Preclinical endodontology: an international comparison

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Abstract

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Aim The aim of this study was to compare preclinical endodontic teaching in Europe, Scandinavia and North America, and to place recent UK data in an international context.

Methodology A postal questionnaire was sent to all undergraduate dental schools in North America, Scandinavia, and Europe. Data were requested on a range of issues relating to endodontic teaching.

Results Forty-three percent of the 170 schools surveyed returned completed questionnaires. There was considerable international consensus on the content of preclinical courses, with most schools advocating preflaring canal preparation techniques, sodium hypochlorite for irrigation, and cold lateral condensation as the standard obturation method. There was little consensus on the standard use of intracanal medicaments, though calcium hydroxide was universally popular. The practice of single visit treatment was advocated by at least 70% of schools in all geographical areas.

A number of innovations appear to be gaining acceptance in preclinical teaching, with more than 20% of schools teaching the use of electronic apex locators, and a quarter of Western European, Scandinavian and North American schools embracing nickel-titanium instrumentation. Regional differences in the priority and resource given to endodontic teaching were striking. On average, UK schools had the worst staff:student ratios for preclinical endodontic teaching, and allocated substantially less time allocation for this teaching compared with Western European, Scandinavian and North American schools.

Conclusions It was concluded that although teachers in the UK were broadly advocating techniques recommended elsewhere, the academic infrastructure and priority given for endodontic teaching in the UK was limited in the international context. This may have some impact on the quality of endodontic provision within the UK General Dental Services.

Keywords: endodontology, multinational, preclinical, teaching, undergraduate.

Introduction

Endodontics is an established core element of dental practice in the developed world. It is therefore the responsibility of dental schools to prepare their students to undertake uncomplicated root canal treatments of predictable quality on graduation.

The growth of interest in evidence-based practice brings with it the need to define acceptable standards of care based on a distillation of the best available clinical and scientific information. Such guidelines have been formulated by the European Society for Endodontology to define the acceptable standard of care in clinical endodontics (European Society of Endodontology 1994).

However, a number of recent studies have revealed that much of the endodontic provision within the UK General Dental Services falls below the international standard of care (Grieve & McAndrew 1993, Saunders *et al.* 1997, Dummer 1998). One very recent report (Dummer 1998) has identified that only 10% of the

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provision within the UK General Dental Services was of a technically satisfactory standard, as defined by European guidelines. The reasons for this are probably complex, and involve not only the quality and uptake of undergraduate and postgraduate education, but organizational and fiscal issues within the British National Health Service. It is relevant that the British Endodontic Society Second Workshop in Endodontics, held in 1990, identified as a recurrent theme the perception that UK dental schools did not prepare students adequately for endodontics in practice (Brookman 1991, Dummer 1991, Stock 1991). Sixty-seven per cent of the recent UK graduates surveyed (Brookman 1991) voiced dissatisfaction with their undergraduate training in endodontics. Lack of priority for endodontic teaching in the undergraduate curriculum, and inadequate numbers of properly trained staff were identified as major problems (Brookman 1991, Dummer 1991, Stock 1991).

A recent survey by Qualtrough & Dummer (1997) showed promising trends in the delivery of undergraduate endodontic teaching in the UK, with greater time allocation for preclinical instruction, but it was not clear from this survey how this reflects the international status of undergraduate teaching as the millennium approaches.

The aim of this postal survey was to compare the preclinical teaching of endodontology in the United Kingdom with that in Continental European, Scandinavian, and North American Dental Schools. Issues of particular interest included the time allocated to this element of undergraduate education, the number and educational qualification of teachers, consensus within didactic coverage, and evidence of innovation.

The evidence presented provides descriptive data on preclinical endodontic education in Continental Europe, Scandinavia and North America, and places the most recent UK data in an international context.

Method

A postal questionnaire was sent to all of the undergraduate dental schools in North America, Scandinavia, Western (nonformer 'Iron Curtain') Europe, and the Eastern European states of Bosnia, Croatia, Hungary and Poland, representing former communist 'Iron Curtain' states (170 in total). The questionnaire has been described previously (Dummer 1991, Qualtrough & Dummer 1997), and explores a range of issues including:

- Major department delivering preclinical endodontic courses
- Number and educational qualifications of teaching staff
- Staff:student ratios
- Teaching resources
- Methods of appraisal
- Time allocation to preclinical teaching
- Recommended textbooks
- Recommended procedures and materials

Secondly, follow-up questionnaires were sent 1 month later to all non-responding schools.

Data were stored in a Microsoft Excel spreadsheet on PC for later analysis.

Data sets were defined for Western European, Eastern European, Scandinavian and North American schools, and assessed in comparison with previously published data on UK dental schools (Qualtrough & Dummer 1997).

Results

Response

Completed questionnaires were received from 72 schools, representing a 43% overall response rate. Table 1 shows the breakdown of responses by geographical region.

Resources and infrastructure

Issues related to organization and responsibility for endodontic teaching, resources, and internal evaluation are presented first. Most recent UK data (Qualtrough & Dummer 1997) are tabulated in each section for comparison.

Academic responsibility for preclinical endodontic teaching

In Scandinavia and North America, where endodontics is an established clinical academic specialty, teaching is largely the responsibility of dedicated endodontic departments or divisions (Table 2). It also follows that

Table 1 Response by geographical region

Geographical region	Questionnaires returned (%)
Western Europe	30 (35)
Eastern Europe	9 (47)
Scandinavia	8 (100)
North America	25 (49)

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teaching in these countries is delivered by academically trained endodontists (Table 3). By comparison, European and UK dental schools are less likely to have dedicated endodontic units or staff with recognized postgraduate training in the discipline (Table 2 and 3).

Staff:student ratios

Table 4 shows the mean and range of staff:student ratios encountered in each geographical area. Mean ratios are the least favourable in the UK, with 25% less staff resource than in Scandinavia and North America, and an even greater shortfall compared with European countries. There was, however, substantial school-to-school variation.

Supplementary teaching resources

Didactic lectures and practical classes were conducted by all schools, but many provided additional resources for self-directed learning. Table 5 shows the range of common supplementary aids. Home-produced manuals and videos were the most popular in all geographical areas. Computer-assisted learning was particularly prevalent amongst UK schools, with smaller numbers of Western European, Scandinavian and North American schools using multimedia resources.

Assessment of knowledge and skills

Teaching aims to provide undergraduate students with knowledge and skills. Formal written assessment of knowledge was most common in Scandinavia and North America (Table 6). Informal continuous assessment was also popular in all geographical regions. *Viva voce* examination was popular in Europe and the UK. Practical skills (Table 7) were assessed by formal testing in nearly all North American schools, and formalized continuous assessment was also widespread.

Time allocated to preclinical endodontic teaching

Time devoted to preclinical endodontic teaching is shown in Table 8. Mean time allocation was the greatest in Scandinavia, followed by North America and Western Europe. UK and Eastern European schools made substantially less time allocation to preclinical endodontics. Ranges varied widely in all regions, but were consistently high in Scandinavia and North America (Table 8).

Recommended textbooks

A wide range of standard texts were recommended (Table 9). However, selected texts did appear to bear some geographical loyalty, with the Scandinavian text by Tronstad being recommended by 88% of Scandina-

Table 2 Major academic department delivering preclinical endodontic courses *n* (%)

Department	West Europe	East Europe	Scandinavia	UK	North America
Endodontics	6 (20)	1 (11)	5 (63)		16 (64)
Endodontic division of restorative dentistry	3 (10)		3 (38)		7 (28)
Restorative dentistry	15 (50)	6 (67)		14 (100)	1 (4)
Applied dental medicine		1 (11)			1 (4)

Table 3 Educational qualification of undergraduate endodontic teachers *n* (%)

Educational status	West Europe	East Europe	Scandinavia	UK	North America
Qualified specialist			8 (100)		25 (100)
Special interest	21 (70)	4 (44)		12 (86)	
No special interest	1 (3)	4 (44)		2 (14)	

Table 4 Staff: student ratios

	West Europe	East Europe	Scandinavia	UK	North America
Mean	1 : 8	1 : 6	1 : 9	1 : 12	1 : 9
Range	1 : 3–1 : 20	1 : 3–1 : 8	1 : 6–1 : 10	1 : 6–1 : 25	1 : 3–1 : 25

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Table 5 Teaching resources for self-directed learning *n* (%)

Resource	West Europe	East Europe	Scandinavia	UK	North America
Manuals	16 (53)	4 (44)	7 (88)	9 (64)	23 (92)
Videos	16 (53)	5 (56)	5 (63)	7 (50)	16 (64)
Computer-aided learning	3 (10)		1 (13)	5 (36)	5 (20)
Tape/slide	2 (7)	1 (11)	3 (38)	3 (21)	5 (20)
None	4 (13)	2 (22)		2 (14)	

Table 6 Knowledge assessment *n* (%)

Method	West Europe	East Europe	Scandinavia	UK	North America
Continuous assessment	10 (33)	6 (67)	3 (38)	10 (71)	16 (64)
Written exam	9 (30)	2 (22)	5 (63)	6 (43)	22 (88)
Oral	4 (13)	1 (11)		4 (29)	
MCQ					1 (4)

Table 7 Skills assessment *n* (%)

Method	Wets Europe	East Europe	Scandinavia	UK	North America
Continuous assessment	10 (33)	6 (67)	3 (38)		20 (80)
Practical test	14 (47)	5 (56)	5 (63)	6 (43)	23 (92)
Case report	1 (3)			1 (7)	
OSCE				2 (14)	
Self-assessment	1 (3)		2 (25)	2 (14)	

Table 8 Mean and range of times (h) allocated to preclinical endodontic teaching

	West Europe	East Europe	Scandinavia	UK	North America
Mean	38	16	66	24	41
Range	6–150	3–48	42–108	15–51	29–62

Table 9 Recommended textbooks *n* (%)

Textbook	West Europe	East Europe	Scandinavia	UK	North America
[a]Walton & Torabinejad	1 (3)	2 (22)	4 (50)	4 (29)	13 (52)
[b]Cohen & Burns	5 (17)	2 (22)		1 (7)	7 (28)
[c]Ingle	2 (7)	1 (11)		1 (7)	4 (16)
[d]Tronstad	1 (3)		7 (88)	1 (7)	1 (4)
[e]Gutmann					2 (8)
[f]Harty	1 (3)			11 (79)	
Other	16 (53)	5 (56)		10 (71)	
None					2 (8)

[a]Walton & Torabinejad: *Principles & Practice of Endodontics,* Saunders.
[b]Cohen & Burns: *Pathways of the Pulp,* Mosby.
[c]Ingle and Bakland: *Endodontics,* Williams & Wilkins.
[d]Tronstad: *Clinical Endodontics,* Thieme.
[e]Gutmann *et al. Problem Solving in Endodontics,* Mosby.
[f]Harty's *Endodontics in Clinical Practice,* Wright.

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Table 10 Standard methods taught for determining working length (% of schools)

Method	West Europe	East Europe	Scandinavia	UK	North America
Radiographs	100	100	100	100	100
Electronic apex locator	43	22	38	21	36

Table 11 Canal preparation sequence by geographical area *n* (%)

Method	West Europe	East Europe	Scandinavia	UK	North America
Stepback	7 (23)	7 (78)	2 (25)	1 (7)	11 (44)
Stepdown/crowndown	17 (57)		5 (63)	12 (86)	14 (57)
Standardized	1 (3)	1 (11)			

Table 12 Instruments used routinely for canal preparation *n* **(%)**

Instruments	West Europe	East Europe	Scandinavia	UK	North America
Steel K files	24 (80)	4 (44)	7 (88)	13 (92)	18 (72)
Steel H files	11 (37)	7 (78)	2 (25)	2 (14)	5 (20)
Gates Glidden drills	3 (10)	3 (33)	2 (25)		10 (40)
NiTi hand files	3 (10)		2 (25)		5 (20)
NiTi rotary instruments	8 (27)		2 (25)		3 (12)

Table 13 Standard irrigant solutions *n* (%)

Irrigant	West Europe	East Europe	Scandinavia	UK	North America
Sodium hypochlorite	24 (80)	8 (89)	8 (100)	13 (93)	25 (100)
EDTA		2 (22)	2 (25)		2 (7)
Saline		3 (33)		2 (21)	1 (4)
Iodine/potassium iodide					1 (4)

Table 14 Standard obturation technique *n* (%)

Technique	West Europe	East Europe	Scandinavia	UK	North America
Cold lateral condensation	22 (73)	6 (67)	8 (100)	14 (100)	24 (96)
Warm vertical condensation	7 (23)	1 (11)	1 (13)		1 (4)

Table 15 Standard choice of root canal sealer cement *n* (%)

Material	West Europe	East Europe	Scandinavia	UK	North America
Zinc oxide–eugenol-based	14 (47)	1 (11)	4 (50)	14 (100)	22 (88)
Calcium hydroxide-based	6 (20)	6 (67)	5 (63)	7 (50)	3 (12)
Resin-based	12 (40)	5 (56)	7 (88)	4 (29)	1 (4)

vian schools, and by less than 7% in other regions. Similarly, the UK text by Harty was the predominant text in UK schools, and the North American texts by Walton & Torabinejad, Cohen & Burns, and Ingle preferred by North American schools. A number of non-English language texts were utilized by European schools.

Operative techniques

Working length determination All dental schools routinely employed radiographs for working length determination (Table 10). More than one-third of Western European, Scandinavian and North American schools routinely taught the supplementary use of

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Table 16 Interappointment canal dressing materials *n* (%)

Medicament	West Europe	East Europe	Scandinavia	UK	North America
Routine medication	16 (53)	2 (22)	6 (75)	7 (50)	16 (64)
No routine medication	10 (33)	7 (78)	1 (13)	7 (50)	9 (36)
Calcium hydroxide	24 (80)	7 (78)	8 (100)	9 (64)	22 (88)
Steroid/antibiotic preparations	5 (17)	3 (33)		5 (36)	
Formocresol	1 (3)	1 (11)			4 (16)
Others, including volatile phenolics					6 (24)
None ever recommended					3 (12)

Table 17 Encouragement of single-visit treatment where possible *n* (%)

	West Europe	East Europe	Scandinavia	UK	North America
Yes	20 (67)	8 (89)	8 (100)	10 (71)	19 (76)
No	8 (27)	1 (11)		4 (29)	4 (17)

electronic apex locators. Fewer schools in Eastern Europe and the UK embraced this technology.

Canal preparation techniques

Preparation techniques incorporating early coronal flaring were predominant in all regions except Eastern Europe, where traditional stepback and standardized techniques were still the norm (Table 11). Eighty-six per cent of UK schools had embraced preflaring techniques. However, a simple stepback technique was still the standard method in a quarter of Western European and Scandinavian schools, and in 44% of North American schools.

Instruments for canal preparation

Stainless steel K and H files predominated in all geographical areas (Table 12). However it was noteworthy that a number of North American, Scandinavian, and Western European schools had incorporated the routine use of nickel-titanium hand instruments into their routine preclinical teaching. One quarter of Western European and Scandinavian schools, and 12% of those in North America, had even embraced ''state-of-the-art'' rotary techniques (e.g. Profile, Maillefer, Ballaigues, Switzerland; Lightspeed, Lightspeed Technologies, San Antonio, TX, USA) in their courses.

Irrigant solutions

There was international consensus that sodium hypochlorite is the preferred irrigant in root canal therapy (Table 13). Some schools advocated the alternated use of sodium hypochlorite with a chelating EDTA solution, whilst a very small number of schools taught the use of non-antimicrobial, and non-tissue solvent saline solution. Only one North American school recommended the occasional use of iodine/potassium iodide solution for selected infected cases.

Standard obturation techniques

Cold lateral condensation remained the most popular undergraduate obturation technique in all regions (Table 14). One quarter of Western European schools, and smaller numbers in Eastern Europe, Scandinavia and North America advocated warm vertical condensation as the principal obturation method.

Sealer cements

Most schools employed a variety of sealer cements in their preclinical teaching (Table 15). Slow-setting zinc oxide-eugenol sealers dominated in North America, whilst the use of calcium hydroxide and resin-based products had greater prevalence in other regions.

Interappointment dressings

There appeared to be no consensus on the routine use of intracanal medicaments (Table 16). Most schools recognized the selected use of a variety of agents, and calcium hydroxide predominates. Steroid/antibiotic preparations were particularly prevalent in Europe and the UK, whilst formocresol and volatile phenolic agents

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remained in mainstream use in almost a quarter of North American schools.

Single visit treatment advocated

Single visit treatment appeared to have gained credibility, at least in principle, in all regions (Table 17). There was universal recognition that undergraduate endodontic treatment, especially for molars, would often stretch out to two, three or even more appointments.

Discussion

Postal surveys provide a convenient means of gathering information from a geographically diverse sample as represented by the 170 responding dental schools. In common with many similar postal surveys, the response rate was lower than desired (43% overall). Scandinavian dental schools were exceptional in providing a 100% return. Reminder (follow-up) questionnaires were sent to nonresponding units, but there were no realistic incentives which the researchers could use to encourage response. Busy academics may have many such requests, and may well have been discouraged from completing a lengthy and complex questionnaire for no tangible gain. We are, however, content that this survey provides rigorous evidence of regional trends and complements the previously published report of Dummer (1991), based on a North American sample of five dental schools, and on Swedish and Western European samples of only two schools each. The UK sample referred to throughout this report is based upon a survey with 100% return (Qualtrough & Dummer 1997).

Resources and infrastructure

Curriculum guidelines published by the European Society of Endodontology (European Society of Endodontology 1992) provide detailed recommendations on the delivery of undergraduate endodontology in European Dental Schools. They closely model guidelines published for North American schools (American Association of Dental Schools 1986).

The European guidelines recommend that undergraduate endodontic teaching should be delivered by skilled and experienced staff, where possible with advanced training in endodontology, and ideally should devote their university time fully to endodontology (European Society of Endodontology 1992). This is undoubtedly the case in North American and Scandinavian schools where endodontics is an established specialty, and where academic departments or units of endodontology are the rule rather than the exception. All of the endodontic teaching in these regions was delivered by educationally qualified endodontists. Although some variation existed, it was more probable in Continental Europe and the UK that endodontic teaching would be delivered by departments of Restorative Dentistry, and it was less likely that teaching staff would have formal advanced training. That is not, of course, to imply that staff without formal advanced training are not 'skilled and experienced'. However it has been noted that staff with advanced specialist training 'invariably provide a higher and more uniform standard of teaching' (Dummer 1991) than generalists, who may be less well grounded in the literature, and have less clinical experience of the discipline.

On 15 April 1998, the General Dental Council of the United Kingdom (Distinctive Branches of Dentistry) regulations recognizing the distinctive specialty of endodontics came into force (General Dental Council 1998). The specialist list for endodontics opened on 1 June 1998, and guidelines for 3-year advanced postgraduate training pathways in endodontics have been approved.

Since the report of Qualtrough & Dummer (1997), one UK school has established a unit of Operative Dentistry and Endodontology, responsible for undergraduate and postgraduate teaching, and a number of schools are considering the development of specialist training programmes. These may yield a larger pool of appropriately qualified individuals who may contribute to undergraduate education in the UK. A similar survey conducted one decade into the new millennium could well reveal a changed complexion of endodontic teaching resources in the UK, provided that political and fiscal limitations permit.

European guidelines also recommend that adequate staff:student ratios are required to ensure that the curriculum guidelines (European Society of Endodontology 1992) are delivered. The results of this survey indicate that there is substantial variation in staff:student ratios. On average, UK schools appear to devote substantially fewer teaching staff to preclinical endodontology than any of the other regions surveyed. This may reflect the resources available or to the priority given to

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endodontic education. UK provision cannot be deemed inadequate as the European guidelines provide no indication of minimum staff:student ratios, but it is recognized that teachers have difficulty in recognizing student weakness in the presence of poor staff:student ratios (Dummer 1991).

Another marker of teaching priority relates to the time allocated for preclinical endodontic teaching. There was again substantial variation, ranging from 3 h to 108 h. On average, Scandinavian and North American schools allocated the most time. UK dental schools once again had substantially less time than schools in other regions, with the exception of Eastern Europe. A major finding of Dummer's 1991 survey, and one which caused most concern was the limitation of time for preclinical practice of endodontics in the UK. Despite a recent report that indicated the UK picture had improved (Qualtrough & Dummer 1997), the present survey reinforces the earlier findings of Dummer (1991), when the UK is placed within the current international context.

The need to assess knowledge and practical skills appeared to be recognized in all regions, and a variety of means were employed. It is impossible, however, from the data supplied to determine the degree of formality of continuous assessment in different dental schools, especially in those in which staff:student ratios were low.

Effective continuing education should encourage understanding and deep learning. Toward this end, many dental schools supplemented the traditional lecture with instructional manuals, videos and textbooks. Interactive, computer-aided learning has gained particular popularity in the UK where more than one-third of schools have adopted this new technology. The major North American textbooks by Walton & Torabinejad, Cohen & Burns, and Ingle remain universally popular resources, and reflect the growing international consensus in endodontic education. It was perhaps not surprising that regional loyalties were seen in the choice of some standard texts, and this will inevitably be reflected in subtle differences in philosophy and emphasis related to undergraduate training.

Operative techniques

The second section of this survey was designed to examine in detail the practical procedures recommended in the schools surveyed. Of particular interest was evidence that there was a general international consensus within teaching programmes, and that recently introduced innovations were gaining recognition and becoming accepted in the mainstream of basic undergraduate education.

In general terms, there was international agreement related to curriculum content. All of the schools surveyed recommended radiographs as the first choice for working length determination, most were recommending preflaring during canal preparation, and advocating stainless steel K and H files. Sodium hypochlorite solution was almost universally used for canal irrigation, and cold lateral condensation was still the benchmark obturation technique.

There was less consensus with respect to the choice of root canal sealer cements, with many schools advocating more than one class of material. In common with the survey of Dummer (1991) slow-setting zinc oxide-eugenol sealers, such as Grossman's formula, were by far the most popular in North American schools, though a small number of schools advocated the more recently introduced calcium hydroxide-based materials. Resin- based sealers were not popular.

Resin-based sealers were more popular in Scandinavia and Continental Europe, but not to the exclusion of zinc oxide- or calcium hydroxide-based materials. Long-term evidence is not available on the clinical performance of root canal sealers, and this may be reflected in the diversity of materials considered acceptable.

There was also little consensus on the use of intracanal medicaments, although it did emerge that calcium hydroxide pastes were the most widely used medicaments, followed in Europe and the UK by antibiotic/steroid preparations. The use of volatile phenolic compounds and aldehydes appeared to be waning in all regions surveyed.

The practice of single-visit treatment appeared to be accepted in the majority of dental schools, and not just for vital cases. It was, however, universally acknowledged that most undergraduate treatments, especially molar treatments, would occupy two, three or even more clinical sessions.

Endodontics has not been short of procedural or technological innovations in the last decade. Frequently, such developments occur rapidly, and products often appear before they have been validated. Teachers are correctly cautious in introducing innovations until there is sufficient evidence.

This study indicates that a limited number of advances are becoming established in the mainstream of undergraduate teaching as the practice of

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endodontics evolves. More than 20% of responding UK and Eastern European schools, and approximately 40% of those in Western Europe, Scandinavia, and North America are routinely teaching the use of electronic apex locators as an aid in working length determination. A smaller number of schools also acknowledge the enhanced preparation derived from hand and engine-driven nickel-titanium instrumentation (Himel *et al.* 1995, Alexander *et al.* 1997).

It is uncertain as to when such quality-enhancing innovations gain sufficient acceptance to be incorporated into basic teaching, but important factors include the evidence-base in international literature, the attitudes, training and experience of teachers, and the cost implications for students and educational institutions.

There is one standard of care for root canal treatment, and dental schools should strive to be progressive in the content and quality of their teaching provision. This paper presents evidence that there is general consensus amongst endodontic educators in the regions surveyed, but that resources and priority vary considerably from region to region.

Conclusion

It appears that teachers in the UK are broadly advocating techniques recommended elsewhere, and that there is considerable international consensus on the content of preclinical undergraduate endodontic courses.

It is also clear that the academic endodontic infrastructure is less well established in the UK than in some other regions, notably Scandinavia and North America, and that there is still less priority given to endodontic teaching in the UK than in many other developed countries. It is possible that this position will have some impact on the quality of care provided by UK dental graduates as they strive to deliver endodontic treatment within the General Dental Services.

Based on the evidence of this study, and on the body of evidence on treatment standards in this core element of UK general practice, it is recommended that UK dental schools should review their priority and provision of resources for endodontic teaching. Consideration should also be given to the enhancement of the academic base for endodontology by the establishment of dedicated departments or units of endodontology within undergraduate and postgraduate teaching institutions.

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