

# *Prevalence of Endodontic Perforations Committed by Bulgarian General Dental Practitioners*

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**Abstract**—Endodontic perforations that result in a communication of the root space with the periodontal tissues may occur occasionally during root canal treatment. The aim of this study was to determine the prevalence of iatrogenic perforations committed by Bulgarian general dental practitioners. A total of 2460 cases of endodontic treatment were investigated and the incidence of iatrogenic perforations, committed by general dental practitioners in Bulgaria for a period of 7 years was evaluated. Data were collected from clinical examination and observation of the periapical radiographs. In 137 cases of root canal treatment a different types of perforation were found. 100 of them were iatrogenic (4.06%), 34 (1.38%) were the result of carious process and 3 (0.12%) were the result of resorption. In the total number of perforations, the iatrogenic ones represented 72.99%. The most commonly affected tooth groups were mandibular molars (42%) and maxillary molars (22%). 59% of perforations were found in the lower jaw and 41% - in the upper jaw. The prevalence of iatrogenic perforations in Bulgaria is relatively high. Therefore, emphasis on continuing education and post graduate courses in endodontics must be a priority.

**Keywords**—Endodontic root perforations, Prevalence, Etiology

## I. INTRODUCTION

Endodontic root perforations are complications in the course of endodontic treatment, representing mechanical or pathological communications between the root canal system and the outer root surface. They can be of iatrogenic origin or the result of a resorptive or carious process [1]. Iatrogenic perforations are more common and are a result of procedural errors in the endodontic access preparation, the search for canal orifices, improper negotiation and instrumentation of the root canal or preparation of intra-radicular post space [2, 3].

Root perforations are relatively rare endodontic problems (4, 5). The occurrence of perforations ranged from 0.6% to 17.6% [6, 7]. However, they can create serious difficulties in endodontic treatment, worsen its prognosis, and may lead to alveolar bone loss, treatment failure, and even to an extraction of the affected tooth [1, 8, 9]. According to Iqbal et al. root perforations are responsible for endodontic failures in 5.5% [10]. Yamaguchi et al. found that most endodontic cases diagnosed with refractory periapical periodontitis by general practitioners in Japan were compromised by any other factors rather than extraradicular biofilms. The perforation was one of the main causes of endodontic treatment failure (17.5%) [11].

Along with the most common causes of tooth extraction such as periodontal disease, endodontic failure, vertical root fracture, nonrestorable crown fracture, nonrestorable caries, etc., iatrogenic perforations also may be a reason for extraction in 4.2-8.8% [4, 12, 13]. Additionally, Kvinnsland et al. evaluated the treatment outcome of 55 root perforations and reported that 21% of perforations showed a size and location hopeless for repair and the teeth were extracted [14]. According to Yamaguchi et al. 44.4% of hopeless cases with refractory periapical periodontitis were extracted due to perforations [11].

There is little information in the dental literature regarding endodontic practice profiles and the reasons for referral to endodontic specialists. In an older study, Abbot reported that among 2000 patients referred to an endodontist in Australia, root perforations were the reason for referral in 6% [6]. Among 851 claims submitted to the Swedish Patient Insurance Scheme for a period of one year, Cronström et al. found that the most frequent claims referred to root fractures of roots with posts, and to root perforations also related to root posts [15]. In contrast, in a more recent study, Kim suggested that referrals in cases involving endodontic difficulties such as canal calcification, broken instruments, post, perforation, and resorption were less than 5.0%, respectively [16].

The studies regarding the prevalence of iatrogenic root perforation in the current literature is insufficient. Investigations determining the incidence of iatrogenic endodontic errors and complications in treatment cases performed by undergraduate students are predominant [17, 18, 19]. Therefore, the **aim** of this study was to evaluate the prevalence of endodontic perforations committed by Bulgarian general practitioners and their distribution by etiology and type and group of teeth.

### II. MATERIALS AND METHODS

This retrospective cross-sectional study was carried out at Faculty of Dental Medicine, Sofia Medical University, Bulgaria. A total of 2460 patients who received nonsurgical root canal treatment during the period from December 2014 to December 2021 were included into this study, regardless of gender or age. Most of the patients were referred to the Department of Conservative Dentistry by general dental practitioners due to endodontic treatment complications.

Additionally, only teeth treated using at least three radiographs (preoperative, working-length and postoperative) of good quality that showed the entire length of the root and the periapical area, were included. The exclusion criteria were: (1) Patients with teeth subjected to previous endodontic surgical procedures; (2) Cases with immature root development; (3) Cases with unreadable radiographs. Informed consent forms were signed by all the patients. The study was approved by the Ethics Commission for Research at the Sofia Medical University (KENIUMUS). The perforations were diagnosed clinically and radiographically. Iatrogenic errors were recorded from the interoperative or immediate postoperative digital radiographs of each case.

All radiographs were evaluated by two independent calibrated clinicians at the Department of Conservative Dentistry with more than 10 years of endodontic experience. The method of viewing the radiographs was standardized and an evaluation form was designed to record the information gathered from the radiographs. All the radiographs were systematically examined in a darkened room using an illuminated viewer box with magnifying glass. When the two examiners were in disagreement, they discussed the case with a radiologist, to solve the problem. The examiners agreement was measured by Cohen kappa test using one hundred radiographs for assessment. Kappa values obtained for the inter-examiner reliability was 0.80, which indicate strong agreement.

The presence of perforations was detected and proven by an endodontic instrument in the perforation site or when an extrusion of the filling material outside the root confines was detected in any area of the root (lateral wall, furcation or the apical foramen). The perforations were classified according to the following criteria: (1) etiology (cause of the perforation) - resorption, caries or of iatrogenic origin; (2) tooth group; (3) tooth type. Once the investigation of radiographs was completed, all associated data were gathered and the prevalence of iatrogenic perforations relative to the total number of endodontic treatments and the total number of perforations was calculated and analyzed statistically.

#### Statistical Analysis

All data were entered and processed with the statistical package IBM SPSS Statistics 25.0 (SPSS, Inc. Chicago, IL). The results were submitted to the descriptive and alternative statistical analysis to evaluate the perforation prevalence. The significance of the differences between the groups was examined by using t-test.  $\alpha$ -level was set at 0.05 and P-value less than 0.05 ( $p < 0.05$ ) was considered as statistically significant. Graphical analysis (pie chart) was used to visualize the results.

### III. RESULTS

This retrospective cross-sectional study evaluated the incidence of iatrogenic perforations committed by general dental practitioners for a period of 7 years. Table I summarizes the overall results (in number and percentage) of the prevalence of perforations. Of the 2460 patients studied, in 132 cases (one tooth per patient) were registered a total of 137 teeth with perforations (5.57%). 100 of them (4.06%) were of iatrogenic origin, 34 (1.38%) were caused by carious lesions, and 3 (0.12%) were the result of resorptive process. When calculated relative to the total number of perforation cases (n=137), 72.99% were iatrogenic, 24.82% were due to caries and 2.24% were due to resorption. In fact, although the number of cases of iatrogenic perforations was 100, the total number of perforations was 106, because in some cases more than one perforation was registered.

TABLE I. DISTRIBUTION OF THE PERFORATION ACCORDING TO THE ETIOLOGICAL FACTOR

Etiological factor	EDT N=2460	%	Sp	Perforations n=137	%	Sp
Iatrogenic origin	100	4.07 <sup>a</sup>	0.40	100	72.99 <sup>a</sup>	3.79
Carious lesion	34	1.38 <sup>b</sup>	0.24	34	24.82 <sup>b</sup>	3.69
Resorptive process	3	0.12 <sup>c</sup>	0.075	3	2.19 <sup>c</sup>	1.25
Total	137	5.57		137	100	

\*Sp – Standard Error; Different letters reveal statistically significant difference at  $p < 0.05$

Most often perforations were registered in the lower molars – 42%, followed by the upper molars, but with twice lower frequency rate – 22%, and upper frontal teeth – with three times lower frequency of 11%. A statistically significant difference between these three groups of teeth was found ( $p < 0.05$ ). The lowest perforations rate was established in upper and lower premolar groups (8%, respectively). Fig. 2 illustrates the distribution of the perforations according to tooth groups. In general, mandibular teeth were affected in a higher extent than maxillary ones (59% and 41%, respectively) with statistically significant difference in between.

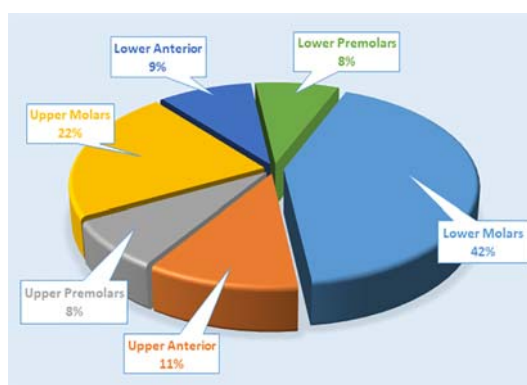


Fig. 1. Distribution of iatrogenic perforations according to tooth groups.

According to tooth types, the mandibular first molars were most affected by perforations (27%), followed by the mandibular second molars and maxillary first molars in equal extent (15%). As a comparison, maxillary second premolars and mandibular central incisors showed the lowest perforation rate (1%, respectively). In the group of third molars, both in the lower and in the upper jaw, perforations were not registered. The data on the relation between the presence of iatrogenic errors and tooth type in the dental arch are presented in Table II.

TABLE II. DISTRIBUTION OF THE PERFORATIONS ACCORDING TO THE TOOTH TYPE

Tooth type	N	%	Sp
Maxillary central incisor	6	6.00 <sup>c</sup>	2,37
Maxillary lateral incisor	2	2.00 <sup>d,e</sup>	1,40
Maxillary canine	3	3.00 <sup>d</sup>	1,71
Maxillary first premolar	7	7.00 <sup>c</sup>	2,55
Maxillary second premolar	1	1.00 <sup>c</sup>	0,99
Maxillary first molar	15	<b>15.00<sup>b</sup></b>	3,57
Maxillary second molar	7	7.00 <sup>c</sup>	2,55
Maxillary third molar	0	0.00	-
Mandibular central incisor	1	1.00 <sup>c</sup>	0,99
Mandibular lateral incisor	6	6.00 <sup>c</sup>	2,37
Mandibular canine	2	2.00 <sup>d,e</sup>	1,40
Mandibular first premolar	4	4.00 <sup>d</sup>	1,96
Mandibular second premolar	4	4.00 <sup>d</sup>	1,96
Mandibular first molar	27	<b>27.00<sup>a</sup></b>	4,44
Mandibular second molar	15	<b>15.00<sup>b</sup></b>	3,57
Mandibular third molar	0	0.00	-
Total	100	100%	-

\*Sp – Standard Error; Different letters reveal statistically significant difference at  $p < 0.05$

#### IV. DISCUSSION

Root perforations that result in a communication of the root space with the periodontal tissues occasionally occur during endodontic procedures. They may be induced iatrogenically, by resorptive process, or by caries [1]. The purpose of this study was to determine the incidence of iatrogenic perforations, in cases treated by Bulgarian general dental practitioners. Only a few studies investigating procedural errors in RCT performed by general dental practitioners were found in the literature. In an older study Kvinnsland et al. reported that 47% of the perforations were due to endodontic and 53% due to prosthodontic treatment [14].

Some authors found very low perforation rate. Jamani and Fayyad evaluated procedural errors encountered in 3178 teeth with RCT in a Jordanian population, and registered perforations of the root walls or the floor of the pulp chamber in only 1.10% of the evaluated teeth [20]. Mozayeni et al. investigated the "procedural accidents" in a total number of 150 patients referred to endodontic department for RCT treatments in Iran and found strip perforation in 0.7%, while no case of furcation and cervical perforation was observed [21].

According to Tsisis et al., of a total of 5,048 root canal-treated teeth, 116 root perforations (2.29%) were identified in 101 patients [5]. Akbar evaluated a total of 100 cases of endodontic treatment and observed the presence of furcal and strip perforations in 4% of the teeth [4]. In Bulgaria, Stamatova investigated the frequency of perforations committed by general dentists through questionnaires and found that perforations are relatively rare complications, less than 5 cases per year for a dentist [22]. The results found in the present study was significantly higher than that reported by most of the authors [5, 20, 21], in which perforations ranged from 0.7-1.10-2.29% of the cases. However, they were consistent with those of Akbar, which was

4% [4].

Many authors investigated the incidence of accidental root perforations committed by undergraduate dental students and their findings are often contradictory. Eleftheriadis and Lambrianidis evaluated the technical quality of RCT in an undergraduate dental clinic at the Aristotle University of Thessaloniki in Greece and detected root perforation in 2.7% [23]. In contrast, Khabbaz et al. reported that 4th and 5th year undergraduate students at the Dentistry School of Athens, also in Greece, created root perforations in 13.89% (3.7% and 10.19%, respectively) [24].

Abdulrab et al. found high frequency of reported endodontic procedural errors by Saudi senior dental students in the 5th and 6th levels (5<sup>th</sup> and 6<sup>th</sup> year) [17]. Among them furcation perforations were 25 (32.1%) and apical perforations - 49 (31.6%). In contrast, Alamoudi et al. evaluated for iatrogenic errors a 1000 cases treated by 5th and 6th year students also in Saudi Arabia, and according to them all types of registered perforations accounted only for 2.5% of the total number of cases and represented 11% of the iatrogenic errors cases [18]. In a recent study in the same country Alghamdi et al. reported 2.9% of root perforations, committed by undergraduate students [25].

Evaluating the radiographic quality of RCTs performed by undergraduate clinical students of Dental School of Isfahan, Iran, Saatchi et al. found foramen perforation in 2% and root perforation in 2.4% [26]. Conversely, Haji-Hassani et al. found 18.9% apical perforations and 0.9% strip perforation, made by senior students at the dentistry school clinic in Tehran, Iran [27]. In another recent study, Hendi et al. reported 17.6% apical perforations in RCT performed by fifth year dentistry students in Iran [28]. Dimitrova et al. found the overall frequency of perforations committed by 6<sup>th</sup> year students in Sofia, Bulgaria to be 3.9% for 2015 and 4.1% for 2016 [19]. The iatrogenic perforation frequency found in the current study (4.06%) took an intermediate position among other cited research.

Only a few authors investigated the distribution of root perforations according to the tooth type and tooth groups. In the present study the highest prevalence of root perforation was found in lower molars (42%), in particular in mandibular first molar (27%) and the lowest rate – in upper and lower premolars (8%). Hendi et al. reported that the prevalence of apical perforation were significantly higher in molars (31.4%) in comparison with premolars and anterior teeth (12.4% and 11.8%, respectively) [28], and these results are close to ours.

Dimitrova et al. found root perforations mainly in maxillary canines and incisors (23.9%) [19]. Alghamdi et al. reported that only upper premolars and lower canines were affected [25]. When consider all the patients' teeth in three groups, Haji-Hassani et al. found that premolars had the most occurrences of errors (86.11%), followed by molars (63.2%) [27]. These findings are completely or partially inconsistent with ours. The higher rate of perforations in lower molar teeth, found by us, seems to be associated with the great number of endodontic treatment in this group of teeth. In the third molars perforations were not registered. This fact may be due to their anatomical characteristics – they often have fused roots or are single-rooted. In addition, they are often extracted due to the difficult conditions of endodontic treatment and coronal restoration.

With respect to the affected jaws, the perforation rate for the mandible found in this study was 59% and 41% for the maxilla. Hendi et al. found 21.5% apical perforations in mandible and 15.6% in maxilla [28]. Similarly, Haji-Hassani et al. registered 21% apical perforations in mandible and 17.8% in maxilla [27]. Contrary to that, Kvinnsland et al. reported that maxillary teeth were perforated three times more often (74.5%) than mandibular teeth (25.5%) [14]. Evaluating the treatment outcome of 21 teeth with root perforation, Mente et al. notified that 62% of them were in the upper jaw and 38% in lower ones [29]. Alghamdi et al. found that maxillary teeth had a higher frequency of perforations (1.7%) than mandibular ones (1.3%) [25]. Only a small number of authors have studied the frequency of perforation types relative to their total number. Most of them have indicated their rate in relation to the total number of endodontic treatments. For this reason, it was difficult to compare our results with those reported by other researchers.

Alrahabi et al. stated that in the recent years, a sharp rise in the endodontic malpractice cases has been observed worldwide [30]. Ciobanu et al. suggested that in most of the cases, the endodontic stripping is the result of the lack of care or lack of experience of the dentist. According to them a referral toward a specialist or consultant endodontist is always an appreciable option and should be considered in the best interest of the patient [9]. The evaluation of the prevalence of endodontic procedural errors, in particular iatrogenic perforations according to tooth type and group provides information for avoiding, detecting, and treating of such defects. The knowledge of the endodontic morphology of teeth, especially of molars also is essential for reducing the risk of iatrogenic errors.

## V. CONCLUSIONS

The findings of present study suggest that the prevalence of iatrogenic perforations committed by general dental practitioners in our country is relatively high and this fact is a cause for concern. Therefore, emphasis on continuing education and post graduate courses in endodontics must be a priority in Bulgaria.

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