, USA), Tubli Seal (SybronEndo), Endomethasone (Septodont, Saint-Maur-des-Fosses, France), CRCS (Calcibiotic Root Canal Sealer, Hygenic, Akron, OH, USA), AH26 (Dentsply De Trey, Konstanz, Germany), AHPlus (Dentsply De Trey), Diaket (ESPE, Seefeld, Germany)]. In some cases, an apical plug with

mineral trioxide aggregate [ProRoot MTA (Dentsply Tulsa Dental, Tulsa, OK, USA)] was used. A temporary restoration was placed after canal filling and the patient referred to the general dentist for a final restoration.

Most of the root canal treatments and retreatments were performed in a single visit. Only those patients with more than 2 years of clinical and radiographic follow-up and with unintentional overfilling were included. When patients returned for recalls, one or multiple (in mutirrooted teeth) periapical radiographs were taken. The exact horizontal angulation as marked in the X-ray beam was annotated in the dental record of the patient, guarantying reproducible images with the same angulations for preoperative, postoperative and follow-up periapical radiographs.

Table 1 Distribution of pre/post-treatment data for all cases included in the study with either favourable or unfavourable outcomes and uncertain healing, as well as for the persistence or complete resorption of the extruded material (n)

	Outcome			Resorption of sealer	
	Favourable	Uncertain	Unfavourable	Persistence	Complete resorption
Sealer/Material extruded					
Resin-based sealer					
AH26	94	8	3	40	65
Diaket	36	6	0	24	18
AHPlus/Topseal	9	0	1	10	0
ZOE-based sealer					
Endomethasone	4	0	0	0	4
CRCS	6	1	0	2	5
Tubliseal	4	2	0	2	4
Grossman	6	0	0	1	5
PCS	17	3	0	11	9
Gutta-percha	14	0	0	9	5
MTA	4	2	0	6	0
Group of teeth					
Anterior					
Max.	60	11	0	40	31
Mand.	13	4	1	11	7
Premolar					
Max.	31	3	2	18	18
Mand.	28	2	0	10	20
Molar					
Max.	10	0	0	3	7
Mand.	52	2	1	23	32
Arch					
Maxillary	101	14	2	61	56
Mandibular	93	8	2	44	59
Tooth location					
Anterior	73	15	1	51	38
Posterior	121	7	3	54	77
Size of periapical radiolucency					
1 mm^2 or less	119	12	1	58	74
More than 1 mm^2	75	10	3	47	41
Recall time					
<5 years	67	12	1	47	33
5–10 years	67	5	1	31	42
>10 years	60	5	2	27	40
Type of treatment					
Primary	131	11	1	62	81
Retreatment	63	11	3	43	34
Resorption of sealer					
Complete resorption	105	8	2		
Persistence	89	14	2		

Table 2 Logistic regression analysis

Dependent variable (categorization)	Independent variables (categorization)	OR (95% CI)	*P*
Treatment outcome (favourable/ uncertain + unfavourable)	Type of treatment (**primary**/nonsurgical retreatment)	3.3 (1.3–8.5)	0.02
	Tooth location (**posterior**/anterior)	3.4 (1.2–9.5)	0.02
Resorption of sealer (**complete resorption**/persistence)	Recall time (in months)	1.4 (1.04–2.04)	0.03
	Tooth location (**posterior**/anterior)	1.9 (1.1–3.3)	0.02

Significant parameters, categorization, *P* values (*P*), odds ratio (OR) and 95% confidence interval (CI). Notice that reference categories for each categorical factor are highlighted in bold.

As shown in Table 1, tooth-related factors (tooth location, arch, presence or absence of radiolucent lesions), treatment-related factors (primary treatment or retreatment, type of sealer/material extruded, extent of the extruded filling material) and the time of the most recent follow-up were recorded.

Two calibrated independent observers evaluated the radiographs for both radiographic outcome assessment and resorption/persistence of the extruded material. The PAI score was used to assess radiographic outcome. Score 1 was considered health, 2 or 3 were considered uncertain, and 4 or 5 were considered diseased (Ørstavik *et al.* 1986). Those cases in which there was not a complete resorption of the unintentional overfilling were rated as persistence of the filling material.

Data were tabulated, and a kappa coefficient (*K*) was calculated to determine inter-observer agreement. When there was disagreement between the observers, a consensus was reached by a second evaluation of the radiographic images with both observers together.

Statistical analysis

A logistic regression was performed with the consensus data to assess the impact of those factors that affected treatment outcome.

Separately, a second logistic regression analysis was used to analyse the factors that influenced the resorption or persistence of the extruded material. Those cases rated as uncertain healing were included with those determined as having unfavourable outcome in the analysis.

A stepwise protocol was used to statistically enter and exclude factors from the logistic regression model for a better global fitting. The following independent factors were introduced in both analyses: type of treatment (primary or retreatment), type of sealer, arch (maxillary or mandibular), tooth location (anterior or posterior) and recall time after treatment. For the analysis of treatment outcome, the persistence or resorption of the extruded material was also considered as an independent factor and introduced in the analysis. In the same way, the healing or persistence of the lesion was also included in the second analysis to discard any potential influence in the resorption of the extruded material.

Odds ratios and their 95% CI were also estimated to measure the magnitude of the effect and quantify the strength of the association for each significant variable.

Results

Two hundred and twenty cases met the inclusion criteria. The range of recall time of the cases included varied from 2 to 30.1 years (24–361 months) with a median value of 6.25 years (75 months).

Table 1 shows the distribution of pre/post-treatment data for all cases included in the study with either favourable or unfavourable outcomes and uncertain healing, as well as related to the persistence or complete resorption of the extruded material. The level of inter-observer agreement was 66.1%.

Table 2 shows the significant parameters in the logistic regression analysis, their categorization, *P* values, odds ratio (OR) and 95% confidence interval (CI).

The only factors that significantly affected the outcome of root canal treatment were the type of treatment ($P = 0.015$) and tooth location ($P = 0.019$). Primary treatments had a significantly greater rate of success (91.6%) when compared to retreatments (81.8%). At the same time, posterior teeth had significantly more complete healing than anterior teeth ($P = 0.019$) with an OR = 3.4 (95% CI 1.2–9.5) when extruded material was present. Overall, 92.4% of the posterior teeth had complete healing compared to 82% for anterior teeth.

Neither the type of extruded material, nor its resorption or persistence after primary root canal treatment or retreatment had a significant association with the outcome of treatment (Fig. 1).

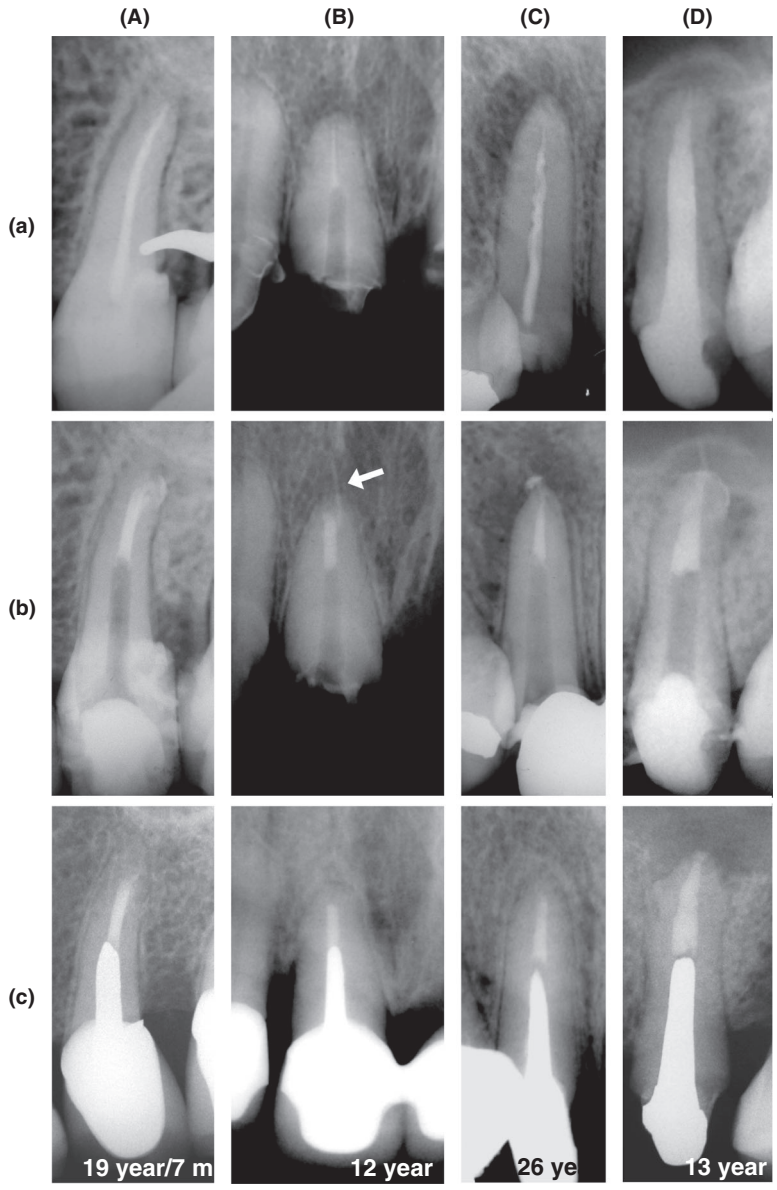

Figure 1 Examples of cases with complete resorption of unintentional overfilling. (a) Preoperative; (b) Immediate postoperative radiographs; (c) Follow-up (please notice that follow-up time for each case varies and the information is included in the Figure). (A) Nonsurgical retreatment of maxillary premolar with extrusion of resin-based sealer (Diaket). The 19-year/7-month follow-up showed total resorption of sealer and complete healing. (B) Nonsurgical retreatment of maxillary incisor. Extrusion of gutta-percha occurred during the removal of prior filling (white arrow). The 12-year follow-up showed complete resorption of the extruded gutta-percha and healing. (C) Nonsurgical retreatment of maxillary canine. Unintentional overfilling of zinc oxide eugenol-based sealer (CRCS) is observed. A 26-year follow-up showed the resorption of the extruded sealer and complete healing. (D) Nonsurgical retreatment of maxillary premolar with unintentional overfilling of resin-based sealer (Diaket). The 13-year follow-up showed unfavourable outcome and sealer resorption.

The persistence of extruded material was affected significantly by tooth location and the time to recall after treatment. Posterior teeth were associated with significantly greater resorption of the extruded material over time than anterior teeth ($P = 0.02$) with an OR = 1.9 (95% CI 1.1–3.3). Furthermore, extruded

material persisted in a large number of cases (57.3% in anterior and 41.2% in posterior teeth). On the other hand, recall time was related significantly to the chances of resorption of the material and resorption of extruded material significantly increased over time ($P = 0.03$) with an OR = 1.4 (95% CI 1.04–2.04).

Persistence of material was present in 58.8% of the cases with recalls between 2 and 4 years, in 42.5% of those cases with recalls between 5 and 10 years and decreased to 40.3% for those with recalls longer than 10 years after treatment. There were no significant differences in the persistence of extruded material whether the healing outcome was favourable or unfavourable.

Discussion

This retrospective clinical study was undertaken to address the relationship between unintentional overfilling and the long-term outcome of both primary root canal treatments and retreatments performed by experienced endodontists.

The main drawback of the study is its retrospective approach and the limitation of historic records that are often incomplete, which invariably have a negative impact on the quality of retrospective studies (Levin 2003). However, the two clinicians performing the endodontic treatments (F.G and C.C) have devoted their professional life to their clinical practice and preserved all radiographic documentation in an excellent condition.

A randomized clinical trial related to extrusion of filling materials would be very difficult to design and would probably be unethical. Both clinicians accumulated a large number of cases root filled filled with various endodontic sealers with unintentional overfill over the years. The results of this study are of help to the endodontic community and hopefully enrich the endodontic literature despite the limitations.

The biological implications of overextended root fillings on the outcome of root canal treatment are controversial. While several studies found similar results in the long-term outcome of teeth with and without overfilling (Farzaneh *et al.* 2004a,b, Ricucci *et al.* 2016); others, on the contrary, pointed out that overfilling could negatively affect periapical tissue (Bergenholtz *et al.* 1979, Sjögren *et al.* 1990, Ricucci & Langeland 1998, Ricucci *et al.* 2011). On the one hand, Ng *et al.* (2011) reported a greater success rate in teeth without extrusion of the filling material, whilst Molven *et al.* (2002) and Fristad *et al.* (2004), in a long-term follow-up evaluation, reported that the presence of an overfilling did not seem to be the reason for a failure; although, it could delay the healing process in periapical tissues.

The results of the present retrospective study revealed that neither the type of extruded material, nor its resorption or persistence after treatment were related significantly to the outcome of root canal treatment. These results are consistent with previous findings (Ricucci *et al.* 2016). Ricucci *et al.* (2016) reported that the treatment outcome was not significantly affected by the type of extruded sealer after the radiographic evaluation of 105 unintentional overfilled cases with six different endodontic sealers. In fact, in many situations, the persistence of small particles of endodontic material in the periapical area was not detected radiographically (Schaeffer *et al.* 2005, Ng *et al.* 2011).

In the present study, extruded material persisted in a large number of cases filled either with resin-based materials (47.1%) or zinc oxide eugenol (ZOE)-based sealers (37.2%). Nevertheless, although the logistic regression analysis did not reveal significant differences, cases filled with ZOE-based sealers were associated with the highest rates of total resorption over time (62.8%). Muruzabal & Erausquin (1966) reported the response of periapical tissues to various resin-based sealers in the connective tissue of rats: Diaket (ESPE GmbH, Seefeld, Germany) overfillings often appeared surrounded by a capsule, while AH26 (Dentsply De Trey) had a tendency to phagocytosis. In the present study, the extruded material persisted in almost half of the teeth with unintentional resin-based overfilling demonstrating low rate of solubilization, disintegration and phagocytosis. Similarly, Schäfer & Zandbiglari (2003) also observed low rates of solubilization of AHPlus and Diaket sealers whilst Ricucci *et al.* (2016) described the persistence of AHPlus after long-term follow-up. At the same time, the findings might be somewhat limited due to the use of periapical radiographs and their lack of sensitivity with the possibility that some cases with extruded material were not identified; although follow-up radiographs were taken at various angulations.

Nair *et al.* (1990) described gutta-percha as the least cytotoxic and tissue-irritant root canal filling material; although in rare circumstances when irritating substances are present within the material, gutta-percha can evoke a foreign body reaction in the periapical tissues. Moreover, Pascon & Spångberg (1990) attributed the toxicity of gutta-percha points to the

leakage of zinc. It has also been suggested that a smooth and dense surface of the filling material produces a lower inflammatory reaction than an irregular one (Muruzábal & Erausquin 1973). However, Goldberg *et al.* (1991) in a SEM analysis of gutta-percha cones described morphologic variations such as gross protuberances or deeply cratered areas containing numerous free or entrapped crystal-like particles, presumably zinc oxide. In the present study, the teeth overfilled with gutta-percha were not associated with a negative healing process and in some cases extruded gutta-percha was completely reabsorbed from the periapex. More specifically, 10 out of 11 cases with gutta-percha overfilling were root canal retreatments in which the pre-existing gutta-percha was extruded accidentally. Despite the fact that the extruded material was presumably contaminated, it did not seem to jeopardize the treatment outcome judged by periapical films as long as the cleaning, disinfection and filling of the root canal system during the retreatment was adequate (Fig. 1).

Sjögren *et al.* (1995) evaluated the tissue reaction to gutta-percha particles of various sizes implanted subcutaneously in guinea pigs and found that the larger pieces were well encapsulated and the surrounding tissue was free of inflammation, while the fine particles evoked an intense tissue response. It is interesting to remark that the behaviour of each extruded material varied in the present study; while in some cases a complete resorption of the overfilling was observed, in others it persisted for long periods of time.

Consistent with the literature, in the present study, primary root canal treatment had a greater success rate (91.6%) when compared to retreatments (81.8%). In fact, reported success rates of root canal treatment and retreatment with the correct length of canal filling and performed by specialists (Imura *et al.* 2007) do not differ from success rates reported in the present report. These results further support the concept that unintentional overfilling may not jeopardize the outcome of root canal treatments performed by specialists since the overfilling is likely to be unrelated to faulty shaping procedures and inadequate canal filling. Furthermore, the difference in success rates between primary root canal treatment and retreatment does not seem to be related to the presence or absence of extruded material, but to the fact that retreatment involves a new intervention in those teeth in which primary root canal treatment was not successful for a variety of reasons that can jeopardize the outcome (Sjögren *et al.* 1990, Farzaneh *et al.* 2004a,b, Imura *et al.* 2007, Ng *et al.* 2011). Moreover, in agreement with previous studies with a recall time of 20–27 years, the authors consider that asymptomatic persistent periapical radiolucencies in cases with short recall time, especially in unintentionally overfilled root canals, may not be a failure since many of them can still repair after an extended observation period (Molven *et al.* 2002, Fristad *et al.* 2004). Although in terms of generalizability, caution should be paid considering that all treatments were performed by endodontists; therefore, the results of this study are influenced by the skills of these practitioners and may differ from other clinicians if the reason for the overfilling is related to either faulty canal preparation procedures or inadequate root filling.

Conclusion

Within the limitations of this retrospective study, the results suggest that:

- The outcome of root canal treatment with unintentional overfilling is not related to the type of extruded material or its resorption or persistence after treatment and likewise the persistence of extruded material does not relate to a favourable or unfavourable outcome.
- Posterior teeth had both significantly greater resorption of extruded material over time and a greater rate of complete healing than anterior teeth when judged in periapical radiographs.
- Recall time significantly influenced the chances of material resorption.
- As in teeth with the correct length of canal filling, a greater success rate occurred after primary root canal treatment when compared to retreatment in cases with unintentional overfilling performed by specialists.

Conflict of interest

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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