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Title page

Dental students' observations about teaching of endodontic access cavities in a French dental school

Running title: Students opinions on teaching of access cavities

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Conflict of interest statement

The authors declare no conflict of interest.

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Dental students' observations about teaching of endodontic access cavities in a French dental school

Abstract

Introduction: Teaching in French universities has undergone deep changes for several years. Dental studies are no exception to the rule. Endodontics is one of the most difficult fields requiring good knowledge of anatomy before performing clinical procedures. The access cavity is the key step of endodontic therapy. The aim of this study was to collect and understand what students feel and expect from theoretical and practical training on endodontic access cavity.

Materials and methods: A questionnaire survey on the teaching and learning of endodontic access cavities in a French dental school was sent by e-mail to the 4th year students (n=66). The questionnaire consisted of 13 questions of different formats. Qualitative variables were analyzed using a word cloud according to the words of the participants. Students were also asked how to improve teaching with new educational tools.

Results: 60 students answered the questionnaire (response rate of 90.9%). When students were asked which stage of endodontic treatment they feared the most, performing access cavity came in 3rd place. Upper molar (71%) and lower molar (58%) appeared to have the most difficult endodontic access cavities. Within the word cloud gathered after students' answers analysis, the words "fear", "perforation", "cavity" and "axis" were highlighted. Among the 3 new educational tools proposed to students, most were in favour of realistic models of teeth with their ideal endodontic access cavity (79%).

Discussion: This study highlighted the feelings of students during their hands-on training on endodontic access cavities. Although they seemed satisfied with practical classes on endodontic access cavities, this step seemed to be stressful for students especially because of the great internal anatomical variabilities of teeth. To help them better understand the root canal anatomy and improve their training, students asked for new educational resources, especially macro-models of teeth with their optimal access cavities.

Conclusion: This study showed that students are seeking for innovative resources in addition to traditional resources that would make it easier for them to visualize the root canal system and help them feel more comfortable and facilitate learning when performing endodontic access cavities.

Keywords

Undergraduate teaching and learning, endodontics, dental pulp cavity, surveys and questionnaire

Introduction

Today, the field of education has to make a huge effort to offer new resources to improve students learning. Universities are permanently looking for new attractive innovative pedagogy. Medical studies are no exception to the rule. They have undergone deep changes in teaching and learning methods. New digital simulation tools have been introduced for several years, for example, in nurse education or in the training of heart specialists (1,2).

In dentistry, practical skills development is a complex and challenging process (3). Endodontics is one of the most difficult and stressful dental fields for many students, especially because of the great internal anatomical variabilities of teeth which differ from one patient to another (4). Root canal treatments are composed of several steps which range from access to root canal systems to root canal filling. Access cavity is the first step, which, if not carried out properly, may influence the final result. This generally causes anxiety for most students because bad achievement of this critical step may lead to permanent tooth loss.

To address this problem, the implementation of new educational resources is now considered to improve current teaching and learning. Indeed, Donnely *et al.* showed that introducing new pedagogical technologies significantly improves the endodontic treatments on multirooted teeth performed by undergraduates (5).

Our dental school has already produced several digital resources available online (slideshows, digital sheets with photographs and videos, exercises with Multiple Choice Questions) since 2010, which aim to help 3rd year students in the learning of theoretical and practical training on endodontic access cavity among other disciplines. However, our dental school has never asked students whether these tools are adequate for their learning and whether they should be interested in new educational devices. Therefore, it seems critical to collect and to consider students opinions in order to enhance key strategies in teaching of endodontics (6). Many studies have stated that questionnaire surveys help to resolve lots of issues and to make students acquisition of knowledge and practical skills easier (7–10).

The purpose of this study, carried out by a questionnaire, was to know the observations of the 4th year students about the teaching of endodontic access cavities and about their needs to facilitate their learning and training and reduce stress.

Materials and Methods

Study population and questionnaire administration

The questionnaire survey (Fig.1), which was drawn up on LimeSurvey (<https://www.limesurvey.org/fr>), was sent by email to the 4th year dental students (n=66) of our French dental school during February 2019. As the questionnaire only concerned the learning outcomes, no ethics committee approval was required according to the French regulation. The population studied was composed of 57% of women and 43% of men. The mean age of students was 23 years (SD: 2). A single reminder was sent by e-mail after two weeks to increase the number of respondents. This population was selected because the 4th year students took part in all practical classes the year before (with 20 hours dedicated to endodontic access cavities during which students were asked to train on about 50 teeth of all types) and because it shed lights on the students' skills after practical training and didactic teaching and learning. Information about the objectives of the questionnaire were given before completing the questionnaire. Participation was made on a voluntary basis and all answers were entirely anonymous. The questionnaire consisted of 13 questions of different formats: yes/no questions, closed-ended questions with forced choice or multiple allowable answers and open-ended questions with open answers.

The survey included:

- 3 questions related to the theoretical part of the teaching on endodontics and the contribution of the educational resources available online,
- 8 questions related to training on endodontic access cavities during practical courses (relevance of the program, number of hours devoted to endodontic access cavities, difficulties encountered, etc.),
- 2 questions related to new educational tools to be developed based on the students' opinions.

With the help of educational engineers of the education department of our university, the questionnaire was developed targeting the objectives of expected answers on the topic of the access cavity. Before the questionnaire was distributed, several readings were carried out by teachers and a few students from the upper years were selected to answer the questionnaire to ensure the relevance, the order of items and the understanding of the questions (pilot study). This questionnaire is a part of the project that was selected in 2018 after a call for proposals launched by the French National Research Agency (ANR), which aims to accelerate the digital transformation of higher educational institutions.

Data collection and analysis

Data were instantly collected and processed by the LimeSurvey software. Data were recorded in a slideshow, whose statistics were modified after each new answer. Questions with forced choice or multiple allowable answers were presented in the form of graphs. Open-ended questions with qualitative variables were analyzed according to the participants words. The answers were analyzed by topics when possible ("Free comments" section) and with a word cloud generation (www.nuagesdemots.fr) in which the most cited words appeared in larger size and the least cited in smaller size.

Results

Students' endodontic theoretical knowledge and feelings about educational resources available online

The response rate for this questionnaire survey was 90.9%. Except for the question on repeating the year, no information on the age, gender or previous academic experience was requested among students who answered the questionnaire. Only one of the respondents repeated the 3rd year. 39% of students thought their theoretical knowledge about root canal anatomy rather poor or even very poor before their 3rd year practical classes. 87% of students considered that educational resources for the learning of access cavity preparation, available online, were complementary to lecture courses, tutorials and practical classes. These resources helped them to better understand the concepts seen in class (77%) and to practice dental access cavity preparation (59%). However, some students thought that these tools did not help them quite (29%) or not at all (12%). Furthermore, 60% of students used these resources all along the year while only 36% consulted them after class and 4% just before the exam.

Endodontic practical classes

Students were asked to classify the endodontic treatment process from the most difficult step to the easiest (Fig. 2A). Performing endodontic access cavity appeared in third position (55% of students) after root canal filling (87%) and working length determination (76%). 40% of students considered the endodontic access cavity practical training really good and 54% good. When performing an access cavity, 32% said they had difficulty determining the axis of the tooth without causing perforation, 11% made perforation, 9% did not remove the whole roof of the pulp chamber and 4% achieved a destructive access cavity. Otherwise, 14% of students explained that they either had other difficulties – such as a reduced visibility or root canals that could not be found – sometimes several simultaneously or that they had none at all.

Difficulties differed according to the teeth. Students ranked them from the most difficult tooth to the easiest (Fig. 2B). Upper molar (71%) and lower molar (58%) were the teeth with the most difficult endodontic access cavities. In their clinical practices, students' feelings regarding the endodontic access cavity are quite similar. Half of them do not feel comfortable with this step of the endodontic treatment (Fig. 1).

In the word cloud collected after students' answers, the words "fear", "perforation", "cavity" and "axis" were highlighted (Fig. 3). A better learning of dental anatomy, root canal system, instrumentation as well as a better preoperative visual and radiological analysis (axis of the tooth and depth of the pulp

chamber) before gesture are some elements that students would improve if they had to redo their 3rd year practical work (Fig. 1).

Proposition of new educational tools to students

When students were asked which educational tools and/or approaches should be developed, a lot of proposals were mentioned (Fig. 1). Among the 3 new educational tools proposed to students, realistic macro-models of teeth and their ideal access cavity came first (79%). Interactive 3-dimensional models in augmented reality to visualize root canal anatomy and the development of a virtual reality software allowing performing endodontic access cavity came in second (75%) and third position (56%), respectively (Fig. 1).

Discussion

Endodontics is one of the most technical fields for many students, which requires strong theoretical knowledge on dental anatomy and adequate practical training to better understand the importance of each step of the endodontic treatment. Most of the studies already published focused on students' confidence levels and feelings when undertaking root canal treatments in general and few about students' perceptions of the teaching of endodontics (7,11–14). The current study focused on students' feelings and expectations about the learning and teaching of the endodontic access cavity, which is one of the skills they should acquire during their curriculum (15). This study also aimed to evaluate from the students' point of view the relevance of the training program during the 3rd year which is supposed to ensure an easier transition from preclinical to clinical practice. We obtained a satisfying response rate of 90.9%, which is representative of the opinions of the population studied.

During the dental course which lasts six years, the endodontic program starts in the 3rd year and ends in the 4th year in our dental school. The 3rd year studies are devoted to the basics of endodontics with a year-round program while in the 4th year, the learning approach is more in-depth and lasts only one semester. For the practical part, students benefit from several hands-on training sessions before being regularly assessed throughout the year. Without taking into account the students' personal working time, 3rd year students have 27 hours of lecture courses and tutorials (including 6 hours on endodontic access cavity) and 60 hours of practical classes (including about a third of the time devoted to endodontic access cavities) throughout the year. The time allocated to endodontics in our university seems to be an appropriate time compared with some other dental schools in Europe and in the world (4,13,16–19). Indeed, De Moor *et al.* showed that the time and resources dedicated to endodontics differed between dental schools. The European Society of Endodontology (ESE) published guidelines with a list of skills that students may acquire in endodontics during curriculum and after graduation (15). Similarly, the Association for Dental Education in Europe (ADEE) sought to develop a joint program, which could be applied in the overall European dental schools (15,20,21).

Our study raised the question of theoretical knowledge of our students on the anatomy of root canal systems. Although this topic is widely covered during tutorials, almost 40% of students considered that their knowledge is poor or even very poor. Some students underlined the lack of link between the importance of the access cavity and the quality of the following endodontic treatment. Unfortunately, this lack of knowledge is responsible for procedural errors (problem with teeth axis, perforation...) made when students performed an access cavity during practical classes in most cases (22). It should be noted that, in our university, students who still have difficulties in correctly performing endodontic access cavities are invited to train more than the others before assessments. Only students who have acquired the required skills at the end of the evaluations, in particular in carrying out endodontic access cavities, are authorized to move on to the following year.

Students indicated that they felt stressed during the transition from preclinical to clinical endodontics especially when they start treating real patients. Indeed, students seemed to feel more confident with other clinical procedures such as local anesthesia and rubber dam isolation, than with endodontic (or root canal) access cavities (4,18,23). Students mentioned upper and lower molars to have the most difficult root canal anatomy, which is consistent with other studies (7,18,23). Although the training in endodontic access cavity appeared to be satisfying or very satisfying for more than 90% of students, half of them stated they did not feel confident with this step of the endodontic treatment, especially in real clinical conditions, as was confirmed by Grock *et al.* (4). Within the word cloud collected after students' answers analysis, the word "fear" is highlighted. Indeed, the words "perforation", "perforating" and "axis" underlined the main cause of students' anxiety because mistakes in performing endodontic access cavity could lead to permanent loss of teeth (23). Heimerl *et al.* raised that the use of word clouds in qualitative studies are significant because they summarize very important information lost in the large quantity of data (24).

In our study, another point was identified by students. Educational resources, produced in our school on dental access cavities (photos, videos and explanatory texts) and available online, seemed to be insufficient for some students. A quarter of them reported that they did not help them to understand this step of the endodontic treatment before training in practical classes. For others, they were unsuitable for training but were additional support to lecture courses. However, 59% of them thought that they helped them to train in performing access cavity in an effective way especially thanks to exercises with Multiple Choice Questions (MCQ) recently made available online. Furthermore, these resources were viewed all along the year by the majority of students, which confirms the seeking of available resources for reinforcing the knowledge base. Some disparities became apparent and it seemed that our students' needs differ. Indeed, while some students content themselves with face-to-face lessons only, others felt the need to look for other information elsewhere such as in books, internet resources, demonstration videos... In order to target as many students as possible, it therefore seems necessary for teachers to diversify educational contents by offering a variety of activities and/or tools to give students the choice in the way to learn and facilitate their learning (25).

Some students complained about the absence of three-dimensional resources which could facilitate the learning of dental access cavity preparation by allowing a better spatial visualization of the root canal spaces. Nevertheless, our students are already familiar with realistic model of teeth in restorative dentistry practical classes. In the questionnaire, they mainly asked for a three-dimensional endodontic model of teeth with their ideal access cavity pre-prepared to better visualize the location of root canal orifices, the root canal anatomy and the shape of dental access cavity. Luz *et al.* pointed up the importance of three-dimensional spatial visualization. Indeed, participants reported that they did not feel safe when performing endodontic treatments due to the difficulty in visualizing anatomical complexities (23). Clear instructions about the good axis of preparation and about the type of burs to use were also two important elements for students. They also requested videos showing the realization of endodontic access cavity in a real clinical situation. These videos could help them to view the techniques and the gesture to obtain an ideal access cavity. Training based on drawing (that is already done in tutorials), additional photographs of access cavities and individual supervision during practical classes were also requested.

Surprisingly, among the 3 new educational tools proposed to students, realistic models of teeth and their ideal access cavity came first for almost 80% of them, ahead of digital technologies. It is very likely that our students find that handling physical models is more practical. It may also be easier for them to replicate the observed shape of the endodontic access cavity onto their training teeth. Although explanations were given to students, it is also likely that students did not visualize perfectly what augmented or virtual reality is, especially since they have had very few opportunities so far to use these technologies in their curriculum. This is why the development of digital software to observe and/or to achieve endodontic access cavity has also been discussed. Some authors were interested in this type of new technologies but showed there was no difference in the reduction of procedural errors during endodontic access cavity preparation between students who trained on the haptic virtual reality simulator compared with those who trained on conventional phantom head (26). Although they look promising in particular in learning endodontic access cavity preparation, these tools were not selected in our study because they need to be improved to facilitate the learning of endodontics. It is of course obvious that the use of physical macro-models can be easily combined with augmented and virtual reality software to perfect the knowledge and learning of the endodontic access cavity by our students.

However, this study has some limitations. First, as it aimed to obtain an overall opinion of the population studied and not an analysis of the data by age, gender or previous academic experience, no such information was requested to participants. The fact that they did not have to fill in this kind of descriptive element likely resulted in the high participation rate. Moreover, while students ranked the endodontic access cavity in third place after working length determination and root canal filling, this study focused more particularly on this particular step. With regard to the working length determination, it should be noted that our students do not have apex locators during practical work

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sessions. This may therefore explain why they found this step difficult. Apex locators are available from the 4th year during their clinical apprenticeship, which makes this step easier. In addition, the difficulties experienced by students in root canal filling undoubtedly come from the fact that they only carry out manual root canal shaping (and not with mechanized instruments) during their 3rd year study. This final stage generally highlights all the steps previously carried out. Errors during endodontic access cavities or incorrect working length determination can be responsible for poor root canal fillings. Although aware that each stage of the endodontic treatment can present difficulties, it seemed important to take an interest in the particular stage of endodontic access cavities, which requires an in-depth knowledge of dental and root canal anatomy and for which teachers in our university reported the most procedural errors committed by students. Although a large majority of our 4th year students answered the questionnaire, this only represents a little part of all of our students. The choice to survey the 4th year students and not the 3rd year or final year students (5th and 6th year) was made because the 4th year students had participated in all endodontic hands-on training courses and had more perspectives on teaching than the 3rd year students. Although they have not yet been confronted with emergency situations, they all had a little clinical experience. Indeed, in France, the care of patient by dental students starts at the beginning of the 4th year and usually ends in 6th year. At the time of the questionnaire, the students interviewed had already treated patients, especially for endodontics. Without taking into account other disciplines, each 4th year students are asked to perform 6 endodontic treatments on average over the year. Finally, this study only concerns one French dental school. A larger study including all French dental universities could be intended to confirm our results as it was done in other countries (16,27).

Conclusion

Access cavity preparation is the first step in endodontic treatments, that should not be neglected because it may affect the rest of the treatment. Although students do not place the access cavity first in the most difficult stages, our study highlights that half of students are afraid to perform this step especially in real clinical situations because they are aware of any procedural errors. The aim of this study was also to collect information about the educational resources available online from students who carried out both practical and clinical work. These resources seem to be of interest but not enough for many students. The survey identified a need to improve teaching and learning in our university. The main difficulty in education lies in the fact that not all students learn and understand the lessons and given instructions the same way. To facilitate the learning of the greatest number of students, a few proposals of new innovative resources in addition to traditional resources have been made. The great majority of students expressed a real interest in realistic models of teeth and their ideal access cavity.

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Data Availability statement

The data that support the findings of this study are available on request from the corresponding author upon reasonable request.

Titles of figures

Fig. 1 Questionnaire and students' answers

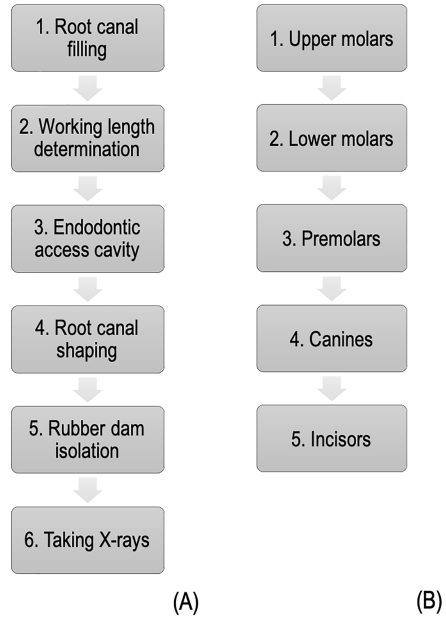
Fig. 2 Ranking in order of difficulty according to students (A) Stages of endodontic treatment (B) Endodontic access cavities for different groups of teeth

Fig. 3 Frequency of words regarding the achievement of dental access cavities according to students

Question 1 In your opinion, your theoretical knowledge of root canal anatomy before practical work was:	
<input type="radio"/> Very poor	6%
<input type="radio"/> Poor	33%
<input type="radio"/> Good	59%
<input type="radio"/> Really good	2%
Question 2 In your opinion, the educational resources on the endodontic access cavities available online:	
are complementary to face-to-face learning?	
<input type="radio"/> Yes	87%
<input type="radio"/> No	13%
<input type="radio"/> Not enough	0%
allow a better understanding of the concepts seen in class?	
<input type="radio"/> Yes	77%
<input type="radio"/> No	6%
<input type="radio"/> Not enough	17%
allow to train effectively?	
<input type="radio"/> Yes	59%
<input type="radio"/> No	12%
<input type="radio"/> Not enough	29%
Question 3 When did you consult the educational resources available online?	
<input type="radio"/> Never	0%
<input type="radio"/> Just after the lesson on this topic	36%
<input type="radio"/> All along the year	60%
<input type="radio"/> Only before the exam	4%
Question 4 Could you classify from the most difficult (1) to the least difficult (6) the following steps of the endodontic treatment? Rubber dam isolation, taking X-rays, endodontic access cavity, working length determination, root canal shaping, root canal filling	
See figure 2A	
Question 5 In your opinion, the training on the endodontic access cavity in practical classes is:	
<input type="radio"/> Very poor	0%
<input type="radio"/> Poor	6%
<input type="radio"/> Good	54%
<input type="radio"/> Really good	40%
Question 6 The training proposed for the learning of endodontic access cavities seems appropriate to you (corresponds to the training objectives)?	
<input type="radio"/> Yes	98%
<input type="radio"/> No	2%
Question 7 If you had to redo your 3rd year practical work, what are the 3 elements of the course you would focus on in order to better master the realization of the access cavity? Free comments	
Better learning on dental anatomy and root canal anatomy (some examples) "Classic location of root canal orifices", "Anatomical variations", "Frequency of the number of canals depending on the tooth type"	
Better learning of the burs and instruments dedicated to endodontic access cavities (some examples) "The order of use of the different burs", "The use of the Gido 2 bar for the removal of the roof of the pulp chamber", "The use of flare instruments to remove a first curvature of the canal", "Instruments used and their order of use"	
Better preoperative visual and x-ray analysis, gesture and working position (some examples) "Use a retro-alar radiography (distance between occlusal face / pulp chamber, axis of the tooth, etc.), "Tips for correct orientation of burs", "I would watch the available videos on the access cavities to memorize the gesture", "Analysis of the tooth axis"	

Question 8 When performing endodontic access cavities, which procedural errors did you make?	
<input type="radio"/> I encountered problems with the axis of teeth without making perforation	32%
<input type="radio"/> I made an incorrect choice of the point for preparing the access cavity (ledges)	30%
<input type="radio"/> I made perforations	11%
<input type="radio"/> I did not remove the whole roof of the pulp chamber	9%
<input type="radio"/> I made destructive access cavities	4%
<input type="radio"/> Other	14%
Question 9 When performing endodontic access cavities, could you classify the teeth listed below from the most difficult (1) to the least difficult (5)? Incisors, Canines, Premolars, Upper molars, Lower molars	
See figure 2B	
Question 10 When performing an endodontic access cavity, how do you feel?	
<input type="radio"/> I feel really confident	2%
<input type="radio"/> I feel confident	48%
<input type="radio"/> I feel uncomfortable	48%
<input type="radio"/> I really feel uncomfortable	2%
Question 11 If you answer "I feel uncomfortable or really uncomfortable", why do you feel insecure? Free comments	
See figure 3	
Question 12 In your opinion, which educational tools and/or approaches should be developed to facilitate your learning on endodontic access cavities? Free comments	
<input type="radio"/> "Drawing of endodontic access cavity on photographs with occlusal or palatal view (the one the practitioner has)" <input type="radio"/> "Videos of the realization of an access cavity in real situations" <input type="radio"/> "More companionship and/or demonstration by the teachers during hands-on training to guide students in finding the right work positions and the right axis of access according to the tooth to be treated" <input type="radio"/> "Doing more tutorials on root canal anatomy before the hands-on training for a better visualization of the anatomy of the tooth in three dimensions" <input type="radio"/> "Many physical models in full size to see all the different cavities according to the anatomical variations of the teeth" <input type="radio"/> "3D digital software allowing to see the axes of the burs to avoid perforations"	
Question 13 In your opinion, are the educational tools proposed below suitable for improving your skills?	
<input type="radio"/> Realistic macro-models of teeth and their ideal access cavity "You will be able to manipulate physical 3D-printed macro-models of teeth with the ideal access cavity and the root canal system visible through"	79%
<input type="radio"/> Interactive 3-dimensional models of teeth with ideal access cavity in augmented reality "Via your smartphone or tablet, you will be able to visualize a virtual tooth in a real familiar environment with the possibility of rotating and enlarging the tooth in order to observe the root canal anatomy and the ideal access cavity in the 3 dimensions of space"	75%
<input type="radio"/> Virtual reality software allowing performing endodontic access cavity "Via a virtual reality headset and motion sensors, you will be immersed in an environment with a virtual patient on which you will be able to make an access cavity on one of his teeth"	56%

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