doi:10.1111/j.1365-2591.2008.01438.x

Pre-clinical endodontics: a survey amongst German dental schools

D. Sonntag[1], R. Bärwald[1], M. Hülsmann[2] & V. Stachniss[1]

[1]Department of Operative Dentistry, Philipps-University, Marburg; and [2]Department of Operative Dentistry, Preventive Dentistry and Periodontology, Georg-August-University, Göttingen, Germany

Abstract

Sonntag D, Bärwald R, Hülsmann M, Stachniss V. Pre-clinical endodontics: a survey amongst German dental schools. *International Endodontic Journal*, **41**, 863–868, 2008.

Aim To evaluate the state and level of pre-clinical endodontic education in German dental schools and to evaluate differences with regard to intensity and extent of teaching, time devoted to teaching pre-clinical endodontics, personnel resources in teaching and technical equipment.

Methodology Twenty-eight questionnaires were e-mailed to those in charge of pre-clinical endodontic education in German dental schools. The extent of education, the student–teacher ratio, the teaching content as well as the application of teaching materials and technologies were asked. If, after 4 weeks, no response had been received, the questionnaire was sent out by e-mail again. In the absence of a reply, a phone call was made to the corresponding university to conduct the survey by phone.

Results With feedback from 27 of 28 dental schools, the response rate was 96%. Pre-clinical endodontic education at German universities varied considerably. Theory classes ranged from 5 to 30 h (13.3 h mean), practical classes from 12.5 to 60 h (45.4 h mean). The student to staff ratio varied between 9 : 1 and 30 : 1 (16 : 1 mean). Forty-eight per cent of the universities had a specialist in endodontics or a teacher with a special interest. A dental microscope was available for pre-clinical teaching purposes in 38% of the universities. The majority (63%) of universities taught root canal preparation with rotary nickel titanium instruments.

Conclusion Pre-clinical endodontic education varied considerably between German universities because of differences in programme design, staff and course content.

Keywords: endodontics, pre-clinical, survey, teaching, undergraduate education.

Received 3 September 2007; accepted 10 April 2008

Introduction

In Germany, as well as in other European countries, the standard of root canal treatment is not high (Kirkevang *et al.* 2001, Boucher *et al.* 2002, Eriksen *et al.* 2002, Boltacz-Rzepkowska & Pawlicka 2003, Loftus *et al.* 2005). Schulte *et al.* (1998) reported that 56.8% of the patients examined at the Clinical Department of Operative Dentistry, Phillips-University in Marburg, Germany, had root fillings that were short and over 25% of the teeth with root fillings had signs of persistent apical pathosis. Furthermore, a retrospective cohort study carried out by Weiger *et al.* (1997) revealed that 78.6% of root fillings in maxillary molars and 67.6% of root fillings in mandibular molars ended more than 2 mm short of the radiographic apex. Although many factors could account for these technical deficiencies, it is possible that the quality and quantity of pre-clinical and clinical endodontic education has an impact.

The quality of endodontic treatments performed during clinical and pre-clinical education has been evaluated in only a few studies. Radiographic homogeneity and length of root fillings performed with lateral compaction by dental students were shown to be sufficient in no more than 62.7% of cases (Eleftheriadis

Correspondence: Dr David Sonntag, Department of Operative Dentistry, Philipps-University Marburg, Georg-Voigt-Str. 3, 35033 Marburg, Germany (Tel.: 0049 6421 286 3194; fax: 0049 6421 286 3245; e-mail: sonntag@staff.uni-marburg.de).

& Lambrianidis 2005). According to Barrieshi-Nusair *et al.* (2004), 61.3% of the students managed to reach the desired working length. Hayes *et al.* (2001) considered only 13% teeth root filled by students during their clinical experience were satisfactory, whereas 82% of the teeth had root fillings with voids and were either long or short.

The German Medical Licensure Act ('Deutsche Approbationsordnung') of the dental undergraduate programme schedules a preliminary dental examination after the fifth term of the dental undergraduate programme. Apart from general medical subjects such as anatomy, physiology and physiological chemistry, the only required dental subject is prosthodontics (Bundesgesetzblatt (BGBI) 1999). Restorative dentistry including inlays, partial crowns, restorative treatment with composite and amalgam as well as the field of endodontics are only taught from the sixth term (3rd year) onward, just before students start undertaking root canal treatment on patients during the seventh term. During the sixth term, students have to complete an average of 180 h of practical work in restorative dentistry to allow them to treat patients in various courses that follow.

Qualtrough *et al.* (1999) in their international survey observed that the average period of pre-clinical endodontic training in Western Europe of 38 h was low. This explains why the undergraduate curriculum guidelines, established that most dental schools in Europe included insufficient endodontic training (European Society of Endodontology 2001). Despite the existence of EU directives and guidelines, which were devised to assure comparable and acceptable standards of dental education and competence gained from training programmes, there are major differences amongst countries. The differences are greater in those countries about to join an expanding EU (Shanley 2004). The first version of the undergraduate curriculum guidelines published by the European Society of Endodontology (ESE) in 1992 had a detailed requirement profile for dental education, whereas the current guidelines leave much more scope for interpretation. However, this does not necessarily lead to more consistent standards of endodontic education (European Society of Endodontology 1992, 2001). The General Assembly of the Association for Dental Education in Europe (ADEE) published a draft survey entitled 'Profile and competences for the European dentist' in 2004 (Plasschaert *et al.* 2006). Additional to the range of core dental competencies, the specific competencies in endodontics students should have acquired at the end of their undergraduate education were reported (Plasschaert *et al.* 2006).

Rotary nickel titanium instruments are an example that the general use of new materials and techniques is a slow process (Parashos & Messer 2006) even though they may have an influence on the outcome of treatment. Students achieve significantly better results in root canal preparation with rotary instruments than with stainless steel hand instruments (Namazikhah *et al.* 2000, Garip & Gunday 2001, Gluskin *et al.* 2001, Peru *et al.* 2006). Despite this fact, rotary instruments are still not being used for training purposes by all universities (Arbab-Chirani & Vulcain 2004).

The purpose of this survey was to assess the current status of pre-clinical endodontic education and to determine whether quality and quantity of pre-clinical endodontic education in German Dental Schools are comparable with regard to personnel and technical equipment, supervision and complexity of the training.

Materials and methods

Twenty-eight questionnaires were e-mailed to directors of 3rd year pre-clinical courses (manikin, phantom head) in the 28 German departments or clinics for restorative dentistry running their own independent pre-clinical course. The questions were answered either by ticking boxes (yes/no decision) or by short written responses giving detailed data (e.g. information about student–teacher ratio, number of teeth treated, preparation techniques, etc). Sufficient space was provided on the sheets to include additional comments. If the course directors and/or their e-mail addresses were not known, the information was requested from the clinic's secretarial department. Four weeks after the first mailing, the questionnaires were sent out again by e-mail if no response had been received. In the repeated absence of feedback, a phone call was made, if possible, to the corresponding course director to conduct the survey by phone. In doing so, responses were received from 27 of 28 clinics, giving a response rate of 96%.

Results

Student–teacher ratio

A mean total of 41 students attended pre-clinical endodontic training courses at the same time. The student–teacher ratio varied between 9 : 1 and 30 : 1, the average ratio being 16 : 1 (Tables 1 and 2).

Table 1 Number of students attending pre-clinical classes as well as number of universities and corresponding group sizes

Students	Universities (%)
11–20	2 (7.4)
21–30	3 (11.1)
31–40	9 (33.3)
41–50	6 (22.2)
51–60	3 (11.1)
60–80	4 (14.8)

Table 2 Student–faculty ratio for pre-clinical endodontic training as well as number of universities by ratio

Students–staff ratio	Universities (%)
9–12 : 1	7 (25.9)
13–16 : 1	11 (40.7)
17–20 : 1	5 (18.5)
21–24 : 1	1 (3.7)
25–28 : 1	2 (7.4)
29–31 : 1	1 (3.7)

Extent of education

An average of 13.3 h was spent on didactic teaching in endodontology and an average of 45.5 h on training. Overall, the practical endodontic exercises were conducted on 1.7 artificial root canals, 1.5 incisors and/or canines and 2.5 pre-molars and/or molars. Each student, therefore, treated 10 canals (mean value). Forty-eight per cent of the universities (n = 13) had a specialist endodontist leading the pre-clinical endodontic training.

Observing a clinical root canal treatment performed by a staff member was mandatory in 48% (n = 13) of the universities, voluntary in 37% (n = 10) of the universities and not required in 15% (n = 4) of the universities (Tables 3–6). Three universities offered problem-based learning units.

Assessment and teaching material

To assess students' practical work, dentists supervised root canal treatment continuously in all universities

Table 3 Theory lessons (at 45 min) for endodontic education

Theory lessons (h)	Universities (%)
6–10	10 (37.0)
11–15	8 (29.6)
16–20	7 (25.9)
21–25	1 (3.7)
26–30	1 (3.7)

Table 4 Practical training lessons (at 45 min) for endodontic education

Practical training (h)	Universities (%)
10–20	5 (18.5)
21–30	4 (14.8)
31–40	8 (29.6)
41–50	5 (18.5)
51–60	5 (18.5)

Table 5 Minimum number of artificial canals, incisors/canines and molars/pre-molars to be prepared

Type of canals/teeth	Number	Universities (%)
Artificial canals	n/a	3 (11.1)
Artificial canals	1–2	18 (66.6)
Artificial canals	3–4	6 (22.2)
Incisors/canines	n/a	2 (7.4)
Incisors/canines	1–2	23 (85.2)
Incisors/canines	3–4	2 (7.4)
Molars/pre-molars	n/a	0
Molars/pre-molars	1–2	14 (51.8)
Molars/pre-molars	3–4	12 (44.4)
Molars/pre-molars	5–6	1 (3.7)

n/a, not applicable.

Table 6 Minimum number of canals to be prepared and filled

Total number of canals	Universities (%)
1–5	4 (14.8)
6–10	9 (33.3)
11–15	12 (44.4)
16–20	1 (3.7)
21–25	1 (3.7)

[e.g. rubber dam placement, access cavity, radiographic length determination, mastercone fit, etc.). To assess theoretical knowledge, written examinations were used. A practical test such as preparing an access cavity in a maxillary first molar was carried out in 30% (n = 8) of the universities, an additional individual theory examination was carried out in 27% (n = 7) of the schools. A total of 14 different textbooks were recommended, three of which were in English. In addition to text books, 41% of the universities offered lecture hand-outs as well as intranet and internet access to the relevant subjects.

Content of teaching

The stepback technique was the most commonly taught (70%) manual preparation method. Preparation of root canals with rotary nickel titanium instruments

was taught by 63% (n = 17) of the universities. All universities teaching rotary preparation used instruments with torque controlled motors. Lateral compaction was the filling method taught by the majority of schools (Tables 7–9).

Equipment and costs

A minority of universities (37%, n = 10) had a dental microscope for pre-clinical endodontic training purposes. The costs borne by the students for consumable material such as root canal instruments, X-ray films, silver points, gutta-percha, sealer, etc. varied considerably and were on average approximately 145€. Six universities gave no feedback regarding material costs. The answers given in several questionnaires and in direct interviews made clear that the programme directors are unsure about the exact material costs (Tables 8–10).

The overall most unfavourable staff–student ratio was 20 : 1. Time for didactic teaching was 6 h and there were 20 h of practical experience. A total of seven root canals are prepared and filled. The department did not have a microscope and did not teach rotary instrumentation. Furthermore, the department had no endodontic specialist.

The clinic with the overall most favourable education situation had a student to teacher ratio of 10 : 1. Theory was taught for 13 h and there were 45 h of practical experience. A total of 15 root canals are prepared and filled. The department had several dental microscopes and taught preparation with rotary instruments. Furthermore, two endodontic specialists were working in the department.

Table 7 Teaching materials at the students' disposal (the percentages refer to n = 27 universities)

Teaching materials	Yes (%)	No (%)	Partially (%)
Endodontic script	10 (37%)	17 (62.9)	0
Lecture print-outs	11 (40.7)	7 (25.9)	9 (33.3)
CD hand-outs with information	2 (7.4)	22 (81.5)	3 (11.1)
Videos/files available via intranet/internet	11 (40.7)	16 (59.3)	0

Table 8 Preparation methods taught in class (multiple answers possible)

Manual preparation	Universities (%)
Crown-down/step-down	7 (25.9)
Step-back	19 (70.4)
Balanced force	4 (14.8)
Coronal crown-down, then step-back	4 (14.8)
Standardized technique	3 (11.1)

Table 9 Rotary preparation techniques with nickel titanium instruments (multiple answers possible)

Preparation system	User (%)
FlexMaster, VDW	15 (88.2)
ProFile, Dentsply	4 (23.5)
ProTaper, Dentsply	3 (17.6)
Mtwo, VDW	1 (5.8)
GT, Dentsply	1 (5.8)

The percentages apply to the number of universities using NiTi instruments (n = 17).

Table 10 Use of microscopes (multiple answers possible). The percentages refer to the universities possessing a microscope (n = 10)

Intended use	Universities (%)
Demonstrations	6 (60)
Evaluation of access cavity + root canal orifices	5 (50)
Hands on training	3 (30)

Discussion

Multiple national and international surveys on endodontic education have been carried out (Shovelton 1979, Qualtrough & Dummer 1997, Qualtrough *et al.* 1999). Sending out questionnaires has proven to be an effective method for capturing data on educational issue. Whilst Dummer (1991) reported a response rate of 100%, the present survey did not receive a response from one school; the person in charge of courses was unavailable. Other national surveys achieved response rates of 87% (Cruz *et al.* 2000) and of 91% (Cailleteau & Mullaney 1997). Based on questionnaires sent out by e-mail and on selective interviews by phone, this survey managed to achieve a response rate of 96%. The survey results available, thus give a reliable reflection of pre-clinical endodontic education in Germany.

The education level varied significantly from clinic to clinic. Theory lessons vary from 5 to 30 academic hours (equivalent to 45 min), practical training from 12.5 to 60 h. This reflects amongst other things the different focus on pre-clinical education. Many clinics consider pre-clinical education to be mainly for the teaching of manual skills. The underlying theory comes second and is often only taught in subsequent terms.

The total number of hours for pre-clinical theory varied in Germany around the factor of 5, and for practical training around the factor of 6. In a comparison in Western Europe, results varied more widely:

around a factor of 25 (Qualtrough *et al.* 1999). On average, 45 h were spent on practical training in Germany compared with 78 h in France, which is 1.5 times more. The ESE guidelines, however, reveal that 'it is neither expected nor desirable that all courses in endodontics are given before students start clinical work on patients'. 'It is therefore not intended to give definite directions. Innovative ways in which endodontic curricula can be progressed are to be encouraged' (European Society of Endodontology 2001).

The ratio between students and teachers varied between 9 : 1 and 30 : 1. The average faculty to student ratio of 16 : 1 in Germany is worse than the corresponding ratio in the UK (12 : 1), which came out the worst in an European comparison. The same survey conducted in 1999 revealed that Eastern Europe has the best supervision ratio: 6 : 1. A national survey in France, however, revealed an even worse student to faculty ratio (18 : 1) than the ratio established in the present survey (Arbab-Chirani & Vulcain 2004). The actual outcome-oriented guidelines completely refrain from mentioning a tutoring ratio, whereas the guidelines in 1992 still claimed that an adequate faculty to student ratio was essential for a successful implementation of the endodontic curriculum (European Society of Endodontology 1992, 2001).

Before undertaking clinical practice on patients during the seventh term, students performed root canal treatment on an average of four extracted natural teeth. Comparable figures for Europe are not available. In the Philippines, however, the average was four teeth, the same as in Germany (Cruz *et al.* 2000). The undergraduate curriculum guidelines advise '…to gain the requisite experience on twenty teeth (…including extracted teeth)' during pre-clinical and clinical undergraduate education (European Society of Endodontology 2001). The remaining 16 teeth would, therefore, have to be prepared in clinical courses on patients. Based on the number of patients and on the amount of time available, it seems highly improbable that this objective of education can be reached by the majority of German universities.

Only 63% of the universities taught root canal preparation with rotary nickel titanium instruments. In 1999, 27% of the Western European universities interviewed stated that rotary preparation methods were taught. In Scandinavia, the percentage was 25% (Qualtrough *et al.* 1999). According to a survey conducted in 2004, 81% of the French universities were teaching rotary instrumentation during pre-clinical and clinical education (Arbab-Chirani & Vulcain 2004). The great majority of surveys on rotary preparation confirms that it preserves the original canal geometry with only minimal canal straightening (Peters 2004, Hülsmann *et al.* 2005). Even practitioners with little experience or practice can preserve the canal geometry when using rotary instruments (Namazikhah *et al.* 2000, Garip & Gunday 2001, Gluskin *et al.* 2001, Peru *et al.* 2006). Only three universities had a dental microscope available for pre-clinical exercises. None of the universities possesses a sufficient amount of equipment to enable every student to practice using dental microscopes. Since 1997, the US requirements for postgraduate endodontic training include the use of microscopes (Selden 2002). However, there is no information available as to what extent these requirements have been implemented. The surveys with regard to endodontic education do not reveal any information nor have European guidelines made any statements regarding the use of dental microscopes.

Pan-European surveys on the situation of endodontic education have repeatedly revealed considerable differences (Qualtrough *et al.* 1999). Shanley *et al.* (1997) already stated important differences 10 years ago with regard to resources, qualification of staff, availability of adequate training facilities as well as to research and patient care within the European Union.

Conclusion

Pre-clinical endodontic education at German universities varied considerably because of differences in programme design, staff and course content. Students' experiences before the treatment of their first patient varied substantially. Only a national conference of university staff, responsible for restorative dentistry and in the position to take decisions, will allow for a consistent academic education. Specific and detailed recommendations, together with outcome-oriented guidelines, could assist decision makers to improve academic education and facilitate step-by-step implementation at the various locations.

Acknowledgements

We would like to thank all those colleagues of the 27 clinics interviewed, who took time to reply to our questionnaires.

References

Arbab-Chirani R, Vulcain JM (2004) Undergraduate teaching and clinical use of rotary nickel–titanium endodontic

instruments: a survey of French dental schools. *International Endodontic Journal* **37**, 320–4.

Barrieshi-Nusair KM, AlOmari MA, Al Hiyasat AS (2004) Radiographic technical quality of root canal treatment performed by dental students at the Dental Teaching Center in Jordan. *Journal of Dentistry* **32**, 301–7.

Boltacz-Rzepkowska E, Pawlicka H (2003) Radiographic features and outcome of root canal treatment carried out in the Lodz region of Poland. *International Endodontic Journal* **36**, 27–32.

Boucher Y, Matossian L, Rilliard F, Machtou P (2002) Radiographic evaluation of the prevalence and technical quality of root canal treatment in a French subpopulation. *International Endodontic Journal* **35**, 229–38.

Bundesgesetzblatt (BGBI) (1999) Approbationsordnung für Zahnärzte. Gesetz zur Ausübung der Zahnheilkunde. *Bundesgesetzesblatt* Teil III, Gliederungsnummer. **50**, 2123-1, 2175–85.

Cailleteau JG, Mullaney TP (1997) Prevalence of teaching apical patency and various instrumentation and obturation techniques in United States dental schools. *Journal of Endodontics* **23**, 394–6.

Cruz EV, Jimena ME, Puzon EG, Iwaku M (2000) Endodontic teaching in Philippine dental schools. *International Endodontic Journal* **33**, 427–34.

Dummer PMH (1991) Comparison of undergraduate endodontic teaching programmes in the United Kingdom and in some dental schools in Europe and the United States. *International Endodontic Journal* **24**, 169–77.

Eleftheriadis GI, Lambrianidis TP (2005) Technical quality of root canal treatment and detection of iatrogenic errors in an undergraduate dental clinic. *International Endodontic Journal* **38**, 725–34.

Eriksen HM, Kirkevang LL, Petersson K (2002) Endodontic epidemiology and treatment outcome: general considerations. *Endodontic Topics* **2**, 1–9.

European Society of Endodontology (1992) Undergraduate curriculum guidelines for endodontology. *International Endodontic Journal* **25**, 169–72.

European Society of Endodontology (2001) Undergraduate curriculum guidelines for endodontology. *International Endodontic Journal* **34**, 574–80.

Garip Y, Gunday M (2001) The use of computed tomography when comparing nickel–titanium and stainless steel files during preparation of simulated curved canals. *International Endododontic Journal* **34**, 452–7.

Gluskin AH, Brown DC, Buchanan LS (2001) A reconstructed computerized tomographic comparison of Ni–Ti rotary GT files versus traditional instruments in canals shaped by novice operators. *International Endodontic Journal* **34**, 476–84.

Hayes SJ, Gibson M, Hammond M, Bryant ST, Dummer PMH (2001) An audit of root canal treatment performed by undergraduate students. *International Endodontic Journal* **34**, 501–5.

Hülsmann M, Peters OA, Dummer PMH (2005) Mechanical preparation of root canals: shaping goals, techniques and means. *Endodontic Topics* **10**, 30–76.

Kirkevang LL, Hörstedt-Bindslev P, Ørstavik D, Wenzel A (2001) A comparison of the quality of root canal treatment in two Danish subpopulations examined 1974–75 and 1997–98. *International Endodontic Journal* **34**, 607–12.

Loftus JJ, Keating AP, McCartan BE (2005) Periapical status and quality of endodontic treatment in an adult Irish population. *International Endodontic Journal* **38**, 81–6.

Namazikhah MS, Mokhlis HR, Alasmakh K (2000) Comparison between a hand stainless-steel K file and a rotary NiTi 0.04 taper. *Journal of the Californian Dental Association* **28**, 421–6.

Parashos P, Messer HH (2006) Rotary NiTi instrument fracture and its consequences. *Journal of Endodontics* **32**, 1031–43.

Peru M, Peru C, Mannocci F, Sherriff M, Buchanan LS, Pitt Ford TR (2006) Hand and nickel–titanium root canal instrumentation performed by dental students: a micro-computed tomographic study. *European Journal of Dental Education* **10**, 52–9.

Peters OA (2004) Current challenges and concepts in the preparation of root canal systems: a review. *Journal of Endodontics* **30**, 559–67.

Plasschaert AJ, Lindh C, McLoughlin J *et al.* (2006) Curriculum structure and the European Credit Transfer System for European dental schools: part I. *European Journal of Dental Education* **10**, 123–30.

Qualtrough AJE, Dummer PMH (1997) Undergraduate endodontic teaching in the United Kingdom: an update. *International Endodontic Journal* **30**, 234–9.

Qualtrough AJE, Whitworth JM, Dummer PMH (1999) Preclinical endodontology: an international comparison. *International Endodontic Journal* **32**, 406–14.

Schulte A, Pieper K, Charalabidou O, Stoll R, Stachniss V (1998) Prevalence and quality of root canal fillings in a German adult population. A survey of orthopantomograms taken in 1983 and 1992. *Clinical Oral Investigation* **2**, 67–72.

Selden HS (2002) The dental-operating microscope and its slow acceptance. *Journal of Endodontics* **28**, 206–7.

Shanley DB (2004) Convergence towards higher standards in international dental education. *New York State Dental Journal* **70**, 35–9.

Shanley DB, Barna S, Gannon P *et al.* (1997) Undergraduate training in the European Union. Convergence or divergence? *European Journal of Dental Education* **1**, 35–43.

Shovelton DS (1979) The teaching of endodontics in the United Kingdom and Ireland. *Journal of the British Endodontic Society* **12**(Suppl.), 9–16.

Weiger R, Hitzler S, Hermle G, Löst C (1997) Periapical status, quality of root canal fillings and estimated endodontic treatment needs in an urban German population. *Endodontics & Dental Traumatology* **13**, 69–74.