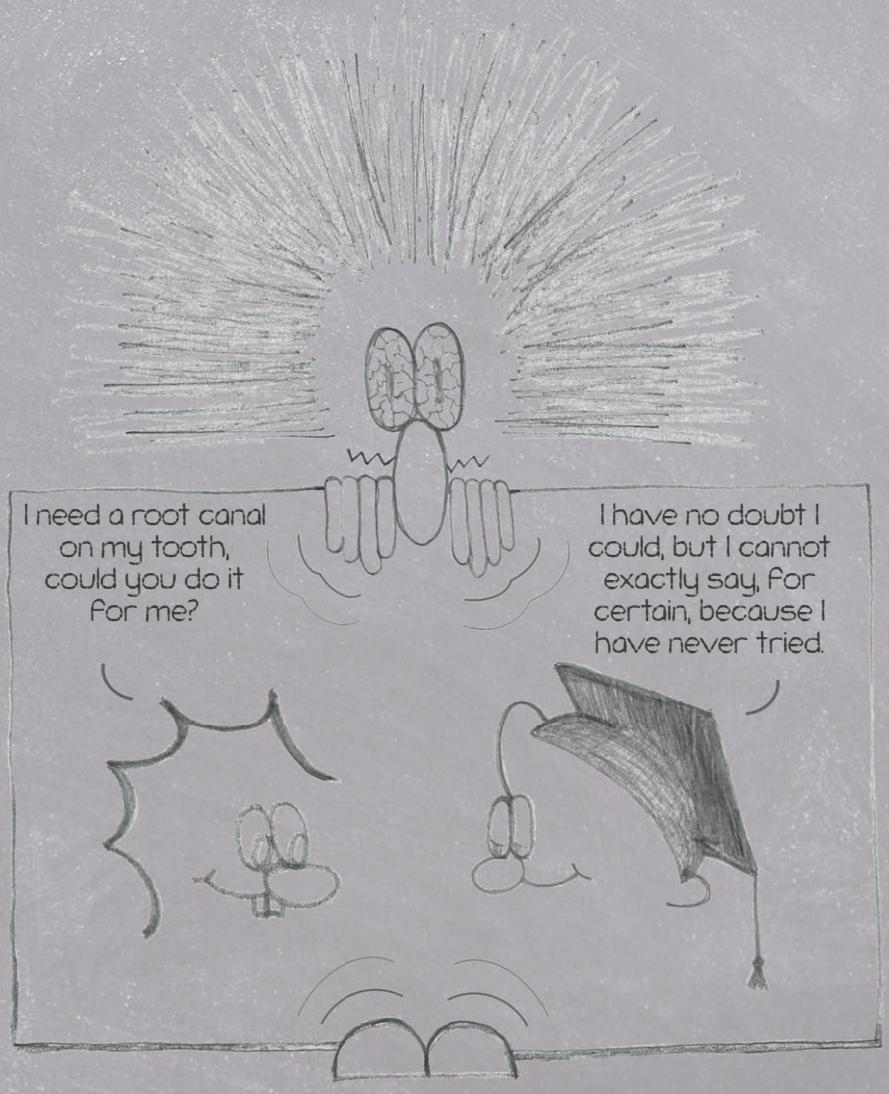
UNDERGRADUATE EDUCATION IN ENDODONTOLOGY

Steps towards understanding how to make everyone feel more comfortable with root canal treatment



Annemarie Baaij

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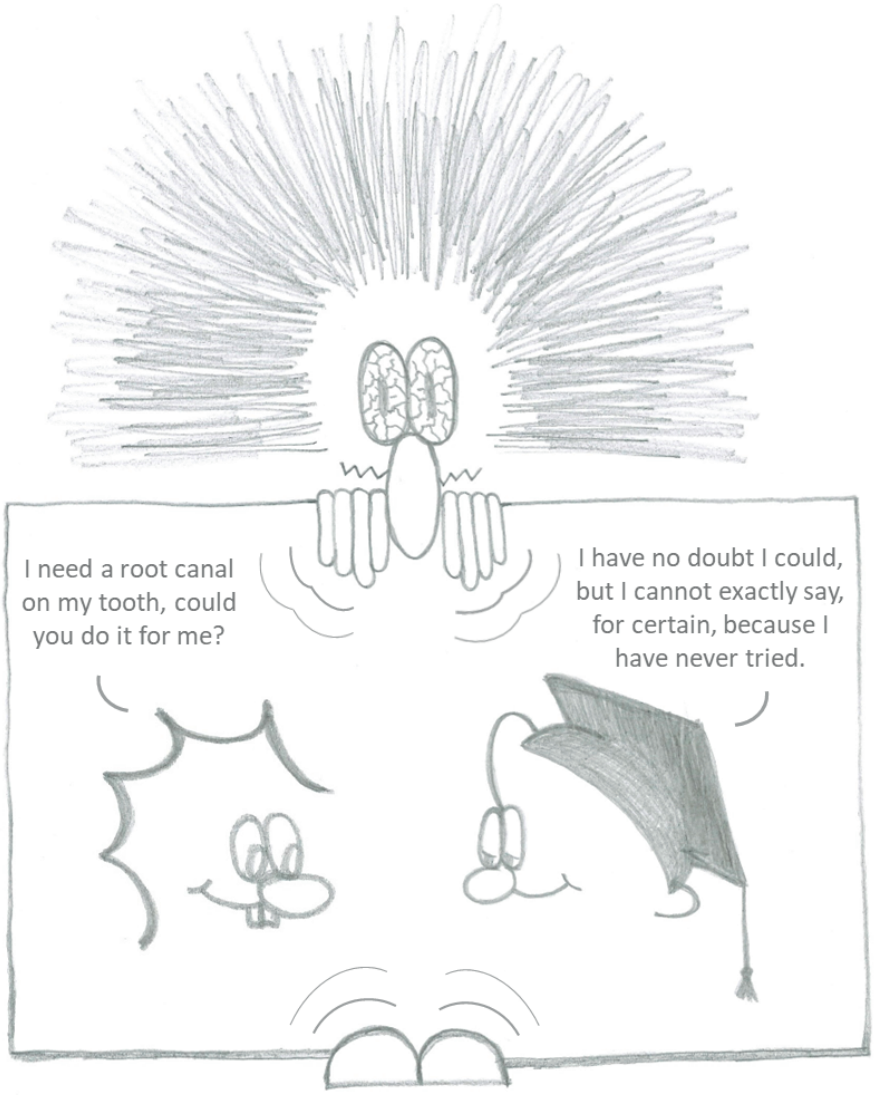

Annemarie Baaij

The research resulting in this thesis has been conducted at the Department of Endodontology, Academic Centre for Dentistry Amsterdam (ACTA), University of Amsterdam and Vrije Universiteit Amsterdam, Amsterdam the Netherlands; part of the research has been conducted in collaboration with the Department of Dentistry and Oral Health, Aarhus University, Aarhus, Denmark.

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Undergraduate education in endodontology

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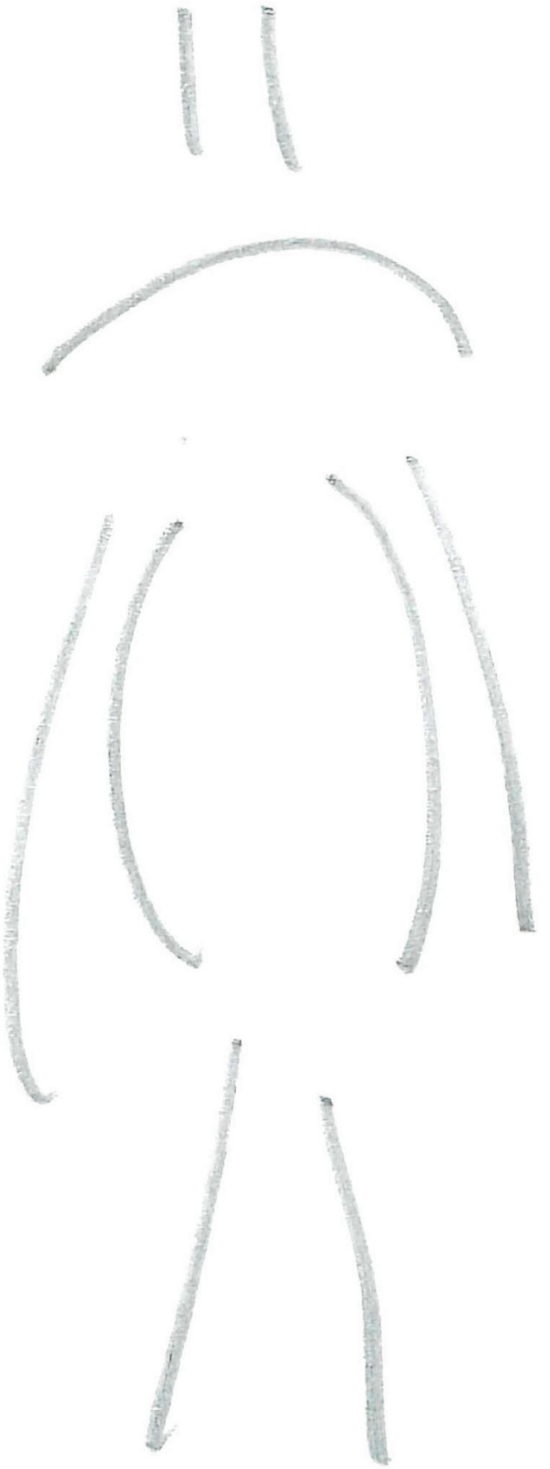
Faculteit der Tandheelkunde

Contents

Prologue

When I was an undergraduate dental student, the endodontists who were my clinical supervisors said to me that I was good at Endodontics. I just did what I was taught to do, and despite the compliments of my supervisors, performing root canal treatment still felt to me like stirring in a black hole.

It was within the first year after graduation, when I practised general dentistry in a practice with a population that already had – but also needed additional – extensive restorative treatment, that I started to like Endodontology. Endodontic cases challenged me the most; more than the other fields of Dentistry, Endodontics obliged me to reason and to apply problem-solving skills.



Chapter 1

General introduction

"I'd rather have a root canal…" is a well-known saying to express how unpleasant something is. This saying is based on a patient's point of view; many people have a very negative idea of a root canal treatment because they associate it with discomfort and excruciating pain. Remarkably, many general dental practitioners do not have a very positive attitude towards root canal treatment either. Root canal treatments cause them high levels of stress and frustration, and the treatments are often performed with an overall sense of lack of control (Dahlström *et al.* 2017). This is not only inconvenient for the dental practitioner, but also not very comforting to know for the patients who need a root canal treatment.

When addressing a problem, it is usually most effective to start at its roots. It would be wonderful if root canal treatments had become completely unnecessary. Much effort is being put into preventing caries and preserving pulp vitality in cases of reversible and even irreversible pulpitis (European Society of Endodontology 2019). It seems, however, unrealistic to think that root canal treatment will become obsolete, at least not in the near future. Thus, the problem regarding the attitude towards root canal treatments still needs to be tackled.

Over the past decades more and more innovative materials and methods to facilitate root canal treatment have been developed and exhaustively studied: dental operating microscopes, electronic length measurement devices, instruments made of newly evolved nickel titanium alloys, cone beam computed tomography, and templates with sleeves for guided access cavity preparation, to name a few (Ordinola-Zapata *et al.* 2019). However, it is still the "craftsmanship" that gets the job done. General dental practitioners should be well-equipped and well-prepared for their task of performing root canal treatment. The roots of achieving the necessary skills for this task lie in undergraduate dental education, which not only forms a basis but also determines to the greatest extent the endodontic performance of general dental practitioners throughout their career (McColl *et al.* 1999, Stewardson *et al.* 2003, Christensen *et al.* 2022).

During my teaching career, I heard several times from undergraduate dental students that they would like to take a course in Endodontology following graduation, because they did not feel well prepared for the practice. Not only the students at the institution where I worked but also the students from other institutions – from other countries – had feelings of unpreparedness and lack of confidence regarding Endodontics (Stewardson *et al.* 2003, Patel *et al.* 2006, Lynch *et al.* 2010, Murray & Chandler 2014, Davey *et al.* 2015). This intrigued me very much. Why do they not feel prepared enough? Do they lack skills? Do they have too little

clinical experience and how important is clinical experience? Are the methods of teaching efficient and effective? Are students' expectations of required skills correct, or do they overrate them? Is it just a matter of confidence, or a matter of self-perceived competence, or both? Why do they have this feeling especially with Endodontics and not so much in other fields of dentistry?

To help students improve, I always attempt to unveil the composition of their performance and by doing so to discover the obstacles that prevent them from succeeding. Together with the student, I aim to find a way that fits the student best, usually by helping them to reflect on their performance in detail and by making use of questions like: "What do you see, or experience, and what does that mean?", "Could you explain why you got this result?", or "Can you explain or show in detail what you have done?". While I emphasize in the feedback to the student the processes that go well, I also try to make them aware of the elements that are causing a problem. Then, I help them to consider alternative ways, or stimulate them to try and subsequently analyse those alternative ways, to get insight in what works in their hands. I thought that this method I use to get insight in the learning process of the students and to help them improve, could perhaps be used also to study, and possibly improve, the undergraduate education in Endodontology per se. Here we find the origin for this thesis: An educator's approach to research.

Endodontics is regarded difficult compared to other fields in dentistry (Dahlström *et al.* 2017). Root canal treatment differs from any other treatment in dentistry or medicine in that the area under treatment is not directly nor indirectly (i.e. through a scope) visible for the operator. The dental practitioner has to treat the inside of a tooth – the root canal system which has a very complex three-dimensional anatomy – through a restricted access. The available two-dimensional radiographic image of the tooth is often distorted and superimposed on other anatomical structures, and the root canals are not always visible. To treat the root canal system well, one must rely on sound knowledge that has to be combined with the things one can see and the feedback one gets from appropriate tools to get insight into the complex anatomy along the way. It is important to treat all canals even though it is sometimes hard to find or penetrate them. Besides, the treatment needs to be performed with great precision; half a millimetre can determine the difference between success and failure. Reflection and insight are needed to be able to see and interpret the pieces of information that become available before or during the treatment; to subsequently convert that into action effectively, cognitive visualization capacity is needed in addition to dexterity. To

acquire those advanced skills, a different approach of training may be preferred than methods proven to be effective and efficient to train other procedures in dentistry or medicine. When I started with this PhD-project, there were a limited number of scientific publications on methods of teaching Endodontology. It occurred to me that although we teach our students the importance of evidence-based practice, the way Endodontics is taught seemed, ironically, the most empirical.

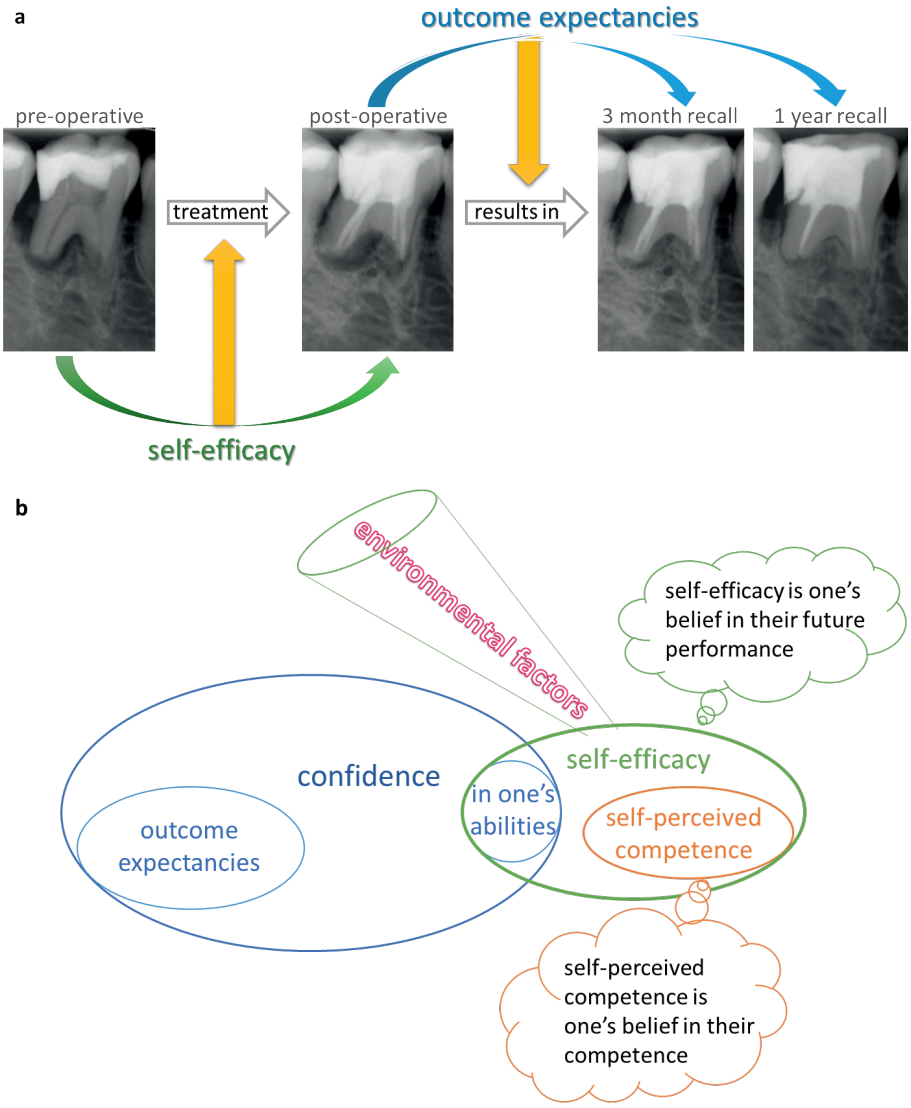
Around 2010, at the Academic Centre for Dentistry Amsterdam (ACTA) some curricular changes have been made, which included changes in methods of teaching Endodontology. This provided us with the opportunity to study those teaching methods. We studied the influence of methods of teaching on the performance of undergraduate students in Endodontics (chapter 2), and on their self-perceived competence and self-efficacy (chapter 3). To this end, to measure self-perceived competence and self-efficacy in Endodontics, we composed questionnaires. To get further insight in undergraduate students' and novice dentists' self-efficacy in Endodontics, a collaboration was established with Aarhus University (Aarhus, Denmark) (chapters 4 & 5).

Self-efficacy is the major outcome measure in this thesis. As far as we know, we were the first who studied self-efficacy in relation to Endodontics. Self-efficacy is an important motivational construct, which predicts performance on work-related tasks (Gist & Mitchell 1992). A change in self-efficacy may lead to a change in performance, and in learning situations self-efficacy influences the degree of skill acquisition and retention (Gist & Mitchell 1992). Previous studies on education in Endodontics looked at confidence or self-confidence (Stewardson *et al.* 2003, Lynch *et al.* 2010, Tanalp *et al.* 2013, Murray & Chandler 2014), perception of confidence (Davey *et al.* 2015), confidence in practical skills (Manogue *et al.* 1999), feelings of preparedness (Manogue *et al.* 1999, Patel *et al.* 2006), self-assessed competence (Karaharju-Suvanto *et al.* 2014), and perception of competence (Davey *et al.* 2015), but not at self-efficacy. Self-efficacy differs from both confidence and self-perceived competence. Confidence or self-confidence is much broader than self-efficacy. Self-efficacy focuses on abilities that are associated with behaviours (Oney & Oksuzoglu-Guven 2015). It is, for example, the belief that one can perform good quality root canal treatments in future situations. This is irrespective of whether one believes that a root canal treatment will solve the problem; whether it will prevent or heal apical periodontitis. Such outcome expectancy is, however, a constituent of confidence (Oney & Oksuzoglu-Guven

2015). Confidence is a wide belief or conviction but without reference to self-perceived competence (Oney & Oksuzoglu-Guven 2015). One might be confident, even when one is not competent, such as people who are unconsciously incompetent. Unlike self-confidence, self-efficacy does include self-perceived competence (Oney & Oksuzoglu-Guven 2015). Self-perceived competence is one's belief in their competence, whereas self-efficacy is one's belief in their future performance (American Psychological Association 2021). Being competent is a prerequisite for self-efficacy (Bandura 1977). One might be competent and one might be well aware of that (i.e. one has high self-perceived competence), but if one lacks confidence, one will have decreased self-efficacy. An example of this might be an excellent harpist, singer or ballet dancer that gets stage fright. In dentistry, this might be a dental practitioner who proved to be competent by successfully passing exams and who is well aware of their skills – who knows very well that they are capable of performing good quality root canal treatment – but who feels nevertheless insecure performing root canal treatment on patients in practice. Besides, a person who is both competent and confident can as well have decreased self-efficacy, due to low self-perceived competence. Self-perceived competence and therefore self-efficacy are significantly influenced by normative feedback, and it does not even matter whether this feedback is true or not (Wulf *et al.* 2010). If a supervisor tells a student that their level of competence is below the norm, the student's self-perceived competence and therefore their self-efficacy may decrease, and if a supervisor tells a student that their level of competence is above the norm, the student's self-perceived competence and their self-efficacy may increase (Wulf *et al.* 2010). A final cue to discriminate between the concepts are environmental factors that may influence performance. Self-efficacy takes those into account as well (Gist & Mitchell 1992). Self-efficacy is the belief and self-assurance that, despite the prevailing circumstances, one will be able to perform specific tasks successfully. Figure 1 presents a visual summary of the explanation of the concept of self-efficacy.

Curricular changes at ACTA included also changes in clinical protocols, in the methods of providing care for patients and the materials used for that purpose. In undergraduate clinics, many treatments are performed following strict protocols and, therefore, much data of potential interest could be extracted from such clinics and be studied. It feels like a duty to utilize this privilege. Based on the best available scientific evidence, ACTA quit using calcium hydroxide as an intracanal medicament in root canal treatment. One of the reasons for using an

Figure 1



a) Graphical presentation of an example of the use of the concepts self-efficacy and outcome expectancies in relation to Endodontics.

b) Graphical presentation of how the concepts confidence, self-efficacy and self-perceived competence relate to each other. The ellipses are not necessarily in scale.

intracanal medicament is to reduce the incidence of pain which may cause an interappointment emergency (American Association of Endodontists 2011). Interappointment emergencies are inconvenient not only for the patient but also

for the dental practitioner, and may contribute to a negative attitude toward root canal treatment. We studied whether omitting calcium hydroxide as an intracanal medicament during multiple visit root canal treatment in our undergraduate clinic influenced the incidence of interappointment emergencies (chapter 6).

Regarding the undergraduate education, there shall always be questions. The best approach of teaching today might be different from the best ones of yesterday or tomorrow since the world is dynamic. Over time, legislation changes, economy changes, materials change, patients change, and very importantly: also students change, so our education in Endodontology has to change accordingly. Hence, educators need to be openminded and change course with shifting wind, and to do that effectively, insight in this matter is essential. This thesis provides some insight in several factors associated with education in Endodontology (chapter 7).

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Chapter 2

Method of teaching undergraduate students to perform root canal treatment: Its influence on the quality of root fillings

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European Journal of Dental Education 2018; 22: e221–e227.

Abstract

Introduction: This study aimed to assess whether the method of teaching endodontology influenced the quality of root fillings made by undergraduate students.

Materials and methods: The method of teaching endodontology at our institution was revised. Changes concerned: the programme (i.e. method of clinical training and summative assessment), and the supervision whilst performing root canal treatment on patients. An intermediate cohort (N=91) comprised partly students attending the former programme (involving patients) and partly students attending the revised programme (without patients). After succeeding in the summative assessment, the quality of the first root filling made by the student in a patient under supervision of either a general dental practitioner or an endodontist was evaluated according to pre determined criteria. Data were analysed using Cohen's Kappa, Chi-square, Fisher's exact, Mann-Whitney and Kruskal-Wallis tests.

Results: Sixty-two per cent (47 of 76) of root fillings made by students who attended the revised programme were of good quality, in comparison with 47% (seven of 15) of those made by students who attended the former programme (P=.274). Less complex treatments had better quality root fillings if students were supervised by endodontists (88% (14 of 16) good quality) than supervised by general dental practitioners (59% (22 of 37) good quality) (P=.045). Complex treatments did not differ in quality of root fillings for the supervision types (P=.825).

Conclusion: The quality of root fillings made by students who attended the revised programme seems at least as high as that of those who attended the former programme. Higher quality root fillings might be obtained under supervision of endodontists than under supervision of general dental practitioners.

Keywords: endodontology, number of periapical radiographs, quality of root fillings, supervision, teaching method, undergraduate.

Introduction

More than half of the root fillings made on a Dutch population have been shown to be of inadequate quality.[1,2] The quality of the root filling influences the outcome of the root canal treatment.[3,4] Increasing the prevalence of good quality root fillings, should decrease the prevalence of post-treatment apical periodontitis.

Most root canal treatments are carried out by general dental practitioners, skills of whom were mainly developed when they were students. Thus, the undergraduate endodontic education determines, to a large extent, the way root canal treatment is performed in the dental practice.[5,6]

The way dental schools around the world teach their undergraduate students endodontology vary,[7-10] as do the quality of root fillings made by the students.[11-18]

The European Society of Endodontology published guidelines for an undergraduate curriculum for endodontology (ESE guidelines) in 1992[19] that were updated in 2001[20] and 2013.[21] The aim of these guidelines was to guarantee that undergraduate training in endodontology was taken to a level that would eventually improve the standards of clinical practice. A number of dental schools in the European Union deviated from these guidelines.[22] Most probably, those deviations were not only due to differences in resources, but also due to differences in opinions. For example, the ESE guidelines stated that it would be beneficial for undergraduate students to be taught and supervised by endodontists, especially for clinical endodontology. Whereas, at our institution, the departments had delegated their undergraduate clinical teaching to general dental practitioners using clinical manuals, strict guidelines and forms listing criteria how each procedure must be carried out. The student and/or the supervisor contacted an endodontist from the department of endodontology for advice or assistance, only when they encountered difficulties or complications during a root canal treatment. This method of polyclinical teaching was selected to teach students to provide "integrated oral treatment" for patients from the start.[23] This method, however, seemed to be prone to creation of unnecessary endodontic complications, which could have been avoided.

In 2010, the undergraduate dental curriculum at our institution was extended, from 5 to 6 years, and therefore, the method of teaching endodontology had to be adjusted, and it could be improved concurrently. Reasons for revision of the clinical training and assessment in endodontology (in this study called "programme") were as follows: first, the assumption that training under conditions

that closely mimic the actual situation with a patient is of added value; second, the observation that it becomes more and more difficult to obtain — for the students to practice their skills — sufficient numbers of patients needing root canal treatment; and final, most importantly, a need to minimise risks to patients. The revised method of teaching aimed at providing students equally competent as the former methods did in a shorter period of time and using more readily available resources. In this study, we hypothesised that the revised method of teaching endodontology prepares students in performing root canal treatment equally well as the former method did. The null hypotheses tested were as follows: that the quality of root fillings made by undergraduate students, and occurrence of procedural errors, had neither been influenced by the type of programme the student attended, nor by the type of supervision they received, whilst performing root canal treatment on a patient; and that the number of radiographs taken for those treatments had neither been influenced by the type of programme the student attended, nor by the type of supervision they received, whilst performing root canal treatment on a patient.

Materials and methods

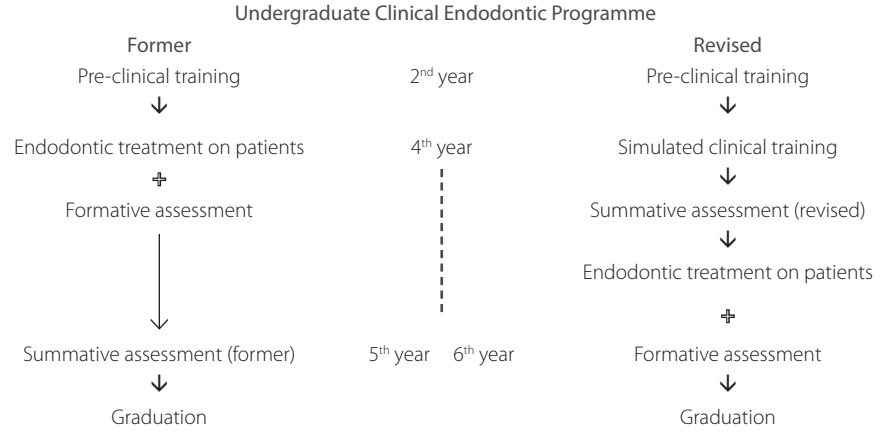
The institutional research board approved the research protocol on 16 November 2012.

Figure 1 presents the changes in the structure of the method of teaching endodontology in the undergraduate clinical endodontic programme.

Students start with a pre-clinical training using extracted human teeth. This training focuses on the procedure as well as on the instruments and materials used for performing root canal treatment. This is basically on tooth level, and the actual situation with a patient is not strictly simulated yet.

Formerly, in the here called "former programme," after this pre-clinical training, students proceeded performing root canal treatment, in the main clinic being supervised by general dental practitioners, on their regular patients. To qualify for the summative assessment that would prove their competence, and thus allow them to graduate, they first had to perform several root canal treatments in patients. This assessment (former assessment) involved students performing root canal treatment in a premolar or a molar on a patient; their competency was proven when they demonstrated that they were able to perform good quality root canal treatment without assistance from a supervisor.

Figure 1



Structure of the method of teaching endodontology in the undergraduate clinical endodontic programme before (former) and after (revised) the changes in the undergraduate curriculum.

Currently, in the here called "revised programme," after the pre-clinical training, students proceed with an extensive training in root canal treatment supervised by endodontists in the endodontic clinic. During this simulated clinical training, students perform root canal treatment on extracted human teeth under conditions that closely mimic the actual situation with a patient: the teeth are mounted on an artificial jaw in a manikin head fixed to a dental chair in the clinic, and students have to act, and perform the treatment, as if it is a real patient that they are treating. Upon finishing this training and before they are allowed to perform root canal treatments on patients, students have to prove their competence by a summative assessment. During this assessment (revised assessment), students perform a root canal treatment in an extracted human molar under conditions mimicking the actual situation with a patient same as in the simulated clinical training. As in the former assessment, students' competence is proven when they demonstrate that they are able to perform good quality root canal treatment without assistance from a supervisor.

Changes were also made to the supervision of the students, whilst performing root canal treatment on a patient. Currently, the more complex root canal treatments are performed in the endodontic clinic and supervised by endodontists. The relatively easy root canal treatments are still performed in the main clinic and supervised by general dental practitioners. The complexity of the treatments is

determined with the use of an index, the Dutch Endodontic Treatment Index (DETI),[24] and if applicable a classification, the Endodontic Treatment Classification (ETC).[24]

Due to the implementation of those changes, there was an intermediate cohort comprising partly students attending the former programme and partly students attending the revised programme. This intermediate cohort of students (N=91) was included in this study. The students of this cohort were, whilst performing root canal treatment, supervised by general dental practitioners or by endodontists, but allocation of supervision was not yet based on DETI and if applicable ETC.

The quality of the root filling of the first root canal treatment, in a patient, the student performed after succeeding in the summative assessment was evaluated.

Two observers, who were unaware of the type of programme the student attended and the type of supervision they got evaluated the radiological quality of the root fillings separately. The observers scored all the criteria that are listed below, per root canal. In case of disagreement between the observers, they discussed the observation, also on criterion and root canal level, until they reached a consensus. When there was no consensus, a third independent observer was introduced.

The quality of the root filling under investigation was, finally, determined on tooth level and was scored as "good" when all the separate root canals of the corresponding tooth met the following criteria:

- Root filling follows the natural root canal and is completely within the confines of the root (no extrusion).
- Root filling ending not shorter than 0-2 mm from the apex.
- Root filling appears well condensed on the periapical radiograph.
- No ledges, perforations, transportations or separated instruments are detectable on the periapical radiograph or reported in the chart.

A couple of months after the initial evaluation, the two observers repeated the evaluation of one third of the sample to determine the intra-observer reliability. Intra- and interobserver reliabilities were determined on tooth level.

As additional information to assess skills of the student, the total number of periapical radiographs taken for the treatment and the number of failed ones were recorded. A periapical radiograph was judged as "failed" if it did not reveal the information necessary for the treatment. For instance a length measurement radiograph that is not showing the apices of the tooth treated was classified as "failed."

To determine the difficulty level of the root canal treatment evaluated, observer 1 used DETI and if applicable ETC scoring systems.

A person who was not otherwise involved in this study, transferred the following variables to an Excel data sheet:

- Type of programme the student attended (former programme/revised programme).
- Type of tooth in which the root canal treatment was performed (front tooth/premolar/molar).
- Type of supervision during this treatment (general dental practitioner/ endodontist).
- Assessed quality of the root filling (poor/good).
- The total number of the periapical radiographs, and the number of failed ones.
- Difficulty level of the root canal treatment (less complex (DETI and ETC scores A, BI and BII)/complex (DETI and ETC score BIII))

As the numerical data were not normally distributed, only non-parametric tests were used. Data were analysed through IBM SPSS Statistics version 21.0 software (IBM corporation, Armonk, NY, USA) using Cohen's Kappa, Chi-square, Fisher's exact, Mann-Whitney and Kruskal-Wallis tests. The significance level was set at 0.05.

Results

Observers reliability

For the quality of the root fillings, using Cohen's Kappa analysis, the intra-observer reliability of observer 1 was κ=0.67 and of observer 2 it was κ=0.57. The interobserver reliability was κ=0.39.

In all cases of disagreement, a consensus was reached after discussion, without a need of consulting the third observer.

Distribution of independent variables

Using Fisher's exact test analysis no statistically significant relation was observed between the variables "type of supervision" and "type of programme" (Table 1).

Using Pearson Chi-Square analysis no statistically significant relation was observed between both the variables "type of supervision" and "type of programme" and the variables "type of tooth" or "difficulty level" (Tables 2 and 3). As these variables were not related, they could be tested for their influence on the performance of students in carrying out root canal treatments.

Table 1. Distribution of the data according to the programme the student attended and the type of supervision during the first root canal treatment they performed, on a patient, following succeeding in the summative assessment. Using Fisher's exact test analysis no statistically significant relation was found between the type of programme and the type of supervision (P=1.000).

	Former programme N (%)	Revised programme N (%)
General dental practitioner	11 (18)	52 (83)
Endodontist	4 (14)	24 (86)

Table 2. Distribution of the data according to the type of root-canal-treated-tooth, the type of supervision during the first root canal treatment the student performed, on a patient, following succeeding in the summative assessment and the programme the student attended. Using Pearson Chi-Square analysis no statistically significant relation was found between the type of tooth and the type of supervision (P=.678), and neither a statistically significant relation was found between the type of tooth and the type of programme (P=.247).

	Front tooth N (%)	Premolar N (%)	Molar N (%)	Total N (%)
General dental practitioner	14 (22)	23 (37)	26 (41)	63 (100)
Endodontist	4 (14)	11 (39)	13 (46)	28 (100)
Former programme	5 (33)	6 (40)	4 (27)	15 (100)
Revised programme	13 (17)	28 (37)	35 (46)	76 (100)

Table 3. Distribution of the data according to the difficulty level of the root canal treatment, the type of supervision during the first root canal treatment the student performed, on a patient, following succeeding in the summative assessment and the programme the student attended. Using Pearson Chi-Square analysis no statistically significant relation was found between the difficulty level and the type of supervision (P=.887), and neither a statistically significant relation was found between the difficulty level and the type of programme (P=.880).

	Less complex treatments N (%)	Complex treatments N (%)	Total N (%)
General dental practitioner	37 (59)	26 (41)	63 (100)
Endodontist	16 (57)	12 (43)	28 (100)
Former programme	9 (60)	6 (40)	15 (100)
Revised programme	44 (58)	32 (42)	76 (100)

Quality of root fillings

Of the root fillings made by students who attended the former programme, 47% (seven of 15) were of good quality. Of those made by students who attended the revised programme, 62% (47 of 76) were of good quality. Using Pearson Chi--Square analysis no statistically significant difference in quality of root fillings was observed for the two types of programmes (P=.274). Of the less complex root canal treatments, a statistically significantly better quality of root fillings was observed if the student was supervised by an endodontist (88% good quality) than if they were supervised by a general dental practitioner (59% good quality) (P=.045). However, of the complex root canal treatments, no statistically significant difference in quality of root fillings was found for the two types of supervision (P=.825; Table 4).

Table 4. Distribution of the data according to the quality of root fillings of the first root canal treatment students performed, on a patient, following succeeding in the summative assessment, the type of supervision during this treatment and the difficulty level of the treatment. Using Pearson Chi-Square analysis, for the less complex treatments a statistically significantly better quality of root fillings was observed if the student was supervised by an endodontist than by a general dental practitioner. However, no statistically significantly difference in quality of root fillings of the complex treatments was found for the two types of supervision.

		Poor quality root fillings N (%)	Good quality root fillings N (%)
Less complex treatments	Endodontist	2 (13)	14 (88) P=.045
	General dental practitioner	15 (41)	22 (59)
Complex treatments	Endodontist	6 (50)	6 (50) P=.825
	General dental practitioner	14 (54)	12 (46)

Number of periapical radiographs

The type of programme (former or revised) did not influence the number of periapical radiographs taken or the number of periapical radiographs that failed. Using Mann-Whitney U analysis no statistically significant differences were found (respectively P=.940 and P=.091). Neither did the type of supervision (endodontist or general dental practitioner) influence the number of periapical radiographs taken or failed (respectively, P=.092 and P=.452; Table 5). However, using Kruskal--Wallis and as a post hoc test Mann-Whitney U analysis, statistically significantly more periapical radiographs failed in the molar teeth than in the front teeth (respectively, P=.016 and P=.003; Table 6).

Table 5. The number of periapical radiographs taken by the student for their first root canal treatment, on a patient, following succeeding in the summative assessment. Using Mann-Whitney U analysis no statistically significantly influence on the number of exposed or failed periapical radiographs was observed for the type of supervision or the type of programme.

	Total periapical radiographs Mean ± SD	Failed periapical radiographs Mean ± SD
General dental practitioner	8.1 ± 3.6 P=.092	3.1 ± 3.1 P=.452
Endodontist	8.7 ± 2.6	3.3 ± 2.5
Former programme	8.0 ± 2.2 P=.940	2.0 ± 2.0 P=.091
Revised programme	8.3 ± 3.5	3.4 ± 3.0

Table 6. The number of periapical radiographs taken by the student for their first root canal treatment, on a patient, following succeeding in the summative assessment. Between the types of teeth, using Kruskal-Wallis analysis, no statistically significant difference was found in the number of exposed periapical radiographs (P=.073). However, a statistically significant difference was found in the number of periapical radiographs that failed (P=.016). Using as a post hoc test Mann-Whitney U analysis, a statistically significant difference was found between front teeth and molars (P=.003), but, no difference was found between front teeth and premolars (P=.067) nor between premolars and molars (P=.313). The values with the same superscript characters were not statistically significantly different (comparison within the same column).

	Total periapical radiographs Mean ± SD	Failed periapical radiographs Mean ± SD
Front tooth	6.8 ± 2.0[a]	1.6 ± 1.6[b]
Premolar	8.1 ± 2.8[a]	3.0 ± 2.5[b,c]
Molar	9.1 ± 4.0[a]	3.9 ± 3.4[c]
Total	8.3 ± 3.3	3.1 ± 2.9

Discussion

The total number of available students (cohort) for this study was limited. As an alternative to increase the sample size, we could have taken a cohort from before the changes and another one after completing the implementation of the revised undergraduate clinical endodontic programme. However, some other protocols have been changed at the same time as the implementation of the revised clinical endodontic programme. Amongst others, theoretical tutorials and a new rotary root canal preparation system were introduced. Inclusion of these new variables would have biased the results. To limit the number of confounding factors, this smaller but more standardised sample was chosen. Even with this rather small sample size, statistically significant differences were found. However, regarding that the material in this study was underpowered, one cannot overrule

the possibility that statistically significant differences were left undetected. For example, although the difference in percentage of root fillings of good quality made by students who attended the former programme (47%) and those who attended the revised programme (62%) was substantial (15% difference), this difference was not statistically significant. We, therefore, avoided drawing firm conclusions regarding these data.

Determining the quality of a root canal treatment by assessing the quality of root fillings through interpreting periapical radiographs is arguable. Unfortunately, in clinical endodontology, respecting ethical grounds, we do not really have better alternatives. Besides, this method is often used in endodontic research and practice, and there is evidence that quality of root fillings is related to treatment outcome.[3,4]

The intra-observer reliability was substantial and moderate respectively; the interobserver reliability was fair.[25] The observer variability in this study was, however, higher than that in similar studies.[26,27] Our observer reliability might have been higher if we had determined it per criterion, like Koch et al.[26] did in their study for the density of the root filling and for its length separately. Instead we observed on tooth level including several criteria (i.e. length and density of the root filling, as well as occurrence of procedural errors). Although Dahlström et al.[27] had a similar approach, they reached a higher intra-observer reliability than we did. They assessed the periapical radiographs jointly and determined the intra-observer reliability of their consensus. Such a consensus might be more consistent than a single person's observations. We calculated the observer reliability between the single observers and not for the consensus. However, the consensus observations were the dependent variable "quality of root filling" reported and analysed in our study.

Three periapical radiographs (pre-operative, length measurement and final) for a root canal treatment are recommended according to the Quality Guidelines for endodontic treatment of the European Society of Endodontology; in some cases they recommend to take a fourth periapical radiograph (master cone) to check the preparation before filling the root canal and they mention that it may be necessary to take more than one length measurement radiograph resulting in a maximum of five radiographs for a root canal treatment.[28] In the present study, on average, eight periapical radiographs were taken for a root canal treatment, and three of those radiographs have failed. Although this gives the impression that, on average, five recommended periapical radiographs were available, in fact, in nearly half of the treatments not all the recommended periapical radiographs were existing. In difficult root canal treatments, extra periapical radiographs may be of

added value to guarantee the quality of the treatment. However, the number of periapical radiographs taken for complex treatments (mean ± SD = 9.2 ± 3.9) was not statistically higher than those taken for less complex treatments (mean ± SD = 7.6 ± 2.6) (P=.052). It can, therefore, be considered that "unnecessary" periapical radiographs were taken. Taking those unnecessary periapical radiographs may mean that the student did not take "justification of exposure to radiation" into consideration. This may also reflect the uncertainty of the student during performing root canal treatment as well as their lack of knowledge or skills. The latter may also be an explanation for the statistically significantly higher number of failed radiographs in the molar region in comparison with the front region. The students who attended the revised programme could not be trained for the gagging reflex triggered by a phosphor plate as this cannot be simulated in the manikin head. The students who attended the former programme, however, were more "experienced" in taking periapical radiographs and performing root canal treatments in actual patients. It is, therefore, noteworthy that no statistically significant difference in the number of failed periapical radiographs was found between these two groups of students. When this finding is combined with the finding of no statistically significant difference in the quality of the root fillings made by these two groups of students, one can speculate that the revised programme was at least as effective as the former one.

In the present study, when the entire cohort was evaluated, 59% of root fillings were of a good quality. This percentage, and the percentages of the evaluated subgroups (46%-88%), were in accord with the reported "acceptable" quality of root fillings made by undergraduate students of dental schools around the world (23%-79%).[11-18]

The findings of this present study support the ESE guideline statement that students may benefit from teaching and clinical supervision by endodontists,[21] at least in the less complex root canal treatments. We could not find a similar benefit in the complex treatments. The allocation of the type of supervision was mostly performed based on the occurrence of complications. If complications occurred, especially in cases that were already complex, it became difficult even for endodontists to supervise students performing root canal treatment in such a way that good quality is to be obtained. Treatments started under supervision of a general dental practitioner but finished, when a procedural error had occurred, under supervision of an endodontist were categorised in this study to the group of treatments supervised by endodontists, as the final supervisor was decisive for categorising the type of supervision. Those treatments with procedural errors

(i.e. ledge, perforation, transportation or separated instrument), by definition, were assessed as having a poor quality. Supervision of students performing root canal treatment exclusively by endodontists is not always achievable in all dental schools.[21] However, based on our findings we would recommend that whenever possible, dental schools should aim at supervision by endodontists.

Future research with larger sample sizes evaluating teaching methods in endodontology is essential for providing students with evidence-based education.

Conclusion

Within the limitations of this study, the following conclusions can be drawn as follows:

1. The quality of root fillings made by students who attended the revised programme — without the involvement of human subjects until students passed the summative assessment — seems at least as high as that of those who attended the former programme, which involved patients in this part of the training and in the assessment.
2. Whilst performing root canal treatment, undergraduate students might benefit more from supervision by endodontists than from supervision by general dental practitioners; higher quality root fillings might be obtained under supervision of endodontists than under supervision of general dental practitioners.

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Conflict of interest

All authors declare there are no conflicts of interest in relation to this study.

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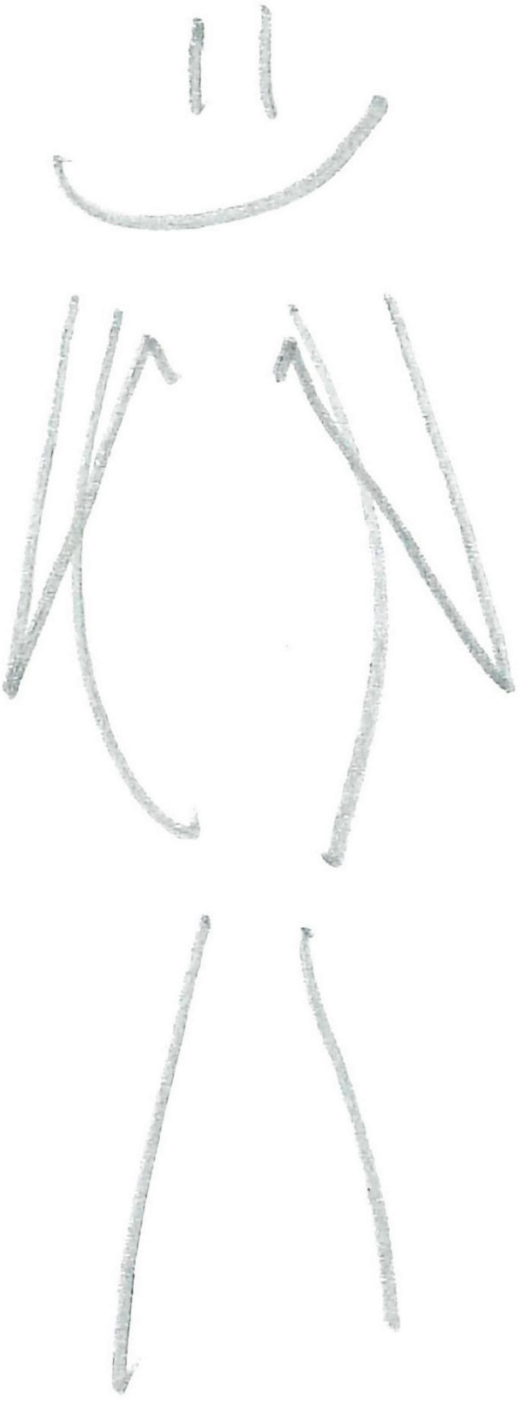

Chapter 3

Influence of method of teaching Endodontics on the self-efficacy and self-perceived competence of undergraduate dental students

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Abstract

Objective: This study assessed whether self-efficacy and the self-perceived competence of undergraduate dental students had been influenced by the method of teaching Endodontics.

Methods: Certain modules of the undergraduate endodontic programme at the Academic Centre for Dentistry Amsterdam (ACTA) including the tutorials, the clinical training and the assessment were revised. The self-efficacy and self-perceived competence close to graduation of an intermediate cohort of 24 students who attended all or some of the former modules or the revised modules were assessed. Additionally, the performance of students in performing root canal treatments was assessed according to predetermined criteria. Data were analysed using Cohen's Kappa, Cronbach's Alpha, Mann-Whitney and T-tests.

Results: Self-efficacy and the self-perceived competence of students who followed the former modules of clinical training and assessment were similar to those of students who followed the revised modules. The revised module with higher number of tutorials increased students' self-perceived competence, but did not influence their self-efficacy statistically significantly. Not the entire number, but the number of root canal treatments performed under supervision of endodontists was related with an increase in students' self-efficacy and self-perceived competence. The performance of students in performing root canal treatments was not statistically significantly related to their self-efficacy and self-perceived competence.

Conclusion: Among the modules and their components assessed in the present study, only the number of tutorials and the number of root canal treatments performed under supervision of endodontists influenced the self-efficacy and the self-perceived competence of students.

Keywords: educational measurement, endodontics, self-concept, self-efficacy, self-perceived competence, teaching.

Introduction

For a general dental practitioner, having to perform a root canal treatment can be stressful (1). To a great extent, a person's action and the amount of effort they will exert while dealing with stressful situations is determined by their self-efficacy (2). Being appropriately skilled is a prerequisite (2).

The majority of root canal treatments are performed by general dental practitioners. There are conflicting reports about how well, in their own perception, dental graduates or students who are about to graduate had been prepared for their work as general dental practitioner by their undergraduate endodontic education (3, 4). Many of them felt unprepared and not very confident (5,7) about performing complex endodontic treatments. They felt incompetent performing uncomplicated root canal treatments as well (8).

Studies assessing the effect of different methods of teaching endodontics on the confidence, the feelings of preparedness and the competence of students are scarce. One of the few available studies provided evidence for the value of a teaching method, which was new at that time and based upon independent learning, structured reflection and self-assessment. This method of teaching increased the feelings of preparedness of the students and their confidence in their practical skills. It also encouraged students to pursue understanding (9).

So far, no research assessing the effect of methods of teaching endodontics has measured students' self-efficacy. Self-efficacy embraces more than confidence and feelings of preparedness and competence. It is situation-specific self-confidence; the conviction that one can successfully execute the behaviour required to produce an intended outcome (2). Students' self-efficacy is responsive to changes in teaching methods and plays a causal role in their development and use of academic competencies (10). Students with high self-efficacy undertake difficult and challenging tasks more readily than students with low self-efficacy do (10). Moreover, the higher the self-efficacy, the greater the perseverance and the higher the likelihood that the task will be performed successfully (11). Therefore, students' self-efficacy is expected to determine how much effort dental graduates will exert into performing endodontic treatments.

In 2010, the undergraduate dental curriculum at our institution was extended, and the endodontic programme was revised. The main changes concerned the increased number of tutorials, the method of clinical training, the method of summative assessment, the number of root canal treatments required and

the supervision while performing endodontic treatment on patients. Students who attended the revised modules and components became at least as skilled in performing root canal treatment as the students who attended the former ones (12). In the present study, it was assessed on module and component level whether self-efficacy and the self-perceived competence of students who were about to graduate had been influenced by the method of teaching endodontics.

Materials and methods

The institutional research board of the Academic Centre for Dentistry Amsterdam approved the research protocol on 16 November 2012.

Former module of clinical training started with a preclinical training where students performed root canal treatments in extracted teeth. This training was basically on a tooth level, and the actual situation with a patient was not well simulated. This module proceeded with students performing root canal treatments on patients under supervision of the general dental practitioners. As a requirement for graduation, students had to perform several root canal treatments, including at least one in a molar, and had to pass a summative assessment. This former module of assessment comprised performing a root canal treatment in a premolar or a molar on a patient. During this summative assessment, students needed to demonstrate that they were able to perform root canal treatment of good quality without assistance of a supervisor.

Currently, in the revised clinical training module following the preclinical training, students proceed with a better simulated clinical training. This training comprises performing root canal treatments on extracted human teeth under conditions that closely mimic the actual situation with a patient: the teeth are mounted on an artificial jaw in a manikin head fixed to a dental chair in the clinic, and students have to act, and perform the treatment, as if it is a real patient. During this simulated component of the module, the students are supervised by endodontists. The revised module of assessment comprises a root canal treatment in a molar under the same strictly simulated conditions where the students demonstrate that they are able to perform root canal treatment of good quality without assistance of a supervisor. Passing this summative assessment is a requirement for students to be allowed to proceed to the last component of the revised clinical training module. In this component, unlike the former clinical

training module, there are no minimum requirements regarding the number of root canal treatments performed on a patient before graduation. The students may graduate when they are considered well prepared for the task of a general dental practitioner. The preparedness for this task is assessed with the use of a formative assessment. The supervision component of the clinical training module has been revised as well. Currently, the students are supervised by general dental practitioners or by endodontists.

The number of tutorials in the revised theoretical training module has been increased. One extensive tutorial in the former module is replaced with trimester-long weekly tutorials guided by an endodontist. During those tutorials, various clinical cases, including the diagnoses, aetiology, prognoses, treatments and on-topic current endodontic literature, are discussed.

As a result of the implementation of the curricular changes, an intermediate cohort comprising students following the whole or a part of the former undergraduate endodontic programme and students following the whole or a part of the revised undergraduate endodontic programme had been formed. The students of this intermediate cohort, who differed in the combinations of modules and components they attended, were asked to volunteer in the present study in their final months prior to graduation. They were informed that the purpose of the present study was to evaluate the influence of teaching methods on their experience in endodontics, and that since their answers would be completely blinded, the researchers would be unable to link the data obtained to a specific student. Only after giving permission to use their data were students able to participate. Participation comprised filling out an online questionnaire that was composed for the present study.

Self-efficacy was assessed using the Dutch Adaptation of the General Self-Efficacy Scale (Bart Teeuw, Ralf Schwarzer & Matthias Jerusalem, Berlin, Germany, 1994), whose questions were adapted to endodontics. This adapted scale was named the 'Endodontic General Self-Efficacy Scale'.

Self-perceived competence was assessed using a self-composed questionnaire, the English translation of which is shown in Table 1. To be consistent, for this 'Endodontic Self-Perceived Competence Scale', like the Endodontic General Self-Efficacy Scale, a four-point Likert-type format was used. Self-perceived competence was defined as the sum of the answers to questions 1 to 10.

Questionnaires are most effective if the separate questions of different questionnaires are mixed to form one combined questionnaire. The two

questionnaires (i.e. the Endodontic General Self-Efficacy Scale and the Endodontic Self-Perceived Competence Scale) were, therefore, merged, and the separate questions of the scales randomly mixed to form one combined questionnaire. The online questionnaire contained this combined questionnaire and additional questions about the type of undergraduate endodontic programme the students followed. These questions concerned whether they attended the revised or former theoretical training modules, modules of assessment and clinical training modules as well as how many root canal treatments they performed on patients under supervision of the general dental practitioners and how many under supervision of the endodontists. It was assumed that the students answered the questions honestly.

All participants can be considered appropriately skilled in performing root canal treatment since they all succeeded in the summative assessment. Still, there might be differences in their performance. Therefore, two observers assessed the quality of the first root canal treatment the students performed on a patient, following succeeding in the summative assessment. This assessment was performed on a radiograph with the use of predetermined criteria. The quality of the treatment was evaluated per root canal, and it was scored as 'good' when it met the following criteria: root filling follows the natural root canal and is completely within the confines of the root (no extrusion); root filling ending not shorter than 0-2 mm from the apex; root filling appears well condensed on the periapical radiograph and no ledges, perforations, transportations or separated instruments are detectable on the periapical radiograph or reported in the chart. The quality of the root canal treatment under investigation was scored as 'good' when all the root canals of the corresponding tooth were scored as 'good'. In case of disagreement between the observers, a discussion took place until a consensus was reached. To determine the intra-observer reliability, the assessment was repeated on one-fourth of the sample a few months after the initial evaluation.

Statistical analysis

Data were analysed using IBM SPSS Statistics version 21.0 software (IBM Corp.; Armonk, NY, USA). The separate questions were ordinal data and therefore analysed using Mann-Whitney U tests. Self-efficacy and self-perceived competence were considered numerical data and therefore analysed using Independent Samples T-tests. Furthermore, Cronbach's alpha and Cohen's kappa tests were used to analyse the reliability of the questionnaires and the observers, respectively.

Results

Twenty-four students participated in the present study. Data are presented in Table 1. Self-efficacy and the self-perceived competence of students who followed the former modules of clinical training and assessment were similar to those of students who followed the revised modules. However, students who attended the revised clinical training module reported a lower need for extra education in endodontics to maintain their competence than students who attended the former clinical training module. Not the entire number of root canal treatments on patients, but the number of treatments performed under supervision of the endodontists was related with an increase in students' self-efficacy and self-perceived competence. The students' self-efficacy was higher when they performed more than two root canal treatments under supervision of the endodontists (P=0.034). Their self-perceived competence was higher when they performed more than three (P=0.022) or more than four (P=0.049) root canal treatments under supervision of the endodontists. The revised theoretical training module with higher number of tutorials increased students' self-perceived competence, but did not statistically significantly influence their self-efficacy.

Table 1. The separate questions of the Endodontic Self-Perceived Competence Scale together with the four-point Likert-type scale, supplemented by self-perceived competence and self-efficacy determined with the Endodontic General Self-Efficacy Scale.

	Separate questions of the Endodontic Self-Perceived Competence Scale	Not at all true	Hardly true	Moderately true	Exactly true	Mean±SD	Range	clinical training module p-value	module of assessment p-value	theoretical training module p-value	performance in performing root canal treatment p-value
1	I feel competent to diagnose independently.	1	2	3	4	3.3 ± 0.5	2 – 4	0.963	0.490	0.301	0.802
2	I feel competent to determine independently the difficulty level of an endodontic treatment.	1	2	3	4	3.2 ± 0.8	1 – 4	0.966	0.874	0.452	0.526

Table 1. continued

	Separate questions of the Endodontic Self-Perceived Competence Scale	Not at all true	Hardly true	Moderately true	Exactly true	Mean±SD	Range	clinical training module	module of assessment	theoretical training module	performance in performing root canal treatment
								p-value	p-value	p-value	p-value
3	I feel competent to perform independently endodontic treatments on patients.	1	2	3	4	2.9 ± 0.7	1 – 4	0.727	0.689	0.263	0.339
4	I feel competent to reflect independently on the procedure and to determine the prognosis of the tooth after finishing endodontic treatment on a patient.	1	2	3	4	3.0 ± 0.7	2 – 4	0.493	0.556	0.582	0.818
5	I estimate my endodontic skills equal to those expected of a general dental practitioner.	1	2	3	4	2.3 ± 0.7	1 – 3	0.640	0.370	0.938	0.906
6	I worry about encountering complications while performing endodontic treatment.	4	3	2	1	2.6 ± 0.9	1 – 4	0.616	0.490	1.000	0.642
7	While performing endodontic treatment, I know how to minimalize risks of iatrogenic damage.	1	2	3	4	3.4 ± 0.5	3 – 4	0.468	0.934	0.280	0.673
8	I know how to manage complications that may occur while performing endodontic treatment.	1	2	3	4	2.7 ± 0.6	2 – 4	0.687	0.485	0.806	0.022*

Table 1. continued

	Separate questions of the Endodontic Self-Perceived Competence Scale	Not at all true	Hardly true	Moderately true	Exactly true	Mean±SD	Range	clinical training module p-value	module of assessment p-value	theoretical training module p-value	performance in performing root canal treatment p-value
9	In root canal treatments difficulty levels DETI A and DETI B class I everything is clear to me: I know and understand everything and I can substantiate and explain it all.	1	2	3	4	3.0 ± 0.8	1 – 4	0.305	0.531	0.327	0.119
10	I have a need for extra education in endodontics because I lack skills and knowledge in endodontics.	4	3	2	1	2.0 ± 0.8	1 – 3	0.435	0.910	0.163	0.330
11	I have a need for extra education in endodontics because I have a special interest in endodontics.	1	2	3	4	3.0 ± 0.6	2 – 4	0.106	0.902	0.510	0.101
12	I have a need for extra education in endodontics to maintain my competence.	1	2	3	4	3.1 ± 0.6	2 – 4	0.011*	0.172	0.639	0.563
Self-perceived competence						28.3 ± 4.3		0.702	0.533	0.028*	0.372
Self-efficacy						27.5 ± 4.3		0.828	0.751	0.413	0.375

To analyse the separate questions, Mann-Whitney U tests were used. To analyse the variables self-perceived competence and self-efficacy, Independent Samples T-tests were used. * P≤0.05.

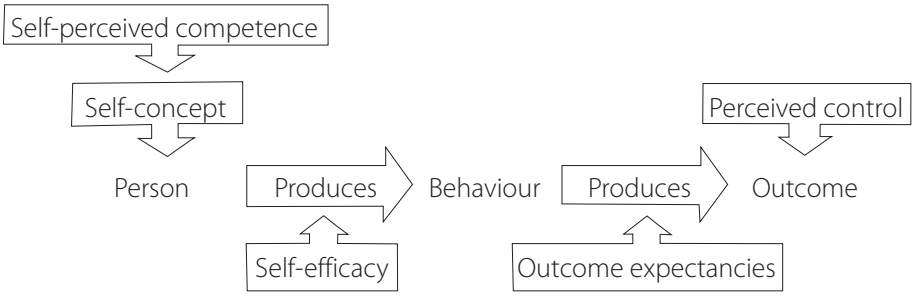
Since two of the participants did not perform a root canal treatment on a patient between the summative assessment and the time of the evaluation, the quality of the root canal treatment was determined for 22 participants. Sixty-eight percent of the evaluated root canal treatments were of good quality. Students who performed root canal treatment of good quality answered the question 'I

know how to manage complications that may occur while performing endodontic treatment' more positively than those who performed root canal treatment of poor quality. The performance of students in performing root canal treatments was not statistically significantly related to their self-efficacy and self-perceived competence.

Discussion

Self-efficacy is different from self-concept, perceived control and outcome expectancies (Figure 1) and has discriminant validity in predicting a variety of academic outcomes (10). Both within and outside the medical field, self-efficacy is used in various educational studies and seems a valid outcome measure for testing teaching methods in endodontics as well. To use self-efficacy as an outcome measure, the questionnaire has to be adapted to the specific tasks (10). A Cronbach's alpha value of 0.874 for the Endodontic General Self-Efficacy Scale suggests that the internal consistency of this scale is good. It can, therefore, be considered as a reliable method to test the self-efficacy of the undergraduate dental student.

Figure 1



Diagrammatic representation of the process on which self-efficacy and self-perceived competence act. A person's outcome expectancies are their beliefs that certain behaviour will cause a certain outcome (2). A person's self-efficacy is their belief that they are able to fulfil the behaviour necessary to achieve an intended outcome (2). Perceived control is a person's belief that they can influence an outcome. Self-concept is a person's idea of the self, based on the beliefs one holds about oneself and the responses of others. Self-perceived competence is assumed to be part of self-concept; it is expected to represent a person's belief in their competence.

Being appropriately skilled is a prerequisite for self-efficacy (2). All participants in the present study can be considered appropriately skilled in performing root canal treatment since they all succeeded in the summative assessment. The performance of the participants in performing root canal treatment was in accordance with that of students of other dental schools around the world – of whom the reported 'acceptable' quality of root canal treatments varied between 23% and 79% (13-20) – and was not related to their self-efficacy or self-perceived competence. Exaggerated findings of self-efficacy or self-perceived competence because of over-confident students who might think that they are competent while they are actually incompetent are thus not expected in this sample.

The influence of undergraduate endodontic education on the students' perception of preparedness for performing endodontic treatment was measured differently in several previous studies (3-8). In the absence of a gold standard, a new questionnaire was composed for the present study to survey students' perception of their competence and their confidence. The internal consistency of this Endodontic Self-Perceived Competence Scale seemed good: Cronbach's alpha=0.818. For the dependent variable 'self-perceived competence', statistically significant differences were found between some of the independent variables. Among the answers to the separate questions of the scale, statistically significant differences were found as well. The Endodontic Self-Perceived Competence Scale seems to be a reliable test.

Determining the quality of a root canal treatment through interpreting periapical radiographs is arguable. Regarding interpreting periapical radiographs, the intra-observer reliability of observer one was almost perfect (κ=0.91), of observer two it was moderate (κ=0.55); the inter-observer reliability was moderate (κ=0.48) as well (21). It is known that the agreement between observers is in general low (22, 23). Unfortunately, in clinical endodontics, respecting ethical grounds, we do not really have better alternatives. Besides, this method for determining the quality of root canal treatments is often used in endodontic research and practice, and there is evidence that the quality determined this way is related to the outcome of a root canal treatment (24, 25).

The intermediate cohort of students was limited in size, and in case of convenience sampling, like here, it is unknown whether the participants represented the population well. Therefore, drawing firm conclusions regarding these data is avoided.

No one estimated his or her endodontic skills to be completely equal to those expected of a general dental practitioner (Table 1, question 5). That may reflect feelings of unpreparedness, which in their turn may be caused by lack of confidence, even though the answers to the questions regarding how competent the students felt were more favourable (Table 1, questions 1-4). This difference might indicate that students who are about to graduate have higher expectations of a general dental practitioner's skills than they do of their own. To graduates, this may be an incentive to continue learning and improving their skills. Moreover, no student denied completely the need for extra education (Table 1). Altogether, this fits the underlying principle of the Undergraduate Curriculum Guidelines for Endodontology of the European Society of Endodontology (ESE guidelines) that: 'a minimal level of competence is reached prior to graduation and that an ethos of continuing professional development is instilled in the graduate' (26).

The relationship found between the performance of students in performing root canal treatment and their answer to the question 'I know how to manage complications that may occur while performing endodontic treatment' might be explained by the influence of feedback. Especially in situations where students are aware that they perform below the norm, their feelings of confidence in their performance decrease (27). The assessed root canal treatment to determine students' performance was presumably one of the last endodontic treatments the student performed before completing the questionnaire and thus might have influenced the students' answers. The way the quality of the root canal treatment was determined in the present study was based, among other criteria, on the occurrence of ledges, perforations, transportations or instrument separation, which are all considered 'complications'. If one of those complications occurred, the quality was determined as 'poor'. A recently experienced complication while performing a root canal treatment which caused a 'poor' result might have lowered the student's feelings of knowledge about managing those complications (28).

The increased self-perceived competence of students who attended the revised theoretical training module might have been due to vicarious learning. During the weekly tutorials given over a trimester, numerous as well as various cases can be discussed. This adds knowledge; one can learn from the experiences of another, and tutoring by endodontists may add credibility. Fellow students are good role models to increase feelings of preparedness: 'if they can do it, I can do it'. Moreover, imagining or watching another person's actions activates the same

neural structure of the brain as performing the same actions oneself (29). Amplification of knowledge and skills presumably motivates a person to perform (2).

Students who attended the revised clinical training module reported a lower need for extra education in endodontics to maintain their competence than students who attended the former module and trained their clinical skills exclusively by performing endodontic treatment on patients. Consequently, the simulated component of the clinical training module seemed of added value to students. A possible explanation for this finding can be the 'safer' clinical environment the simulated component of the clinical training module provides. The students have there the possibility to perform root canal treatments in a variety of teeth with differing anatomy and difficulty in a clinical environment without the risk of iatrogenic damage on a patient. The number of available patients with suitable cases is decreasing, and, more importantly, risks to patients should be minimised. To overcome the influence of limited resources, the quality feedback by endodontists with their comprehensive knowledge of endodontics might increase students' feelings of competence (26). Self-efficacy increases not with the total number of experiences but with the number of successful ones (2).

In the ESE guidelines, no recommendations are made on the number of root canal treatments an undergraduate dental student should perform before graduation (26). Based on the findings in the present study, it might be recommended that before graduation students should perform at least three root canal treatments on patients, preferably under supervision of an endodontist.

Self-efficacy, determined with the use of the Endodontic General Self-Efficacy Scale described here, seems to be a useful outcome measure to evaluate the effectiveness of any given method of teaching endodontics. Accordingly, the goal of endodontic education should be improving not only the students' skills but also their self-efficacy. Future research should use the Endodontic General Self-Efficacy Scale on larger populations, to study which method of teaching endodontics provides students with the appropriate skills as well as the highest self-efficacy.

Conclusion

Within the limitations of the present study, it might be concluded that the method of teaching endodontics can influence the self-efficacy and self-perceived competence of undergraduate dental students. Among the modules and their components assessed in the present study, only the number of tutorials and the number of root canal treatments

performed under supervision of the endodontists influenced the self-efficacy and the self-perceived competence of students.

Highlights

- The method of teaching endodontics can influence the self-efficacy and self-perceived competence of undergraduate dental students.
- This work implies that not only skills are important, but also self-efficacy. Self-efficacy is expected to influence how an undergraduate dental student, and following graduation, a general dental practitioner, will handle endodontic cases and how successful they will be.
- The Endodontic General Self-Efficacy Scale may be used to assess the self-efficacy since it seems to be a reliable test.

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Conflict of interest

No conflict of interest was declared by the authors.

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Authorship contributions

Concept – A.B.; Design – A.B., A.R.Ö.; Supervision – A.B., A.R.Ö.; Materials – None; Data Collection and/or Processing – A.B., A.R.Ö.; Analysis and/or interpretation – A.B., A.R.Ö.; Literature search – A.B., A.R.Ö.; Writing – A.B.; Critical Review – A.B., A.R.Ö.

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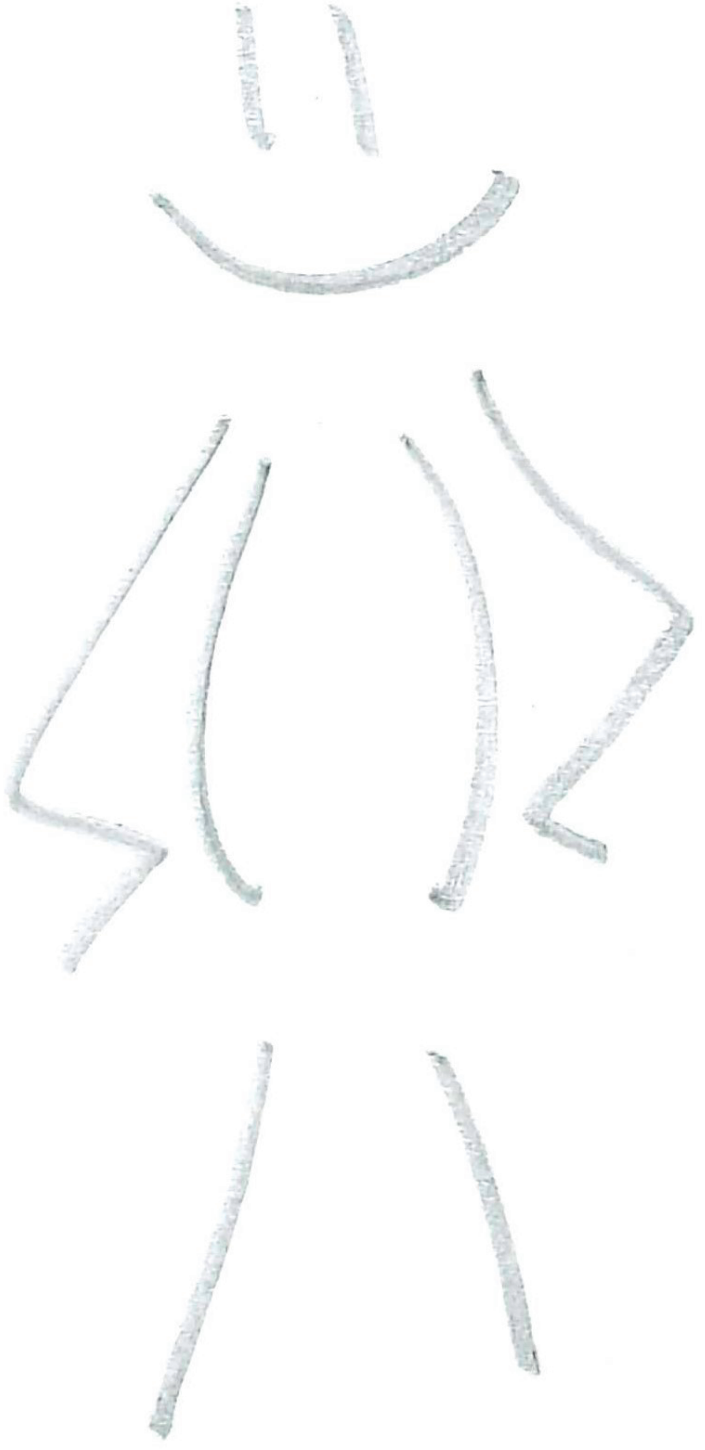

Chapter 4

Self-efficacy of undergraduate dental students in Endodontics within Aarhus and Amsterdam

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Abstract

Aim: To understand whether the self-efficacy of undergraduates is associated with the extent of the endodontic education they received.

Methodology: Data were obtained from three undergraduate endodontic programmes in two universities: Aarhus University (AU), Denmark and the Academic Centre for Dentistry Amsterdam (ACTA), the Netherlands. Just before their graduations in 2016 or 2017, students completed a questionnaire that contained the Endodontic General Self-Efficacy Scale and questions on how they valued the education they received in Endodontics. The information on the number and type of root canal treatments participants had performed on patients was collected from dental clinic management systems. Data were analysed using non-parametric tests and multiple regression analyses.

Results: The median number of treated root canals on patients per student was 5 in the standard programme at ACTA, 10 in AU, and 14.5 in the extended programme at ACTA. Students' self-efficacy increased with the number of treated root canals; however, retreatments and root canal treatments in molars were negatively associated with self-efficacy. All students wanted more experience in performing root canal treatment on patients.

Conclusions: The endodontic self-efficacy of students from the standard programmes of the two participating universities was comparable. Students' self-efficacy was influenced mostly by their clinical experience when performing root canal treatment. It seems that the more root canal treatments students perform on patients, the greater their self-efficacy is at graduation. However, treating difficult cases (molars and retreatments) might reduce their self-efficacy.

Keywords: education, endodontics, root canal treatment, self-efficacy, undergraduate.

Introduction

Root canal treatments are considered challenging and stressful by general dental practitioners (Dahlström *et al.* 2017). For the technical procedure of root canal treatments, quality guidelines are available (European Society of Endodontology 2006), and the skills to perform uncomplicated root canal treatments ought to be acquired during undergraduate dental training (Cowpe *et al.* 2010, European Society of Endodontology 2013). Although most general dental practitioners acknowledge the importance of quality treatment and perceive they are competent to conduct root canal treatments (Bjørndal *et al.* 2007), they tend to perform root canal treatment with inadequate adherence to quality guidelines and below the standard of care (Peciuliene *et al.* 2009, Peters *et al.* 2011, Kirkevang *et al.* 2014, Neukermans *et al.* 2015, Dahlström *et al.* 2018, Kirkevang 2018). It has been documented that challenging cases are being referred to endodontic specialists with increasing frequency (Neukermans *et al.* 2015).

Self-efficacy refers to feelings of competence and confidence defined as self-assurance that you will be able to perform specific tasks successfully. Being competent is a prerequisite for self-efficacy (Bandura1977). Self-efficacy has a direct positive effect on performance (Pajares & Miller 1994) and is positively associated with making use of academic competencies (Zimmerman 2000). Challenging tasks are more readily undertaken by those individuals with higher self-efficacy (Zimmerman 2000). Furthermore, individuals with high self-efficacy exhibit greater perseverance and perform under stressful situations better than individuals with low self-efficacy (Bandura 1977, 2006). The performance of general dental practitioners when performing root canal treatment has been hypothesized to be influenced by their self-efficacy (Baaij & Özok 2018a). In summary, increasing practitioners' self-efficacy is expected to increase the quality of care.

Research is lacking on the self-efficacy of general dental practitioners in relation to Endodontics. Furthermore, not much is known about the self-efficacy of undergraduate dental students. Undergraduate dental curricula are based on a list of competences that the student has to achieve to be able to work independently in a dental practice following graduation (Cowpe *et al.* 2010, European Society of Endodontology 2013). However, not all students feel confident after graduation (Murray & Chandler 2014, Davey *et al.* 2015).

The aim of the present study was to understand whether the self-efficacy of undergraduates is associated with the extent of the endodontic education they

received. Data from two universities (Aarhus University, AU, Denmark and the Academic Centre for Dentistry Amsterdam, ACTA, the Netherlands) were obtained and compared.

Materials and methods

The research protocol of this study was independently reviewed and approved by the ethics committee of ACTA under the reference number 2017014.

Education in Endodontics at both AU and ACTA adhere to the undergraduate curriculum guidelines of the European Society of Endodontology (2013) and the profile and competences for the European dentist of the Association for Dental Education in Europe (ADEE guidelines; Cowpe *et al.* 2010).

In Denmark, dentistry is 5 years of study. At AU, the education in Endodontics is given in the third year, where the students have 30 h of lectures, 30 h of preclinical exercises at a simulation clinic set-up, and eight clinical seminars. At graduation all students are expected to have performed root canal treatment of at least eight root canals in patients. The simulation exercises include root canal treatment of extracted human teeth: one anterior tooth, one premolar and one molar, all mounted in artificial jaws on manikin heads. Furthermore, they prepare and cement a post, and perform surgical endodontic retreatment on one tooth mounted in an artificial jaw. Before engaging in treatment of patients, the clinical instructor must approve the completion of the preclinical course work, and the students must pass a formal test in Endodontics. At the student clinic, the students work in pairs. The supervising instructor gives formal feedback including on self-evaluation and feedback after each session. Finished and approved treatments are registered in the dental clinic management system KLIPS. At the end of the fifth year of the study, the students have a final examination. Here, the student must make a comprehensive treatment plan based on anamnestic, clinical and radiographic information. The treatment plan covers all aspects of the necessary dental treatment including endodontics. The student is given 15 min to present the plan and is afterwards examined for 45 min.

In the Netherlands, dentistry is 6 years of study. The education in Endodontics at ACTA starts in the second year with 13 h of lectures, 2 h of tutorials, 32 h of preclinical training and an optional blended and problem-based learning course, that almost all students attend. In the fourth year, the students follow a 4-week

course that consists of 5 h of lectures and 7 h of tutorials on dental pain and traumatology. In the same year, the students follow a 10-week course which consists of 6 h of tutorials where discussions on scientific literature and clinical cases take place. In addition to the tutorials, the students follow 25 h of simulated clinical training during which they perform root canal treatment in a maxillary incisor, a maxillary molar and a mandibular molar, that are mounted in artificial jaws in manikin heads that are fixed to the dental chairs in the clinic. The students are supervised by endodontists and conclude this course with a summative assessment. Here, the student receives an endodontic case including patient anamneses, clinical findings and a periapical radiograph. The student then makes a diagnosis and a treatment plan based on this diagnosis and performs this treatment on an extracted human molar that is mounted in an artificial jaw in a manikin head that is fixed to a dental chair in the clinic. Consequently, students reflect on the treatment and their performance, which is evaluated by endodontists. Only passing students are allowed to perform root canal treatments on their patients in the clinic and only under supervision. A requirement to proceed to the final year is that the student has performed root canal treatment of at least three root canals in patients. Throughout their study, students are expected to apply their endodontic knowledge into their treatment planning, and this is tested on several occasions. At the final year of the undergraduate curriculum, an additional elective course in Endodontics is available, and approximately 17% of the students choose this course. The additional elective course consists of 21 h of tutorials to discuss endodontic literature and 128 h in the clinic to perform more complicated root canal treatments, on patients and on extracted human teeth, under supervision of endodontists. This course is open to all final year students.

For the present study, all undergraduate dental students from AU and ACTA who were in their final year in 2016 or 2017 were invited to participate close to their graduations. The students were informed that the data would be processed anonymously. Participating students gave informed consent. Participation included completing a paper questionnaire that contained the Endodontic General Self-Efficacy Scale (Table 1) (Baaij & Özok 2018a) and questions on the appreciation of the amount of education the students received in endodontics (Table 2). The questionnaires were in their national languages and also provided space for the students to give supplementary comments.

Table 1. The Endodontic General Self-Efficacy Scale.

	The Endodontic General Self-Efficacy Scale	Not at all true	Hardly true	Moderately true	Exactly true
1	I can always manage to solve difficult endodontic problems if I try hard enough.	1	2	3	4
2	If a patient opposes me, I can find the means and ways to get what I want.	1	2	3	4
3	It is easy for me to stick to my endodontic aims and accomplish my goals.	1	2	3	4
4	During an endodontic treatment, I am confident that I could deal efficiently with unexpected events.	1	2	3	4
5	Thanks to my resourcefulness, I know how to handle unforeseen endodontic situations.	1	2	3	4
6	I can solve most endodontic problems if I invest the necessary effort.	1	2	3	4
7	I can remain calm when facing difficulties concerning an endodontic case because I can rely on my coping abilities.	1	2	3	4
8	When I am confronted with an endodontic problem, I can usually find several solutions.	1	2	3	4
9	If I am in trouble during an endodontic treatment, I can usually think of a solution.	1	2	3	4
10	I can usually handle whatever comes my way during endodontic treatment.	1	2	3	4

Table 2. Questions used to measure students satisfaction with content and extent of education.

I would have had more:	
Literature	yes / no
Lectures	yes / no
Clinical seminars / Tutorials	yes / no
Preclinical / Simulated clinical training	yes / no
Root canal treatments on patients	yes / no
Difficult cases of root canal treatments on patients	yes / no
Feedback on my performance from my supervisor	yes / no
Feedback on my performance from my peer	yes / no

I would have had less:	
Literature	yes / no
Lectures	yes / no
Clinical seminars / Tutorials	yes / no
Preclinical / Simulated clinical training	yes / no
Root canal treatments on patients	yes / no
Difficult cases of root canal treatments on patients	yes / no
Feedback on my performance from my supervisor	yes / no
Feedback on my performance from my peer	yes / no

In 2016, 50 students graduated from AU and 62 from ACTA, and in 2017, the figures were 45 and 109, respectively. The participation rates from AU were 94% in 2016 and 78% in 2017 and from ACTA 77% and 62%, respectively. The students from ACTA were divided into two groups, based on their participation in the additional elective course in the final year. Students who had taken the additional elective course in Endodontics were categorized as 'ACTA extended'; the remaining students from ACTA were categorized as 'ACTA standard'. Four participants who graduated in 2017 from ACTA could not be categorized since it was not clear whether they had taken the additional elective course in Endodontics or not. Table 3 shows the sample. Information on the participants' clinical experience in performing root canal treatments on patients was retrieved from the dental clinic management systems of the institutions (Table 4). However, 12 participants (including the abovementioned four students who could not be categorized) did not provide the information necessary to retrieve data on their experience and were omitted from the analyses.

Table 3. Number of undergraduate dental students in the study sample from ACTA and AU in 2016 and 2017.

Year	ACTA		AU
	standard	extended*	
2016	38	10	47
2017	46	18	35
Total	84	28	82

* Students who had Endodontics as an elective course during their final year of dental education, in addition to the standard education all students at ACTA receive in Endodontics.

Data treatment and statistical analyses

For each of the three programmes, the number of teeth treated by the students was tabulated according to tooth type and calendar year. Non-parametric tests were used for comparisons. Questionnaire data were tabulated according to programme and year. The total self-efficacy score, computed as the sum of the scores from the 10 questions of the Endodontic General Self-Efficacy Scale, was studied by multiple regression analyses. Three regression models were considered: Model 1 included programme and calendar year as independent variables. In Model 2, the number of treated canals was included as an additional independent variable, and in Model 3, the number of retreatment and the number of treated molars were further included. Stata Release 15 (Stata Corp. 2017; College Station, TX, USA) was used for all statistical analyses.

Results

For both universities, the overall number of root canal treatments was lower in 2017 compared to 2016 ($P = 0.01$), but this did not influence the self-efficacy score, and information from the 2 years was therefore combined in tables and figures. The number and types of root canal treatments performed by the students are described in Table 4.

Table 4. Clinical experience of students in performing root canal treatments during their undergraduate dental training.

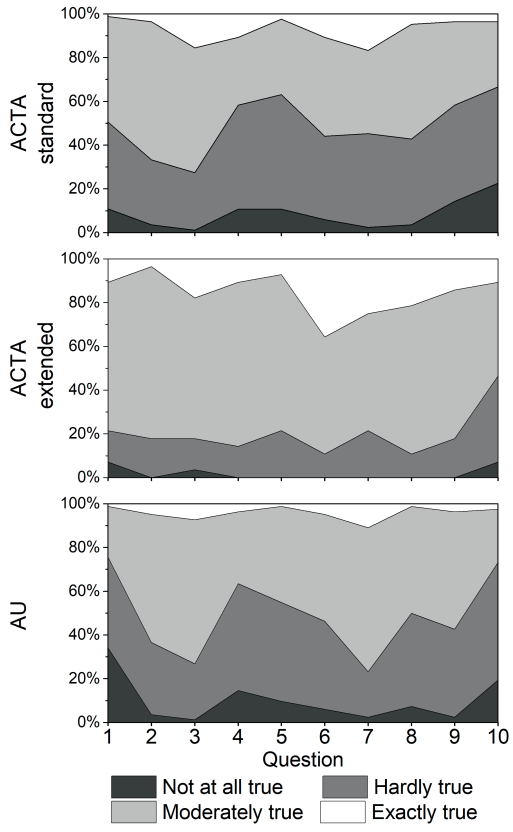
No of teeth	ACTA		AU
	standard	extended	
Anterior			
0	39	6	17
1	30	7	31
2	6	8	24
3	5	2	4
4		2	2
5			2
8		1	
Total ≥1	41 (51%)	20 (77%)	63 (79%)
Premolar			
0	22	3	16
1	33	7	26
2	13	8	24
3	11	2	10
4	1	5	4
5		1	
Total ≥1	58 (73%)	23 (88%)	64 (80%)
Molar			
0	24		
1	42	3	17
2	11	3	40
3	3	8	16
4		11	7
5		1	
Total ≥1	56 (70%)	26 (100%)	80 (100%)
Retreatment			
0	74	6	24
1	5	8	32
2		7	17
3		5	3
4			3
5			1
Total ≥1	5 (6%)	20 (77%)	56 (70%)

Table 4. continued

No of teeth	ACTA standard	ACTA extended	AU
Teeth			
median no.	3	6	5
Canal			
median no.	5	14.5	10

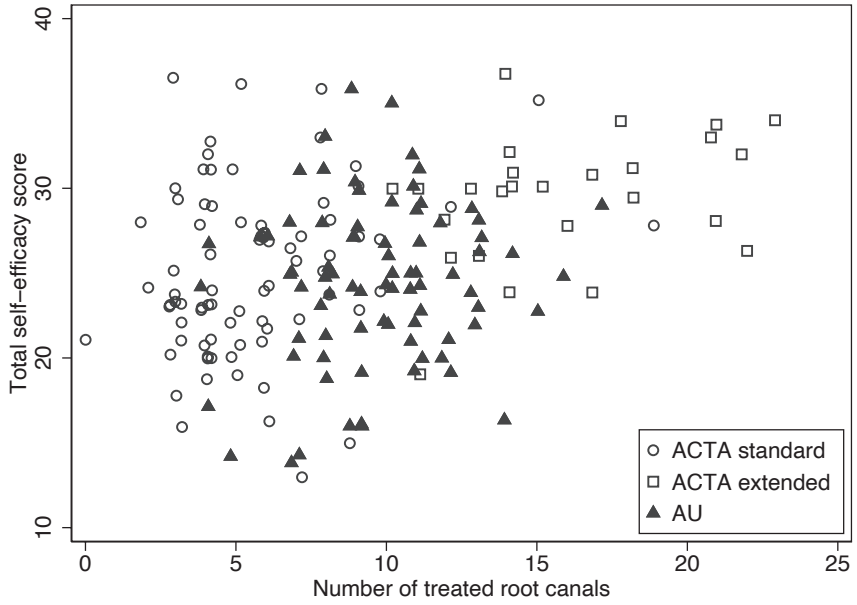
For different types of root canal treatments, the number of students who performed the specified numbers of treatments on patients are presented on tooth level. This is complemented with the total number of students who gained experience in this type of treatment on patients (i.e. the sum of students who performed one or more root canal treatments of this type on patients) and its percentage in regard to all the students within the corresponding programme. Finally, for every programme, the median number of total root canal treatments on patients is given, both on tooth level and on root canal level.

Figure 1



Distribution of the students' responses to the 10 questions of the Endodontic General Self-Efficacy Scale.

Figure 2



Students' self-efficacy (total self-efficacy score) plotted against number of treated root canals on patients.

All participants completed the Endodontic General Self-Efficacy Scale. For each of the three programmes, the distribution of the students' responses to the ten questions of the Endodontic General Self-Efficacy Scale (Table 1) is shown in Figure 1. In all programmes, the students' self-efficacy increased with the number of treated root canals (Figure 2). The students at AU and the students attending the standard programme at ACTA had similar self-efficacy profiles, whereas the students attending the extended programme at ACTA had in general higher self-efficacy scores. The results of three multiple regression analyses with total self-efficacy score as the dependent variable are shown in Table 5. Model 1 revealed that the self-efficacy was significantly higher for students in the extended programme at ACTA than for students in the standard programme at ACTA. The self-efficacy of students from AU did not differ significantly from that of students in the standard programme at ACTA. However, when the number of treated root canals was included in the analysis (Model 2), it was revealed that the students at AU had significantly lower self-efficacy than those of the standard programme at ACTA, and the difference between the standard and the extended programmes

Table 5. Results of three multiple regression analyses with students' self-efficacy (i.e. total self-efficacy score) as the depended variable.

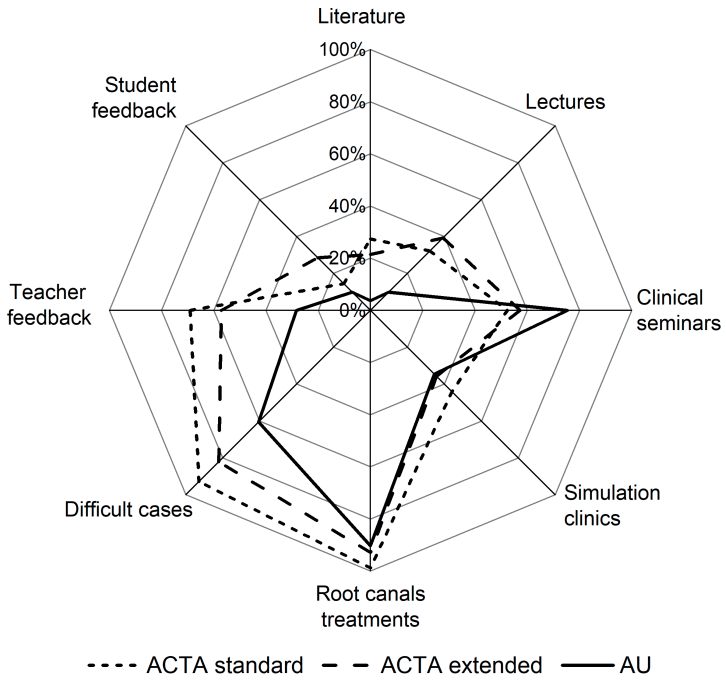
Variable		Model 1			Model 2			Model 3		
		Coeff.	SE	*P*-value	Coeff.	SE	*P*-value	Coeff.	SE	*P*-value
Programme	ACTA standard	reference			reference			reference		
	ACTA extended	4.47	1.02	<0.001	0.72	1.67	0.67	1.49	1.70	0.38
	AU	-0.56	0.73	0.45	-2.08	0.88	0.02	-1.18	0.98	0.23
Year	2016	reference			reference			reference		
	2017	-0.36	0.68	0.60	0.44	0.72	0.55	0.26	0.73	0.72
No of treated root canals					0.36	0.12	0.004	0.52	0.16	0.002
No of retreatments								-0.73	0.43	0.09
No of molars								-0.66	0.53	0.22
Constant		25.17	0.63		22.82	1.03		22.66	1.04	

Model 1 includes programme and year as independent variables; Model 2 includes programme, year, and number of treated root canals on patients as independent variables; and Model 3 includes the independent variables included in Model 2 supplemented with both the number of retreatments and the number of molar treatments that the students performed on patients.

at ACTA was no longer significant. When also the number of retreatments and the number of treated molars were included in the analysis (Model 3), there were no longer significant differences between the programmes. The regression coefficient for the number of treated root canals was positive. However, for retreatments and the treatment of molars, the regression coefficients were negative.

Two participants did not complete one or more of the 'I would have had more' questions, and six participants did not complete some or all of the 'I would have had less' questions. Figure 3 shows of which components students would have had more during their undergraduate education. Components of which students would have had less were identified by very few students of AU. Students from the extended programme at ACTA requested less lectures (21%), less simulation clinics (18%) and less feedback from other students (14%). A similar tendency, but less pronounced, was seen among the students from the standard programme at ACTA.

Figure 3



Students' satisfaction with the extent of education. For each component, the radar plot shows the proportion of students wanting more of this particular component.

Discussion

For this study, all students of two successive years of graduation from two universities in two European countries with, in total, three endodontic programmes were invited. The participation rates were satisfactory (Draugalis *et al.* 2008); and the internal consistency of both the Danish and the Dutch versions of the Endodontic General Self-Efficacy Scale appeared to be good in this study (Cronbach's alpha = 0.878 and 0.872 respectively), and similar to what has previously been reported (Baaij & Özok 2018a). The diverse sample provided data that seemed generalizable.

The participants' comments indicated that they appreciated the endodontic education they received. Most of the students were satisfied with the amount of lectures, literature and simulated clinical training. Nearly half of the students wanted more tutorials to discuss literature and/or clinical cases, and more feedback from their teachers, but this may probably reflect the considerable variability in students' learning preferences (Divaris *et al.* 2008). Students appreciated the supervision by endodontists (ACTA) or teachers with special interest and knowledge in Endodontics (AU), as became clear from their comments. Supervision by teachers with advanced knowledge and skills in Endodontics is advised by the ESE guidelines (European Society of Endodontology 2013), and increasing numbers of treatments under their supervision increases self-efficacy (Baaij & Özok 2018a). Almost all students in this study would like to have had performed more root canal treatments on patients during their undergraduate dental training.

The ADEE and ESE guidelines state that students should be competent to perform root canal treatment on uncomplicated anterior and posterior teeth (Cowpe *et al.* 2010, European Society of Endodontology 2013); and according to the ESE guidelines, students should gain adequate clinical experience in the treatment of anterior, premolar and molar teeth (European Society of Endodontology 2013). The precise meaning of the phrase 'adequate clinical experience in the treatment of anterior, premolar and molar teeth' used in the ESE guidelines may be elusive, but it might be concluded that many students in the present study sample did not achieve that (Table 4). For students, opportunities to gain clinical experience depend on the available patients and the types of treatments they need. Clinical experience and requirements of a mandatory number of procedures vary widely between undergraduate programmes globally, and there are even programmes that have no such requirements at all (Gatley *et al.* 2009, Seijo *et al.* 2013, Tanalp *et al.* 2013, Murray & Chandler 2014, Alrahabi 2017). The arguments for quantitative

requirements 'to ensure clinical competence' are a traditional mystery (Chambers 2012). Currently, a competency based approach is recommended (Cowpe *et al.* 2010) and requirements for graduation are given in a list of competencies instead of fixed numbers of treatments; no recommendations are made on the appropriate number of root canal treatments (European Society of Endodontology 2013). For ethical reasons and patient safety, the students must already be competent when they start performing root canal treatment on patients. At this point, the students are supposed to have reached a maintenance stage of learning, and the number of additional root canal treatments to be performed on patients in order to further improve performance is not achievable during undergraduate education (Chambers 2012). The value of performing root canal treatments on patients during undergraduate education might actually be to transition from competent to self-efficacious, rather than increasing the level of competence.

Self-efficacy increases due to positive experiences, but it decreases due to negative ones, particularly if they occur early in the course of events when no or only little positive experience has gained (Bandura 1977). Both retreatments and root canal treatments in molars were negatively associated with self-efficacy. Such treatments can be regarded as 'difficult' (Tanalp *et al.* 2013, Murray & Chandler 2014, Davey *et al.* 2015) and may evoke a negative experience to the student (Tanalp *et al.* 2013). It is debatable whether undergraduate students should be introduced to difficult cases at all (Tanalp *et al.* 2013). One might conclude that, to increase self-efficacy, students should perform as many root canal treatments as possible, but not too difficult ones. Interestingly, most participants of the present study did request more difficult root canal treatments on patients. It is important for students to be aware of the boundaries of their capabilities (Cowpe *et al.* 2010, European Society of Endodontology 2013) and having experience with more difficult cases might make them more aware of the reality of handling such cases (Murray & Chandler 2014). Although students might want to push those boundaries to acquire advanced competences in Endodontics (Tanalp *et al.* 2013, Murray & Chandler 2014, Baaij & Özok 2018a), patient safety should always be the prime concern. One of the participants of the standard programme at ACTA commented: 'I learned a lot from the supervising endodontist in the emergency clinic. If I cannot handle a case myself, I will refer the patient to an endodontist'. The Dutch Endodontic Treatment Index and Endodontic Treatment Classification are used by students and general practitioners in the Netherlands to assess difficulty; cases that are regarded too difficult are referred to an endodontist (Ree *et al.* 2003).

In the Netherlands, a 3-year full-time postgraduate programme in Endodontics, recognized by the Netherlands Society for Endodontology (NVvE), is available. In Denmark, possibilities to refer are more restricted since there no such programme is available. The present investigation further raises the question of the need for a formalized postgraduate programme in Endodontics in Denmark.

The undergraduate clinical training should reflect the types of treatments that the students are expected to perform when they enter clinical practice after graduation (Divaris *et al.* 2008). Not only a certain level of competency should be acquired, preferably in simulation (Baaij & Özok 2018b), this acquired level of competency should be retained, and self-efficacy should then be built further. To raise self-efficacy, root canal treatments of lower difficulty levels on patients are preferred to start with. The number of available patients who need root canal treatment of a suitable difficulty level for the undergraduate students is limited, not only at AU and ACTA, but in many dental schools (Divaris *et al.* 2008). In an attempt to compensate for limited time and suitable cases, students at AU perform treatments in pairs. If peer students train in pairs, they reach similar level of competence as students who train alone and perform double the amount of treatments (Bjerrum *et al.* 2014). A similar effect of training in pairs could not be observed on students' self-efficacy in the present study; the study was not designed with particular focus on assessing this effect. Although students at ACTA are not trained to work in pairs, they usually work with a peer while performing root canal treatment on patients. Future research should investigate the influence of training in pairs on students' self-efficacy in Endodontics.

The findings of the present investigation could be useful in improving undergraduate programmes to increase students' self-efficacy in Endodontics. To further understand self-efficacy and how it is related to undergraduate education, it would be interesting to study the self-efficacy of students in other endodontic programmes as well. Further research should not only focus on comparisons of the self-efficacy of students between other universities in other countries, but also on other factors that might influence the self-efficacy in Endodontics, such as the possible effect of graduation and clinical experience outside the dental institution. Another interesting direction in this line of research is investigating the expected relation between the self-efficacy of both students and general dental practitioners and their performances in the clinic.

Conclusion

The self-efficacy regarding Endodontics of undergraduate students from the standard programmes of the two participating universities is comparable. Students' self-efficacy appeared mostly influenced by their clinical experience when performing root canal treatment. The more root canal treatments students perform on patients, the greater their self-efficacy is at graduation. However, treating difficult cases (molars and retreatments) might reduce their self-efficacy.

Students of both universities seem mainly satisfied with the amount of education they receive. They request, though, more experience in performing root canal treatments.

Conflict of interest

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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Chapter 5

The change in self-efficacy of novice dentists in Endodontics within the first year following graduation from Aarhus University or the Academic Centre for Dentistry Amsterdam

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Abstract

Aim: To understand whether the self-efficacy of novice dentists in Endodontics changes within the first year following their graduation, and to reveal factors related to a possible change.

Methodology: Data were obtained from dental graduates from Aarhus University, Denmark or from the Academic Centre for Dentistry Amsterdam, the Netherlands. The 60 participants filled out the Endodontic General Self-Efficacy Scale questionnaire close to their graduation (baseline) and 1 year following their graduation (follow-up). Additionally, data on their experience in Endodontics within the first year following graduation were gathered, as well as data on their work environment, their referral behaviour and the postgraduation education they attended. For comparisons, chi-square tests, Fisher's exact tests, Mann-Whitney tests, and *t*-tests were used. Referral behaviour and the change in self-efficacy were studied by multiple regression analyses.

Results: Most participants showed an increase in self-efficacy after graduation. The increase in self-efficacy was higher for those whose baseline self-efficacy was lower, and lower for those whose baseline self-efficacy was higher. Self-efficacy increased with experience in performing root canal treatments within the first year following graduation. Participants with higher average self-efficacy (i.e. mean of baseline and follow-up self-efficacy) referred patients for endodontic surgery more often than participants with lower average self-efficacy did.

Conclusions: The self-efficacy of novice dentists in Endodontics generally increased within the first year following their graduation. The increase in self-efficacy was greater for those who had low self-efficacy at graduation than for those who already had high self-efficacy. Performing root canal treatments was an important factor in increasing self-efficacy.

Keywords: education, endodontics, novice dentist, referral, root canal treatment, self-efficacy.

Introduction

Despite the fact that undergraduate dental education prepares students for their role as dentists, transitioning from dental school to independent practice is challenging (ESE 2013; Field *et al.* 2017, Musaeus 2018). Lack of clinical experience in performing root canal treatments during undergraduate dental education is considered to be a problem, which may add to the various challenges of the transition into general practice (Dahlström *et al.* 2017, Davey *et al.* 2015). Although novice dentists are regarded as being competent in performing uncomplicated root canal treatments upon graduation, this may not always be their own perception (Dahlström *et al.* 2017, Davey *et al.* 2015, ESE 2013, Murray & Chandler 2014). Many dentists find it difficult to accomplish a good quality and economically viable root canal treatment, and feel frustrated about this (Dahlström *et al.* 2017). Although they have unpleasant associations with root canal treatment, they have to deal with these regularly in their practice (Dahlström *et al.* 2017). As it is unachievable to be exposed to every possible situation during undergraduate dental training, novice dentists have to trust their capabilities and rely on transfer. Hence, it is important that novice dentists feel that they have developed sufficient knowledge and skills to cope with challenges they meet whilst practising dentistry, including the ones that they have not yet dealt with during their undergraduate training.

One's performance on work-related demanding tasks, and whether one will use the academic competencies one has achieved, could be predicted by one's self-efficacy (Gist & Mitchell 1992, Pajares & Miller 1994, Zimmerman 2000). Self-efficacy combines one's perceived competence with confidence in their abilities, and also takes environmental factors that may influence performance into account (Gist & Mitchell 1992, Oney & Oksuzoglu-Guven 2015). Self-efficacy can be defined as the belief and self-assurance that you will be able to perform specific tasks successfully, and it is an important motivational construct (Gist & Mitchell 1992). People with high self-efficacy undertake challenging tasks more readily and pursue greater perseverance than people with low self-efficacy do, and the chances that a task is performed successfully are higher when performed by people with high self-efficacy (Bandura 2006, Zimmerman 2000). Besides, a high level of self-efficacy improves the degree of skill retention (Gist & Mitchell 1992). Hence, novice dentists should not only be competent, but also be self-efficacious.

At the end of their undergraduate dental training, a certain level of competence is assured, but the level of self-efficacy varies amongst students (Baaij *et al.* 2020). Their self-efficacy may increase with performing root canal treatments on patients during undergraduate training, but it also may decrease if those root canal treatments are difficult (Baaij *et al.* 2020). Novice dentists may face root canal treatments of various levels of difficulty in their practices, and the conditions under which the tasks are to be performed may be different from those in dental school. Besides, the novice dentist may be influenced by their colleagues. Other dentists might function – deliberately or unconsciously – as role models for the novice dentist and hence persuasion or modelling might occur, which can influence their self-efficacy (Gist & Mitchell 1992). Another factor that can influence self-efficacy is the normative feedback that the novice dentist may receive from various sources (Gist & Mitchell 1992, Wulf *et al.* 2010). Self-efficacy may thus change after graduation. A change in self-efficacy may lead to a change in performance, and this may result in ongoing positive professional development, however, it may also result in an exacerbation cycle that may be difficult to reverse (Bandura & Schunk 1981, Gist & Mitchell 1992). The aim of the present study was to understand whether the self-efficacy of novice dentists in Endodontics changes within the first year following their graduations from Aarhus University (AU), Denmark or from the Academic Centre for Dentistry Amsterdam (ACTA), the Netherlands, and to reveal factors related to a possible change.

Materials and methods

The research protocol of this study was independently reviewed and approved by the ethics committee of ACTA under the reference number 2017014.

The present study is a follow-up to a previous study on the self-efficacy of undergraduate dental students from AU or ACTA (Baaij *et al.* 2020). The students who participated in that study were contacted 1 year following their graduations, and were invited to participate in this follow-up study. Participants gave informed consent. Participation comprised filling out a questionnaire that contained the Endodontic General Self-Efficacy Scale (Baaij & Özok 2018, Baaij *et al.* 2020) and additional questions on their experience in Endodontics after graduation, their work environment, their referral behaviour and the postgraduation education

they attended (Table S1). The questionnaires were in their national languages. The data were collected and processed anonymously.

The response rate was 30%. People who participated in the follow-up study (i.e. the present study) were similar to those who participated only in the previous study (Baaij *et al.* 2020) (Table 1). The graduates from ACTA were divided into two groups: 'ACTA standard' and 'ACTA extended'. Whilst the graduates from both groups followed the regular endodontic programme before their graduation, the graduates from the latter group followed an additional elective course in Endodontics during the final year of their undergraduate training. Hence, there are three programmes from which the participants could have graduated: AU, ACTA standard, or ACTA extended.

Table 1. Responders participated both close to their graduation (i.e. baseline) and a year following their graduation (i.e. follow-up), whereas non-responders participated close to their graduation (i.e. baseline) only.

	Responders	Non-responders	p-value
Total n	60	138	
School n (%)			.50
ACTA	33 (28)	83 (72)	
AU	27 (33)	55 (67)	
Group (ACTA only) n (%)			.07
Standard	21 (25)	63 (75)	
Extended	12 (43)	16 (57)	
Root canal treatments performed during undergraduate dental training mean (sd)			
Root canals	9.2 (4.3)	8.6 (4.7)	.25
Teeth	4.2 (2.4)	4.6 (1.8)	.05
Incisors	0.7 (0.9)	0.6 (0.9)	.18
Canines	0.5 (0.7)	0.5 (0.8)	.73
Premolars	1.6 (1.1)	1.4 (1.2)	.30
Molars	1.9 (1.2)	1.7 (1.2)	.33
Baseline self-efficacy mean (sd)	25.9 (5.6)	25.3 (4.6)	.34

Data treatment and statistical analyses

The data obtained close to the participants graduation in the previous study (Baaij *et al.* 2020) were regarded as the baseline registration for the present study. The data obtained in the present study, 1 year after the graduation of those participants, was the follow-up registration.

Self-efficacy was determined by summing up the scores from the 10 questions of the Endodontic General Self-Efficacy Scale (i.e. total self-efficacy score). Baseline self-efficacy is the total self-efficacy score at graduation. Follow-up self-efficacy is

the total self-efficacy score 1 year following graduation. The change in self-efficacy was calculated by subtracting the baseline total self-efficacy score from the follow-up total self-efficacy score. Average self-efficacy was calculated by dividing the sum of baseline and follow-up total self-efficacy scores by two. The relationship between the baseline self-efficacy and the follow-up self-efficacy was initially studied by a Bland-Altman plot (Kirkwood & Sterne 2003) and then described by an errors-in-variables model fitted by orthogonal regression (Deming regression) (Cornbleet & Gochman 1979).

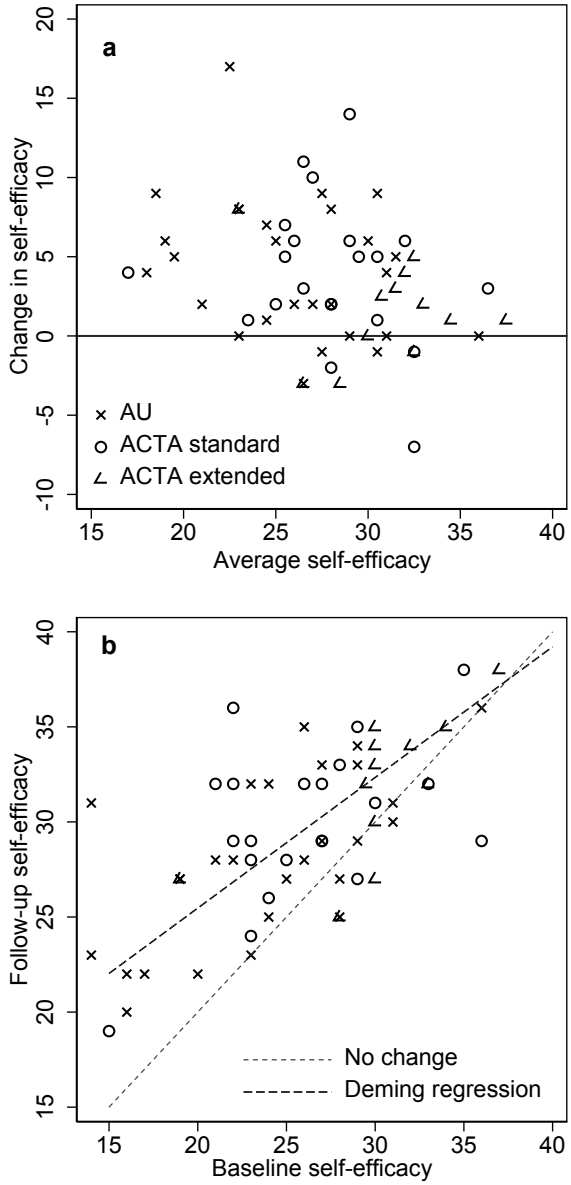
For comparisons of programmes, chi-square tests, Fisher's exact tests, Mann-Whitney tests, and *t*-tests were used. Predictors of the change in self-efficacy were studied by linear regression and multiple regression analyses. To this end, categorical independent variables were dichotomized due to the modest sample size. Referral behaviour was also studied by multiple regression analyses. The results of the multiple regression analyses were presented as regression coefficients with standard errors or as partial correlation coefficients. Stata Release 15 (Stata Corp. 2017, College Station, TX, USA) was used for all statistical analyses.

Results

All participants completed the Endodontic General Self-Efficacy Scale questionnaire. Since the change in self-efficacy for the graduates of each school was similar, the data were combined (Figure 1).

Self-efficacy of most of the participants increased within the first year following graduation (Figure 1a). The correlation between the change in self-efficacy and average self-efficacy was statistically significant (rho = –0.32, p = .01). The increase in self-efficacy was higher for those whose baseline self-efficacy was lower, and lower for those whose baseline self-efficacy was higher. The 'Deming-regression-line' (Figure 1b) shows the relationship between follow-up and baseline self-efficacy. The line has intercept 11.7 (se = 2.6) and slope 0.69 (se = 0.09) and was obtained from an errors-in-variables model fitted by orthogonal regression. The expected change in self-efficacy was 8.6 for those with baseline self-efficacy of 10 (i.e. the lowest possible total self-efficacy score), and it was –0.8 for those with baseline self-efficacy of 40 (i.e. the highest possible total self-efficacy score).

Figure 1



a) A Bland-Altman plot showing the change in total self-efficacy score (follow-up score minus baseline score) plotted against the average of the total self-efficacy score at follow-up and the total self-efficacy score at baseline.

b) Total self-efficacy score at follow-up plotted against total self-efficacy score at baseline.

Table 2. Results of linear regression analyses and multiple regression analyses with independent variables from the baseline registration and the change in total self-efficacy score (i.e. total self-efficacy score at follow-up minus total self-efficacy score at baseline) as dependent variable.

	Unadjusted			Adjusted for baseline self-efficacy		
Independent variables	coeff.	se	p-value	coeff.	se	p-value
School (ref = ACTA)	1.15	1.12	.31	-0.74	0.92	.42
Group (ACTA only, ref = standard)	-2.33	1.51	.13	-0.19	1.35	.89
Number of teeth treated in school	-0.23	0.31	.47	0.14	0.25	.58
Number of canals treated in school	-0.27	0.13	.04	-0.04	0.11	.74
Number of molars treated in school	-0.79	0.48	.10	-0.27	0.39	.49

Note:
"coeff." is the regression coefficient
"se" is the standard error
Each independent variable was analysed separately.

Table 3. Results of linear regression analyses with independent variables from the follow-up registration and the change in total self-efficacy score (i.e. total self-efficacy score at follow-up minus total self-efficacy score at baseline) as dependent variable.

Independent variable	coeff.	se	p-value
Performed root canal treatments			
Primary treatment	0.05	0.02	.001
Retreatment	0.34	0.20	.09
Total (i.e. primary treatment + retreatment)	0.05	0.02	.002
Encountered difficulties in diagnosing [a]	0.10	1.17	.93
Encountered difficulties in determining the prognosis [a]	-1.22	1.14	.29
Encountered complications [a]	0.25	1.17	.84
Encountered post-operative complaints [a]	1.87	1.25	.14
Frequency of emergency treatment [b]	1.10	1.17	.35
Frequency of consultation following dental trauma [c]	0.63	1.41	.66
Frequency of treatment following dental trauma [d]	0.58	1.34	.67
Colleagues available for help when difficulties were encountered whilst performing root canal treatment [e]	-2.06	1.13	.07
Colleagues available to discuss an endodontic case if necessary [e]	-2.75	2.26	.23
Materials similar to those at school [f]	-0.07	1.24	.96

Note:
"coeff." is the regression coefficient
"se" is the standard error
Each independent variable was analysed separately.
[a] rarely, never. Ref = often, sometimes.
[b] weekly, monthly, rarely, never. Ref = daily.
[c] monthly, rarely, never. Ref = daily, weekly.
[d] rarely, never. Ref = daily, weekly, monthly.
[e] sometimes, never. Ref = always.
[f] no. Ref = yes.

Table 2 presents the results of linear regression analyses with independent variables from the baseline registration. When corrected for baseline self-efficacy, none of these variables had a significant impact on the change in self-efficacy. Results of linear regression with independent variables from the follow-up registration are shown in Table 3. The change in self-efficacy was positively associated with the amount of experience in performing root canal treatment after graduation. These results did not change substantially when corrected for programme or for baseline self-efficacy (results not shown).

The median number of primary root canal treatments performed within the first year following graduation was 25, and the median number of retreatments was 1. Graduates from AU performed more primary root canal treatments than graduates from ACTA did (Mann-Whitney test: $p < .001$), and they referred fewer cases to another practitioner (Mann-Whitney test: $p < .001$) (Table 4). Although the number of referrals for primary root canal treatments was negatively correlated with the number of primary root canal treatments that the novice dentists performed themselves (correlation = –0.28, $p = .03$), no correlation was found after correction for the programme from which the novice dentists had graduated (Table 5). Both the number of root canal treatments performed and novice dentists' average self-efficacy were positively correlated with the number of cases they referred for endodontic surgery (Table 5).

Graduates from ACTA performed emergency treatments more frequently than graduates from AU did (Fisher's exact test: $p = .008$). Treatment following dental trauma was rarely performed by the graduates from both AU or ACTA, but graduates from AU performed consultations following dental trauma more frequently compared with the graduates from ACTA (Fisher's exact test: $p = .005$) (Figure 2). Experience with emergency treatments, or providing care following dental trauma was not associated with the change in self-efficacy (Table 3).

Approximately 70% of the participants, both graduates from AU or ACTA, had similar materials available in the practice to the ones which were available during their undergraduate dental training (Fisher's exact test: $p = .58$). Availability of familiar equipment was not associated with the change in self-efficacy (Table 3). The items participants reported that they missed in the practice are listed in Table S2.

The frequency of encountering problems was similar for graduates from AU or ACTA (Table S3). Encountering difficulties in diagnosing endodontic cases, difficulties in determining the prognosis of a tooth, complications whilst performing root canal treatment, or post-operative complaints from patients were not associated with the change in self-efficacy (Table 3).

Table 4. Management of endodontic cases within the first year following graduation: the amount of root canal treatments novice dentists performed themselves, and the number of cases they referred to a colleague.

	Undergraduate programme that the participants had graduated from											
	ACTA standard				ACTA extended				AU			
	median	Q1	Q3	range	median	Q1	Q3	range	median	Q1	Q3	range
Treatments performed by novice dentist:												
Primary treatment	20	12.5	30	0-60	15	11	26.5	6-100	40	25	65	0-150
Retreatment	0	0	1.5	0-3	1	0	2.5	0-10	3	1	5	0-10
Referrals by novice dentist for:												
Primary treatment	5.5	1.5	12.5	0-30	2	0.5	10	0-25	0	0	2	0-10
Retreatment	7.5	3	20	0-30	2.5	0.5	10	0-25	0	0	1	0-10
Endodontic surgery	1	0	3	0-10	2.5	0	5	0-10	3	1	5	0-20
Other	0	0	1	0-3	1.5	0	4	0-5	0	0	1	0-3

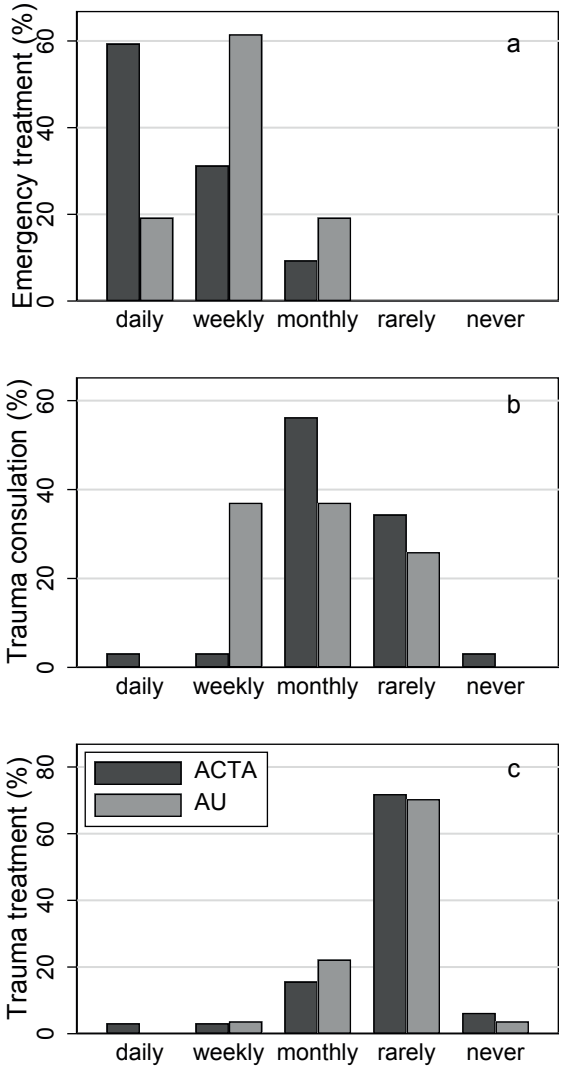
Note:
"Q1" is the lower quartile
"Q3" is the upper quartile

Table 5. Partial correlations between the referrals novice dentists' made and the number of primary root canal treatments they performed themselves within the first year following graduation, the change in their self-efficacy, and their average self-efficacy.

	Primary treatments performed		Change in self-efficacy		Average self-efficacy	
Referrals for:	Part. corr.	p-value	Part. corr.	p-value	Part. corr.	p-value
Primary treatment	-0.11	.42	-0.07	.58	-0.02	.88
Retreatment	0.18	.18	-0.04	.75	0.08	.55
Endodontic surgery	0.54	<.001	0.75	.39	0.28	.04
Other (trauma, resorptions)	-0.12	.40	-0.24	.09	0.04	.80

Note:
"Part. corr." is the partial correlation
The partial correlations are correlations adjusted for the undergraduate programme that the participants had graduated from, that is, the pooled within programme correlations between the type of referral and the dependent variable.

Figure 2



a) Frequency of emergency treatment by novice dentists within the first year following graduation from the Academic Centre for Dentistry Amsterdam (ACTA) or Aarhus University (AU).

b) Frequency of consultations following dental trauma by novice dentists within the first year following graduation from ACTA or AU.

c) Frequency of treatments following dental trauma by novice dentists within the first year following graduation from ACTA or AU.

Most graduates from ACTA worked in group practices, three worked in solo practices as well, and two graduates worked exclusively in solo practices. Graduates from ACTA had less on-site access to help from colleagues than graduates from AU did (Table S4). Availability of help was not associated with the change in self-efficacy (Table 3).

Postgraduation education in Endodontics was undertaken by 16 graduates from AU, and 12 from ACTA (Fisher's exact test: $p = .10$), and included courses, congresses, lectures or symposia. Time allocated to this postgraduation education varied from 2 to 120 h. The graduates from ACTA standard programme or ACTA extended programme undertook similar amount of postgraduation education (Mann-Whitney test: $p = .69$).

Discussion

This study included novice dentists from two countries who were graduates from three different undergraduate endodontic programmes. These factors appeared to have little influence on the change in self-efficacy (Tables 2 and 3). Although the response rate in the present study may be considered low, the responders seemed to resemble the non-responders (Table 1), and therefore, it is expected that the findings in the present study would not have changed substantially if the participation rate had been higher (Draugalis *et al.* 2008). The sample comprised novice dentists with varying clinical experience in Endodontics prior to graduation, and varying baseline self-efficacy (Baaij *et al.* 2020). Floor and ceiling effects, since self-efficacy has a lower and upper limit, as well as measurement error, were anticipated, but seemed not to fully explain the change in self-efficacy (Figure 1) (Bland & Altman 1995, Gist & Mitchell 1992, Kirkwood & Sterne 2003). Besides, increase in self-efficacy is controlled by one's performance, and therefore an inaccurate increase in self-efficacy seems unlikely since it is expected to be corrected automatically when performance lags behind (Gist & Mitchell 1992).

Endodontic self-efficacy increased with the number of root canal treatments performed within the year following graduation, and the increase in self-efficacy also depended on the level of self-efficacy that had been built-up until graduation (Tables 2 and 3 and Figure 1). Obviously, a high baseline self-efficacy leaves less room for an increase in self-efficacy than a low baseline self-efficacy (Gist & Mitchell 1992). The value of performing root canal treatment on patients during undergraduate dental training is to transition from competent to self-efficacious

more readily (Baaij *et al.* 2020). The novice dentists who participated in this study had stated previously that they would have liked to have more clinical experience with root canal treatments during their undergraduate education (Baaij *et al.* 2020). One might question, however, whether that is actually necessary, as part of the process of building self-efficacy may take place following graduation. At many dental schools, there is a lack of root canal treatments of a suitable difficulty level for the undergraduate students (Divaris *et al.* 2008). It could be speculated that it would be better to accept less experience with performing root canal treatments on patients prior to graduation than allowing students with limited clinical experience to perform difficult root canal treatments on patients (Baaij *et al.* 2020). Difficult root canal treatments may evoke a negative experience that may decrease one's self-efficacy, especially in the early phase of building it (Bandura 1977, Tanalp *et al.* 2013). Performing a retreatment in the year following graduation was, however, not negatively associated with the change in self-efficacy (Table 3). Participants who performed retreatments following graduation performed high numbers of primary root canal treatments as well (Spearman's rho = 0.80, $p < .001$). Self-efficacy is usually higher when experience accumulates, and then the impact of a negative experience on one's self-efficacy diminishes; the number of positive experiences will probably outgrow the number of negative ones (Bandura 1977). Besides, an increase in self-efficacy may lead to an improvement in performance (Gist & Mitchell 1992). Undertaking more challenging tasks at this stage may be less prone to cause negative experiences and may even contribute to a positive professional development (Bandura & Schunk 1981). This might explain the noteworthy finding that some of the participants who did not have experience with performing retreatments prior to graduation did manage to perform retreatments after graduation. They may gradually have pushed their goals.

The duration of undergraduate dental education in Denmark is 5 years, whereas it is 6 years in the Netherlands. In Denmark, dental graduates are not allowed to own a private practice before they have had 1 year full-time employment, including both private and public practice. That implies that they have access to support from a more experienced colleague during their first year of transition. In the Netherlands, however, newly graduated dentists can immediately obtain authorization to practice dentistry independently. It is nevertheless common for novice dentists in the Netherlands to start working in group practices with other dentists. One would assume that the availability of a colleague who could offer help when it is needed would give more confidence to the novice dentist, and would be positively associated with the change in self-efficacy. Although the

findings from the present study may suggest such a positive effect, it was not statistically significant. Besides, when a colleague helps to overcome a difficulty, this does not necessarily contribute to the novice dentist's feeling of being capable of performing a similar difficult task without any help. The novice dentist may give the credit to their helping colleague instead of to themselves when appraising their performance.

A reason that the novice dentists in Denmark performed more root canal treatments and referred less in comparison to the novice dentists in the Netherlands might be that there are less referral possibilities for a root canal treatment in Denmark. Ideally, a practitioner should refer a patient when they lack the necessary skills to perform the indicated treatment themselves. A practitioner may also decide to refer when they believe that they lack the necessary skills, regardless of whether that belief is accurate or not. Such belief may be reflected in lower self-efficacy; the novice dentists with low self-efficacy may overrate required skills, or doubt their own skills (Gist & Mitchell 1992, Wulf *et al.* 2010). Those skills might include not only the skills in performing different types of endodontic treatments, but also the skills in diagnostics and treatment planning.

Decision-making is influenced by the practitioner's knowledge and confidence in treatment options (McCaul *et al.* 2001). Self-efficacy influences individual choices and outcome expectancies and might also be a factor influencing the choice of treatment (Bandura 2006, Gist & Mitchell 1992). Self-efficacy, however, is the belief that one will be able to successfully perform the treatment regardless whether that treatment in itself will lead to a good prognosis or not (i.e. regardless of the outcome expectancies), and it should, therefore, not necessarily influence the treatment choice. In the interest of the patient, the choice of treatment should be based on outcome expectancies that are based on evidence.

The novice dentists in the present study were not educated to the level of competency to perform endodontic surgery on patients during their undergraduate education. It is therefore expected that the participants referred their patients when they selected this treatment option. Novice dentists with more experience and higher self-efficacy decided more often to refer for endodontic surgery. They may have had a more realistic perception of their skills as well as of their limits, and may make a more realistic distinction between operator-dependent factors and what the external factors contributing to the prognosis are; their high self-efficacy may remain high even if they have to refer a patient because the treatment that they had performed appears unsuccessful (Gist & Mitchell 1992, Ng *et al.* 2011). One might speculate that the choice of treatment

and referral behaviour may be influenced by the combination of practitioners' skills, their experience and self-efficacy, and their knowledge about and confidence in treatment options (Taha *et al.* 2019).

Conclusion

The self-efficacy of novice dentists in Endodontics generally increased within the first year following their graduation. The increase in self-efficacy was greater for those who had low self-efficacy at graduation than for those who already had high self-efficacy. Performing root canal treatments was an important factor in building up self-efficacy.

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Conflict of interest

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

Ethical statement

This study has been independently reviewed and approved by an ethical board. The research was undertaken with the understanding and consent of each participant and in full accordance with ethical principles.

Author contributions

All authors contributed substantial to: conception and design of, or acquisition of data or analysis and interpretation of data; drafting the article or revising it critically for important intellectual content; and final approval of the version to be published.

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Table S1. Questionnaire questions on experience, work environment, referral behaviour and education attended during the first year following graduation.

In what kind of practices did you work during the first year following graduation?					
Community practice for adults (AU graduates only)				months in total: …	
Community practice for children (AU graduates only)				months in total: …	
Solo practice	number of days a week: …			months in total: …	
Group practice	number of days a week: …			months in total: …	
Total of different practices you have worked in				number: …	
How many root canal treatments did you perform during the first year following graduation?					
Primary treatments	number of teeth: …				
Retreatments	number of teeth: …				
How often did you refer during the first year following graduation?					
For primary treatment	number of teeth: …				
For retreatment	number of teeth: …				
For endodontic surgery	number of teeth: …				
For other reasons (trauma, resorptions)	number of teeth: …				
Problems encountered during the first year following graduation					
How often did you encounter difficulties in diagnosing endodontic cases?		often	sometimes	rarely	never
How often did you encounter difficulties in determining the (overall) prognosis of a tooth?		often	sometimes	rarely	never
How often did you encounter complications while performing root canal treatment?		often	sometimes	rarely	never
How often did you encounter post-operative complaints from patients?		often	sometimes	rarely	never
How often did you deal with emergency treatment or dental trauma in the year following graduation?					
Emergency treatment	daily	weekly	monthly	rarely	never
Consultation following dental trauma	daily	weekly	monthly	rarely	never
Treatment following dental trauma	daily	weekly	monthly	rarely	never
Availability of help during the first year following graduation					
When you encountered difficulties during a root canal treatment, was there a colleague available who could offer help to you?			always	sometimes	never
If necessary, did you have a possibility to discuss with colleagues an endodontic case (not necessarily at the time the patient was in the practice, it may also have been beyond the clinical time)?			always	sometimes	never
Available equipment					
Are the materials available in the practice similar to those used at school?				yes	no
Did you miss anything specific?				yes *	no
* please specify what you missed: …					
What additional education in Endodontics did you undertake in the year following graduation?					
Congresses, lectures or symposia attended				hours: …	
Courses taken				hours: …	
Scientific papers read				number: …	

Table S2. Specification of what novice dentists reported that they missed in the practice.

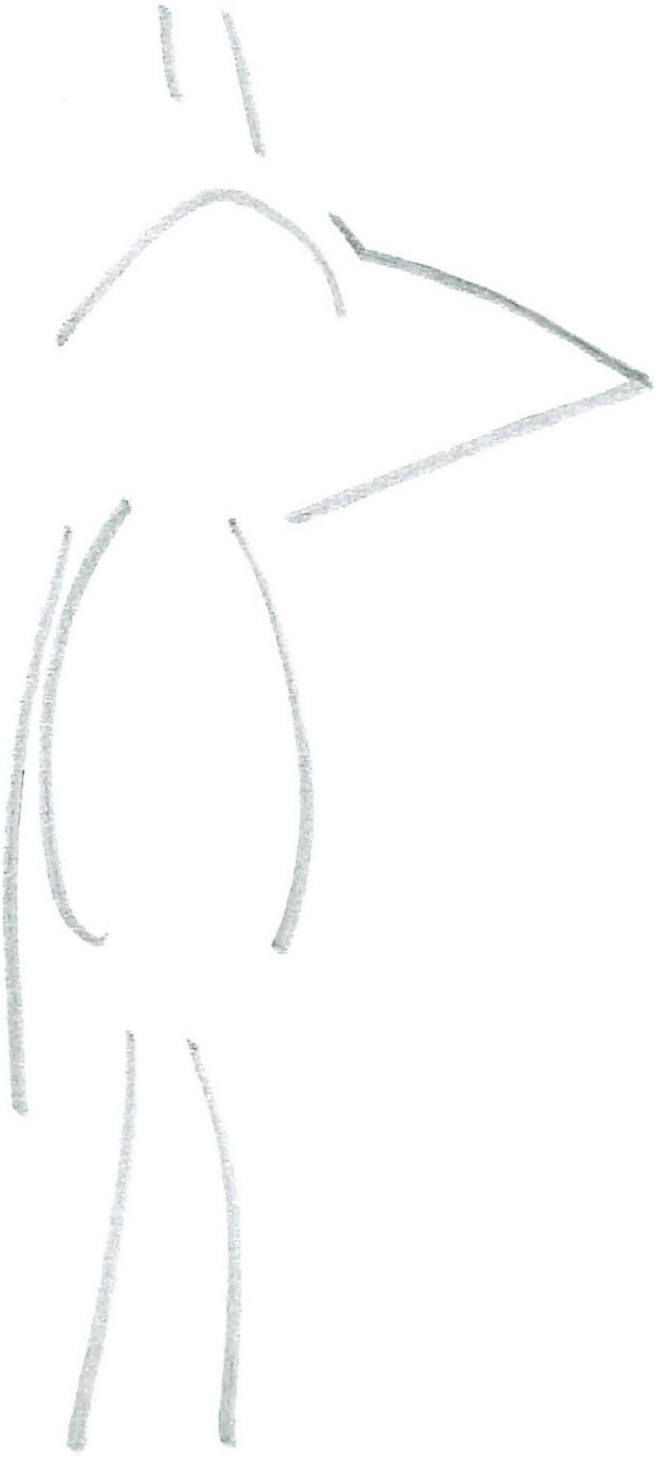
	Number of times reported
Microscope	7
Electronic length measurement device	3
Fuji Triage	3
Thermoplastic gutta-percha	2
Electrical heat plugger	2
Ultrasonic irrigation needle	2
MTA	2
NaOCl 1%	1
EDTA	1
Chlorhexidine	1
Right film holders and aiming devices	1
Phosphor plate number 1	1
Long neck burs	1
Good rotary instruments	1
Reciproc	1
Endo motor	1
One of the clinical teachers	1

Table S3. How often problems were encountered by novice dentists within the first year following their graduation from the Academic Centre for Dentistry Amsterdam (ACTA) or Aarhus University (AU).

	often	sometimes	rarely	never
Did you encounter difficulties in diagnosing endodontic cases? (n)				
ACTA	0	11	19	2
AU	0	12	15	0
Total	0	23	34	2
Fisher's exact: p = .52				
Did you encounter difficulties in determining the (overall) prognosis of a tooth? (n)				
ACTA	1	12	17	2
AU	1	12	13	1
Total	2	24	30	3
Fisher's exact: p = .96				
Did you encounter complications while performing root canal treatment? (n)				
ACTA	3	12	14	3
AU	1	17	8	0
Total	4	29	22	3
Fisher's exact: p = .13				
Did you encounter post-operative complaints from patients? (n)				
ACTA	0	10	13	9
AU	0	7	17	2
Total	0	17	30	11
Fisher's exact: p = .09				

Table S4. The access novice dentists had to help from colleagues within the first year following their graduation from the Academic Centre for Dentistry Amsterdam (ACTA) or Aarhus University (AU).

	always	sometimes	never
When you encountered difficulties during a root canal treatment, was there a colleague available who could offer help to you? (n)			
ACTA	13	18	1
AU	19	7	0
Total	32	25	1
Fisher's exact: p = .02			
If necessary, did you have a possibility to discuss with colleagues an endodontic case (not necessarily at the time the patient was in the practice, it may also have been beyond the clinical time)? (n)			
ACTA	30	1	1
AU	24	2	0
Total	54	3	1
Fisher's exact: p = .77			



Chapter 6

Incidence of interappointment emergencies in multiple-visit root canal treatments performed with or without intracanal medicament by undergraduate students

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Abstract

Objective: This retrospective cohort study analysed the incidence of interappointment emergencies during multiple-visit root canal treatments in molars performed by undergraduate students. Treatments that were performed without the use of an intracanal medicament were compared to treatments performed with the use of calcium hydroxide as intracanal medicament.

Methods: The occurrences of interappointment emergencies, defined as pain or swelling that necessitated the patient paying an unscheduled follow-up visit, were recorded up to two months following intervention. Only unscheduled visits occurring between the start and end of the root canal treatment were included to avoid the influence of obturation on the incidence of emergency visits observed.

Results: Seventy-seven of the 719 patients included in this study (10.7%) registered interappointment emergencies. Sixty-two percent of the interappointment emergencies occurred within two weeks following the latest intervention. The incidence of interappointment emergencies in the cohort of patients who received no intracanal medicament was 11.9% (46/385) compared to 9.3% (31/334) in those who received calcium hydroxide intracanal medicament (odds ratio=1.33, 95% confidence interval 0.82 – 2.15; p=0.249).

Conclusions: Although interappointment emergencies can occur at any time during the course of a root canal treatment, most seem to occur within the first two weeks following intervention. The incidence of interappointment emergencies was not significantly increased by omitting the use of an intracanal medicament in molar root canal treatments performed in multiple visits by undergraduate students.

Keywords: clinical outcomes, dental education, endodontics, pain, patient outcomes, prevention.

Introduction

Root canal treatments are often performed in more than one visit. Patients may return to the clinic between the scheduled visits due to pain or swelling, which is defined as an interappointment emergency [1,2]. An interappointment emergency is not only unpleasant for the patient as well as the dentist, but also demands extra materials and costs, and contributes to the carbon footprint [3].

It is possible that root canals are not prepared and irrigated thoroughly during the first visit of a root canal treatment, resulting in tissue remnants or persisting infection that may cause an interappointment emergency [4]. Even though incomplete preparation itself is not necessarily related to a higher incidence of interappointment emergencies [5], one might consider the use of an intracanal medicament in such situations more relevant.

Using calcium hydroxide as an intracanal medicament has become common practice in root canal treatment [6]. Calcium hydroxide is believed to play a significant role in disinfecting the root canal system [7], and in preventing regrowth of microorganisms [8]. Healing of apical periodontitis upon finishing a root canal treatment has been partly attributed to the use of calcium hydroxide [9]. The ascribed benefits of calcium hydroxide as an intracanal medicament in root canal treatment, however, remain questionable. Healing of apical periodontitis following single-visit root canal treatment appears to be similar to both the healing following multiple-visit root canal treatment with calcium hydroxide as an intracanal medicament [10] and the healing following two-visit root canal treatment without the use of an intracanal medicament [11]. Microorganisms can regrow between visits, even when calcium hydroxide is enclosed as an intracanal medicament [11]. To exert its disinfecting properties, calcium hydroxide has to be brought into direct contact with the microorganisms, which is not possible in all parts of the root canal system or in the dentinal tubules [12]. Besides, most microorganisms inhabiting the root canal system live in biofilms that make them more resistant to alkaline stress [13] and, therefore, less vulnerable to the effect of calcium hydroxide. Calcium hydroxide may even enable opportunistic microorganisms to proliferate and cause a shift in biofilm composition towards more resilient species [14], and it may lead to an enhanced biofilm mass production [15].

There is no scientific evidence on which to assess whether calcium hydroxide has any therapeutic effect in root canal treatment [16]. Besides, the complete removal of calcium hydroxide from the root canal system is very difficult or impossible to achieve [17], and the presence of its remnants in the root canal

system negatively affect the sealing ability of the root filling [18]. Furthermore, it has been reported that exposure to calcium hydroxide not only reduces the flexural strength and the fracture resistance of the dentine [19], but also, in cases of extrusion into periradicular tissues, causes irreversible changes such as paraesthesia and necrosis [20,21].

The use of calcium hydroxide intracanal medicament is not without risk and undergraduate students may experience difficulty in placing a medicament into the root canals [22]. In undergraduate clinics, root canal treatment usually takes several visits [23]. The use of calcium hydroxide intracanal medicament might be more relevant in undergraduate clinics than in other clinics. The patients in undergraduate clinics who are confronted with an interappointment emergency are less likely to have the root canal treatment completed, and incomplete root canal treatment may pose a risk to the patient's general health [23]. However, scientific evidence on which to assess whether calcium hydroxide intracanal medicament reduces the risk of interappointment emergencies is lacking. Up to two days following intervention, the use of calcium hydroxide does not reduce the incidence and intensity of pain [24], but pain or swelling that necessitates an emergency visit may as well present later.

Since it has not yet been verified whether the use of calcium hydroxide as an intracanal medicament reduces the risk of interappointment emergencies in undergraduate clinics, this retrospective cohort study analyzed the incidence of interappointment emergencies during molar root canal treatments performed by undergraduate students in more than one visit. Molar root canal treatments were studied because both the number of visits to complete a root canal treatment [23] and the incidence of interappointment emergencies is higher in molars [1,25]. In this study, treatments that were performed without the use of an intracanal medicament were compared to treatments performed with the use of calcium hydroxide intracanal medicament.

Materials and Methods

The ethics committee of our institution independently reviewed and approved the research protocol of this study (nr. 2017013). Written informed consent was not required for this retrospective cohort study. Subjects' rights have been protected.

This study followed the STROBE checklist for cohort studies.

Design

Interappointment emergency was defined as pain or swelling during the course of the root canal treatment that necessitated the patient paying an unscheduled visit to the institution. To avoid the influence of obturation on the incidence of emergency visits observed, only the unscheduled visits occurring between the start and the end of the root canal treatment (interappointment emergency visits) were included in the present study. The time elapsed between the interappointment emergency and the preceding intervention was recorded. Although the time between successive appointments can exceed two months, the occurrence of interappointment emergencies was assessed up to two months following intervention because that was considered most relevant.

The primary independent variable of this study was the use of intracanal medicament between visits: multiple-visit treatments without intracanal medicament were compared to multiple-visit treatments with calcium hydroxide intracanal medicament. However, other variables that may be related to the incidence of interappointment emergencies were studied as well. Table 1 shows the additional variables that were assessed. The patient's sex was retrieved from the patient chart in the dental record system and is based on the patient's identification. Medically compromised patients — i.e., patients with primary immunodeficiency diseases or using immunosuppressive medication — were detected based on the recorded information from the medical anamneses and using classification criteria from the International Union of Immunological Societies Expert Committee for Primary Immunodeficiency [26] and the Dutch Pharmacotherapeutic Compass (National Health Care Institute, Diemen, The Netherlands), respectively. Furthermore, if a root canal treatment was not completed within a year after its initiation, it was categorized as 'quit treatment following initial treatment', which is incomplete root canal treatment.

All data in the present study were retrieved from the information captured in the patient charts.

Sample

Patients who underwent primary root canal treatment in a molar in two or more visits at the undergraduate clinic of our institution were included. If a patient received root canal treatment in more than one molar, only the treatment of one of the molars was included in this study. Random tables generated on https://www.random.org (RANDOM.ORG, Dublin, Ireland) were used to select the molar

included. Root canal treatments that had been started outside the undergraduate clinic were excluded.

The cohort of patients who received calcium hydroxide intracanal medicament during their molar root canal treatment consisted of patients who were treated between September 2010 and September 2011 (n = 334). The time frame for data collection of this sample could not be expanded without introducing risk of bias because from September 2010, the method of root canal preparation had been revised, and from September 2011, using calcium hydroxide as an intracanal medicament during root canal treatment had been removed from the protocol. Because calcium hydroxide was available in the undergraduate clinic for a few more months, the cohort of patients who did not receive an intracanal medicament during their molar root canal treatment consisted of patients who were treated between September 2012 and September 2014 (n = 385). A sample size calculation was performed with the use of G*Power 3.1.9.7 for Windows (Heinrich Heine University, Düsseldorf, Germany). For this, the incidence of interappointment emergencies was estimated from the literature which indicates that it ranges from 1.5% to 5.5% [4] with a tendency towards 1.5% [1,2,27]. Hence, for the sample size calculation, the lower and upper limit of the reported range of interappointment emergencies were used for proportion 1 and 2, respectively. The sample size calculation revealed that 290 patients were required in each group (α type error = 0.05, power = 0.8).

The included treatments were performed by dental students in their final years of undergraduate training. They used the then prevailing protocols, that only differed concerning the intracanal medicament use. All treatments were performed under isolation of rubber dam. Before the root canal treatment was initiated, any caries, if present, were excavated. Throughout the preparation process, the root canal system was irrigated with 2% sodium hypochlorite using 10 cc Luer Lock Tip Syringes (Terumo Medical Corporation, Somerset, NY, USA) with irrigation needles (NaviTip®, Ultradent Products. Inc., South Jordan, UT, USA) until 1-2 mm short of working length. The root canals were prepared with rotary instruments (Mtwo®, VDW, Munich, Germany) in a modified crown down sequence: after the coronal part of the canals were enlarged with rotary size 20.06, the whole Mtwo® sequence from size 10.04 to size 40.04 was used to full working length. The working length was always confirmed by means of a periapical radiograph before rotary preparation was conducted to this length. Electronic length measurement devices were available to determine the working

length. After finishing the preparation, irrigation was completed using ultrasonic-activated irrigation: three times 20 seconds, using an ultrasound needle (IrriSafe™, ACTEON® Group, Merignac, France) and 2% sodium hypochlorite.

In the cohort of patients who received an intracanal medicament, the canals were dried with paper points and calcium hydroxide paste (UltraCal® XS 30%-35%, Ultradent Products. Inc., South Jordan, UT, USA) was placed using a capillary tip (Ultradent Products. Inc., South Jordan, UT, USA) before the temporary restoration was made. Both teeth with or without intracanal medicament were temporarily restored with temporary filling material (Cavit™ W, 3M, St. Paul, MN, USA) and glass ionomer cement (Ketac™, 3M, St. Paul, MN, USA) between visits.

Data acquisition

Data were obtained from the dental records system using spreadsheets with drop-down lists to prevent typos. They were retrieved by two observers. A third observer checked the data randomly to assure that the collection was done properly. The observers signed confidentiality agreement forms, and the data were processed anonymously.

Statistical Analyses

Data were analysed using IBM SPSS Statistics version 21.0 software (IBM corporation, Armonk, NY, USA). Pearson's chi-squared, and if indicated, Fisher's exact tests were performed to analyse the distribution of variables other than the dependent variable – interappointment emergencies – over the two cohorts, and to analyse the relationship between those variables and the occurrence of interappointment emergencies. For cross tables larger than two by two, adjusted standardized residual values were used to find out for which sub-variables the count deviated from the expected count. To analyse whether omitting the use of calcium hydroxide intracanal medicament during multiple-visit root canal treatment was associated with the incidence of interappointment emergencies, binary logistic regression analyses were performed, and corrections were done for the variables that were related to interappointment emergencies and may influence the incidence of interappointment emergencies. The significance level was set at 0.05.

Results

The distribution of variables other than the dependent variable over the two cohorts is shown in Table 1. The relation between those variables and the occurrence of interappointment emergencies is shown in Table 2.

Table 1. Distribution of variables over the two cohorts of patients receiving multiple-visit root canal treatment for a molar.

			No intracanal medicament (n=385)	Calcium hydroxide (n=334)	
		n	column % (n)	column % (n)	p-value
Sex	male	392	54.0% (208)	55.1% (184)	0.775
	female	327	46.0% (177)	44.9% (150)	
Pain (pre-operative)	present	565	77.9% (300)	79.3% (265)	0.644
	absent	154	22.1% (85)	20.7% (69)	
Diagnosis (pre-operative)	irreversible pulpitis	282	38.7% (149)	39.8% (133)	0.139
	irreversible pulpitis with apical periodontitis	112	13.2% (51)	18.3% (61)	
	symptomatic apical periodontitis	215	30.6% (118)	29.0% (97)	
	asymptomatic apical periodontitis	110	17.4% (67)	12.9% (43)	
Abscess (pre-operative)	present	55	6.8% (26)	8.7% (29)	0.332
	absent	664	93.2% (359)	91.3% (305)	
Sinus tract (pre-operative)	*present*	71	12.2% (47)	7.2% (24)	0.024 *
	absent	648	87.8% (338)	92.8% (310)	
Location treated molar	upper jaw	321	42.3% (163)	47.3% (158)	0.181
	lower jaw	398	57.7% (222)	52.7% (176)	
Diabetes	yes	37	4.7% (18)	5.7% (19)	0.540
	no	682	95.3% (367)	94.3% (315)	
Medically compromised	*yes*	24	1.0% (4)	6.0% (20)	<0.001 *
	no	695	99.0% (381)	94.0% (314)	
Treatment follow-up	*root canal treatment completed*	613	82.1% (316)	88.9% (297)	0.029 *
	extraction following initial treatment	33	5.2% (20)	3.9% (13)	
	quit treatment following initial treatment	73	12.7% (49)	7.2% (24)	
Complications †	no	616	87.3% (336)	83.8% (280)	0.415
	calcifications	51	5.7% (22)	8.7% (29)	
	fracture	18	2.9% (11)	2.1% (7)	

Table 1. continued

		n	No intracanal medicament (n=385) column % (n)	Calcium hydroxide (n=334) column % (n)	p-value
	perforation	17	2.3% (9)	2.4% (8)	
	separated instrument	17	1.8% (7)	3.0% (10)	
Age	≤ 30	159	20.3% (78)	24.3% (81)	0.282
	31 - 40	158	20.3% (78)	24.0% (80)	
	41 - 50	180	26.0% (100)	24.0% (80)	
	51 - 60	127	20.3% (78)	14,7% (49)	
	61 - 70	75	10.1% (39)	10.8% (36)	
	≥ 70	20	3.1% (12)	2.4% (8)	
Antibiotics (pre-operative)	yes	25	3.9% (15)	3.0% (10)	0.510
	no	694	96.1% (370)	97.0% (324)	

* The variables that were not equally distributed over the two cohorts are marked with an asterisk. The sub-variables that were not equally distributed over the two cohorts are in italic typeface. P-values ≤ 0.05 were considered significant.
† The number of the complications observed in this study were low and they were, therefore, excluded from further analyses.

Table 2. The relation between variables and the occurrence of interappointment emergencies.

		Interappointment emergencies			
		Incidence	Present column % (n)	Absent column % (n)	p-value
Sex	male	10.7%	54.5% (42)	54.5% (350)	0.996
	female	10.7%	45.5% (35)	45.5% (292)	
Pain (pre-operative)	*present*	12.6%	92.2% (71)	76.9% (494)	0.002 *
	absent	3.9%	7.8% (6)	23.1% (148)	
Diagnosis (pre-operative)	irreversible pulpitis	9.6%	35.1% (27)	39.7% (255)	0.006 *
	irreversible pulpitis with apical periodontitis	14.3%	20.8% (16)	15.0% (96)	
	symptomatic apical periodontitis	14.4%	40.3% (31)	28.7% (184)	
	asymptomatic apical periodontitis	2.7%	3.9% (3)	16.7% (107)	
Abscess (pre-operative)	*present*	43.6%	31.2% (24)	4.8% (31)	<0.001 *
	absent	8.0%	68.8% (53)	95.2% (611)	
Sinus tract (pre-operative)	present	12.7%	11.7% (9)	9.7% (62)	0.572
	absent	10.5%	88.3% (68)	90.3% (580)	
Location treated molar	upper jaw	10.0%	41.6% (32)	45.0% (289)	0.564
	lower jaw	11.3%	58.4% (45)	55.0% (353)	

Table 2. continued.

		Interappointment emergencies			
		Incidence	Present	Absent	
			column % (n)	column % (n)	p-value
Diabetes	yes	13.5%	6.5% (5)	5.0% (32)	0.582
	no	10.6%	93.5% (72)	95.0% (610)	
Medically compromised	yes	16.7%	5.2% (4)	3.1% (20)	0.313
	no	10.5%	94.8% (73)	96.9% (622)	
Treatment follow-up	*root canal treatment completed*	9.1%	72.7% (56)	86.8% (557)	<0.001 *
	extraction following initial treatment	39.4%	16.9% (13)	3.1% (20)	
	quit treatment following initial treatment	11.0%	10.4% (8)	10.1% (65)	
Age	≤ 30	8.2%	16.9% (13)	22.7% (146)	0.053
	31 - 40	15.2%	31.2% (24)	20.9% (134)	
	41 - 50	12.2%	28.6% (22)	24.6% (158)	
	51 - 60	11.8%	19.5% (15)	17.4% (112)	
	61 - 70	4.0%	3.9% (3)	11.2% (72)	
	≥ 70	0.0%	0.0% (0)	3.1% (20)	
Antibiotics (pre-operative)	*yes*	32.0%	10.4% (8)	2.6% (17)	0.003 *
	no	9.9%	89.6% (69)	97.4% (625)	

* The variables that were related to interappointment emergencies are marked with an asterisk. The sub-variables that were related to interappointment emergencies are in italic typeface. P-values ≤ 0.05 were considered significant.

Seventy-seven of the 719 patients included in this study (10.7%) registered interappointment emergencies. The majority of interappointment emergencies occurred within two weeks following intervention (Table 3). The incidence of interappointment emergencies in the cohort of patients who received no intracanal medicament was 11.9% (46/385) compared to 9.3% (31/334) in the cohort of patients who received calcium hydroxide intracanal medicament (odds ratio=1.33, 95% confidence interval 0.82 – 2.15; p=0.249). Also after correction for the variables that were related to interappointment emergencies and could have influenced the findings, no association was found between omitting the use of calcium hydroxide intracanal medicament and interappointment emergencies (Table 4).

Table 3. The time elapsed between the latest intervention and the occurrence of the interappointment emergency.

	Interappointment emergencies	
	Cumulative percentage	Cumulative incidence
1 day	14.9	1.6%
2 days	23.0	2.5%
4 days	31.1	3.3%
1 week	43.2	4.6%
2 weeks	62.2	6.7%
1 month	78.4	8.4%
2 months	100	10.7%

The occurrence of interappointment emergencies was assessed up to two months following intervention. The cumulative incidence is the incidence of interappointment emergencies found up to the given moment. The cumulative percentage is the percentage of the total number of interappointment emergencies which occurred up to the given moment in the follow-up period of two months.

Table 4. The association between omitting the use of calcium hydroxide intracanal medicament and interappointment emergencies determined with binary logistic regression analysis.

Incidence of interappointment emergencies		Odds ratio	95% Confidence interval	Regression coefficient
No intracanal medicament compared to calcium hydroxide		1.33	0.82 – 2.15	0.28
Corrected for pre-operative:	Pain	1.35	0.83 – 2.19	0.30
	Diagnosis	1.32	0.81 – 2.13	0.28
	Abscess	1.48	0.89 – 2.47	0.40
	Antibiotics	1.31	0.80 – 2.12	0.27

Discussion

In the dental record system of our institution, all patient communications are recorded. The incidence of interappointment emergencies could, therefore, be reliably assessed in the retrospective study design that was used for the present study [28]. Since the undergraduate dental students had to follow strict protocols that were the same for all included root canal treatments, and since the variables that affected the incidence of interappointment emergencies were distributed similarly over both cohorts (Tables 1 and 2), the two cohorts were highly comparable.

The findings of the present study are in accordance with previous studies where root canal treatments had been performed by undergraduate students, general dental practitioners, postgraduate students, or endodontists: the incidence of

interappointment emergencies is not related to the patient's sex, age, possibility of compromised healing due to medical conditions, or whether it concerned a maxillary or mandibular molar; though it is related to the (pre-operative) diagnosis of the tooth, and to the presence of pre-operative pain or an abscess [1,2,5,25,29].

The relation between the incidence of interappointment emergencies and the usage of antibiotics found in the present study should be interpreted cautiously. Information on the reasons for prescription of antibiotics was not always available in our sample. The reason might have been preoperative abscess, severe pain or swelling, and all these factors are related to the incidence of interappointment emergencies themselves [5,29].

In undergraduate clinics, it is more likely that the root canal treatment will be completed when no interappointment emergency visit becomes necessary [23]. This was also found in the present study (Table 2), and this might suggest that an interappointment emergency would be a reason for a patient to refuse further treatment. The results of the present study, however, did not confirm the presence of such an association; the decision to quit during the course of the root canal treatment – and have incomplete treatment for the endodontic pathology – appeared unrelated to interappointment emergencies (Table 2). The results of the present study did suggest, however, that an interappointment emergency might be a reason to have the tooth extracted, instead of having the root canal treatment completed. The incidence of interappointment emergencies in the group of patients who had the tooth extracted was four times higher than that in the group of patients who had the root canal treatment completed (Table 2).

The percentage of patients who had the tooth extracted following initial treatment was distributed similarly over both cohorts (Table 1). Hence, omitting the use of an intracanal medicament seems not to affect the decision to have the tooth extracted midway the root canal treatment. However, the percentage of patients who had the root canal treatment completed was higher in the cohort that received intracanal medicament (Table 1). Interestingly, the number of root canal treatments started in the period 2010-2011 (representing the cohort receiving intracanal medicament) was two times higher than the number of treatments started in the period 2012-2013 or 2013-2014 (representing the cohort that received no intracanal medicament). Both the reason for the decrease in the number of root canal treatments started and the reason for the increase in the number of incomplete treatments is uncertain. One might speculate that changes in financial circumstances over the years can be a reason, and if that would be

the case, the question might raise whether that also would have influenced the number of interappointment emergencies. Those extra visits, though, were always free of charge for the patient, and they were aware of that.

The incidence of interappointment emergencies found in the present study seems high. However, this might be explained by the length of the follow-up interval. Until eleven days following intervention, the incidence found in the present study was within the previously reported range of 1.5% to 5.5% (Table 3). Most studies assessed the incidence only a few days following intervention. In a recent study that was comparable to the present study, an incidence of 2.3% in three days interval was found [2], which is close to the incidence in the same time interval in the present study (2.9%).

The longer follow-up interval used in the present study made it possible to see that interappointment emergencies might occur not only in the first few days following intervention but also considerably later. An interappointment emergency occurs only in cases of pain or swelling that is severe enough to influence a patient's normal life, resulting in an unscheduled visit to the dental clinic [5]. Most studies used the term 'flare-up' to define similar emergency situations of pain or swelling [1,2,5]. According to the American Association of Endodontists, the definition of a flare-up is 'an acute exacerbation of an asymptomatic pulpal and/or periradicular pathosis after the initiation or continuation of root canal treatment' [30], the onset of which usually falls within a few days following intervention [5]. In the present study, both asymptomatic and symptomatic teeth were included, and the follow-up interval was extended to two months. This is the reason that in the present study the term interappointment emergency is used instead of flare-up. Interappointment emergencies as defined in the present study are clinically relevant since the time between appointments for the root canal treatment may take weeks or even months, not only in the undergraduate clinic, but also in other dental clinics. The apparent absence of increased risk of interappointment emergencies when no intracanal medicament is used in multiple-visit root canal treatment is valuable information that presumably contradicts opinions of practitioners and educators.

Conclusions

Interappointment emergencies can occur any time during the course of a root canal treatment, not only days but also weeks following intervention. However, most seem to occur within the first two weeks following intervention. Omitting the use of intracanal medicament in multiple-visit root canal treatment did not significantly increase the incidence of interappointment emergencies. The present work may encourage to reconsider using intracanal medication in multiple-visit root canal treatment.

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

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Authors' contributions

Conceptualization: Baaij A, Özok AR; Data curation: Baaij A, Jansen M; Formal analysis: Baaij A, Jansen M; Funding acquisition: n/a; Investigation: Baaij A, Jansen M, Özok AR; Methodology: Baaij A, Visscher CM, Jansen M, Özok AR; Project administration: Özok AR; Resources: Özok AR; Software: n/a; Supervision: Baaij A, Visscher CM, Özok AR; Validation: Baaij A; Visualization: Baaij A; Writing - original draft: Baaij A; Writing - review & editing: Baaij A, Visscher CM, Jansen M, Özok AR.

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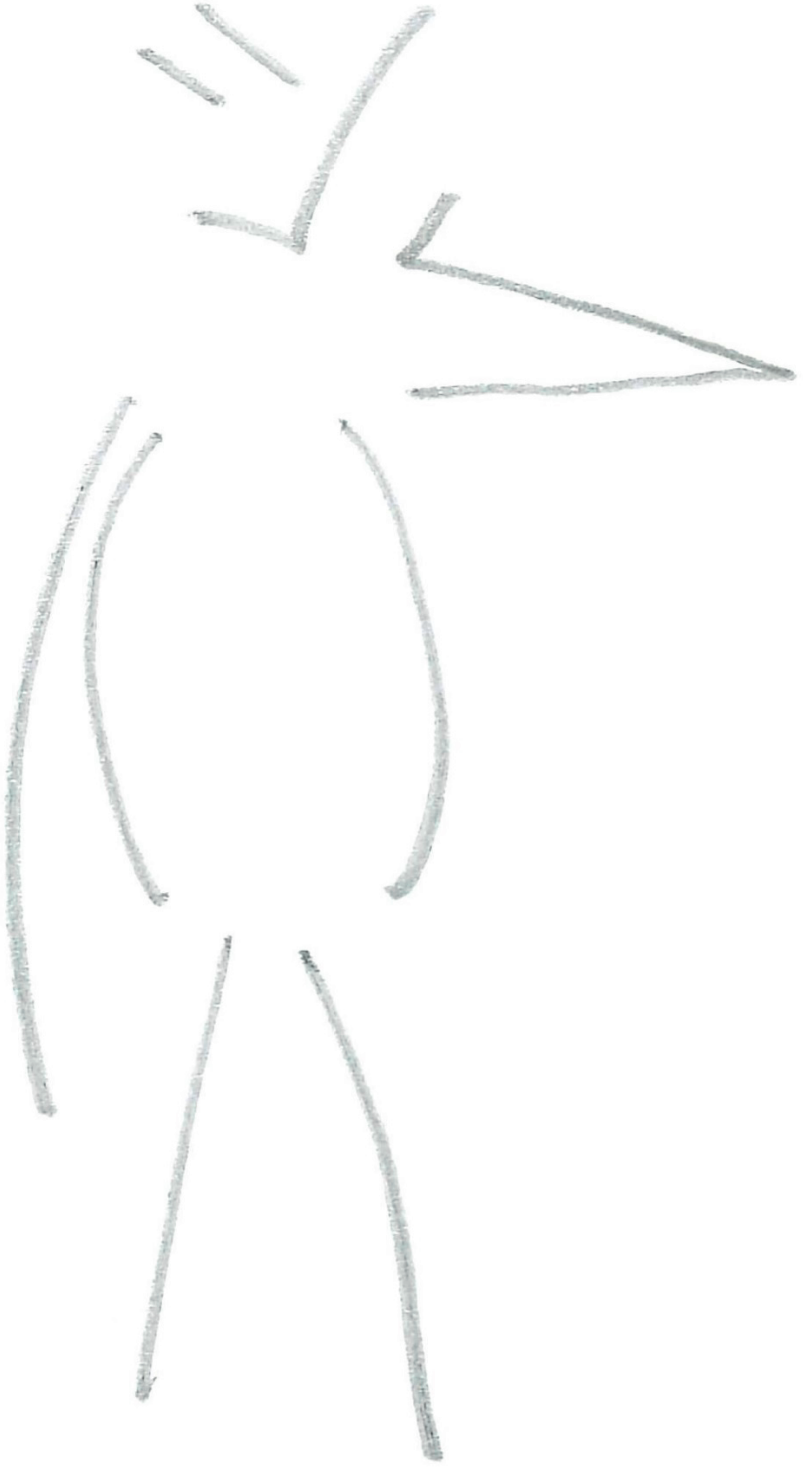

Chapter 7

General discussion

Comprehensive interpretation of findings

Extent of undergraduate education in Endodontology

At the end of their undergraduate dental education, students should be competent to perform indirect and direct pulp capping, and uncomplicated root canal treatments in both anterior and posterior teeth. This, in a nutshell, is what the European Society of Endodontology (ESE) states in their Undergraduate Curriculum Guidelines for Endodontology (ESE 2013). According to these guidelines, there is no need for the undergraduate education to accomplish that students reach the level of 'be competent at' for each and every competency within the field of Endodontology. The Association of Dental Education in Europe (ADEE) recommends in their Undergraduate Curriculum Framework that the Undergraduate Curriculum Guidelines for Endodontology of the ESE should be followed (Field *et al.* 2017).

Raamplan Mondzorg 2020 is the latest Dutch undergraduate curriculum framework for the education of dentists and dental hygienists. Although the Raamplan Mondzorg 2020 states that it follows the ADEE's Undergraduate Curriculum Framework (VSNU 2020), and consequently should follow the ESE's Undergraduate Curriculum Guidelines for Endodontology, it says that the novice dentist should be competent to treat endodontic cases that will be encountered in everyday practice. However, dentists will not only encounter uncomplicated cases in their practices, they will also encounter complex cases (Kirkevang 2021). It would be better if the complex cases are treated by more experienced practitioners who have followed formalized postgraduate education in Endodontology for three years (i.e. endodontists) (Kirkevang 2021). In the Netherlands, such a formalized postgraduate programme is present, and there are endodontists to whom dentists can refer the complex cases.

We would advise that the Raamplan Mondzorg follows the Undergraduate Curriculum Guidelines for Endodontology of the ESE. More specifically, we suggest that, in line with the requirements concerning other fields of dentistry, the level of competence described in the Raamplan Mondzorg for the field of Endodontology should be narrowed down to: 'at graduation, dental students are competent to provide uncomplicated endodontic care and they are trained to refer their patients for endodontic care that is beyond their skill set'. Preferably, for each of the subareas within the field of Endodontology (i.e. diagnosis and

decision-making, vital pulp therapies, regenerative treatments, care following dental trauma, surgical endodontic treatments, nonsurgical root canal treatments including retreatments, and the scientific foundations of endodontic practice) the required level of competence would be specified, just as done in the ESE's Undergraduate Curriculum Guidelines for Endodontology.

The students at ACTA are trained to perform indirect pulp capping and root canal treatments of difficulty levels DETI A or DETI BI to the level of 'being competent at'. The Guidelines for Endodontic Diagnostics and Treatment of the Dutch Society for Endodontology states that it would be good practice to use the Dutch Endodontic Treatment Index (DETI) and the Endodontic Treatment Classification (CEB) to assess the level of difficulty of a root canal treatment (Nederlandse Vereniging voor Endodontologie 2018). DETI A relates to uncomplicated cases and DETI BI relates to cases of average complexity that an experienced practitioner should be able to treat (Ree *et al.* 2003). Besides root canal treatments that are more difficult (i.e. DETI BII and BIII), also other types of endodontic treatments exist that are not fully covered in the undergraduate training, such as surgical treatments, vital pulp therapies and regenerative treatments. Hence, there is room for professional development in Endodontics following graduation.

In the introduction, we reported that many students would like to take a course in Endodontology following graduation. In our work, it was confirmed that a considerable number of novice dentists did take additional education in Endodontology already in the first year after graduation (chapter 5). Novice dentists in Denmark have to take 10 hours of continuing education in dentistry each year. In the Netherlands, continuing education is not obligatory but strongly encouraged. Continuing education might be undertaken to acquire advanced skills, but is also necessary to remain up to date.

For a novice dentist, the need for further education in Endodontology may depend on the level of competence they have acquired during their undergraduate training, their personal preferences, whether they feel prepared enough for their role as a dentist and the availability of referral possibilities for endodontic treatments that are beyond their skill set. Our data revealed that ACTA graduates feel a need for additional education in Endodontology since not only it appeals to their interest, but also, they think that they have acquired insufficient theoretical and practical skills and that additional education is necessary to maintain their skills (chapter 3). This is valuable information that may provide a basis for the improvement of the endodontic education at ACTA.

Be prepared and feel prepared

Even students who feel competent do not estimate their skills as being at the level that is expected of a general dental practitioner (chapter 3). This discrepancy might result from employing the term 'safe beginner' for dentists at graduation (Field 2017). Or it may result from anticipating lifelong learning (chapter 3). Another reason may be, however, that students feel competent because they have passed the assessments, while the discrepancy might reflect failure to fail (i.e. passing underperformance). When teaching staff for any reason pass a student who has not the required level of competence, it is a blessing if the student has higher expectations of the skills of a general dental practitioner than they have of their own, since that will probably be an incentive to improve their skills. To ensure that students have the required level of competence at graduation, assessments should be valid and reliable, and teaching staff should be successful in failing students who have not the required knowledge, practical skills or deep understanding.

At graduation, students are considered to be prepared enough for their jobs as dentist. However, they should not only be prepared but also feel prepared, and understand that they have enough skills to manage in practice and fulfil all the duties of a dentist. Learning for deep understanding may help to accomplish this. Deep understanding facilitates the transfer of skills (Perkins 1991).

Within ACTA's undergraduate curriculum, there might be room to improve understanding in Endodontology (chapter 2). This is illustrated by the finding that most of the ACTA students underestimated the complexity of the root canal treatment that they were planning to perform, and that students took unnecessary radiographs while performing root canal treatment (chapter 2). Determining the difficulty level of the root canal treatment is important to get insight into the possible challenges one could encounter while performing the treatment. If one foresees the possible challenges, it will be more likely that one will be able to manage and provide quality treatment than if one is not aware that these may be faced.

Deep understanding in Endodontology is important for taking good care of patients (chapters 1 and 5). Students' understanding should be assessed, both formative and summative. To assess understanding, it might be useful to ask students to provide a reflective narrative in relation to their work: what went well and how did they reach their conclusions, what did not go so well and what

were the reasons, what would they do differently or better next time, what is the expected prognosis if the treatment had been conducted on a patient, what did they learn (ESE 2018).

When we realized that there might be room to improve understanding in Endodontology, we revised the manual for root canal treatment that is used for the undergraduate training at ACTA. To stimulate students' reflection and understanding, a new structure was conceptualized. The manual now starts with the overall aim of a root canal treatment. For each step of the root canal treatment there is a dedicated chapter that starts with the purpose of that particular step, followed by an instruction to accomplish the objective safely. To help students to keep control over the treatment and to encourage learning for deep understanding, each chapter concludes with a checklist that may stimulate the reflection process and help them understand the procedure and their own results.

The level of being competent in performing root canal treatment can be reached by using simulated clinical training (chapter 2). Subsequently, clinical experience is important to raise feelings of preparedness and to build self-efficacy (chapters 4 and 5). Although the students would like to gain more clinical experience during their undergraduate training, this might be difficult to accomplish since the number of available patients is limited (chapter 4). To get more out of the available experience with practicing Endodontics, we introduced 'peer discussion about lessons learned': following a – for a student – remarkable experience in practicing Endodontics (clinically or preclinically), they share and discuss this experience and the accompanying lessons they have learned with their peers in the presence of a supervisor who guides the discussion, if needed. This may amplify the learning process of both the students who share their experiences and their peers. Besides, it may increase their self-efficacy as well. We learned from the feedback of the students that they found peer discussion about lessons learned very valuable. Sharing negative experiences and the accompanying lessons learned was, according to them, even more valuable than sharing positive experiences with lessons learned, and this applies not only to the peer students but especially to the student who shared the experience. To be able to share it, they have to reflect on what happened, what helps to process the experience and understand Endodontics. The subsequent discussion with their peers usually reveals that it could have happened to any one of them, which is comforting for the one who shares their experience but also for the peers. The questions of their peers show that they try to get insight and learn from the experience as well. Later on, while

reflecting on their own performance, students refer to experiences that their peers had shared earlier and this seems to comfort them.

Although the course evaluations by the students are positive regarding both the revised manual and peer discussion about lessons learned, further evaluation by means of scientific research is important to determine whether the aim of feeling well prepared for clinical practice following graduation has been achieved.

Teaching and learning methods

Lectures, literature and tutorials

Regarding Endodontology, students value small-group discussions on clinical cases and scientific literature with a tutor (chapter 3). At ACTA, the tutorials were scheduled concurrently with the simulated clinical training, and two years after a series of lectures. Although the number of tutorials in the undergraduate education at ACTA has increased (chapter 3), a considerable number of students would like to have even more (chapter 4). Other students seemed satisfied with the increased number of tutorials (chapter 4). Based on our data, it may be recommended to incorporate at least ten tutorials in the endodontic curriculum.

Tutorials may be regarded as an active teaching method. Currently, active teaching methods are preferred, since they are more effective to accomplish deeper learning. Providing students with lectures and literature is considered a passive teaching method, which is regarded as outdated (Manogue *et al.* 2011). However, students still appreciate lectures and literature; only a few students preferred less lectures and literature than they have received (chapter 4). Knowledge is required for learning for deep understanding (Perkins 1991), and lectures and literature may be advantageous and efficient in providing students with the necessary basis of theoretical knowledge in Endodontology (Shao *et al.* 2016). They may, therefore, be preserved in the endodontic curriculum, provided that the education in Endodontology starts with lectures and literature and continues with case-based or problem-based learning.

Although a combination of lectures, literature, tutorials, and case-based or problem-based learning may be sufficient to acquire the necessary theoretical knowledge and learning habits, it is not enough for learning Endodontics (ESE 2013). Additional clinical observation, or clinical pictures or videos, and preclinical training – even if it does not perfectly simulate clinical reality – is essential to prepare students for clinical practice (ESE 2013, Chevalier *et al.* 2021).

Active learning methods may possess the risk of causing confusion that may hamper the student's learning process and their self-efficacy when there is insufficient guidance by supervisors (Chevalier *et al.* 2021). The tutorials in our education were integrated with the simulated clinical training, which may have contributed to the tutorials being appreciated. The integration of tutorials with clinical observation, clinical training or simulated clinical training may be valuable to reduce any negative effects of confusion that may be caused by the different approaches that may be employed in the clinic, and the varying opinions that students and their clinical or preclinical supervisors may have.

Simulated clinical training versus clinical training

Training through simulation instead of on patients is safer and beneficial for both patients and students (chapters 2, 3 and 4). The Dutch law 'Wet BIG' dictates that skills training up to the level of being competent should be done in simulation whenever possible. Only when training in simulation is not possible, students may gradually and under close supervision train the required skills by performing the procedure in patients.

Based on our work, it can be concluded that it is possible to train and assess skills in performing root canal treatment effectively in an environment that simulates clinical reality as closely as possible (chapter 2). It is therefore recommended that students perform root canal treatments on patients only after they have trained in such simulated clinical environment and proved that they have acquired the required skills.

For building self-efficacy, clinical training is essential (chapters 3, 4 and 5). Performing root canal treatment in patients should therefore follow the simulated clinical training as an integral part of the undergraduate endodontic curriculum.

Clinical experience

Accomplishing a treatment of good quality is not only important for the patient but also for the student. Students who performed a root canal treatment of poor quality on a patient were more pessimistic about their capabilities of managing complications that may occur during a root canal treatment than students who performed a root canal treatment of good quality (chapter 3). People with low self-efficacy, and especially in the early phase of building it, attribute a failure to their capabilities that they regard insufficient even though that might be incorrect (Bandura 1977, Gist & Mitchell 1992, Leganger *et al.* 2000).

To build self-efficacy efficiently, the first treatments on patients should ideally be positive experiences. The chances for success are higher when the treatment is uncomplicated (chapter 2). Performing root canal treatments on molars or performing retreatments may cause a drop in the student's self-efficacy (chapter 4).

It remains difficult to predict how many relatively easy root canal treatments on patients should be performed ideally before starting to perform slightly more difficult treatments on patients, or how many root canal treatments on patients should be required minimally before graduation. Both the number and the types of root canal treatments the students performed on patients during their undergraduate training varied between the three programmes studied, as did the students' self-efficacy at graduation (chapter 4). Nevertheless, their self-efficacy generally increased following their graduation (chapters 5). Graduates from ACTA's standard programme had the least clinical experience before graduation; on average, they performed root canal treatments on three teeth (chapter 4). Although as little clinical experience as that may be adequate (chapter 5), more clinical experience would be preferred (chapter 4). Instead of providing a recommendation on the number of root canal treatments that should be performed on patients before graduation, we would advise that the difficulty level of cases accepted for students should be such that the aim of building self-efficacy will be accomplished and a drop in self-efficacy prevented as much as possible.

Supervision by general dental practitioners versus supervision by endodontists or dentists with special interest in Endodontology

It is reasonable to assume that general dental practitioners are skilled to perform the treatments that students are allowed to perform during their undergraduate dental training and therefore equipped to supervise them. However, helping a novice perform a treatment generally is more difficult than performing it yourself, and the root canal treatments the students perform in the undergraduate clinic are on many occasions more complicated than anticipated (chapter 2). Besides, general dental practitioners are often not comfortable performing root canal treatment themselves (Dahlström *et al.* 2017), let alone supervising students with little experience performing those treatments under their responsibility.

Endodontists or dentists with special interest in Endodontology have enhanced knowledge and skills in Endodontics, and they are probably more self-efficacious in Endodontics and in teaching Endodontology and supervising students who are providing endodontic care than general dental practitioners.

Their enhanced knowledge, skills and self-efficacy are probably the reason that under their supervision root canal treatments of higher quality were performed (chapter 2), which is not only preferred medically but may also result in higher self-efficacy of the students who performed the treatment (chapter 3). Besides, a supervisor who feels comfortable with Endodontics might be a better role model for the students than one who does not. When the supervisor does not feel comfortable it is probably more difficult for the students to feel comfortable, and that may negatively influence their performance and self-efficacy.

In the questionnaire used in chapter 4, students from ACTA commented that they highly appreciated the supervision by endodontists who have up-to-date experience from their own practices. These endodontists can facilitate challenging clinical case discussions, and their assistance in the clinic is of high quality. The students suggested that there should be more supervision by endodontists.

Recently, ACTA has reimplemented the 'endodontic consultants system' in the undergraduate clinic of ACTA where the daily supervision of dental care is provided by general dental practitioners. Within the endodontic consultants system there is an endodontic consultant present at the undergraduate clinic to assist the general dental practitioners and supervise students who are providing endodontic care to patients. The endodontic consultants are endodontists or dentists with special interest in Endodontology.

In the Undergraduate Curriculum Guidelines for Endodontology, the ESE already stated that clinical Endodontics should ideally be supervised by specialists or by staff with special knowledge and interest in Endodontology (ESE 2013). The present work provides scientific evidence to support their expert opinion by showing that supervision by endodontists or dentists with special interest in Endodontology is more advantageous than supervision by general dental practitioners (chapters 2, 3 and 4).

Continuity of education in Endodontology

The students commented on the lack of continuity in education in Endodontics at ACTA as being problematic, and they suggested to ensure more repetition in Endodontics in the curriculum, not only between the preclinical training and the simulated clinical training but also following the simulated clinical training until graduation (comments in questionnaire used in chapter 4). At ACTA, due to a shortage of available patients, students usually perform root canal treatments on patients only in the final year of their undergraduate training. Hence, there

is a gap of approximately two years between the simulated clinical training and the moment students start performing root canal treatments on patients. Ideally, students start with providing endodontic care to patients once they have acquired the required competencies, and continue to provide endodontic care to patients regularly. When there are not enough patients available who need endodontic care of a suitable difficulty level for the students to build self-efficacy and ensure continuity, students should regularly perform endodontic treatments in simulation and discuss cases. That the acquired skills should be employed regularly applies also for students who have not yet reached the required level of competency to treat patients. Also the gap between the simulated clinical training in the fourth year of ACTA's curriculum and the preceding theoretical and preclinical training in the second year is too large. Students feel that by the time they receive the simulated clinical training, all the skills and knowledge they had acquired earlier have faded away (comments in questionnaire used in chapter 4). Consequently, the simulated clinical training functions mainly as a refresher training instead of serving as an additional training to acquire advanced skills. This is quite unfortunate, especially because within the undergraduate curriculum the time dedicated to Endodontology is limited. It is even considered too little according to students of ACTA (comments in questionnaire used in chapter 4). Within the undergraduate curriculum of ACTA, the time dedicated to Endodontology will increase in the coming years. However, probably not every dental school has the possibility to increase the time dedicated to Endodontology when that is desirable. The education in Endodontology may be more efficient and effective when it starts not in the second year but in the third or the fourth year of the curriculum and when continuity in practising Endodontics is ensured. This way, not only skills retention will probably improve, but also a higher level of skills might be acquired.

Culture

Most novice dentists in the Netherlands work in group practices (chapter 5), probably because of the presence of other – more experienced – dentists. However, the availability of help from colleagues was not associated with an increase in the novice dentist's self-efficacy (chapter 5). Besides, when novice dentists referred their patients for endodontic care, it was in most cases not to another general dental practitioner. For root canal treatment, retreatment, care

after dental trauma or for the treatment of resorptions, they generally referred their patients to an endodontist, and for endodontic surgery to an oral surgeon (data not shown). Altogether, this made us wonder which role more experienced dentists play for novice dentists. It would be interesting to further explore this. Modelling, persuasion and feedback can be expected, for instance, and all may influence self-efficacy, positively or negatively (Gist & Mitchell 1992, Wulf *et al.* 2010). Besides, more experienced dentists may influence the attitude of the novice dentist, and attitudes are a cornerstone of professional action (Passi *et al.* 2010). Professional action involves knowledge, skills and attitudes, and professionalism is learned for an important part by modelling (Passi *et al.* 2010). Professionalism is developmental and highly context specific (Passi *et al.* 2010).

At the dental school, teaching staff act consciously or unconsciously as role model (Cruess *et al.* 2008, Passi *et al.* 2010). They should be aware of that and trained for it (Field *et al.* 2017). However, also the conditions should be favourable; an institutional culture that leaves insufficient time for supervisors to promote the type of reflective practice needed to demonstrate best practices amongst students, is detrimental to effective role modelling (Cruess *et al.* 2008). Besides, the prevailing culture can facilitate failure to fail (i.e. passing underperformance) (Monrouxe *et al.* 2011). Failure to fail jeopardizes the assurance that at the end of their undergraduate training students fulfil all the requirements for graduation, which is the basis for professional action. Hence, the dental school's culture should be reflected on to be able to ensure quality education.

That the majority of ACTA students wanted more feedback from their supervisors (chapter 4), might be a sign of an institutional culture that is suboptimal. However, it could as well be a sign that the supervisors were not trained enough in providing feedback. Although the finding was considered to be a reflection of the variability in students' learning preferences (chapter 4), it is advised to explore other possibilities as well, because that may help to understand which measures would be effective to accomplish that the students perceive that they receive ample feedback from their supervisors.

With the recent introduction of a new portfolio system to monitor the student's individual progress in their clinical work, ACTA has taken a step to improve the educational system. The new system uses entrustable professional activities (EPAs) for the assessment of student's learning and their development, and to collect feedback. With an EPA-based clinical assessment system, the students are responsible for the acquisition of sufficient feedback (Bremer *et al.* 2022). This

may result in a change of the culture (Bremer *et al.* 2022). The newly implemented system also includes training of teachers in providing rich feedback to the students. It would be interesting to study whether this new system improves student's development, as supposed, and to study how valid and reliable the EPA-based portfolio system is for determining whether an undergraduate dental student is ready for independent clinical practice outside the dental school. It would also be interesting to study the effects of this new system on the teaching staff.

Other factors related to education in Endodontology

Education in Radiology

More training in taking periapical radiographs for Endodontics is necessary at ACTA (chapter 2). On top of the general difficulties of taking periapical radiographs, the cofferdam that is in place during a root canal treatment complicates taking periapical radiographs for Endodontics. Besides, one should be careful to not displace files or gutta-percha cones that could be present in the tooth and, moreover, the radiograph should be taken from an appropriate angle which can be challenging to accomplish. To reduce the number of failed radiographs and to expose patients to as little radiation as possible (ALARA principle), students should be trained well for this task. To accomplish this, it might be helpful to integrate part of the preclinical training in Radiology with the simulated clinical training in Endodontics. Training conditions that closely simulate the actual situation with a patient should be created for the students.

Shortages

The students at ACTA found it unfortunate that there were, to their perception, too few patients available for gaining clinical experience in performing root canal treatment (comments in questionnaire used in chapter 4). Shortage of resources is a widespread problem causing challenges. Shortages may include not only the available patients, but also available materials, time or staff for instance (chapters 2 and 4).

The collateral finding that the number of root canal treatments performed by undergraduate students on patients was reduced by half from one year to another (chapter 6) caught our eye. This reduction in performed root canal treatments coincided with the implementation of a new course in Implantology in the undergraduate curriculum at ACTA (ACTA 2012). As part of this course, students

could give away four implants for free to their patients (ACTA 2012) while patients had to pay for other treatments. This might have influenced the decision making in the undergraduate clinic. Patients may have decided to choose for extraction and an implant instead of saving the tooth by root canal treatment. Apart from the financial benefits, the new course in Implantology might have influenced decision making also in another way. Regarding the handling of endodontic pathology, the decision making by undergraduate students is influenced not only by the education in Endodontology but also by the education in Implantology (Pineda *et al.* 2018). Implant treatment is found to be indicated more often when the education in Implantology is scheduled after the education in Endodontology in the dental curriculum (Pineda *et al.* 2018), which is the case in ACTA's undergraduate curriculum.

When developing an undergraduate dental curriculum, it is important to realize that certain treatments may be favoured over others due to the way the curriculum is structured. If one treatment is favoured over another, the attitude of patients – and hence the general attitude of people towards those treatments in general – may change. Both teaching staff and students should be aware of this mechanism and their role in it. Following the implementation of curricular changes, it would be good practice not only to evaluate whether the educational goals aimed for are reached, but also to explore whether the changes had any secondary consequences (e.g. changes in patient care).

Although our work suggests that little clinical experience in performing root canal treatment during undergraduate training might be enough (chapter 5), a reduction in the number of root canal treatments performed on patients can be considered as problematic. Root canal treatment is not obsolete and students should gain experience in performing uncomplicated root canal treatments on patients during their undergraduate training (chapters 1 and 4).

To increase the number of root canal treatments available for the students, uncomplicated root canal treatments were performed free of charge at the undergraduate clinic of ACTA since 2020, which seems to be an effective measure. Apparently, the treatment costs can influence patients' decision making. It is in the patient's interest when this allows them to receive the indicated treatment that they could otherwise not afford. However, the fact that the treatment is – temporarily – free of charge might be an incentive to choose for this treatment even if it is not the recommended option. Performing root canal treatments free of charge cannot endure because it is not financially sustainable, at least not in the Netherlands.

For a sustainable solution, and to ensure sound decision making, it might be useful to reflect on the decision-making process in the undergraduate clinic, and to adjust the education if indicated. Integration of the education in Endodontology with the education in Implantology regarding decision making might be helpful.

When root canal treatment is chosen and started, there remains a chance that the treatment will not be completed (Krishnan *et al.* 2019). The decision for extraction midway the treatment may be triggered by an interappointment emergency (chapter 6), and therefore, among other reasons, it would be beneficial when the risk for interappointment emergencies during the root canal treatment is reduced. To that end, it might help to reduce the number of appointments and the amount of time between appointments of the root canal treatment whenever possible (chapter 6). The reason for patients to neither return for completion of the root canal treatment nor for extraction of the tooth in which the root canal treatment was started, remains unsure (chapter 6). It is not only inconvenient for the student if their patient does not return for completion of the root canal treatment, but also incomplete treatment of endodontic pathology is risky for the patient, and therefore the reasons to have the root canal treatment not completed should be studied further (Krishnan *et al.* 2019).

As part of the measures taken to increase the amount of experience students will get in performing root canal treatments in patients before they graduate from ACTA, it has been decided that students are allowed to perform root canal treatments in the general dental practice where they perform their final year's internship. Even though our work reveals that part of the process of building self-efficacy may take place outside the dental school, this approach cannot be validated based on our work. Participants in our study were graduates and they generally had more clinical experience in Endodontics in an undergraduate clinic before they started to perform root canal treatments outside the dental school (chapter 4). To keep track of what the students learn from performing root canal treatments in the general dental practices, we would advise to integrate the students' experience in Endodontics during their internships with in-school peer discussion about lessons learned, under the supervision of endodontists. In addition, the value – along with possible risks – of this approach to acquire clinical experience in Endodontics outside the dental school should be studied.

As an alternative measure to deal with the challenges of limited numbers of – for students suitable – endodontic patients, students can be trained in dyads (chapter 4); peers train their clinical skills in pairs. They think together, discuss

together, and provide each other feedback before they consult their supervisor who subsequently will discuss with, and provide feedback to, the pair instead of only to the student who physically performed the treatment. The peers will alternate roles; one time the one student will actually perform the treatment (i.e. physically and mentally performing treatment) while the other student is observing, helping, and providing feedback (i.e. mentally performing the treatment), and the other time the roles will be switched. This way, resources are used more optimally. Moreover, training in dyads benefit students' learning since it can result in enhanced retention and transfer of skills (Wulf *et al.* 2010).

Society

Our work may inspire to reconsider the materials used for endodontic treatment (chapter 6). Are they all necessary, or could we quit or replace some? Should we adapt protocols in our undergraduate clinics in the interest of the patients, the students, or the planet? One cannot longer ignore to take environmental sustainability into account, which has many facets within dentistry and dental education (Duane *et al.* 2021).

Healthcare costs are a widespread problem. Regarding Endodontics, money can be saved when the primary root canal treatment is effective and the need for root canal retreatment or surgical endodontic treatment reduced. When no additional treatment becomes necessary, less material, energy and travel would be necessary, which is beneficial for the planet (Duane *et al.* 2020). Besides, effective primary root canal treatment is favourable to the patient and may contribute to improving the general attitude towards root canal treatment.

To increase the chances that primary root canal treatment will be effective, a root canal treatment of good quality has to be performed (Ng *et al.* 2011). Undergraduate education should accomplish that at graduation students are skilled to perform root canal treatments of good quality, and, equally, that the students are aware of their limits and that they will refer their patients when that is necessary to ensure quality treatment.

Implications for practice

It is important to be clear about the level of competence that is to be acquired during the undergraduate training (ESE 2018), and each school should provide up-to-date information about this. Although the European guidelines (ESE 2013, Field *et al.* 2017) state clearly what the minimum level should be, not all schools comply (Al Raisi *et al.* 2019). Presumably, limited time or resources are the reason for not complying. As it comes to clinical experience, the guidelines may be slightly more open to interpretation (chapter 4).

To provide students with clinical experience when there is a shortage of patients who need uncomplicated root canal treatment, dental schools may decide to allow students to perform more complicated treatments (Al Raisi *et al.* 2019). Although students would like to gain plenty of clinical experience in performing root canal treatments of varying difficulty levels during their undergraduate training (chapter 4), this 'solution' is not recommended since it probably will decrease the self-efficacy of those students with no or barely any clinical experience (chapter 4). Besides, allowing students to perform complicated treatments on patients could undermine a fundamental message that practitioners should refer patients for treatments that are beyond their skill set.

To build self-efficacy efficiently, students should start with performing uncomplicated root canal treatments on patients (chapter 4). Only little clinical experience before graduation seems necessary to manage to perform root canal treatments – of increasing difficulty level – in practice after graduation, and to build self-efficacy (chapter 5).

Our work may bring about a shift in the opinion about the actual value of clinical experience from acquiring or testing skills in performing endodontic treatment to building self-efficacy (chapters 4 and 5). As a consequence, the simulated clinical training can be regarded as most important for both formative and summative assessment of the student's level of competence. It is still unclear, however, whether for all endodontic treatments the required skills can currently be trained and assessed effectively in an environment that simulates clinical reality as closely as possible. We studied root canal treatments only; our findings cannot be generalized to direct pulp capping for instance.

Whenever possible, skills should be trained and assessed in simulated conditions, and teaching staff should not compromise and should ensure that the required level of competence is reached before students are allowed to perform

the treatment on patients. This would be beneficial to the students' learning since it provides them with the opportunity to improve, when necessary, without the risk of harming a patient; we owe that to them, to their future patients, and to our profession (Scholes & Albarran 2005, Bush *et al.* 2013, Monrouxe *et al.* 2011). In clinical education not only the development of the student is important but also the safety of both the patient and the student, and the quality of care the patient receives.

If there is too little time or staff to provide students with both simulated clinical training and clinical training in performing root canal treatment, our work may be used to decide that acquiring the necessary skills – in simulation – should have priority over clinical experience per se (chapters 2, 3 and 5). However, dental schools should work towards a situation where both simulated clinical training and clinical training are an integral part of the undergraduate endodontic curriculum. Although transfer of patient management skills that are learned elsewhere in the undergraduate dental education will probably occur and may be sufficient to be able to deal with the patient related factors encountered while performing endodontic treatment (chapter 2), it would be desirable if students get some experience in providing endodontic care to patients before they graduate to experience that they have enough skills to manage in practice. Clinical experience is important for building self-efficacy, and that should start before graduation (chapters 3, 4 and 5).

To be able to provide students with the preferred supervision by endodontists or dentists with special interest and knowledge in Endodontology, and to provide dentists with possibilities to refer patients who need more complicated endodontic care, these experts should be available in sufficient numbers (chapters 4 and 5). A formalized postgraduate programme in Endodontology may help to ensure this (chapter 4). It is unachievable and unnecessary for every dental school to have a formalized postgraduate programme in Endodontology, but it would be advisable to have at least one such programme in every country. Our work may motivate regulatory bodies to ensure that there will be enough formalized postgraduate programmes in Endodontology.

Future directions

Teaching staff at dental schools around the world encounter many challenges, such as shortage of resources, failure to fail (i.e. passing underperformance), and changing of generations of students, to name a few. Although the challenges may be similar among the dental schools, their staff deals with these usually all by themselves. As long as little is published on insights in relation to undergraduate education in Endodontology, staff may spend time and effort reinventing the wheel, probably often by trial and error. Although this thesis provides clues about the effectiveness of some teaching methods, the preferred expertise of supervisors, and the clinical experience that would be necessary for an effective undergraduate education in Endodontics, it is not enough. More research is necessary to point out which ways of teaching and learning Endodontology are most efficient and effective.

Fortunately, a growing number of people shares the desire for drawing attention to education in Endodontology. The ESE supports both education in Endodontology and research on education in Endodontology, and luckily the number of publications on education in Endodontology is increasing. Not only established methods are being analysed, but also new tools for providing education in Endodontology are being developed and studied (Shao *et al.* 2016, Al Raisi *et al.* 2019, Hanafi *et al.* 2020, Reymus *et al.* 2020, Segura-Egea *et al.* 2021). The goal of undergraduate education in Endodontology – to prepare students for their jobs as dentist – should be kept in mind when conducting research, interpreting findings and making policy. The education should accomplish the objective that dentists are both competent and self-efficacious in Endodontics. Tools and methods should be complementary to accomplishing this objective, but not overshadow it nor become a goal on their own.

For thorough insight, the development process both during undergraduate dental education of the student and following graduation of the novice dentist needs to be understood. Continuing research on education in Endodontology is not only important to improve insight, but also to remain up to date when situations change. Gained insights should naturally result in curricular changes to provide – or keep providing – optimal education.

Reflection

I aimed to optimize undergraduate dental education and I searched for the 'ideal' education. Personal experiences with dental education together with reasoning and the things that I learned during my training and practice as sailing instructor, formed the starting point. I believe in learning for deep understanding, in transfer and in a student-centred approach that not only focuses on the end products that should be relevant but also on the processes that result in those end products. I believe in methods that Perkins described as 'Educating for Insight' (Perkins 1991).

When I started this doctoral programme, I wanted students to learn and experience as much as possible during their undergraduate dental training, and my view on 'the ideal' was to set the bar high. This may fit quality education, where dental schools stand for. Academia, however, concerns more than education, scholarship and research. An academic centre is a business too, often with limited resources. Yearly, a new cohort of students arrives who should be educated within given timeframes. For the individual staff members, the education they provide usually could be summarized as 'the best one could do under the given circumstances'. But, is that good enough? And what does it do to the dedicated staff when they continuously give the maximum that they can? Should they push themselves continuously this far, or is that not always necessary? Besides, is there no risk of a downward spiral when one just keeps conforming to the prevailing circumstances? To keep the ball rolling when there is a chronic imbalance between the number of students who need to be educated, the allocated time and the available teaching staff, one may need to set the bar lower to survive and to prevent escalation. Setting the bar too high may result in failure to fail (i.e. passing underperformance). When there has been too little time or supervision for the students to reach the set level of competence, teaching staff may feel responsible for the student's underperformance and may compromise while assessing the student's skills (Duffy 2003, Bush *et al.* 2013). Besides, it often is easier to pass students than to fail them (Bush *et al.* 2013). The assessor needs to be skilled to detect all cases of underperformance. It also necessitates extra time and effort from the assessor to fail a student (Scholes & Albarran 2005, Bush *et al.* 2013), and usually only the students who have failed request their assessors to substantiate their decision (Bush *et al.* 2013). Furthermore, the students who failed should be provided with additional training and assessment which means that they put an extra load on the resources (Bush *et al.* 2013). When there is an imbalance between the number of students and the available resources, repeaters may cause that this

imbalance deteriorates. I now understand better that 'learning as much as possible during undergraduate dental training' involves more factors that are influential than solely the learning curve of the student, and I started to reconsider whether my previous idea of 'the ideal' is actually optimal. I now feel that on certain aspects, and in certain situations, less is more. Also using self-efficacy as an outcome measure helped me to understand and accept this. Besides, we recognize that in the current society deeper learning and collaboration is preferred. In line with that, a dentist should not be expected to be able to provide all endodontic care themselves but to work together with other experts.

It can be concluded that self-efficacy is a useful outcome measure, and that the Endodontic General Self-Efficacy Scale a reliable tool worth introducing in research on education in Endodontology (chapters 3 and 4). Studying the development of the young practitioners both before and after graduation provided new insights in the field of Endodontology.

New insights are not always received enthusiastically. They may cause a need to reconsider the methods in use, and that may be uncomfortable for the teaching staff, especially for those who are not self-efficacious. When the teaching staff do not feel assured that they meet all the expectations that may be assigned to their position, new insights and changes may make them feel vulnerable which may cause resistance. Traditionally, teaching staff at an academic centre comprised of experts in their field of study. In sports, however, it is well known that being a champion does not necessarily mean that one is a good trainer or a good coach too. To lead a sportsperson to the top, an educator, a trainer, and a coach are selected. The educator builds the educational programme, the trainer supervises the sportsperson while they are exercising, and the coach provides moral support. Each position requires its own specific skills. It could, however, be possible for one person to fulfil all the three positions. In dental education, to supervise students, teaching staff should have at least training skills, and preferably coaching skills as well, on top of their expertise in the field of study. They should be skilled at assessing not only students' performance and theoretical knowledge but also their insight, and at providing effective feedback. They should stimulate the students' development. Those skills should be acquired before, or at the latest when, they begin their position as supervisor. Being skilled is a prerequisite for self-efficacy, and teaching staff should be self-efficacious in their position.

To frame and build the education, one needs the capacity to integrate the various aspects fundamental to education. Expertise in the field of study and

understanding of the circumstances under which the future graduates will practise are necessary to determine the extent and content of what the students should learn, and to decide on the theory and methods that will be taught. To subsequently build a good educational programme, one should be aware of the various learning styles and the effectiveness of various learning and teaching methods. Besides, one should have the skills to supervise the teaching staff who execute it.

The institutional culture should not be ignored. Staff has to collaborate, and they have to be open for feedback – from various sources – and new insights. To collaborate successfully, transparency is required. It may be helpful to also be transparent about the contribution of the individual team members since this may make them feel rewarded and may help them to feel safe to speak up and share initiatives. The shared goal should be quality education and the institutional culture should be conducive to accomplish this.

To keep up the quality of the education, reflection is necessary. Unfortunately, the good intentions of teaching staff do not always turn out advantageous. It is important for all teaching staff to frequently reflect on their performance and think over the – possible – consequences of their choices or actions regarding education. It is important to be aware of the implicit messages one may convey. Teaching staff may ask themselves the questions 'What do I transmit; what does the student take from this?' and 'What would or should I transmit?'. Obviously, the answer to both questions should be alike. However, without continuous reflection, they may easily and unnoticed drift apart.

Although it is evident that the education exists for the students and because of the students, it is important to keep this in mind. It can sometimes be challenging to work with students because of their individual or group characteristics. However, the students should never be considered responsible for any ineffective education. Education that turns out to be ineffective should be regarded as a sign for necessary change and as a call for a comprehensive reflection.

For the most part, the content in this reflection section may seem unusual in a doctoral thesis. However, collateral insights may have influenced the considerations throughout this general discussion, and may therefore be considered noteworthy. Besides, being the one who started off in our undergraduate education with peer discussion about lessons learned, I felt somewhat obliged to incorporate various insights that I have gained myself.

My current view on education in Endodontics

Although its effectiveness is not studied and verified in the present work, I uphold the method of guiding students by stimulating them to reflect on their performance, and helping them to find out and understand what works in their hands. Instead of focussing on numbers of performed treatments, students should be guided to the required level of competence by means of improving their understanding in Endodontology and their control over their performance (Perkins 1991). I feel that students' reflection on their skills and limitations that have resulted in their performance is important to achieve their deep understanding of the subject matter, and that it may help them to enhance their skills and their control over their performance. Besides, students should get accustomed to reflecting on the root canal treatment while they are performing it in order to be in control during the treatment and to be able to make adjustments if that would be necessary for success (chapter 1).

Undergraduate students should be provided with a solid base of skills, knowledge and deep understanding, from which they can manage every endodontic case, that is that they are ready to provide uncomplicated endodontic care and that they are aware of their limitations and refer patients for endodontic care that is beyond their skill set and experience. Although I fully recognize the importance of clinical experience, to build self-efficacy and to gain experience in handling the patient related factors, I feel that for undergraduate dental students simulated clinical training to gain experience with different root canal morphologies, and to perform root canal treatments of various difficulty levels, is of utmost importance to acquire the necessary skills for clinical practice. I believe that those conditions without the risk of harming a patient are perfect to safely explore their limits, and push them, along with building understanding and skills that are conducive to transfer. To build such skills and understanding takes time and effort, not only from the student, but also from their supervisor.

With limited time and resources, it might be tempting to choose for an easy and quick way of teaching. However, this would probably be detrimental to retention and transfer of skills in Endodontics. Skills are essential, for professional action and for self-efficacy. To my opinion, it is important to ensure that there is enough time dedicated to Endodontology in the undergraduate curriculum.

Endodontics is difficult, among other reasons, due to the variety in root canal morphology. To reduce the risk of iatrogenic damage or disease and secure optimal

care for patients, it is important that the student recognizes the complexity of the treatment, and knows which cases they can manage with their skill set, the available materials and the methods they master.

To achieve deep understanding in Endodontology, I think that for most students the use of manuals, video clips, or other currently available tools that support self-study or peer-assisted learning are not enough. I feel that in addition to both preclinical and clinical experience, supervision is essential to build the reflection capacity that is necessary for deep understanding of Endodontics. A high staff-student ratio is necessary to interact with the students and guide them in their learning process efficiently (Al Raisi *et al.* 2019). Preferably, the supervision is provided by self-efficacious experts in Endodontics with training and coaching skills. Training in dyads, peer discussion about lessons learned, or other peer-assisted learning methods that include supervision – preferably of an expert in Endodontics – can be used to accomplish optimal utilisation of the available resources for clinical or simulated clinical training.

The method taught for root canal treatment should ideally be one that could be safely applied to all cases. The students should be provided with a base that they can simply use or safely build on in their practices following graduation. Furthermore, a clear and realistic aim that is based on a vision is imperative for effective undergraduate education in Endodontology; not only for the students, but especially for the teaching staff to be able to develop an effective educational programme and teach optimally.

Once the retention of the required minimum level has been achieved, deepening of any kind can be added as an academic bonus. However, whether that would be beneficial may depend, among other things, on the capacity of the individual student. Deepening may result in confusion, which would be counterproductive. To protect students from potential harmful effects of leaps, one should always take the student's skill set and learning curve into account while guiding them, and choose the things one offers accordingly. In the entire learning process, the exposure should be gradual, not only in the clinical training (chapters 4 and 5), but also in the simulated clinical training and the theoretical deepening.

The exit level of undergraduate education in Endodontology may differ between universities due to their philosophies or resources. It may also depend on the referral possibilities that will be available for their graduates. Ideally, there should be no need for general dental practitioners to provide all endodontic care themselves; it should be sufficient for a general dental practitioner to be

competent to deliver uncomplicated endodontic care, provided that there are enough referral possibilities for the more complicated care. However, when they are up to that, dentists may develop their skills in Endodontics to an experienced or expert level. Formalized postgraduate programmes in Endodontology should be available for those who want to become an endodontist.

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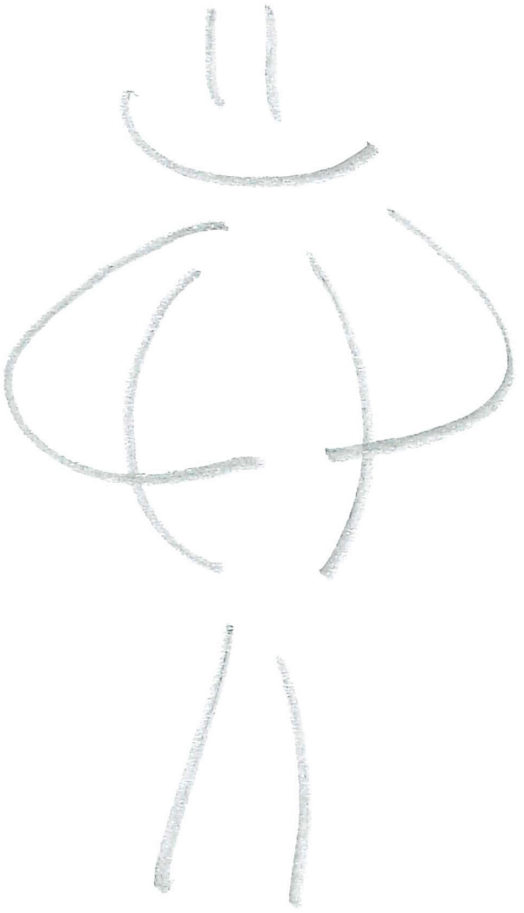


Summary

The research that forms the core of this thesis looked at how well root canal treatments on patients were performed following clinical training versus simulated clinical training (chapter 2), at aspects of undergraduate education in Endodontology that could influence the building of self-efficacy (chapters 3 and 4) and at how self-efficacy changes following graduation (chapter 5). In addition to that, interappointment emergencies, which are inconvenient, were studied (chapter 6).

Our work shows that for building up self-efficacy in Endodontics, clinical experience in performing root canal treatment is vital. Students benefit most from gradual exposure and from supervision by endodontists during their undergraduate training. However, skill training up to the level of being competent should be done in simulation.

Chapter 2: Students who trained their skills in simulation performed root canal treatments on patients at least as well as those who trained their skills by performing root canal treatments on patients. Higher quality root canal treatments were obtained under supervision of endodontists than under supervision of general dental practitioners.

Chapter 3: Not the methods of clinical training and assessment, but the number of tutorials and the number of root canal treatments performed under supervision of endodontists influenced the self-perceived competence and the self-efficacy of students.

Chapter 4: The self-efficacy of students from Aarhus University and from the Academic Centre for Dentistry Amsterdam was comparable. Students' self-efficacy was influenced mostly by their clinical experience when performing root canal treatment. Students' self-efficacy increased with the number of treated root canals in patients; however, retreatments and root canal treatments in molars were negatively associated with self-efficacy.

Chapter 5: The self-efficacy of novice dentists generally increased within the first year following their graduation from Aarhus University or the Academic Centre for Dentistry Amsterdam. The increase in self-efficacy was greater for those who had low self-efficacy at graduation as compared to those who graduated with a high level of self-efficacy. Performing root canal treatments was an important factor in increasing self-efficacy.

Chapter 6: The incidence of interappointment emergencies in molar root canal treatments performed in multiple visits by undergraduate students was 10.7%. Sixty-two percent of the interappointment emergencies occurred within two weeks following the latest intervention. The incidence of interappointment emergencies was not significantly increased by omitting the use of calcium hydroxide intracanal medicament.

Samenvatting

Het onderzoek dat de kern van dit proefschrift vormt, vergeleek voor het aanleren van het uitvoeren van wortelkanaalbehandelingen, training in simulatie, met training door middel van het uitvoeren van deze behandelingen bij patiënten (hoofdstuk 2), het keek naar aspecten van het onderwijs in de endodontologie die eventueel bij zouden kunnen dragen aan het opbouwen van zelfeffectiviteit (hoofdstukken 3 en 4) en het onderzocht hoe de zelfeffectiviteit zich ontwikkelde na afstuderen (hoofdstuk 5). Daarnaast werd er nog gekeken naar pijnklachten (extra behandelafspraken als gevolg van zwelling en/of pijn) die tussen de geplande behandelzittingen voorkomen (hoofdstuk 6).

Uit ons onderzoek blijkt dat essentieel voor het opbouwen van zelfeffectiviteit met betrekking tot endodontologie is, het bij patiënten uitvoeren van wortelkanaalbehandelingen. Idealiter geschiedt dit onder supervisie van endodontologen tijdens de opleiding tandheelkunde. En ervaring opdoen met behandelingen die stapsgewijs steeds wat moeilijker zijn, is het meest gunstig. Het trainen van vaardigheden totdat de student bekwaam is, dient echter in simulatie te geschieden.

Hoofdstuk 2: Studenten die hun vaardigheden trainden in simulatie, voerden wortelkanaalbehandelingen bij patiënten minstens net zo goed uit als studenten die hun vaardigheden trainden door middel van het uitvoeren van wortelkanaalbehandelingen bij patiënten. En onder supervisie van endodontologen werd een hogere kwaliteit behaald dan onder supervisie van algemeen practici.

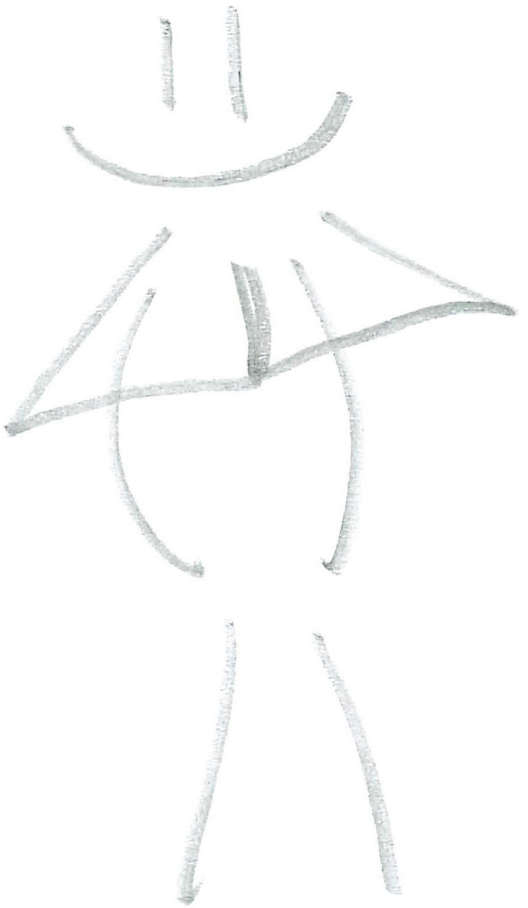
Hoofdstuk 3: Niet de methode van klinische training en toetsing, maar het aantal werkgroepen en het aantal wortelkanaalbehandelingen dat onder supervisie van een endodontoloog was uitgevoerd bij patiënten, beïnvloedde de mate waarin studenten zichzelf competent achtten en de zelfeffectiviteit van studenten.

Hoofstuk 4: De zelfeffectiviteit van studenten van de Universiteit van Aarhus en van studenten van het Academisch Centrum voor Tandheelkunde Amsterdam was vergelijkbaar. De zelfeffectiviteit van studenten werd voornamelijk bepaald door hun klinische ervaring met het uitvoeren van wortelkanaalbehandelingen. De zelfeffectiviteit van studenten nam toe, met het aantal bij patiënten behandelende wortelkanalen. Het uitvoeren van behandelingen in molaren, en het doen van herbehandelingen, had echter een negatieve invloed op de zelfeffectiviteit.

Hoofdstuk 5: De zelfeffectiviteit van net afgestudeerde tandartsen nam over het algemeen toe in het eerste jaar na hun afstuderen van de Universiteit

van Aarhus of van het Academisch Centrum voor Tandheelkunde Amsterdam. Van degenen die ten tijde van afstuderen een lage zelfeffectiviteit hadden, nam de zelfeffectiviteit meer toe, dan van degenen die bij afstuderen een hoge zelfeffectiviteit hadden. Het uitvoeren van wortelkanaalbehandelingen was een belangrijke factor voor het laten toenemen van zelfeffectiviteit.

Hoofdstuk 6: De incidentie van pijnklachten bij wortelkanaalbehandelingen in molaren die in meerdere zittingen uitgevoerd werden door studenten tandheelkunde was 10,7%. Tweeënzestig procent van deze pijnklachten traden op binnen twee weken na een behandelafspraak. De incidentie van pijnklachten was niet significant hoger als er geen calciumhydroxide gebruikt werd.



Author contributions

Chapter 2

Method of teaching undergraduate students to perform root canal treatment: Its influence on the quality of root fillings
Annemarie Baaij, Ahmet Rifat Özok

Conception	AB
Study design	AB, ARÖ
Data acquisition	AB, ARÖ
Data analysis and interpretation	AB, ARÖ
Manuscript preparation	AB
Manuscript editing and review	AB, ARÖ

Chapter 3

Influence of method of teaching Endodontics on the self-efficacy and self-perceived competence of undergraduate dental students
Annemarie Baaij, Ahmet Rifat Özok

Conception	AB
Study design	AB, ARÖ
Data acquisition	AB, ARÖ
Data analysis and interpretation	AB, ARÖ
Manuscript preparation	AB
Manuscript editing and review	AB, ARÖ

Chapter 4

Self-efficacy of undergraduate dental students in Endodontics within Aarhus and Amsterdam
Annemarie Baaij, Ahmet Rifat Özok, Michael Væth, Peter Musaeus, Lise-Lotte Kirkevang

Conception	AB, LLK
Study design	AB, ARÖ, PM, LLK
Data acquisition	AB, LLK
Data analysis and interpretation	AB, ARÖ, MV, LLK
Manuscript preparation	AB
Manuscript editing and review	AB, ARÖ, MV, PM, LLK

Chapter 5

The change in self-efficacy of novice dentists in Endodontics within the first year following graduation from Aarhus University or the Academic Centre for Dentistry Amsterdam

Annemarie Baaij, Michael Væth, Ahmet Rifat Özok, Corine Mirjam Visscher, Lise-Lotte Kirkevang

Conception	AB, LLK
Study design	AB, LLK
Data acquisition	AB, LLK
Data analysis and interpretation	AB, MV, ARÖ, CMV, LLK
Manuscript preparation	AB
Manuscript editing and review	AB, MV, ARÖ, CMV, LLK

Chapter 6

Incidence of interappointment emergencies in multiple-visit root canal treatments performed with or without intracanal medicament by undergraduate students

Annemarie Baaij, Corine Mirjam Visscher, Manon Jansen, Ahmet Rifat Özok

Conception	AB, ARÖ
Study design	AB, CMV, MJ, ARÖ
Data acquisition	AB, MJ
Data analysis and interpretation	AB, MJ
Manuscript preparation	AB
Manuscript editing and review	AB, CMV, MJ, ARÖ

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When I applied for the postgraduate training in Endodontology, the committee asked me how I felt about doing research. I answered honestly that I had far too little experience to know whether I would like doing research or not. That was the truth, but not the whole truth. At that time I thought that I would not like it but I recognized that it was a compulsory part of the postgraduate training.

During my postgraduate training in Endodontology, when I was considering topics for the research project, my eyes were opened that research on education was an option. Once I initiated my research project on education in Endodontology, I started to like doing research, and I am grateful that I got the opportunity to expand this research project – my baby – to become a PhD thesis.

This thesis is about education and professional development. The work we did expanded my perspective on the topic, while the process itself tested my skills. During the years of my doctoral training, I was challenged in several ways; it was resilience training. I learned a lot and I feel gratitude for the lessons I got.

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