Comparative evaluation of unintentional extrusion of gutta-percha versus sealer on teeth presenting periapical radiolucency: a retrospective radiographic study on treatment outcome

Eleni Krikeli  
Aristotle University of Thessaloniki

Theodoros Lambrianidis  
Aristotle University of Thessaloniki

Ioannis Molyvdas  
Aristotle University of Thessaloniki

Georgios Mikrogeorgis (gmicro@dent.auth.gr)  
Aristotle University of Thessaloniki

Research Article

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Abstract

Objective: The purpose of this study is the radiographic evaluation of endodontically treated teeth presenting periapical radiolucency and unintentional overfilling with gutta-percha or sealer on treatment outcome and persistence of the extruded materials.

Materials and Methods: After assessment using periapical index (PAI), 202 roots filled with gutta-percha and Roth 811 sealer, exhibiting unintentional overfilling and periapical radiolucency were selected. All cases had at least 1 year follow-up. Type of extruded material, periapical status, and removal/persistence of the extruded material were evaluated. Data were statistically analyzed using logistic and linear regression analysis.

Results: Tooth location, follow-up period and type of the extruded material were the only factors that significantly affected the outcome (p<0.05). The persistence of extruded material was significantly affected by its type and the recall time (p<0.05).

Conclusions: It can be concluded that posterior roots, overfilling with sealer compared to gutta-percha and cases with long recall period present a significantly better rate of complete healing.

Clinical Relevance

Treatment outcome was not related to the persistence or removal of the extruded material in the follow-up radiograph for teeth with apical periodontitis.

Introduction

One of the main objectives of root canal treatment is the efficient, three-dimensional filling of the cleaned and shaped root canal space. The obturation materials should be biocompatible and extent from the pulp chamber to its apical terminus [1]. There is an ongoing controversy concerning the exact apical extent of root canal instrumentation and obturation. The apical constriction, the cementum-dentinal-canal (CDC) junction, and the apical foramen have been proposed, yet anatomical variations make their clinical identification difficult [2–4]. In any case, it is accepted that instrumentation and obturation should not extend beyond the apical foramen, as it jeopardizes the treatment outcome and exposes the patient to the risk of nearby anatomical structure's injury [5].

When the three-dimensional filling of the root canal system is achieved, but a portion of the filling materials is extruded beyond the apical foramen, then it is characterized as overfilling. On the other hand, the term overextension is used to imply that the root canal space is not completely obturated and part of the filling materials are found in the periapex [6].

Histologically, when root canal filling materials (sealer/gutta-percha) extent into the periapical tissues an inflammatory reaction follows [7]. Tissue reactions are related to the type and quantity of the extruded
material, the site of extrusion, local factors affecting repair and healing and the overall health condition of the host [8]. It has been generally stated that presence of extruded filling materials in cases with periapical lesions delays healing [9–11]. The effect of extruded material on the outcome of root canal treatment and the fate of the extruded materials is not extensively and thoroughly studied. To our knowledge the literature on the topic is limited. Ricucci et al. [12] and Goldberg et al. [13] investigated the influence on outcome of root canal treatment of various apically extruded sealers. In an earlier study the radiographic appearance of two zinc oxide and eugenol-based sealers extruded beyond apical foreman during obturation of root canals was studied over time [14]. Radiographic evaluation of periapical healing of permanent teeth with periapical lesions after extrusion of AH Plus sealer was also studied on young patients [15].

The purpose of the present retrospective study is to evaluate radiographically the outcome of root canal treatment and retreatment in cases of unintentional overfilling in roots with periapical radiolucency.

**Materials And Methods**

**Data collection and interpretation**

Teeth included in this retrospective radiographic assessment were treated by three operators, specialized endodontists, in their private offices using a standardized treatment protocol over a period of 30 years. This protocol includes recall examination of treated cases at 3, 6, 12, 24 and 48 months.

Inclusion criteria for selecting cases for primary analysis in the present study:

- Teeth exhibiting unintentional overfilling in the postobturation radiograph
- Obturation with the lateral compaction of gutta-percha technique and Roth 811 (Roth International, Chicago, IL, USA) as a sealer
- Cases with at least 1-year follow-up
- Teeth with fully formed apices

Exclusion criteria were:

- Teeth with iatrogenic errors (perforations, separated instruments)
- Roots presenting sealer or gutta-percha extrusion from previous treatment
- Teeth with endo-perio lesions

Initially, 259 endodontically treated roots complying with the inclusion criteria were evaluated. Conventional radiographs were scanned and together with digital radiographs were incorporated in PowerPoint software (Microsoft, Redmond, WA, USA) files for further analysis. Each power point slide consisted of the initial radiograph, the postobturation radiograph, the last follow-up radiograph, and a serial number. All images were at least 10:15 cm at 300 DPI.
Two calibrated independent observers, experienced endodontists, evaluated the radiographs for the type of the extruded material (sealer/gutta-percha), periapical status and removal/persistence of the extruded material. The periapical index (PAI score) was used to assess periapical status [16]. Interexaminer agreement, as a part of the calibration procedure, was determined by scoring 50 randomly selected cases. In cases of disagreement the observers discussed the case until consensus was reached. If doubts continued, a third observer was consulted. As the purpose of the study was to assess only teeth with periapical radiolucency, roots with PAI scores 1 and 2 on the initial radiograph were considered having normal periapical status and were excluded from further analysis.

After these assessments, 202 roots from 185 patients, were finally included in the study. Roots with PAI scores 1 and 2 in the follow-up radiograph were considered healed (Fig. 1) and those with score 5 nonhealed (Fig. 2). Roots scoring 3 and 4 in the follow-up radiograph which remained the same or scored higher compared to the initial radiograph were also considered nonhealed, while those scored less than the initial radiograph but not 1 or 2 were considered healing (Fig. 3). Data was tabulated according to: tooth location (maxillary/mandibular), tooth position (posterior/anterior), type of treatment (primary treatment/retreatment), type of extruded material (sealer/gutta-percha), follow-up period (12 months/24 ± 2 months/>24 months), existence of extruded material in the follow-up radiograph (present/absent) and treatment outcome (healed/healing/nonhealed).

**Treatment Protocol**

The initial diagnosis was made after clinical and radiographic examination. All endodontic treatments were performed under aseptic conditions. After rubber dam isolation, access cavity preparation was performed. The working length was established by radiograph alone at 0.5-1mm from the radiographic apex or confirmed by an electronic apex locator when it was available. The coronal two thirds of the root canal were preflared with Gates-Glidden burs and hand instruments (Hedstrom files). The apical third was instrumented by hand instruments (Hedstrom and K-type files) or more recently nickel-titanium rotary instruments. Patency K file No 10 was used after each instrument until the completion of root canal preparation. Irrigation was made using copious amounts of 2.5% sodium hypochlorite with a 30G needle. When 2 visits needed an interappointment medication with calcium hydroxide was used. A master cone radiograph was taken before root canal filling. The root canals were filled with laterally compacted gutta-percha and Roth 811 (Roth International, Chicago, IL, USA) sealer and the final radiograph was taken. The majority of radiographs were taken using the parallel technique. Appropriate intraoral sensor or film alignment instruments (Rinn Corporation Elgin, IL, USA) were used for this purpose. Digital radiographs for each case were taken under constant conditions using a direct digital intraoral radiograph system, RadioVisioGraphy (RVG) (Trophy Radiology S.A., Paris, France) or Visualix (Gendex Dental System, Hatfield, PA, USA) and an Oralix AC Densomat X-ray machine (Gendex Dental System, Hatfield, PA, USA 65kV peak and 7.5mA mean). For non-digital radiographs, Kodak Ultraspeed films 31 x 41 (DF 58) or 22 x 35 (DF 54; Eastman Kodak Company, Rochester, NY, USA) were used and processed according to
manufacturer’s recommendations. After completion of the endodontic treatment, patients were instructed to return to the referral dentist for an appropriate restoration to be placed.

**Statistical analysis**

Logistic regression analysis is used for investigating the impact of five independent variables (i.e., tooth location, tooth position, type of treatment, type of extruded material, follow-up period, treatment outcome) on the presence of extruded material in the follow-up radiograph. This analysis is considered to be appropriate because the dependent variable (periapical extruded material in the follow-up radiograph) is measured with the two qualitative levels of presence and absence. Additionally, a linear regression analysis is used for investigating the impact of the independent variables on treatment outcome. This analysis is considered to be appropriate because the dependent variable (treatment outcome) is measured at more than two levels (healed, healing, nonhealed).

For both types of regressions, a backward methodology in entering the independent variables in each regression equation is used via SPSS in order to investigate their influence on the dependent variables. In the logistic regression together with the actual estimated coefficients of the independent variables the corresponding Odds Ratios (OR) and their 95% Confidence Intervals (CI) are presented. In the linear regression, together with the actual estimated coefficients of the independent variables the corresponding standardized beta coefficients are presented.

**Results**

Two hundred and two endodontically treated roots met the inclusion criteria. The range of follow-up time of the cases varied from 1 to 19 years (12–229 months). 141(69.8%) roots evaluated as healed cases, 41(20.3%) as being under healing and 20(9.9%) as nonhealed. In 140 (69.3%) cases extruded material was still detected in the follow-up radiograph. Table 1 shows the distribution of pre/post-treatment data for all roots included in the study.
Table 1
Distribution of pre/post-treatment data for all roots included in the study with either healed, healing or nonhealed outcome, as well as for the presence or absence of the extruded material in the follow-up radiograph.

<table>
<thead>
<tr>
<th></th>
<th>Treatment outcome</th>
<th>Extruded material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healed</td>
<td>Healing</td>
</tr>
<tr>
<td><strong>Type of the extruded material</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sealer</td>
<td>103</td>
<td>27</td>
</tr>
<tr>
<td>Gutta-percha</td>
<td>38</td>
<td>14</td>
</tr>
<tr>
<td><strong>Tooth position</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxillary</td>
<td>55</td>
<td>23</td>
</tr>
<tr>
<td>Mandibular</td>
<td>91</td>
<td>18</td>
</tr>
<tr>
<td><strong>Tooth location</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior</td>
<td>100</td>
<td>17</td>
</tr>
<tr>
<td>Anterior</td>
<td>41</td>
<td>24</td>
</tr>
<tr>
<td><strong>Type of treatment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary treatment</td>
<td>96</td>
<td>29</td>
</tr>
<tr>
<td>Retreatment</td>
<td>45</td>
<td>12</td>
</tr>
<tr>
<td><strong>Follow-up period</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 months</td>
<td>43</td>
<td>24</td>
</tr>
<tr>
<td>24 ± 2 months</td>
<td>30</td>
<td>8</td>
</tr>
<tr>
<td>&gt; 24 months</td>
<td>68</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 2 presents the results of the logistic regression analysis concerning the extruded material. It is seen that from the five independent variables only the type of extruded material and follow-up period (p < 0.05) have an impact on the presence of extruded material in the follow-up radiograph. The persistence of extruded material was significantly greater when gutta-percha was extruded. On the contrary, the extruded material was significantly less detected when the follow-up period was greater.
Table 2
Logistic regressions analysis with respect to existence of extruded material in the follow-up radiograph (0 = absent, 1 = present)

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Estimated B coefficients (significant levels)</th>
<th>OR</th>
<th>95% CI of OR</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of extruded material</td>
<td>2.433 (0.000)</td>
<td>11.398</td>
<td>4.214</td>
<td>30.827</td>
<td></td>
</tr>
<tr>
<td>(0 = sealer,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 = gutta-percha)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow-up period</td>
<td>-1.216 (0.000)</td>
<td>0.296</td>
<td>0.189</td>
<td>0.466</td>
<td></td>
</tr>
<tr>
<td>(0 = 12 months,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1 = 24 ± 2 months,</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>2 = over 24 months)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>1.678 (0.000)</td>
<td>5.353</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Regression statistics

<p>| | | | | | |</p>
<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Cox &amp; Snell R Square</td>
<td>0.238</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nagelkerke R Square</td>
<td>0.335</td>
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</tbody>
</table>

In Table 3 the results of the linear regression are presented. It is seen that tooth position, type of extruded material and follow-up period significantly affected the treatment outcome (p < 0.05). Treatment outcome is significantly improved for posterior teeth, teeth presenting extrusion of sealer than gutta-percha and those with greater follow-up period.
Table 3  
Multiple regression analysis with respect to treatment outcome (0 = healed, 1 = healing, 2 = nonhealed).

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Estimated B coefficients (significant levels)</th>
<th>Standardized BETA coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tooth position (0 = anterior, 1 = posterior)</td>
<td>-0.395 (0.000)</td>
<td>-0.290</td>
</tr>
<tr>
<td>Type of the extruded material (0 = sealer, 1 = gutta-percha)</td>
<td>0.283 (0.004)</td>
<td>0.196</td>
</tr>
<tr>
<td>Follow-up period (0 = 12 months, 1 = 24 ± 2 months, 2 = over 24 months)</td>
<td>-0.180 (0.000)</td>
<td>-0.241</td>
</tr>
<tr>
<td>Constant</td>
<td>1.746 (0.000)</td>
<td></td>
</tr>
</tbody>
</table>

Regression statistics

<table>
<thead>
<tr>
<th>R Square (significant level)</th>
<th>0.152 (0.000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjusted R Square (significant level)</td>
<td>0.139 (0.000)</td>
</tr>
</tbody>
</table>

Neither the type of the treatment (primary root canal treatment/retreatment) nor extruded material removal or persistence in the follow-up radiograph had a significant association with the periapical healing (p = 0.248 and p = 0.553 respectively).

Discussion

In the present study, endodontically treated teeth with periapical radiolucency were evaluated radiographically, regarding treatment outcome and the fate of extruded materials (sealer/gutta-percha) in the follow-up examination. In the literature, there are studies investigating root canal treatment outcomes including cases with extrusion of filling materials [17–19]. Besides overfilling which may affect the outcome, factors that should be taken into consideration include the periapical status of the cases in question, type of root canal filling materials used, other coexisting iatrogenic errors or pathologies, the inclusion of roots presenting overextensions, the experience level of the therapist and others [20–22]. For this reason, the results of these studies should be analyzed and compared with caution. In the present study, a careful choice of cases has been made for the limitation of other factors affecting the treatment outcome.
Overall, 69.8% of treated roots were evaluated as healed, 20.3% were found being under healing and 9.9% were nonhealed. Ricucci et al. [12] investigating the effect of different types of extruded sealers on treatment outcome, reported that 79% of the cases which presented apical periodontitis at the time of treatment were categorized as healed at the > 4-year follow-up. In a similar study seventy-five (75) out of 88 teeth (85.2%) with periapical radiolucency exceeding 1mm² in size with at least 2 years follow-up and unintentional canal overfilling were evaluated as having a favorable outcome [13]. Sari & Duruturk [15] evaluated 49 canals with periapical lesions and extrusion of AH Plus sealer for its outcome after a 4-year follow-up. Complete healing was observed in 83.67%, incomplete healing in 8.16%, and no-healing in 8.16% of the canals [15]. An earlier attempt was performed by Augsburger & Peters [14] as they radiographically evaluated 50 cases presenting overfilling been diagnosed by at least one author as having preoperative radiolucent lesion and return for recalls from 4 months to 5 + years postoperatively. Forty-eight cases (96%) were subsequently diagnosed as showing radiographic improvement or absence of the lesion [14]. The difference in completely healed cases and the roots assessed being under healing between the studies can be attributed to the variety follow-up periods. As indicated from the results of our study, extended follow-up period significantly improved treatment outcome (p = 0.000). This is confirmed by the 82.9% of the cases found completely healed at > 24 months follow up compared to 56.6% evaluated as healed at 12 months follow up.

In a qualitative analysis of the 20 cases that were characterized as nonhealed in the present study, it was observed that 9 of them, all with extensive periapical lesions, did not meet the radiographic characteristic of another score on the PAI scale despite they presented slight radiographic improvements in the bone structure. As this assessment is based on two-dimensional radiographic images and in order over-diagnosis of healing to be avoided, those cases were also characterized as nonhealed at the given follow-up period.

The results of the present retrospective study show that removal or presence of the extruded material on the follow-up radiograph did not relate to treatment outcome. Tooth location significantly improved treatment outcome with posterior roots presenting more healed cases compared to the anterior roots. These results are consistent with previous findings [13].

Contrary to Goldenberg et al. [13] in the present study overfilling with gutta-percha was associated with a negative healing proses compared to sealer extrusion (p = 0.004). All root canals selected for the study were filled with the same eugenol based sealer (Roth 811), which is less biocompatible than newer bioceramic sealers and with comparable biocompatibility to resin based sealers [23]. Gutta-percha is a well tolerant and biocompatible widely used root canal filling material. Pascon & Spangberg [24] attributed some toxicity of gutta-percha points to the leakage of zinc, whereas Nair et al. [10] clinically associated magnesium and silicon from the talc-contaminated extruded gutta-percha with a foreign body reaction. Furthermore, tissue response to large pieces and fine particles of gutta-percha has been described. Larger pieces of gutta-percha are well encapsulated by collagen whereas fine particles cause an intense tissue response with the accumulation of macrophages and giant cells [25]. Macrophages release proinflammatory cytokines and modulators that are involved in bone resorption. Gutta-percha
cones exceeding the apical foremen are gradually fragmented into fine particles inducing the release of macrophages. Clinically this could lead to an impairment in the healing of apical periodontitis [26]. This finding can be also attributed to the overinstrumentation that usually takes place when gutta-percha extrudes the apical foramen, as sealers can flow even into narrow root canal ramifications [27]. When root canals with infected pulps are overinstrumentated, contaminated dentine or debris extrude into the periapical tissues. In these cases, microorganisms are protected from the host defense mechanisms and maintain periapical inflammation, by surviving within the periapical lesion. The presence of dentinal debris in the periapical lesion has been associated with impaired healing and it is the most common form of extraradicular infection [9, 28].

The presence of the extruded material in the periapex was found to be affected by the follow-up period and the type of the material. Gutta-percha was significantly more present in the follow-up radiograph when it found to be the extruded material. Gutta-percha is a well-tolerated obturating material and less cytotoxic than endodontic sealers. It has been suggested that potential cytotoxic effect of a sealing material found in the periapex may induce self-degradation as a well-vascularized granulation tissue is observed in which the material was phagocytosed by macrophages [29]. The zinc oxide-eugenol based sealer (Roth 811) used in the present study was resolved in 56 out of 141 cases on follow up radiograph when recognized as the extruded material. Ricucci et al. [12] findings revealed that with the passage of time, the zinc oxide eugenol–based sealers had a significantly increased removal rate in comparison with a resinous sealer, and a calcium hydroxide–based sealer. Once set, zinc oxide-eugenol sealers are relatively weak and porous, and are susceptible to decomposition in tissue fluids, particularly when extruded into the periapical tissues [30].

The methodology of the present study was aiming at limiting possible factors other than overfilling, which could affect the treatment outcome. For this reason, teeth treated with the same sealer were selected and inclusion criteria were established. However, there are some limitations considering this retrospective radiographic assessment. The radiographic examination could be misleading, as part of the extruded materials could still exist extraradicular but in small amounts, so they can be detected only histologically. Moreover, the two-dimensional nature of the x-rays makes it impossible to include in the evaluation the size of the lesion, the amount and exact type of material that has been extruded. The retrospective nature of the study leads to an inconsistency in follow-up periods. If all follow-up radiographs were available (12months, 24 ± 2 months and over 24 months) for each case, a more solid conclusion could have been made for both treatment outcome and the fate of the extruded materials over the years.

In conclusion, the present study showed that for teeth with periapical radiolucency, treatment outcome was not related to the persistence or removal of the extruded material in the follow-up radiograph. Recall period significantly influenced treatment outcome and chances of material removal. Posterior roots had a significantly greater rate of healed cases than anterior teeth when judged in periapical radiographs. As in roots with sealer extrusion, an improved treatment outcome and removal of the material were observed when compared to roots presenting overfilling with gutta-percha.
Declarations

Author Contribution

All authors have contributed significantly. More specifically:

Eleni Krikeli, Theodoros Lambrianidis and Georgios Mikrogeorgis wrote the main manuscript text. Eleni Krikeli, Ioannis Molyvdas and Georgios Mikrogeorgis prepared the figures and tables. Theodoros Lambrianidis, Ioannis Molyvdas and Georgios Mikrogeorgis designed the research protocol. All authors reviewed the manuscript.

Ethics Approval and Consent to Participate

The whole research protocol and the study were undertaken according to the ethical guidelines of the Research Committee of Aristotle University of Thessaloniki, Greece.

The ethical committee of School of Dentistry, Aristotle University of Thessaloniki, Thessaloniki, Greece approved the whole research protocol of the study (protocol number: 108/01-02-2021).

Funding

No funding was obtained for this study.

Conflict of Interests

All authors deny any conflicts of interest related to this study.

References


Figures

Figure 1

Radiographs of a retreatment case (tooth #36) that considered healed. (A) Preoperative, (B) postoperative, (C) follow-up (12 months) radiograph. Normal periradicular conditions can be seen and the appearance of the extruded gutta-percha is unchanged.
Figure 2

Radiographs of a retreatment case (tooth #23) that considered nonhealed. (A) Preoperative, (B) postoperative, (C) follow-up (12 months) radiograph. The periapical lesion can still be clearly seen and the extruded gutta-percha is still visible.

Figure 3
Radiographs of a primary treatment case (tooth #21) that considered healing. (A) Preoperative, (B) postoperative, (C) follow-up (24 months) radiograph. The healing of the periapical lesion can be observed and the extruded sealer is still visible.