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Frequently affected teeth by different types of iatrogenic perforations made during dental training in Bulgaria

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ABSTRACT

Background: One of the reasons for endodontic treatment failure is iatrogenic perforation. That is why it is important to provide adequate endodontic education for graduating young practitioners. **Aim:** The aim of this study is to determine the most common locations of the iatrogenic perforations made by last year students in the Dental Faculty in Sofia, Bulgaria, to note the association of particular errors with particular teeth and to determine how this information can improve their education. **Methods:** All patient records of last-year students for 2015 and 2016 were examined. Perforations were diagnosed by radiography, and also confirmed clinically. **Results:** From all 778 teeth 30 incidents of root perforations were found: 10 in 2015 and 20 in 2016. More perforations were found in upper posterior teeth- 80% of all the perforations made in 2015, and 45% of all registered perforations in 2016. For the entire period of the research perforation frequency in upper molars, and in upper anterior teeth were found to be significantly higher than in other group of teeth. In academic 2015 year, 8 of the perforations (80%) were furcal. In 2016 year, 11 (55%) of all perforations were apical. **Conclusions:** More in-depth knowledge of endodontic anatomy, and also more strict supervision on students' tasks are needed, especially regarding standard root canal treatment on molar teeth.

Keywords: Education, endodontics, root canal treatment, iatrogenic perforation

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Introduction

As the population of the Earth grows older, keeping natural teeth for longer time becomes more important for maintaining the quality of life. Quality endodontic treatment allows more natural teeth to be maintained further in life. That is why endodontics is crucial for comprehensive dental healthcare [1,2]. Studies have proven that nonsurgical root canal treatment performed by specialists have success rate >90% [3,4]. The success rate decreases to 40–65% when root canal treatment is performed by general practitioners[5]. This explains why it is important to provide adequate endodontic education for graduating young practitioners. Undergraduate programs should be improved, where it is possible to recognize the reasons that affect the success of dental treatments [6,7].

One of these reasons for failure is iatrogenic perforation. Root perforations occur in 3% to 10% of endodontically treated teeth [8, 9, 10]. With the progress of technical equipment clinicians attempt to treat more and more difficult cases. That is why it is realistic to expect that the frequency of perforations in the future will increase. Perforations in critical areas lead to infection and more often than not to the extraction of the tooth. Prevention of iatrogenic complications is imperative in a modern public healthcare system.

There is a single epidemiological study on the technical quality of root canal fillings in Bulgarian population and it showed a good filling quality only in 29.6% of the cases studied [11]. Inadequate endodontic teaching and training received at dental schools were cited as a possible reason that might explain this finding.

Improving endodontic curriculum in the university may have a positive effect and ultimately improve dental healthcare.

The aim of this study is to determine the most common locations of the iatrogenic perforations made by last year students in the Dental Faculty in Sofia, Bulgaria, to note the association of

particular errors with particular teeth and to determine how this information can improve their education. This will help their teachers to determine which steps of the endodontic procedure requires greater diligence to substantially improve the quality of their students' work and ensure better long-term viability of the treatment.

Materials & Methods

Dental medicine at Sofia Medical University is six years and students take a full preclinical course in conservative dentistry and endodontics in the second, and third year of their training. In the fourth and fifth year students have 4 terms during which they have 30 h of theoretical lectures each year and work 5 h per week in the faculty's clinic. During this time they must complete the endodontic treatment of minimum 15 teeth of different groups, including molars. This is done under the strict supervision and control of experienced professionals.

In last year, students are granted more autonomy when performing endodontic treatment as a part of a comprehensive dentistry-care course.

Radiographic examination is a routine method for the technical quality assessment of root canal treatment.

All patient records of last-year students for 2015 and 2016 at Medical University, Faculty of Dental Medicine, Sofia were examined and a 912 teeth were first included in the study. Records with incomplete information like missing or poor quality radiographs were excluded; the causes for exclusion were summarized. The final data included 778 teeth, 285 treated in the academic year of 2015 and 493 treated in the academic year of 2016. Conventional intraoral radiographic pictures were taken at all stages of treatment : in the beginning, for work length estimation, after root canal preparation, and after post-placement if the post was needed. X-rays with superimposition of tooth structure or anatomical structures were not included in the study sample.

For perforations diagnosed only by radiography, the following criteria are accepted: a clearly visible endodontic instrument in the perforation, a post penetrating the adjacent tissues. Apical perforation: identified when the apical termination of the filled canal was different from the original canal terminus, or when the filling material was extruding through the apical foramen [12]. All perforations were confirmed clinically. Apical iatrogenic perforations were proven by the absence of apical stop and free passage outside the anatomical apex of an endodontic instrument equal to or greater than K file №35 as a criterion, provided that the initial size of the physiological narrowing corresponded to smaller tool.

All patients signed informed consent forms. The Ethics Commission for Research at the Medical University of Sofia approved the study.

The x-rays from patients' records were investigated separately by two experienced examiners with a double-magnifying glass. The two researchers were calibrated before and after the evaluation.

All the data were represented in appropriate form. Cross-tabulation was used to investigate the association between the groups. The differences were tested using Z-test with Bonferroni correction, the differences between the groups were considered statistically significant when the p-value was less than 0.05. The statistical analyses were performed using SPSS 22.0 for Windows (Chicago, IL, USA).

Results

In the years of 2015 and 2016, 1108 cases of endodontic treatments were performed by last year students in the Faculty of Dentistry in Sofia. All patients' charts were examined and 912 teeth were included in the study at first. Only 778 teeth met all inclusion criteria: 285 from 2015 and 493 from 2016. From these 778 teeth 30 incidents of root perforations were found: 10 in 2015 and 20 in 2016.

For cases treated in 2015 there were 3 cases (1.1%) of perforation made in upper premolars, 5 (1.8%) in upper molars and 2 (0.7%) in lower molars. More perforations were found in upper posterior teeth- 80% of all the perforations made in 2015 (Table 1). For the academic year of 2015 the data showed that there were no registered perforations for the groups of anterior teeth and lower premolars. Perforations were found at 5.9% of all upper premolars, 10% of all upper molars and 4.4% of all lower molars.

For cases treated in 2016 there were 2 (0.4%) perforations in upper anterior teeth, 2 (0.4%) perforations in lower anterior teeth, 3 (0.6%) cases of perforation made in upper premolars, 4 (0.8%) in lower premolars, 6 (1.2%) in upper molars and 3 (0.6%) in lower molars. More perforations were made in upper posterior teeth- 45% of all registered perforations made by Bulgarian students during 2016 (Table 2). For 2016 1.5% of all upper anterior teeth, 5.3% of all lower anterior teeth, 4.3% of lower premolars, 3.4% of all upper premolars, 9.4% of upper molars and 3.4% of lower molars had perforations.

The type of the tooth group was found to be of no significance for occurrence of perforation $p > 0,005$ for each year alone. For the entire period of the research perforation frequency in upper molars, and in upper anterior teeth were found to be significantly higher than in other group of teeth.

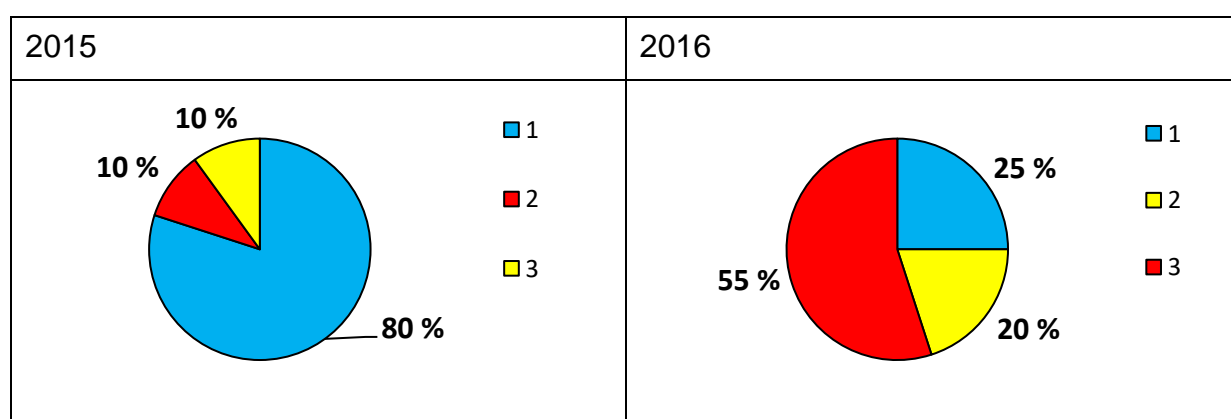
In academic 2015 year 8 of the perforations (80%) were furcal (Fig.1). In 2016 year, 11 (55%) of all perforations were apical. For the two academic years 13 perforations were furcal, 12- apical, 5 -lateral (Fig. 1). For the entire period there were no significant differences found in different types of perforations: furcal, lateral and apical. There was a significant difference between furcal perforations frequency in 2015 and 2016 at $p < 0,05$. There was a significant difference between apical perforations made in 2015 and 2016 at $p < 0,05$.

Table 1. Distribution of perforations according to the total number of teeth for each group during 2015

			Type of the tooth						Total
			Upper anteriors	Lower anteriors	Upper premolars	Lower premolars	Upper molars	Lower molars	
Perforation	Without perforation	Count	68	29	48	42	45	43	275
		%	24,7%	10,5%	17,5%	15,3%	16,4%	15,6%	100,0%
	Perforation	Count	0	0	3	0	5	2	10
		%	0,0%	0,0%	30,0%	0,0%	50,0%	20,0%	100,0%
Total		Count	68	29	51	42	50	45	285
		%							100,0%

Table 2. Distribution of perforations according to the total number of teeth for each group during 2016

			Type of the tooth						Total
			Upper anteriors	Lower anteriors	Upper premolars	Lower premolars	Upper molars	Lower molars	
Perforation	Without perforation	Count	130	36	85	90	58	74	473
		%	27,5%	7,6%	18,0%	19,0%	12,3%	15,6%	100,0%
	Perforation	Count	2	2	3	4	6	3	20
		%	10,0%	10,0%	15,0%	20,0%	30,0%	15,0%	100,0%
Total		Count	132	38	88	94	64	77	493
		%							100,0%

**Figure 1. Perforations according to their localization**

1-apical perforations; 2- furcal perforations; 3- lateral perforations

Discussion

Iatrogenic root perforations are accidents that occur during access, instrumentation or attempted bypassing or removal of fractured instruments during endodontic treatment or

retreatment and misaligned instruments during post-space preparation [13-16].

Kvinnslund et al found in their study that 73% of all incidents of perforations occurred in the maxilla. In the frontal teeth of the upper jaw this

study found that all perforations were situated on the labial root surface due to the clinician's lack of understanding the palatal inclination of the roots of these teeth. In multi-rooted teeth, however, furcation perforations may occur whilst searching for the canal orifices, as dentine is removed from the pulpal floor [17]. Our study confirmed these results with almost 2/3 of perforations occurred in the maxilla (19 out of 30). We also had 13 furcal perforations. This advises more practical learning and more strict supervision on students' tasks, especially regarding standard root canal treatment on molar teeth.

Endodontic mishaps or procedural accidents are unfortunate occurrences. There is a wide range in the reported incidences of perforations ,depending on the size of the sample, type of teeth treated, educational program and supervision of treatment. Comparing results from different studies in different universities is difficult because of inclusion criteria used, type of teeth treated, educational curriculum etc. For example, some of the studies found the following:

In their study of the outcome of endodontic treatments by dental students Heli Rapo, et al. evaluated the quality of 105 root canal treatments performed by undergraduate dental students [18]. They found 3.8% (4 teeth 3 of them in the lower jaw) of teeth had lateral perforation as a complication. In their study Dadresanfar et al. evaluated treatment errors in 613 cases, treated by undergraduate students [19]. Furcal Perforation and Cervical Perforation were not observed. 6 Strip Perforation cases were identified and there was not significant relationship with related factors. All 6 were in molar teeth. We found 13 furcal, 12 apical and 5 lateral perforations in our study. So students should improve their knowledge of tooth anatomy because an insufficient access and an exaggerated or misdirected access cavity is also conducive to misidentification of the root canal, furcal and root perforation.

da Silva et al. evaluated radiographic records of 397 endodontically treated anterior teeth and pre-molars [20]. Iatrogenic errors that were detected in root filled teeth, and no perforations in anterior teeth and premolars were found. So anterior teeth and premolars are less likely to have perforations. In our study for 2015 anterior teeth and lower premolars had no perforations, 5.9% of all upper premolars ,10% of upper molars and 4.4% of lower molars had perforations. For 2016 1.5% of all upper anterior teeth , 5.3% of all lower anterior teeth, 4.3% of lower premolars, 3.4% of all upper premolars ,9.4% of upper molars and 3.4% of lower molars had perforations. That means that molars were more prone to perforations. That is comparable to the results found by Mukhaimer [21]. In his study a total of 612 periapical radiographs were used to assess the radiographic technical quality of 1013 root canals performed by the 4th and 5th undergraduate students between the years 2009 and 2012. They found 47 perforations (4.6%) and 70 % of them occurred in molars with curved canals. In our study 16 of 30, 53% perforations occurred in molars. This may be because of lack of : substantial knowledge of tooth anatomy; a certain skillfulness; knowledge of endodontic treatment protocols; knowledge of obtaining ergonomic working position and perfect vision.

Conclusion

Better knowledge of the prevalence and possible predictors of perforations may assist the clinician in the prevention and treatment of iatrogenic root perforations. Perforations are complications with serious consequences. The lack of understanding all risk factors for root perforations may cause future problems leading to tooth loss. More in-depth knowledge of endodontic anatomy is needed, especially for the group of teeth most affected by iatrogenic perforations. Also, some practical skills for ergonomic working position should be implemented in the curriculum.

Conflicts of interest

No potential conflict of interest was reported by the authors.

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Contribution of authors

All authors participated in designing the study, in gathering the data for the study, in the analysis of the data, and in writing the paper.

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