

This is an Open Access document downloaded from ORCA, Cardiff University's institutional repository: <https://orca.cardiff.ac.uk/id/eprint/119266/>

This is the author's version of a work that was submitted to / accepted for publication.

Citation for final published version:

Drukteinis, S., Peciuliene, V., Dummer, P. M. H. and Hupp, J. 2019. Shaping ability of BioRace, ProTaper NEXT and Genius nickel-titanium instruments in curved canals of mandibular molars: a MicroCT study. *International Endodontic Journal* 52 (1) , pp. 86-93. 10.1111/iej.12961

Publishers page: <http://dx.doi.org/10.1111/iej.12961>

Please note:

Changes made as a result of publishing processes such as copy-editing, formatting and page numbers may not be reflected in this version. For the definitive version of this publication, please refer to the published source. You are advised to consult the publisher's version if you wish to cite this paper.

This version is being made available in accordance with publisher policies. See <http://orca.cf.ac.uk/policies.html> for usage policies. Copyright and moral rights for publications made available in ORCA are retained by the copyright holders.



How is Endodontics taught? A survey to evaluate undergraduate endodontic teaching in dental schools within the United Kingdom

H Alraisi, PMH Dummer, ME Vianna

School of Dentistry, College of Biomedical and Life Sciences, Cardiff University, Cardiff, UK

Running title: Endodontic undergraduate teaching in the UK

Keywords: endodontics, endodontic curriculum, endodontic teaching, online survey, dental schools.

Corresponding author: Professor Paul Dummer, School of Dentistry, College of Biomedical and Life Sciences, Cardiff University, Heath Park, Cardiff CF14 4XY, UK. Email: dummer@cardiff.ac.uk

Abstract

Aim To evaluate the delivery of undergraduate endodontic education in UK dental schools using an online survey and to compare the results with those of a previous paper-based survey (Qualtrough & Dummer 1997). Aspects of delivery were also evaluated in comparison with Undergraduate Curriculum Guidelines of the European Society of Endodontology (de Moor *et al.* 2013).

Methods An online version of an earlier paper-based survey on undergraduate Endodontic education (Qualtrough & Dummer 1997) was created. Invitations to take part were sent via e-mail to the undergraduate endodontic programme leads in the sixteen UK dental schools.

Results The response rate was 94%. The current survey revealed greater convergence among dental schools than previously (Qualtrough & Dummer 1997) on methods of canal preparation, disinfection and filling. Improvements were also noted in staff: student ratios, the involvement of teachers with advanced endodontic training and a greater diversity of teaching methods; developments which align with the recommendations of ESE Undergraduate Curriculum Guidelines (de Moor *et al.* 2013). The majority of schools appeared to be teaching contemporary instrumentation methods and were recommending the application of calcium silicate cements. The exposure of students to advanced topics included in the ESE Undergraduate Curriculum Guidelines (de Moor *et al.* 2013) such as surgical endodontic treatment, root canal re-treatment and the management of complex cases was mixed.

Conclusion Undergraduate endodontic training in the UK has advanced in the last 20 years with more consistency between schools and more contemporary methods adopted.

Introduction

Theoretical and skills training in Endodontics form an essential component of the undergraduate dental curriculum (Cowpe *et al.* 2010, de Moor *et al.* 2013, General Dental Council 2015, Field *et al.* 2017, ADEE 2017).

The quality of root fillings provided by general dental practitioners in the UK and elsewhere (Grieve & McAndrew 1993, Saunders *et al.* 1997, Dummer 1998, Gencoglu *et al.* 2010, Peters *et al.* 2011) and by undergraduate dental students (Hayes *et al.* 2001, Eleftheriadis & Lambrianidis 2005, Er *et al.* 2006) has consistently been reported to be below acceptable levels defined by specialist organisations such as the European Society of Endodontology (ESE 2006). Standards have been linked in at least two reports to the quality and quantity of undergraduate education (Hayes *et al.* 2001, Jenkins *et al.* 2001).

In the UK, the scope of undergraduate dental (including endodontic) education is defined by the General Dental Council's (GDC) document "preparing for practice" (General Dental Council 2015), and all schools are inspected periodically on their compliance. In addition, guidelines from the European Society of Endodontology (de Moor *et al.* 2013) and the Association for Dental Education in Europe (Cowpe *et al.* 2010, Field *et al.* 2017) are available to aid dental schools in building their undergraduate dental (including endodontic) curricula, with the aim of promoting consistent standards within Europe and its member states, and enhancing the quality of patient care in the community.

Previous studies revealed great variation between UK dental schools in the structure of their undergraduate endodontic education (Shovelton 1979, Dummer 1991) with reduced priority given for the subject in the UK than international comparators (Dummer 1991, Qualtrough *et al.* 1999).

Endodontic education has evolved through the years. This has been driven by advances in endodontic materials, equipment and educational methods (Qualtrough 2014, Nagendrababu *et al.* 2019). The present study sought to evaluate the nature of that evolution by repeating a survey last conducted more than 20 years ago. Results were also correlated with a number of key recommendations included in the latest ESE Undergraduate Curriculum Guidelines (de Moor *et al.* 2013).

Methods and materials

Ethical approval was granted by the Cardiff University School of Dentistry Ethics Committee (Reference 1727a). An online version of a previous paper-based survey (Qualtrough & Dummer 1997) was created using Bristol Online Survey software (Online surveys, Bristol, UK). Coverage included various aspects of didactic, preclinical (PC) and clinical (C) endodontic teaching including: methods of endodontic teaching, subjects covered, teaching resources, timing of teaching and time allocation for didactic, PC and C teaching, training of teaching staff, staff: student ratio, recommended procedures, materials and instruments (Table 1). Most of questions were multiple-choice with more than one answer selected when appropriate. Some questions also provided space for free text entry if further explanation was required.

The survey was piloted locally to check for question readability, clarity, validity and functionality and time required to complete. No modifications to the questions were required.

Contact details for undergraduate endodontic teaching leads were obtained from school web pages or contact with school academic offices. Invitations to participate were sent by email and the survey was open from November 2017 to January 2018. A reminder

email was sent two weeks after initial contact and, in the event of repeated no response, an email was sent to the Heads of the dental schools with a request to forward it to the undergraduate endodontic programme lead in their school.

Data collection was managed using the Bristol Online Survey software. Anonymised data summary was generated automatically. Simple descriptive statistics were generated for each survey item.

Results

Fifteen out of 16 dental schools answered the survey (94%), with 18% responses after the first invite, 62% after the reminder and 94% after contact with Heads of Schools.

The type of teaching (Q1); all schools provided both preclinical and clinical endodontic training. There was slight variation between schools in the timing of preclinical training (Q2) with six schools (40%) providing such training in the second and third years, 20% in the third and fourth year, 13% from second to fourth year, 13% from second to fifth year and 7% providing preclinical training only in the second year.

All dental schools used combinations of teaching methods (Q3), including lectures, practical laboratory teaching, independent study and e-learning. Lectures and laboratory practical learning were used in all 15 schools. Other methods in decreasing order were: seminars and tutorials (93%), independent study (86%), manuals and reading lists (80%), clinical cases (80%), e-learning (60%), videos (60%) and assignments and projects (53%) (Figure 1).

All responding schools provided didactic education on a broad range of topics (Q4) including: root canal treatment, restoration of root filled teeth and endodontic surgery. Much of this didactic information was provided in years 3 to 5 (73% of respondents).

Bleaching of endodontically treated teeth, endodontic emergencies and endodontic materials were taught by 93% of schools (Table 2).

Time allocation to aspects of endodontics (Q5): root canal treatment received the largest number of teaching hours, followed by restoration of root filled teeth and dental trauma. Endodontic regeneration received the least input of the topics surveyed (typically less than 2 hours) (Figure 2).

The responding schools employed various combinations of supervising staff for preclinical and clinical training (Q6). General dental practitioners (GDPs) supervised dental students in 80% of the schools for PC and in 87% for C. In 80% of the schools GDPs with a special interest and training in endodontics supervised the students for PC and C training. Endodontists supervised students in 60% for PC and in 67% for C. While in 47% the supervisors were Consultants in Restorative Dentistry for PC and in 80% for C. In addition to the supervisors mentioned above, students were also supervised by other staff such as Specialty Registrars in Restorative Dentistry and Prosthodontists for PC and C.

Staff:student ratios (Q7) in PC training ranged from 1:5 to 1:20. However, more consensus was found during C training with the ratios being from 1:4 to 1:6 in 87% of schools and 1:8 in 13%.

All schools taught root canal treatment (100 % PC, 100% C), vital pulp therapy (9 PC, 14 C), root canal re-treatment (60% PC, 93% C), treatment of teeth with open apices (20% PC, 60% C), endodontic surgery (13% PC, 30% C). None of the schools taught pulp regeneration procedures in the PC setting but 20% taught the subject in the clinical setting.

The time devoted to preclinical and clinical training (Q9) was reported to range from 1 hour to more than 20 hours. Most of the schools (87%) spent more than 20 hours on PC training, 7% reported 6-10 hours and 7% reported 11-15 hours. Similarly, the time allocated

for C training was more than 20 hours in 73% of schools, 11-15 hours in 13%, 16-20 hours in 13% and 1-5 hours in 7%.

Types of teeth included in PC training varied (Q10) with all of the schools using incisors and molars, and 93% also used premolars. During clinical training, students in all schools performed treatment on all types of teeth.

The type of root canals used in the laboratory setting (Q11) were natural teeth in 73% of the schools, plastic teeth in 73%, canals in acrylic blocks with simple curves in 60%, 3D printed teeth containing root canals in 13%, and acrylic blocks with S shaped curves in 7%.

Dedicated clinics for endodontic training (Q12) were reported by 40% of responding schools. Students in all responding dental schools treated cases (Q13) assessed as simple, with 93% providing students with cases of moderate complexity and 27% with cases regarded as complicated.

Magnification including both loupes and dental operating microscope was used during PC and C endodontic training (Q14) in 33% of schools. Twenty percent of schools used only loupes in PC training while 27% employed loupes in C training. Twenty percent did not incorporate the use of magnification.

Ultrasonic instruments were employed in PC training (Q15) in 53% of schools for access cavity preparation and refinement, irrigant agitation and troughing to locate canals. During C training, 20% of schools stated that the ultrasonic devices were not used, with other schools using them for at least one of the following: access cavity preparation and refinement, irrigant agitation and troughing to locate canals.

Working length (WL) was determined by a variety of electronic (EWLDDs) and radiographic means during PC and C training (Q16). During PC training, 8 schools used both electronic and radiographic methods while the remaining schools used one or other of the

methods. For clinical training 14 schools reported the use of both radiographs and EWLDDs with one of these schools also using cone beam computed tomography (CBCT) data to determine the working length when this examination was available. One school used only EWLDDs.

The question on root canal instruments and techniques (Q17) revealed that the ProTaper Gold rotary system (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA) was used most commonly (60% of schools), while the ProTaper Next rotary system (Dentsply Sirona Endodontics, Ballaigues, Switzerland) was used by 13% of the schools. Twenty seven percent indicated they used a ProTaper rotary system but did not specify which type. The WaveOne Gold reciprocating system (Dentsply Sirona Endodontics) was employed in 13% of schools, with a further 7% employing an unspecified form of WaveOne; Reciproc (VDW, Munich, Germany) was used in 20% of schools.

Only nine schools (60%) specified the type of manual files they used. Of them, five used K-files, two used Hedström files, and four indicated they used stainless-steel files without specifying the type. Two schools indicated they used NiTi files without specifying the type. Four schools used ProTaper hand files. The descriptions of the techniques (Q18) differed from school to school but mostly appeared to follow manufacturer instructions.

The most common irrigating solution (Q19) during PC training was water (66%), followed by sodium hypochlorite (NaOCl) (13%), a combination of water and NaOCl (13%) and water and saline (6%). During C training, NaOCl was the main irrigant (40%), NaOCl and EDTA (13%), saline and NaOCl (7%), NaOCl and chlorhexidine (7%), water, NaOCl and EDTA (7%), NaOCl and citric acid (7%), NaOCl and EDTA or citric acid (7%), saline, NaOCl, chlorhexidine and EDTA (7%).

The responding schools used a variety of methods for root filling (Q20) during PC and C training. Cold lateral compaction was used exclusively in 47% of the schools during PC and in 40% during C training. Other methods were also used such as single cone gutta-percha that was used in 20% of the schools during PC and in 27% during C; warm vertical compaction was used in 13% during PC and 33% during C. Thermoplastic injection techniques were used in 13% during PC and in 7% during C. Carrier based gutta-percha was used in 27% in PC and 13% during C. Paste fillers were used in 7% during PC and C training.

Six schools (40%) used endodontic materials (Q21) such as Mineral Trioxide Aggregate (MTA), Biodentine (Septodont, Saint Maur des Fossés, France) and BioRoot (Septodont) during PC. While twelve schools (80%) used such materials during C training.

All schools employed calcium hydroxide as the standard intracanal medicament (Q22). One school also recommended the use of Odontopaste (Australian Dental Manufacturing, Kenmore Hills, Australia).

All responding schools trained their students to place definitive restorations (Q23) after the completion of root canal treatment. In eleven schools (73%), students were also taught how to place provisional restorations.

Eighty seven percent of the schools had minimum requirements for the number of teeth to be completed in PC training (Q24). During clinical training, only 67% had minimum requirements, while 33% had no minimum requirements.

Discussion

The aim of the current survey was to evaluate the delivery of undergraduate endodontic education in UK dental schools using an online survey. This represents an update on work last conducted over 20 years ago (Qualtrough & Dummer 1997). In the intervening years

guidelines from the UK GDC (General Dental Council 2015), ADEE (Cowpe *et al.* 2010, Field *et al.* 2017, ADEE 2017) and the European Society of Endodontology (de Moor *et al.* 2013) have developed the agenda for undergraduate PC and C training, and there has been no previous attempt to assess compliance of dental schools with the latter.

The response rate of the present survey was 94% representing a high level of engagement and robust data. The previous survey (Qualtrough & Dummer 1997) reported that preclinical training was initiated exclusively during the first two years but that some schools had more advanced training during the fourth year. Both PC and C training are recommended in the ESE Undergraduate Curriculum Guidelines (de Moor *et al.* 2013). The present survey revealed wide variation in the timing of preclinical training but did not explore the reasons for this.

The current survey revealed a greater diversity in teaching methods compared with Qualtrough & Dummer (1997) who identified only lectures and seminars. The ESE guidelines (de Moor *et al.* 2013) provide no information on recommended PC and C teaching methods.

The ESE guidelines (de Moor *et al.* 2013) provide extensive recommendations on the scope of endodontic education and the expected depth of coverage. The present survey could not begin to explore this curriculum in any detail, but selected the management of endodontic emergencies, dental trauma, bleaching and endodontic regeneration as examples. The survey revealed that many schools do not cover these topics, and it is therefore suggested that more detailed examination of the ESE curriculum may reveal other gaps in the level of delivery that is possible in European Dental Schools. The previous survey (Qualtrough & Dummer 1997) found a similar absence of topics such as bleaching in the curricula of many schools.

Great variation was noted in the time devoted for teaching elements of the endodontic curriculum. It cannot be ruled out that the large variations noted for example in teaching root canal treatment that had a range from 1 hour to 60 hours may represent misinterpretation of the study questions.

The quality of education is influenced by the teacher's knowledge, experience and interest in the subject (Ahlberg 1991). The ESE (de Moor *et al.* 2013) recommend that students should be supervised by endodontic specialists or by staff with a special interest and training in endodontics. In this survey, the majority of the responding schools employed GDPs with an interest in endodontics, endodontists or a combination of both for PC and C teaching. This can be regarded as a great improvement on the last survey (Qualtrough & Dummer 1997) where none of the schools had supervising staff with advanced training in Endodontics.

Staff:student ratio has an influence on the ability of supervising staff to recognise the weaknesses and limitations of students (Dummer 1991). ESE guidelines (de Moor *et al.* 2013) emphasise the importance of adequate staff: student ratios during endodontic training. In the present survey the variation between schools was less noticeable during C training. This can be regarded as improvement when compared to the previous survey (Qualtrough & Dummer 1997), which reported that staff: student ratios ranged from 1:5 to 1:25, although it is not clear from the previous survey if this ratio was for PC or C training. The variation in the ratios may reflect the differences in resources and the priority given to endodontic teaching. Nevertheless, the ratios of the schools cannot be described as adequate or inadequate as the ESE guidelines do not indicate a required minimum. Logically low staff: student ratios would provide more clinical time to interact during sessions, providing a better learning environment than high staff: student ratios.

ESE guidelines (de Moor *et al.* 2013) emphasise that students should be competent at performing root canal treatment on uncomplicated anterior and posterior teeth. Students in all responding schools were encouraged to treat simple cases for root canal treatment with the majority also allocating cases of moderate and greater complexity, including re-treatments. This may reflect difficulties in recruiting simple primary cases for treatment by undergraduate students, which can impact on the confidence of students when undertaking root canal treatment (Davey *et al.* 2015) and potentially on the quality of the root fillings they provide (Hayes *et al.* 2001, Eleftheriadis & Lambrianidis 2005, Er *et al.* 2006). However, this remains speculative as the questionnaire did not explore the factors underpinning case allocation.

Few schools trained their students on surgical endodontic treatment. In common with the previous survey (Qualtrough & Dummer 1997), the questionnaire did not explore if this training was theoretical or practical. The previous survey only investigated which department was responsible for teaching each subject. The ESE (de Moor *et al.* 2013) advised that students only need to be familiar with such procedures by observation or direct assistance and Guidelines from the UK General Dental Council also place no expectation on the safe-beginner being competent to perform surgical endodontic procedures (General Dental Council 2015).

The number of hours for PC and C training in the current survey was similar to the previous report (Qualtrough & Dummer 1997). However, it cannot be assumed that there was no increase in the time spent by the schools due to the structure of the question which was based on the previous survey and did not explore intervals above 20 hours.

The previous survey (Qualtrough & Dummer 1997) did not investigate the adoption of dedicated clinics for endodontics and the ESE guidelines (de Moor *et al.* 2013) have

recognised that not all schools are able to provide dedicated endodontic clinics. In addition, the guidelines emphasise that endodontic training in mixed clinics can be beneficial to training in holistic patient care. The results of this survey reflected this point revealing that the majority of schools had mixed clinics.

The majority of schools used advanced materials and equipment such as magnification (loupes and dental operating microscopes) and ultrasonic devices. Advanced materials such as MTA and Biodentine (Septodont) were also taught during endodontic training. In addition, the majority of responding schools trained their students to use rotary, manual instruments and reciprocating systems during PC and C training. This reflects the changing attitudes of schools in adopting more contemporary methods in endodontic training and may also reflect the effects of increased commercial support for endodontic education and its influence on the materials and techniques employed. Although this was not investigated in the survey it may have been a driver for changes since the last survey in 1997.

All responding dental schools used sodium hypochlorite as the main irrigating solution. Some schools also used other irrigating solutions such as EDTA, citric acid, chlorhexidine and saline. However, the survey question did not allow an evaluation of the circumstances when the different irrigating regimens were used.

Cold lateral compaction was historically reported as the gold standard root filling method (Whitworth 2005). Cold lateral compaction remained the standard filing technique in all responding schools, though a variety of other methods were also becoming established. The role of commercial encouragement and support could not be ruled-out in making alternative methods available for students.

The majority of responding schools required a minimum number of completed root canal treatment cases from their students during PC and C training. However, it is important

to note that the ESE undergraduate guidelines (de Moor *et al.* 2013) did not make hard recommendations on the minimum number of procedures to reach a threshold of competence but emphasised assessment of the quality and consistency of student performance. Therefore, the adoption of a minimum number of cases may not alone safeguard student competency in endodontics.

Conclusion

Based on the data collected from this survey, the delivery of preclinical and clinical endodontic education has evolved in positive ways since the last survey (Qualtrough & Dummer 1997). Greater priority is given to undergraduate endodontic teaching and more schools are following key recommendations of the ESE, at least in the domains surveyed. This is reflected by improved staff: student ratios in clinical training, more schools having supervisors with advanced endodontic training, more schools having dedicated clinics for endodontics and the use of additional teaching methods. In addition, schools are moving towards more contemporary endodontic practice with the use of rotary or reciprocating instruments, advanced endodontic materials and the use of magnification and ultrasonics. Furthermore, there is greater consistency among the schools on methods of working length determination, the main irrigating solution, inter-visit medicaments and canal filling methods.

Acknowledgments

The authors thank the programme leads for endodontic teaching at undergraduate level who completed the survey. The authors also thank the contribution of John Whitworth during the development of the manuscript.

Conflict of Interest

The authors have no conflict of interest to declare.

References

- ADEE (2017) <https://www.adee.org/taskforces/Undergraduate-Dental-Education-The-European-Perspective-Consultation-draft.pdf> (accessed 23/01/2019).
- Ahlberg KF (1991) Undergraduate endodontic teaching at the London Hospital Dental Institute. *International Endodontic Journal* **24**, 155–60.
- Cowpe J, Plasschaert A, Harzer W, Vinkka-Puhakka H, Walmsley AD (2010) Profile and competences for the graduating European dentist – update 2009. *European Journal of Dental Education* **14**, 193-202.
- Davey J, Bryant ST, Dummer PMH (2015) The confidence of undergraduate dental students when performing root canal treatment and their perception of the quality of endodontic education. *European Journal of Dental Education* **19**, 229-34.
- de Moor R, Hülsmann M, Kirkevang L, Tanalp J, Whitworth J (2013) Undergraduate Curriculum Guidelines for Endodontology. *International Endodontic Journal* **46**, 1105-14.
- Dummer PMH (1991) Comparison of undergraduate endodontic teaching programmes in the United Kingdom and in some schools in Europe and the United States. *International Endodontic Journal* **24**, 169–77.
- Dummer PMH (1998) The quality of root canal treatment provided by general dental practitioners working within the general dental services of England and Wales. Part 2. *Dental Profile (Journal of the Dental Practice Board of England and Wales)* **19**, 8-10.
- 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.

- Er O, Sagsen B, Madsen M, Cinar S, Kahraman Y (2006) Radiographic technical quality of root fillings performed by dental students in Turkey. *International Endodontic Journal* **39**, 867-72.
- ESE (2006) Quality guidelines for endodontic treatment: consensus report for the European Society of Endodontology. *International Endodontic Journal* **39**, 921–30.
- Field J, Cowpe J, Walmsley D (2017) The Graduating European Dentist: A New Undergraduate Curriculum Framework. *European Journal of Dental Education* **21**(Suppl. 1), 2–10.
- Gencoglu N, Pekiner FN, Gumru B, Helvacioglu D (2010) Periapical status and quality of root fillings and coronal restorations in an adult Turkish subpopulation. *European Journal of Dental Education* **4**, 17-22.
- General Dental Council (2015) Preparing for practice. Available online at <https://www.gdc-uk.org/professionals/education> (last accessed 21/01/2019).
- Grieve AR, McAndrew R (1993) A radiographic study of post retained crowns in patients attending a dental hospital. *British Dental Journal* **173**, 197-201.
- Hayes SJ, Gibson M, Hammond M, Bryant ST, Dummer PM (2001) An audit of root canal treatment performed by undergraduate students. *International Endodontic Journal* **34**, 501–5.
- Jenkins SM, Hayes SJ, Dummer PMH (2001) A study of endodontic treatment carried out in dental practice within the UK. *International Endodontic Journal* **34**, 16–22.
- Nagendrababu V, Pulikkotil SJ, Sultan OS, Jayaraman J, Soh JA, Dummer PMH (2019) Effectiveness of technology-enhanced learning in Endodontic education: a systematic review and meta-analysis. *International Endodontic Journal* **52**, 181–92.

Peters LB, Lindeboom JA, Elst ME, Wesselink PR (2011) Prevalence of apical periodontitis relative to endodontic treatment in an adult Dutch population: a repeated cross sectional study. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics* **111**, 523–8.

Qualtrough A (2014) Undergraduate endodontic education: what are the challenges? *British Dental Journal* **216**, 361-4.

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

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

Saunders WP, Saunders EM, Sadiq J, Cruickshank E (1997) Technical standard of root canal treatment in an adult Scottish sub-population. *British Dental Journal* **182**, 382-6.

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

Whitworth J (2005) Methods of filling root canals: principles and practices. *Endodontic Topics* **12**, 2–24.