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Study of Frequency of Iatrogenic Perforations by Group of Teeth and Localization Made by Bulgarian Students

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ABSTRACT

Introduction: Iatrogenic perforation of the pulp chamber floor or the root is a major endodontic complication that may cause treatment failure.

Aims: The objective of this study is to analyze the frequency of iatrogenic perforations made during endodontic treatment by last year dental students. Investigating the most affected groups of teeth, and the most common localization of the perforations will help to determine which steps of the endodontic procedure need an alternative approach in students' training and will ultimately improve the education process.

Methodology: The data were collected from patient records and obtained from clinical exams during the academic year 2016. The final data comprised 493 teeth. All perforations were confirmed clinically and on an x-ray. Clinical criteria included sudden bleeding or pain during instrumentation; the presence of blood on paper points, confirming perforation via apex locator. Results: 20 iatrogenic perforations were identified during the endodontic treatment of 493 teeth or 4,1% of all clinical cases. More perforations were made in upper posterior teeth (premolars and molars) -45% of all the perforations. The type of the tooth was found to be of no significance for the occurrence of perforation $p > 0,005$. 11 teeth or 55% of all 20 perforations were apical, followed by perforations in the furcation area. There are no significant differences found in different types of localization of iatrogenic perforations.

Conclusions: Analyzing the data from the current study allows us to establish the need to improve students' practical skills in endodontic treatment of molars and to improve their training in using apex locators so there are fewer apical perforations.

Key Words: Endodontic education, Root canal treatment, Iatrogenic perforation, Dental students, Epidemiology, Practical training

INTRODUCTION

Accidental perforation of the pulp chamber floor or the root is a major complication of endodontic treatment. Iatrogenic perforations may occur at any time in root canal treatment and may cause treatment failure. Early diagnosis, size, shape, location, type of perforation, the chosen treatment, the experience of the practitioner, the materials used for the obturation, and host response are the factors that affect perforation management and the prognosis of the tooth.^{1,2} Endodontic education must be sufficient and up to date so that graduating young dentists, lacking clinical experience still can perform at their best with minimal iatrogenic mistakes. We have to improve undergraduate programs, where it is

possible to minimize circumstances like lack of theoretical knowledge and practical skills to affect the future performance of the dentist.^{3,4} The frequency of iatrogenic perforations in different groups of teeth and regarding the location of the perforation is not studied well.^{5,6} The localization of the perforation and the type of teeth involved is crucial for the treatment outcome.

To find and analyze where learning difficulties may appear, and where the program fails to provide the necessary skills for students, iatrogenic perforations made by Bulgarian students were studied. Their cause, type, frequency, the most affected groups of teeth are the indicators that helped to define the existing problems. An epidemiological study on

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the technical characteristics of canal fillings in the Bulgarian population⁷ showed a good treatment quality in only 29.6% of the cases studied, which justifies our efforts.

The objective of this study is to analyze the frequency of iatrogenic perforations made by last year students. Investigating the most affected groups of teeth, and the most common localization of the perforations will help to determine which steps of the endodontic procedure need an alternative approach in students' training and will ultimately improve the education process.

MATERIAL AND METHODS

Dental medicine training in Bulgaria lasts six years. In the sixth year, students have to develop skills in the comprehensive treatment of patients, and endodontics is part of this curriculum. They perform their treatment under supervision, but the specialists supervising them do not approve every step of the process so that students have more autonomy and higher responsibility.

The data were collected from patient records and obtained from clinical exams during the academic year 2016. 567 teeth were first included in the study. Case files with missing information and poor radiographs were excluded. The final data comprised 493 teeth and 854 root canals. All 144 last year students participated.

Intraoral radiographs were taken at the beginning, and after each treatment step: determining working length, canal obturation, and post-placement. X-rays with superimposition of anatomical structures, tooth structures, and root canal filling were not included in this research. Criteria for radiographic characteristics of proper endodontic treatment were matched to the European guidelines and other studies on root canal treatment, performed by dental students.^{4,8}

The clinical and radiographical exams constitute the basis of iatrogenic perforation diagnosis.²

Clinical criteria include sudden bleeding or pain during instrumentation of the root canals; the presence of blood on paper points, confirming perforation via apex locator.

Radiographic criteria following the clinical exam: perforations were diagnosed via radiographic evidence of a file passing through the tooth structure and entering into the periodontal ligament or bone for perforations on the pulp chamber floor, lateral root perforations, and apical perforations. The presence of fresh bleeding in the canal or on the surface of files or paper points and lack of an apical stop are indicators of the perforation of the apical foramen. The penetration of the last file beyond the radiographic apex confirms the presence of this procedural accident.

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

Two experienced researchers were calibrated to a high level of reproducibility with Kappa values of 80-90. They examined separately all radiographs with the aid of a double-magnifying glass. The results were compared and where differences occurred the examiners reached a consensus.

STATISTICAL METHODS

The association between the groups was investigated using cross-tabulation. The differences between the groups were tested using Z-test with Bonferroni correction and were considered statistically significant when $p < 0.05$. Statistical analyses were performed using IBM SPSS Statistics 22.0 for Windows (IBM, Chicago, IL, USA).

RESULTS

In this study, 20 iatrogenic perforations were identified from all 493 teeth that underwent endodontic treatment or 4.1% of all clinical cases. Of the total number of treated teeth, 273 were from the upper jaw. Most of the affected teeth were from the maxilla - 11 teeth; distributed as follows: 2 teeth or 0.4% of perforations in upper frontal teeth, 3 teeth or 0.6% of perforation in upper premolars and 6 teeth or 1.2% of perforations in upper molars (Table 1).

Table 1: Distribution of perforations for each group of teeth from the total percentage rate for the academic year 2016

			Types of teeth				Total		
			Upper inter- riors	Lower anterior	Upper pre- molars	Lower pre- molars		Upper molars	Lower molars
Perfora- tions	Without perform.	Count	130	36	85	90	58	74	473
		% from total	26.4%	7.3%	17.2%	18.3%	11.8%	15.0%	95.9%
	Perfor.	Count	2	2	3	4	6	3	20
		% from total	0.4%	0.4%	0.6%	0.8%	1.2%	0.6%	4.1%
Total		Count	132	38	88	94	64	77	493
		% from total	26.8%	7.7%	17.8%	19.1%	13.0%	15.6%	100.0%

All groups of teeth were affected by perforations, but they were most common in the maxilla (55% of all perforations) (Table 2). More perforations were made in upper posterior teeth (premolars and molars)- 45% of all the perforations

made in 2016 (Table 2). The type of the tooth was found to be of no significance for the occurrence of perforation $p > 0,005$ (Table 2).

Table 2: Per cent of perforations for each group of teeth of all the perforations for the academic year 2016

			Type of the tooth				Total		
			Upper anterior	Lower anterior	Upper pre-molars	Lower pre-molars		Upper molars	Lower molars
Perforation	0	Count	130	36	85	90	58	74	473
		%	27.5%	7.6%	18.0%	19.0%	12.3%	15.6%	100.0%
	1	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%

The highest reported per cent procedural error was for the group of upper molars (1.2%) compared to the overall prevalence of perforations (4.1%) (Table 3). The least affected

by iatrogenic perforations in this study are upper and lower frontal teeth (Table 3).

Table 3: Distribution of perforations according to the total number of teeth for each group

			Types of teeth				total		
			Upper anterior	Lower anterior	Upper pre-molars	Lower pre-molars		Upper molars	Lower molars
perforations	Without perforations	Count	130	36	85	90	58	74	473
		%	98.5%	94.7%	96.6%	95.7%	90.6%	96.1%	95.9%
	Perforationa	Count	2	2	3	4	6	3	20
		%	1.5%	5.3%	3.4%	4.3%	9.4%	3.9%	4.1%
Total		Count	132	38	88	94	64	77	493
		%							100.0%

In the academic year of 2016, 11 teeth or 55% of all 20 perforations were apical, followed by perforations in the furcation area (Table 4). There were no significant differences found

in different types of localization of iatrogenic perforations: furcal, lateral, and apical.

Table 4: Distribution of perforation rate according to location/ level of the perforation

			Localization			Total
			Furcation	Lateral	Apical	
Perforation	1	Count	5	4	11	20
		% from total	25.0%	20.0%	55.0%	100.0%

DISCUSSION

Students at the Faculty of Dental Medicine in Sofia Medical University study a two-year preclinical course that starts in their second year of training. During this training, they perform endodontic treatment on extracted teeth: 5 anterior teeth, 2 premolars, 4 molars. The clinical program lasts 2 years and starts in the fourth year. It takes 4 terms; 60 hours

of lectures, and 5 hours of clinical exercises per week. Students treat patients with pulpitis and periodontitis of single and multi-rooted teeth. In the dental training clinic, each stage of treatment is observed and approved by experienced teachers, specialists in endodontics.

Little information is available in the literature regarding the frequency of student's made perforations by groups of teeth and localization.

Smadi et al.⁹ report the greatest incidence of perforation in upper posterior teeth. Our study confirmed these results with more than 1/2 of perforations occurring in the maxilla (11 out of total affected teeth 20). Tsesis et al.¹⁰ found in their study something different: there were significantly more identified perforations in mandibular molar teeth than in any other location ($p < 0.01$). Mandibular molars were 23.7% of all treated teeth and 54.31% of all perforations. The degree of curvature and configuration of mandibular molar root canals can cause difficulties during root canal treatment of these teeth.^{11,12,13} The distal surface of the mesial canals of mandibular molars also has a concavity, which can also make the tooth more prone to iatrogenic perforations.¹⁴ Similar data was found from Kouzmanova in her thesis.⁵ According to Kouzmanova perforations, made by general dental practitioners in Bulgaria, were most often registered in the lower molars - 42%, followed by upper molars, with almost twice lower incidence - 22%, and in the third place - the upper front teeth - 11%. The incidence of perforations in the lower jaw was higher (59%) than in the upper jaw (41%). Analyzing the data from the current study allows us to recognize the need to improve students' theoretical knowledge of molar anatomy and their practical skills in the endodontic treatment of molars.

Our study found that students tend to make more apical perforations than any of the other types. Overinstrumentation at an incorrect working length through the anatomic apical foramen results in perforation and "blowing out" the apical foramen. Ledge formation and application of misdirected pressure can also lead via falsa and eventually an apical perforation. An apical perforation also occurs when the clinician does not respect the apical anatomy and passes endodontic files too aggressively through the apical constriction. According to Kouzmanova⁵ general practitioners in Bulgaria tend to make more perforations in the pulp chamber floor - 46.23%. The lateral root perforations consisted of 35.84% of all perforations and apical perforations were 7.54%.

Due to the students' lack of clinical experience, most of the iatrogenic perforations we have found were apical. Balto et al.¹⁵ like us found that from 550 endodontically treated by students cases 7% had apical perforations.

A study¹⁶ from the College of Dentistry, Taibah University, Saudi Arab are viewed retrospectively charts of 280 patients, treated by students between 2013 and 2016. The frequency of apical perforation was 9.2%; 7.7% of all lower premolars and 6.7% of upper incisors had apical perforation. So apical perforations are more likely to occur in anterior teeth. Haji-Hassani et al.¹⁷ had similar results: from 1335 endodontically treated teeth, 18.2% had apical perforation and were overfilled. Khabbaz et al.⁴ reported 32.6% of the canals had apical perforation.

The high number of apical perforations made us investigate the way students determined their working length. Last year students in 2016 had to determine their working length using both x-ray and apex location. 29 students shared 2 apex locators. Since then more apex locators were provided to last year students but still, our students tend to rely more on the x-ray method for determining working length. The current study allows us to establish the need to improve their training in using apex locators so there is less over instrumentation.

CONCLUSION

The greatest incidence of perforation is in the upper posterior teeth. This study allows us to establish the need to improve students' practical skills in the endodontic treatment of molars and in using apex locators so apical perforations are mostly avoided. The training program must be changed accordingly and subsequently to improve the health care provided by these future clinicians.

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Conflicts of interest

No potential conflict of interest was reported by the authors.

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Ethical approval

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Authors' contribution

Dimitrova Ivanka – concept design, manuscript review

Angelova Liliya – data acquisition and analysis, literature search, manuscript preparation

Hristov Krasimir – literature search, data acquisition, statistical analysis

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