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Original Research

Assessment of Extruded Root Canal Filling Materials in Single-Rooted Teeth Using Cone Beam Computed Tomography

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ABSTRACT

Objective: Overfilling a root canal has a negative influence on the prognosis of teeth with apical periodontitis. This study proposed to assess extruded sealer and gutta-percha in single-rooted teeth within a Turkish subpopulation using cone-beam computed tomography.

Methods: The study included cone-beam computed tomography scans of 2,346 endodontically treated teeth with a single root and foramen from a private dental clinic's archive. Teeth were divided into four groups: maxillary anteriors, mandibular anteriors, mandibular premolars, and maxillary second premolars. Two endodontists analyzed the scans at all planes and recorded information pertaining to tooth number, tooth type, and presence of extrusion. To examine the data, a chi-square test with a 0.05 p-value was performed.

Results: Extrusion was detected in 256 (10.91%) of the single-rooted teeth. There was significant difference among the groups ($p<0.05$). Extrusion was significantly higher in the maxillary anteriors than in the other tooth groups. Maxillary second premolars had lower extrusion compared to the other tooth groups. There was no statistical relationship between the maxillary anterior tooth groups and the presence of extrusion ($p=0.338$).

Conclusion: Maxillary anteriors had higher root canal filling material extrusion than the other tooth groups, while maxillary second premolars had lower extrusion.

Keywords: Endodontically-treated; Gutta-percha; Overfilling; Root canal filling material; Root canal sealer

INTRODUCTION

One of the cornerstones of endodontic treatment is obturating the root canal space to prevent bacterial infection [1]. In theory, the filling material needs to reach the root's apex without affecting periapical tissues. However, there is no consensus on the apical boundary of obturation. While many researchers base the apical limit on the apical foramen, apical constriction, or cement-dentin-canal junction, others claim that these formations are challenging to identify clinically [2–4]. In the presence of an oval-shaped apical foramen, apical foramina, or lateral canal, the root canal filling material may extrude [3, 5, 6]. Teeth with canal obturations 0–2 mm shorter than the radiographic apex had the highest success rate after endodontic therapy, while underfilled or overfilled canals had much lower success rates [7, 8]. In cases of extrusion, the prognosis is influenced by the filling materials' volume, consistency, solubility in tissue fluids, and biocompatibility [9].

There are controversies in the literature about whether filling a root canal beyond the apex prolongs the periapical healing

process. With adequate endodontic treatment, the great majority of overfilled teeth have been demonstrated to recover successfully [10–12]. Extruded root canal sealer has also been shown to have no negative influence on root canal treatment outcomes [9]. On the other hand, some studies have linked overfilling to unsuccessful root canal therapy [10, 13, 14].

Gutta-percha combined with an appropriate sealer is the most typically utilized root canal filling material. Root canal sealers are toxic to cells and have the potential to harm periradicular tissues. Although it is more biocompatible than root canal sealers [15], extruded gutta-percha may trigger tissue reactions by acting as a foreign body [16]. The relationships between the material's characteristics, the extrusion's location, and the periodontal tissues' immune response can all strongly affect this reaction [17]. Furthermore, a German study reported that extrusion might interfere with the healing process of apical periodontitis [18]. The chemical, cytotoxic, and mechanical effects of extruded canal filling materials have the potential to cause tissue damage to surrounding anatomical structures. Warm filling techniques may also cause thermal damage [19, 20]. In addition, teeth with overfilled canals are likelier to fail than teeth with underfilled canals [21].

Cone-beam computed tomography (CBCT) not only makes it possible to diagnose extruded root fillings but also makes three-dimensional examinations of them possible [22]. This study aimed to use CBCT to assess the presence of extruded sealer and gutta-percha in various kinds of single-rooted teeth in a Turkish subpopulation. The study's null hypothesis was that there was no substantial difference in filling material extrusion among various tooth categories.

Main Points;

- It has been found that the root canal filling material extrusion in maxillary anteriors was higher than other teeth groups and that extrusion in maxillary second premolars was lower than in other single-rooted tooth groups.
- The results from this study to examine the extrusion of filling materials in the root canals of single-rooted teeth can guide studies regarding factors affecting extrusion.

MATERIALS AND METHODS

The study was conducted with the permission of the Clinical Research Ethics Committee of Gaziantep University (Decision Date: 26.10.2022, ID No: 2022/292). The ethical guidelines outlined in the 1964 Declaration of Helsinki and its later revisions, as well as other related ethical guidelines, were followed throughout this investigation. A total of 2,346 teeth with a single root and foramen that had undergone root canal treatment, belonging to the subjects between the ages of 18-93, were included in the study. The study's exclusion criteria included teeth with open apices, root resorption, extensive periodontal disease, periapical pathology, or those that could not be correctly screened due to CBCT aberrations.

All full-size scans with a field volume of 8 × 8 cm and a voxel size of 0.4 mm were taken by Orthophos XG 3D (Sirona Dental System, North Carolina, USA) for different purposes at a private dental clinic. In a darkened environment, a 20-inch LED-backlit screen with 2560 × 1600-pixel resolution was utilized to acquire and display the DICOM (Digital Imaging and Communications in Medicine) images. All planes of the CBCTs were oriented with cursors according to the long axis of each root to analyze the periapical parts. Extruded root canal filling material was defined as canal sealer and gutta-percha that were not restricted to the periodontal ligament. The radiological apex was accepted as the limit for the root canal filling, and the obturation was considered 'overfilled' when there was extrusion of material beyond the radiographic root apex (Fig. 1). Extrusion was also defined as a form that surpassed a semilunar pattern near the radiography apex and was abnormally extended beyond the apex. Two endodontists with more than ten years of CBCT experience simultaneously analyzed the scans using the Sirona Galaxis Galileos Viewer Version 1.9.2 program (Sirona Dental Systems GmbH, Bensheim, Germany) until a consensus was reached.

All personal patient information was anonymized. The data comprises the tooth number and the presence of extrusion. The teeth were divided into four groups: maxillary anteriors (364 central incisors, 314 lateral incisors, and 377 canines; total=1,055), mandibular anteriors (103 central incisors, 114 lateral incisors, and 242 canines; total=459), mandibular premolars (211 first premolars, and 269 2nd premolars; total=480), and maxillary second premolars with one root (total=352). For each tooth, the presence of extruded filling material was recorded regardless of its amount.

Statistical Analysis

The results were evaluated with SPSS V25 software (IBM, Chicago, USA). The study characteristics were determined with standard descriptive methods. To compare categorical demographic characteristics between groups, the chi-square test was performed. A 95% confidence range was used, and $p<0.05$ was considered statistically significant.

RESULTS

Of the 2,346 root-filled teeth examined in the present study, 949 (40.5%) teeth were from males and 1,397 (59.55%) from females. The age distributions of the subjects are as follows; 483 (20.59%) teeth, 18–44 years; 1,084 (46.21%) teeth, 45–64 years; 779 (33.21%) teeth, 65+ years (mean±standard deviation 56.62±13.41; range 19–93). No statistical correlation was found between gender (p=0.742), age group (p=0.168), and the presence of root canal filling extrusion in single-rooted teeth. Extruded filling materials were seen in 256 (10.91%) of the 2,346 endodontically treated single-rooted teeth examined. There was a statistically significant difference within tooth categories ($p<0.05$). Extrusion was present in 13.17% of maxillary anteriors, 11.32% of mandibular anteriors, 5% of maxillary second premolars, and 11.64% of mandibular premolars.

Extruded root canal filling material was mostly found in maxillary anterior teeth, more than in other tooth groups. On the contrary, the percentage of extrusion in maxillary second premolars was the least among all tooth groups (Table 1). Extrusion was observed in 14.6% of maxillary central incisors, 14% of lateral incisors, and 11.1% of canines. There was no statistical relationship between maxillary anterior tooth groups and the presence of extrusion (p=0.338; Table 2).

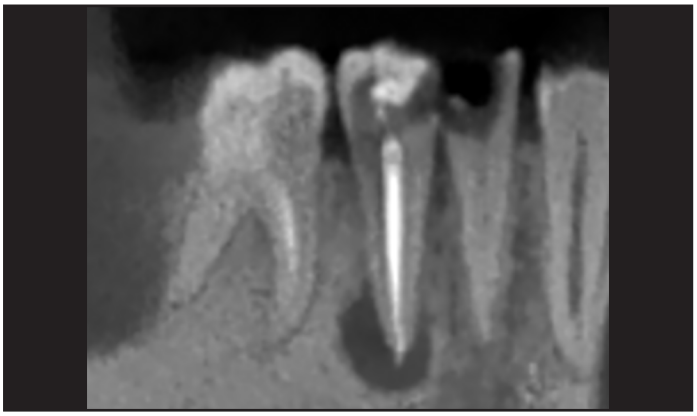

Figure 1. Extrusion of obturation material beyond the radiographic root apex

Table 1. The relationship between tooth groups and the presence of extruded filling material.

Tooth groups	Present N (%)	χ^2	p
Maxillary anteriors	139 (54.3)*	14.484	0.002**
Mandibular anteriors	52 (20.31)#		
Maxillary first premolars	24 (9.38)#		
Mandibular premolars	41 (16.02)#		

Percentages show the distributions within the column.

**p<0.05; chi-square test

*, # Different superscript symbols show statistically significant differences in the same column

Table 2. The relationship between maxillary anterior tooth types and the presence of extruded filling material.

Tooth type	Present N (%)	χ^2	p
Maxillary central incisors	53 (38.13)	2.167	0.338
Maxillary lateral incisors	44 (31.65)		
Maxillary canines	42 (30.22)		

Percentages show the distributions within the column.

chi-square test

DISCUSSION

The most common cause of extruded filling is over-instrumentation. Since the working length of the tooth is not determined correctly, the apical foramen becomes larger than it should be and the apical structure is damaged [23]. Features that affect the formation of the apical barrier, such as complex root canal anatomy, root tip resorption, and immature roots, can often be seen in teeth with overfilling [24, 25]. Due to apical periodontitis, a certain degree of apical root resorption occurs in the teeth. Hence, primary endodontically treated devital teeth and teeth undergoing retreatment are more likely to be extruded than primary endodontically treated vital teeth [9, 24, 26]. Technical problems such as excessive condensation force, hydrostatic pressure, injectable gutta-percha with excessive heat, and the use of a paste carrier during root canal filling processes contribute to extruded root canal fillings [24, 25, 27, 28]. In addition, conditions related to the filling materials, such as excessive fluidity of some sealers and the use of large amounts of sealers and gutta-percha that do not comply with standards, are also factors affecting extruded fillings [25, 27, 28]. No

materials or techniques can completely prevent extrusion [29]. The extrusion rates are 15% with the cold lateral compression technique and between 3–83% with warm vertical compression. This rate can increase to 25–100% using the thermoplasticized gutta-percha technique [27, 30]. The canal-filling technique is a decisive factor in the overfilling of the root canal. Accordingly, the combined application of lateral and vertical condensation techniques significantly increases the probability of overfilling compared with using only a single cone or vertical condensation techniques alone. Furthermore, due to the fluidity created by the compaction techniques applied with heat to the canal-filling material, these techniques are more prone to extrusion [31, 32]. Previous research has classified root filling quality as adequate or inadequate based solely on length [33, 34] or a combination of length and lateral adaptation [35]. A CBCT study in the German population reported an extruded sealer in 8.1% of endodontically treated teeth [36]. Extrusion of all kinds of root-filling material was observed between 1.09% and 31.8% in previous studies [9, 36–41]. Although it is difficult to distinguish gutta-percha from root canal sealer radiographically, studies examining sealer extrusion reported a prevalence of 6.9–8.12% of teeth with extrusion [36, 42]. In the current study, 13.17% of maxillary anteriors with root canal treatment had an extrusion. This rate was similar to studies using CBCT (12.3% and 13.95%) [36, 42], but higher than studies evaluating extrusion with periapical radiography, which ranged from 1.17–5.14% [43, 44]. The percentage of teeth with extrusion (16% and 17.75%) found in two studies evaluating maxillary anterior root canal treatments by dental students, were higher than in the current study [43, 45]. These high results might have occurred due to inexperienced operators.

In our study, extrusion in maxillary second premolars (6.81%) was higher than the only study in the literature (3.75%) in which the maxillary second premolars were evaluated separately [36]. Also, our findings showed extrusion in 11.32% of endodontically treated mandibular anteriors, which was similar to studies using CBCT ranging from 10.5–11.11% [39, 46]. A study focusing on dental students in Türkiye reported that 19.26% of mandibular anteriors had a root canal filling extrusion [45]. However, this rate was higher than in studies using periapical radiography (0–2.63%) [43, 44]. In the current study, 8.54% of root canal filling material extrusion observed in mandibular premolars was similar to that of a German and a Turkish study [36, 45], but higher than other studies [39, 43–45]. When evaluating the maxillary and mandibular anterior teeth together, there was an extrusion in the range of 13–18.13% [38, 41]. Although these studies used periapical radiography, their results were close to the current study (12.61%). Similarly, in some studies where all maxillary and mandibular premolars were evaluated together, extrusion was reported between 4.59% and 23% [38, 40, 41, 43, 45]. The fact that these studies did not distinguish between root and canal counts when obtaining information can be used to explain the large variation in percentage.

Extrusion in maxillary anterior teeth was significantly higher than in other tooth groups. Since these teeth have larger canal diameters, more gutta-percha and canal sealer might be used in the obturation procedure. Moreover, it is easier to physically reach this group of teeth clinically and to perform vertical condensation. These factors might have increased the possibility of extrusion. From the same perspective, the incidence of extrusion in maxillary second premolars was statistically lower than in other tooth groups. The fact that the maxillary second premolars are located more posteriorly in the oral cavity and are more difficult to reach clinically than the other tooth groups in the study, this might have prevented the use of excessive force during root canal filling. Some studies report that the extrusion of root canal sealers is more likely to occur in premolars [47]. Conversely, a randomized clinical experiment reported the occurrence of extruded canal filling material in anterior teeth to be greater than in premolars, similar to our findings [48]. In the same study, it was shown that anterior teeth and premolars cause more overfilling than molars, which might be because anteriors and premolars have flatter and larger root canal morphologies compared with molars. However, it has been determined that tooth type loses its importance as a determining factor in canal filling material extrusion [48].

Limitations

The first limitation was the possibility for the extruded root canal filling materials that were histologically detectable, but too resorbed to distinguish be by CBCT imaging [9]. The second limitation is that CBCT images of teeth after primary or secondary endodontic treatments were not evaluated in the present study. In addition, it was not recorded whether the teeth were vital or devital before the endodontic procedure or filling technique used in the root canal. A further limitation of the present study was the use of the radiographic apex rather than the apical constriction in determining the existence of extrusion. As a final limitation, it was difficult to distinguish gutta-percha from root canal sealers when assessing overfilling

using CBCT images. In previous studies that have experienced this challenge, “overfilled”, “overextended”, “over apex”, “long filling”, and “inadequate obturation” have been used to describe extruding root canal filling material, regardless of gutta-percha or root canal sealers [9, 36–41]. There was only one study that specifically used the term “sealer puff” for the extrusion of root canal sealers [36].

CONCLUSIONS

The current study indicated that the root canal filling material extrusion in maxillary anteriors was higher than in other tooth groups, whereas the extrusion in maxillary second premolars was lower than in other tooth groups. There was no statistical relationship between maxillary anterior tooth groups and the presence of extrusion. In further studies, factors affecting extrusion such as filling technique, filling material, and apical condition should be examined separately, not only in single-rooted teeth, but also in multi-rooted teeth. Dentists should be more careful to avoid extrusion when filling the root canals of single-rooted teeth, especially the maxillary incisors and canine teeth.

Conflict of interest: The authors declare no conflicts of interest.

Informed Consent: Informed consent was obtained from patients participating in the study.

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Ethical Approval: The study was conducted with the permission of the Clinical Research Ethics Committee of Gaziantep University (Decision Date: 26.10.2022, Approval No: 2022/292).

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