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REVIEW

Undergraduate Endodontic Teaching in Dental Schools Around the World: A Narrative Review

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ABSTRACT

This narrative review aims to analyze the published data regarding undergraduate teaching of endodontics throughout the world. A literature survey was conducted to identify articles about undergraduate endodontic teaching, using the following combinations of keywords: (endodontic OR endodontics OR endodontology) AND (teaching OR training OR education OR curriculum) AND (undergraduate OR pre-graduate) AND (evaluation OR assessment) AND (dental schools OR dental faculty). The inclusion criteria established were studies published in the last 10 years, in which those responsible for teaching endodontics reported some data about the undergraduate training of endodontics in dental schools around the world. The data provided by the included studies were extracted and organized into five sections: 1) General characteristics of teaching endodontics in the dental curriculum, 2) Teaching methodology in endodontic training, 3) Root canal treatment protocol used in undergraduate endodontic teaching, 4) Use of contemporary materials and technologies in endodontic training, and 5) Assessment methodology in endodontic training. The data found in the published studies show great consistency and, compared with the data found in studies carried out decades ago, allow us to conclude that the quality of endodontic teaching in dental schools around the world has increased substantially. However, there is still room for improvement in some aspects, especially the incorporation of new technologies and materials into the teaching of endodontics at the undergraduate level. This is the case of magnification, ultrasound and cone beam computed tomography (CBCT).

Keywords: Curriculum, dental schools, dentistry, endodontics, survey, teaching, undergraduate

HIGHLIGHTS

- The data found in the published studies show great consistency in endodontic teaching in dental schools around the world.
- Compared with studies carried out decades ago, the quality of endodontic teaching has increased substantially.
- There is stillroom for improvement in the incorporation of magnification, ultrasound and cone beam computed tomography (CBCT).
- Instrumentation is taught using NiTi rotary files in almost all dental schools around the world.
- Root canal treatment in single-rooted teeth was the endodontic treatment done in more than 90% of all dental schools.

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INTRODUCTION

Undergraduate university training in Endodontics is essential for students graduating from dental schools to adequately develop their profession as dentists. Dental graduates must acquire the knowledge and skills necessary to perform endodontic procedures with an adequate level of competence (1–3).

In recent decades, endodontics has incorporated new materials and equipment, as well as technical innovations, which increasingly facilitate endodontic treatment, and contribute to better care for patients with pulpal-periapical pathology (4). In addition, in the last years there have been important changes in the diagnostic and therapeutic criteria for pulpal and periapical pathology (5–9). For this reason, universities have had to make a significant effort to incorporate all these changes and innovations into both theoretical and practical teaching programs (1, 10). However, as the European Society of Endodontology (ESE) points out in Undergraduate Curriculum Guidelines for Endodontology, it is still the 'craftsmanship' that gets the job done, highlighting the need for both knowledge and skills training in undergraduate education (3).

Since 1992, the ESE has published curricular guidelines for the undergraduate teaching of endodontics that have served as a reference and guide for dental schools. The latest update of the ESE Undergraduate Curriculum Guidelines for Endodontology has just been published last year (3). However, resources for delivering the endodontic curriculum vary from country to country, and even from school to school within a country (1, 10), so students may graduate with different levels of knowledge and experience (11).

Several studies conducted over the past decades, particularly in the United Kingdom, Germany, and France, have evaluated the teaching of endodontics at the undergraduate level, identifying considerable variability in curricula, limited clinical experience, and scarce use of modern technologies (12–14). However, these early studies were often restricted to national contexts and did not reflect the global evolution of endodontic education. Today, important differences persist between countries —and even between dental schools within the same country— in terms of the availability of resources, incorporation of contemporary techniques, staff specialization, and clinical training opportunities (1, 10, 15–17).

Historically, endodontic training was mainly based on didactic lectures and preclinical exercises using extracted or plastic teeth, with minimal exposure to advances such as magnification, rotary instrumentation, and bioceramic materials (12, 14). As undergraduate education forms the foundation of future general dental practice, the quality and scope of endodontic teaching at this stage have a direct impact on the technical competence, confidence, and clinical decision-making skills of new dentists (1, 3, 18). Therefore, a comprehensive understanding of current educational practices worldwide is essential to identify areas for improvement and to promote standardized, high-quality training in endodontology.

Knowing how endodontics is currently being taught in undergraduate dentistry studies is of great interest to determine whether new teaching methodologies, new materials and contemporary techniques, as well as new diagnostic and therapeutic criteria are being incorporated in the teaching of dental students. Therefore, the aim of this study was to analyze undergraduate endodontic teaching worldwide, with particular attention to clinical practices, teaching methodologies, and integration of modern technologies.

METHODS

In the writing of this review article, the Scale for the Assessment of Narrative Review Articles (SANRA) has been followed (19). A literature survey was conducted to identify articles about undergraduate endodontic teaching. The search was carried out in PubMed, SCOPUS and EMBASE, using the following combinations of keywords: (endodontic OR endodontics OR endodontology) AND (teaching OR training OR education OR curriculum) AND (undergraduate OR pre-graduate) AND (evaluation OR assessment) AND (dental schools OR dental faculty).

The included studies were cross-sectional surveys conducted among faculty members responsible for teaching endodontics in dental schools. The inclusion criteria established were studies published in the last 10 years, in which those responsible for teaching endodontics reported some data about the undergraduate training of endodontics in dental schools around the world. Reviews, conference articles, letters to the editor and studies based on surveys to students or expert opinions were excluded. No language restriction was applied. Three reviewers analyzed all titles and abstracts, and in some cases the full text, of the articles found, independently and in duplicate. Articles that did not meet the inclusion criteria were excluded. In case of disagreement between reviewers, it was resolved through debate.

Although a formal risk of bias or quality assessment was not performed due to the narrative nature of this review and the heterogeneity of methodologies, only peer-reviewed articles with clearly reported survey data were considered.

RESULTS AND DISCUSSION

The search yielded 124 articles related to the teaching of endodontics. After reviewing the titles, abstracts and, in some cases, the full texts, 28 studies were found that analyzed some aspects of the teaching of endodontics at the undergraduate level. Ten studies were excluded because they were published more than 10 years ago (12–14, 20–25). The period of ten years has been decided considering that in the last decade there have been very important changes in the teaching of dentistry, as well as the incorporation of numerous new technologies into the practice of endodontics (2, 3).

Three other studies were excluded because they were surveys of undergraduate students (26–28). One study was excluded because the survey had been conducted among directors of postgraduate programs in endodontics (29).

Finally, 14 articles (Table 1) in which the responsible for teaching endodontics in dental schools responded to surveys, reporting data on undergraduate training of endodontics, were selected and included in the review: five studies evaluated undergraduate endodontic teaching in Asian countries (30–34), five other studies analyzed the teaching of endodontics in European countries (1, 10, 15, 16, 35), three studies investigated different aspects of undergraduate endodontic training in Brazil (36–38), and one study analyzed endodontic teaching in Canada (17).

TABLE 1. Studies included in the review

Authors	Year of publication	Country	Number of dental schools respondents to the survey	Percentage of dental schools respondents to the survey
Narayanaraopeta & AlShwaimi (30)	2015	Saudi Arabia	6	100
Al Raisi et al. (10)	2019	United Kingdom	15	94
Brown et al. (35)	2020	United Kingdom & Ireland	15	83
Baharin & Omar (31)	2021	Malaysia	9	69
da Costa Ferreira et al. (36)	2021	Brazil	19	35
Sacha et al. (15)	2021	Germany, Switzerland & Austria	33	89
Segura-Egea et al. (1)	2021	Spain	20	96
Algahtani et al. (33)	2022	Saudi Arabia	25	96
Alobaid et al. (34)	2022	Saudi Arabia	15	72
Rech et al. (37)	2022	Brazil	41	20
Mergoni et al. (16)	2022	Italy	28	78
Algahtani et al. (32)	2023	Saudi Arabia	25	96
Coehlo & Rios (38)	2023	Brazil	35	35
Goyal et al. (17)	2024	Canada	10	100

The number of dental schools included in each study varied between six (30) and 41 (37). The percentage of respondents also varied greatly, from 20% (37) to 100% (30). Taking into account that the response rate was higher than 69% in 11 studies (79%), it can be considered that the data provided are representative of the state of endodontic teaching in their respective countries.

Since the aspects of endodontic teaching assessed in the different studies were different and varied, the data provided by the included studies were extracted and organized into five sections: 1) General characteristics of teaching endodontics in the dental curriculum, 2) Teaching methodology in endodontic training, 3) Root canal treatment protocol used in undergraduate endodontic teaching, 4) Use of contemporary materials and technologies in endodontic training, and 5) Assessment methodology in endodontic training.

General Characteristics of Teaching Endodontics in the Dental Curriculum

Ten studies (Table 2) provided data on the year in which endodontics was taught, the status of the supervising endodontic staff, and the staff: student ratio (1, 10, 15–17, 30–32, 34, 35). In most dental schools, endodontics is taught in the third, fourth and fifth years of the curriculum. Theoretical teaching and preclinical practices are taught in the third and fourth years, while endodontic clinical practice is taught in the fourth, fifth and sixth years. The fourth year of the degree in dentistry is the one in which endodontic contents are most frequently taught.

In all dental schools, at least 50% of endodontics teachers are specialists. A major factor in the quality of teaching a subject lies in the level of training of the teachers and their motivation and interest (39). Therefore, training in endodontics must be supervised by teachers with specific preparation and clinical practice in endodontics (2). The situation shown by the surveys included in this review appears to have improved substantially since the study published in 1997 in UK (Qualtrough and Dummer (12)), when none of the schools had supervising staff with advanced training in endodontics.

The staff-to-student ratio varies greatly depending on whether it is preclinical or clinical practice, being around 1:5 to 1:15 in preclinical practice (15, 17) and 1:3 to 1:8 in clinical practice (17, 31). These staff: student ratio are similar to those in prosthetics laboratory practices in Malaysian dental schools (1:12) (40) and in clinical practice of oral surgery (1:4) in British universities (41). The great variability of the staff: student ratio corresponds to the variable number of students in the different dental schools. Dental schools with large student number tend to have a lower staff: student ratio.

Teaching Methodology in Endodontic Training

Nine studies provided data on teaching methodology (1, 10, 15–17, 30, 31, 33, 34). Lectures, pre-clinical practices and clinical practices were used by almost 100% of dental schools (Table 3). Problem-based learning and seminars were used in more than 50% of schools. Seminars, video and e-learning are also widely used in teaching endodontics. These results differ substantially from those shown by the study carried out almost 30 years ago in the United Kingdom (Qualtrough and Dummer (12)), who only identified lectures and seminars as methods of teaching theoretical content on endodontics at undergraduate level. Undoubtedly, new teaching methodologies have been incorporated into the undergraduate training of endodontics.

The theoretical contents taught in the subject of endodontics are only mentioned in five of the studies, four carried out in Europe (1, 10, 15, 16), and other in Canada (17), showing that almost all dental schools included the contents indicated in the ESE Undergraduate Curriculum Guidelines for Endodontology (3). This is a very important point, taking into account that in endodontics, students' practical skills and theoretical knowledge are significantly correlated (18). Non-vital bleaching, which was not included in the curriculum of some schools in the UK twenty-seven years ago (Qualtrough and Dummer) (12), now it is included in almost 100% of dental schools (1, 10, 15, 16).

Preclinical endodontic practices are taught in all dental schools. This result contrasts sharply with that of a previous survey con-

TABLE 2. General characteristics of undergraduate teaching endodontics in the dental curriculum

Authors	Year& Country	Year of training (% of DS)	Status of the supervising staff in preclinical practices (% of DS)	Status of the supervising staff in clinical practices (% of DS)	Staff: student ratio in pre-clinical practices (% of DS)	Staff: student ratio in clinical practice (% of DS)
Narayanaraopeta & AlShwaimi (30)	2015 Saudi Arabia	Fourth 83 One semester in fourth 17	Pre-clinical GDPs 15 Specialist 85	–	1:2 to 1:8	–
Al Raisi et al. (10)	2019 United Kingdom	Pre-clinical: Second / Third 40 Second / Fourth 13, Third / Fourth 20 Clinical: Fifth 100	Pre-clinical GDPs 80 Specialist* 60	Clinical GDPs 87 Specialist* 67	1:5 to 1:20 100	1:4 to 1:6 87 1:8 13
Brown et al. (35)	2020 UK & Ireland	–	Specialist 87 GDPs 13	Specialist 87 GDPs 13	–	–
Baharin & Omar (31)	2021 Malaysia	–	Specialist* 100 Part-time specialist 56 Tutors 11 GDPs 11	Specialist* 100 Part-time specialist 56 Tutors 11 GDPs 11	Ranging 1:3 to 1:8; Average 1:7	Ranging 1:3 to 1:8; Average 1:7
Sacha et al. (15)	2021 Austria, Germany and Switzerland	–	GDPs 76 Specialist 58	–	Ranging 1:4 to 1:38; Average 1:15	–
Segura-Egea et al. (1)	2021 Spain	Pre-clinical: Second 15, Third 75, Fourth 95 Clinical: Fourth 95, Fifth 100	GDPs 100 Specialist* 65	GDPs 100 Specialist* 65	1:6 15 1:10 55 1:14 25 1:20 5	1:6 65 1:10 35
Alobaid et al. (34)	2022 Saudi Arabia	Pre-clinical: Before fourth 13 Fourth 73, Fifth-Sixth 14 Clinical: Fourth-Sixth 26, Fifth-Sixth 73	Specialist* 100	Specialist* 100	1:6 (median)	1:7 (median)
Mergoni et al. (16)	2022 Italy	Third 7, Fourth 36 Fifth 82, Sixth 29 Several academics years 67	GDPs 50 Specialist* 50	GDPs 50 Specialist* 50	1:4 to 1:20; Average 1:9	1:2 to 1:20; Average 1:7
Algahtani et al. (32)	2023 Saudi Arabia	Pre-clinical: Third Clinical: Fourth and Fifth	Specialist 92%	Specialist 92%	1:8 or less	1:8 or less
Goyal et al. (17)	2024 Canada	–	GDPs 60 Specialist* 40	GDPs 60 Specialist* 40	1:5	1:3

*: Professors with specialized training in endodontics. DS: Dental schools, GDPs: General dental practitioners with private practice mainly dedicated to endodontics

TABLE 3. Teaching methodology in endodontic training

Authors	Year& Country	Teaching methodology (% of DS)	Subjects taught (% of DS)	Type of root canals used in pre-clinical practice (% of DS)	Types of endodontic treatments in pre-clinical training (% of DS)	Types of endodontic treatments in clinical training (% of DS)
Narayanaraopeta & AlShwaimi (30)	2015 Saudi Arabia	Preclinical lectures 100	–	Natural teeth 100 Artificial teeth 67	–	–
Al Raisi et al. (10)	2019 UK	Lectures 100 PC practices 100 C practices 100 PBL (cases) 80 Seminars 14 Video 60 E-learning 60 Tutorials 14	Pulp histology 100 Root canal anatomy 100 Endodontic microbiology 100 Pulp pathology 100 Endodontic radiology 100 Endodontic materials 93 Vital pulp therapy 100 RCT on mature teeth 100 RCT on immature teeth 100 Re-treatment 100 Regenerative endodontics 73 Endodontic surgery 100 Restoration of RFT 100 Non-vital bleaching 93 Dental traumatology 100 Endodontic emergencies 93	Natural teeth 73 Canals in acrylic blocks 60 Plastic teeth 73 3D printed teeth 13 Acrylic blocks with S-shaped curves 7 RCT (one) 100 RCT (multi) 100	RCT (one) 100 RCT (multi) 100	Simple cases 100 Moderate complexity 93 Complicated cases 27
Baharin & Omar (31)	2021 Malaysia	Lectures 100 PC practices 100 C practices 100 PBL 56 Seminars 79 Tutorials 67	–	–	–	–
Sacha et al. (15)	2021 Austria, Germany and Switzerland	Lectures 94 Lecture hands-outs 82 PC practices 100 Demonstrations 94 Seminars 42 Study groups 30 E-learning 24 Tutorials 15 Inverted classroom 15 Endodontics Scripty 55	Root canal anatomy and pulp histology 100 Pulp pathology 100 Endodontic microbiology 100 Endodontic materials 100 Endodontics radiology 100 VPT 100 RCT 100 Re-treatment 100 Endodontic regeneration 100 Endodontic surgery 100 Restoration 100 Non-vital bleaching 100 Immature teeth 100 Endodontic emergencies 100	Natural teeth 94 Plastic teeth 15	RCT (one) 100 RCT (multi) 100	–

TABLE 3. Cont.

Authors	Year& Country	Teaching methodology (% of DS)	Subjects taught (% of DS)	Type of root canals used in pre-clinical practice (% of DS)	Types of endodontic treatments in pre-clinical training (% of DS)	Types of endodontic treatments in clinical training (% of DS)
Segura-Egea et al. (1)	2021 Spain	Lectures 100 PC practices 100 C practices 100 PBL 100 Seminars 80 Video 70 E-learning 50 Tutorials 15 Bibliographic sessions 5	Pulp histology 100 Root canal anatomy 100 Endodontic microbiology 100 Pulp pathology 100 Endodontic radiology 100 Endodontic materials 100 Vital pulp therapy 100 RCT on mature teeth 100 RCT on immature teeth 100 Re-treatment 100 Regenerative endodontics 100 Endodontic surgery 100 Restoration of RFT 100 Non-vital bleaching 100 Dental traumatology 100 Endodontic emergencies 100	Natural teeth 100 Canals in acrylic blocks 40 Plastic teeth 25 3D printed teeth 0 Acrylic blocks with S-shaped curves 0	RCT (one) 100 RCT (multi) 100 VPT 100 Immature teeth 10 Endodontic surgery 5 Pulp revascularization 5 Non-vital bleaching 30 Re-treatment 35	RCT (one) 90 RCT (multi) 40 VPT 90 Immature teeth 5 Endodontic surgery 0 Pulp revascularization 0 Non-vital bleaching 30 Re-treatment 10
Alobaid et al. (34)	2022 Saudi Arabia	–	–	Natural teeth 87 Canals in acrylic blocks 20 Plastic teeth 87 3D printed teeth 13 Acrylic blocks with S-shaped curves 13	RCT 80 VPT 20 Immature teeth 0 Endodontic surgery 13 Pulp revascularization 0 Re-treatment 34	RCT 93 VPT 93 Immature teeth 100 Endodontic surgery 88 Pulp revascularization 100 Re-treatment 93
Algahtani et al. (33)	2022 Saudi Arabia	–	–	Natural teeth 96 Canals in acrylic blocks 8 Plastic teeth 48 3D printed teeth 16 Acrylic blocks with S-shaped curves 0	–	RCT 100 VPT 92 Immature teeth 20 Endodontic surgery 0 Pulp revascularization 8 Re-treatment 68
Mergoni et al.(16)	2022 Italy	Lectures 100 Pre-clinical training 100 Clinical training 89 PBL 21 Textbooks 89 Seminars 68 Video 64 E-learning 25 Recommended readings 71 Study groups21	Biological bases of endodontics (pulp histology, endodontic microbiology, root canal anatomy and pulp pathology, and endodontic radiology). Clinical treatment of endodontic diseases	Natural teeth 82 Canals in acrylic blocks 39 Plastic teeth 46 3D printed teeth 18 Acrylic blocks with S-shaped curves 7	RCT (one) 100 RCT (multi) 96 Re-treatment 46 Endodontic surgery 19 Non-vital bleaching 12 Vital pulp therapy 8 Pulp revascularization 0	RCT (one) 92 RCT (multi) 79 VPT 46 Endodontic surgery 13 Pulp revascularization 4 Non-vital bleaching 29 Re-treatment 50 Only assistants 8

TABLE 3. Cont.

Authors	Year& Country	Teaching methodology (% of DS)	Subjects taught (% of DS)	Type of root canals used in pre-clinical practice (% of DS)	Types of endodontic treatments in pre-clinical training (% of DS)	Types of endodontic treatments in clinical training (% of DS)
Goyal et al. (17)	2024 Canada	Lectures 100 Laboratory training 100 Practical training 100 E-learning 90 Videos 90 Seminars 40 Manuals 60 Reading list 60 Case-based studies 60 Clinical cases 70 PBL 50	Root canal anatomy and pulp histology 100 Pulp pathology and endodontic microbiology 100 Endodontic radiology 80 Endodontic materials 90 Vital pulp therapies 100 RCT 100 RCT on immature teeth 80 Re-treatment 70 Endodontic regeneration 70 Endodontic surgery 80 Restoration of RFT 80 Non-vital bleaching 80 Dental trauma 100 Endodontic emergency 100 Endodontic diagnosis 100	Natural teeth 70 Commercially available simulated teeth 70 3D-printed teeth 40 Acrylic blocks with simple curves 20 Acrylic blocks with S-shaped curves 0	RCT (one) 100 RCT (multi) 100 VPT 90 Re-treatment 10	RCT in incisors 71 RCT in premolars 57 RCT in molars 71

DS: Dental schools, RCT: Root canal treatment, RFT: Root filled teeth, VPT: Vital pulp therapy, PC: Pre-clinical, C: Clinical, PBL: Problem-based learning

ducted in German universities (14), in which it was found that pre-clinical practice endodontic training varied considerably because of differences in program design, staff and course content. Regarding the type of root canals used in pre-clinical practice, natural teeth were used in all dental schools in Spain (1), and Saudi Arabia (30), in most dental schools in Austria, Germany, Switzerland, Italy and Malaysia (15, 16, 31), and in at least 70% of schools in the United Kingdom (10) and Canada (17). Artificial teeth, plastic teeth and canals in acrylic blocks were used in less than 50% of schools.

Few studies indicate the type of endodontic treatments that students perform in pre-clinical practices. Root canal treatment (RCT) in one-rooted and multi-rooted teeth are performed in all dental schools in Spain (1), Italy (16), United Kingdom (10), Austria, Germany and Switzerland (15) and Canada (17).

Re-treatments were carried out in almost 50% of Italian dental schools (16), in one third of the schools in Spain (1) and Saudi Arabia (34), and only in 10% of Canadian dental schools (17).

Concerning the types of endodontic treatments in clinical training, RCT in single-rooted teeth was the endodontic treatment done in more than 90% of all dental schools (1, 10, 33, 34). Vital pulp therapy was carried out by endodontic students in more than 90% of schools in Spain (1) and Saudi Arabia (33, 34), and by almost 50% in Italian universities (16). In view of these results, the objectives set by the ESE in the Undergraduate Curriculum Guidelines for Endodontology, i.e. Students should be competent in performing good-quality root canal treatment and at preserving vital pulp functions by the implementation of vital pulp therapies, including indirect pulp capping, direct pulp capping, partial pulpotomy and full pulpotomy (3), seems that they are being fulfilled.

Non-vital bleaching in clinical training was carried out in a third of dental schools in Italy and Spain (1, 16). Most studies show that endodontic surgery is outside of clinical endodontic practices in most countries. Endodontic surgery is probably covered in most dental schools in postgraduate endodontic teaching.

Root Canal Treatment Protocol Used in Undergraduate Endodontic Teaching

Data on RCT protocol used in undergraduate teaching were found in ten studies (1, 10, 15–17, 30–32, 36, 37) (Table 4), but two of them provided very few data (36, 37), and another study only provided data about pre-clinical practices (15).

A study carried out in Malaysia (31) was the only one who provided data on the use of the rubber dam, specifying that its use was compulsory in all Malaysian dental schools. The fact that only one of the studies investigated the use of rubber dam in endodontics, probably indicates that its use is considered so routine that the possibility of teaching RCT without their use is ruled out.

TABLE 4. Root canal treatment protocol used in undergraduate endodontic teaching

Authors	Year & Country	Working length (% of DS)	Instrumentation (% of DS)	Irrigation (% of DS)	Intracanal medicament (% of DS)	Obturation technique (% of DS)	Sealers (% of DS)	Final restoration (% of DS)
Narayanaraopeta & AlShwaimi (30)	2015 Saudi Arabia	PC practices Periapical radiograph 100 Radiograph + EAL 83	PC practices NiTi files 83 Step back 100 Crown down 100	–	–	PC practices CLC 100	–	–
Al Raisi et al. (10)	2019 UK	PC practices Periapical radiograph 53 EAL 53 Clinical practices Radiography + EAL 93 CBCT 7 Only EAL 7	Hand files 100 Rotary files 100 Protaper Gold 60 Protaper Next 13 Protaper 27 Reciproc 20 WaveOne Gold 13 WaveOne 7	PC training Water 66 SH 13 Water + SH 13 Saline 6 Clinical training SH 40 SH + EDTA 13 SH + other 7	CH 100 Odontopaste 7	PC training CLC 47 WVC 13 Single cone 20 Thermoplastic 13 CBG 27 Clinical training CLC 40 WVC 33 Single cone 27 Thermoplastic 7 CBG 13	–	Definitive 100 Provisional 73
Baharin & Omar (31)	2020 Malaysia	Periapical radiograph 100 EAL 100 CBCT 22	Hand instruments Step-back 78 Crown-down 100 Rotary system 56	SH 100 EDTA 100 CHX 56	CH 100 Corticosteroid-AB 56	CLC 100 WVC 44 Single cone 11	Epoxy resin 100 CH sealer 11 Zinc oxide eugenol 22	–
da Costa-Ferreira et al. (36)	2021 Brazil	–	Rotary system 58 Reciprocating system 37	–	–	WVC 21	–	–
Sacha et al. (15)	2021 Austria, Germany and Switzerland	PC practices Periapical radiograph 58 EAL 58	PC practices Manual files 91 Rotary/reciprocal 82 Step-back 73	PC practices SH 76 CHX 42	CH 82 CH+CHX 6	PC practices CLC 85	PC practices Epoxy resin 91	PC practices Definitive 76
Segura-Egea et al. (1)	2021 Spain	Radiography+EAL 95 Only radiography 5	Hand files 100 Rotary files 100 Protaper Gold 65 Protaper Next 45 Wave One Gold 10	SH <3% 50 SH 3–6% 50 EDTA 60 CHX 25	CH 100	CLC 100 Continuous wave 25 Single cone 20 –	–	Definitive 70 Provisional 20 Depending case 10
Rech et al. (37)	2022 Brazil	Radiography+EAL 71 Only radiography 24 Only EAL 5	–	–	–		–	–
Mergoni et al. (16)	2022 Italy	Radiography+EAL 92 Only EAL 8	PC practices Hand/Rotary files 79 Only hand files 11 Only rotary files 11 Clinical practices Hand/Rotary 79 Only rotary 21	SH 84 EDTA 76	CH 100	PC training Single cone 14 WVC 86 Clinical training CLC 24 Single cone 44 WVC 76 Continuous wave 52	–	–

TABLE 4. Cont.

Authors	Year & Country	Working length (% of DS)	Instrumentation (% of DS)	Irrigation (% of DS)	Intracanal medicament (% of DS)	Obturation technique (% of DS)	Sealers (% of DS)	Final restoration (% of DS)
Algahtani et al. (32)	2023 Saudi Arabia	–	Manual files 100 Rotary system 52 Step-back 76 Crown-down 16 Heat treated files 36	SH 36 SH + EDTA 36 SH + saline 16	CH 60	CLC 92 WVC 4 Single cone 4	–	Provisional Spacer+cavit 56 Cavit+glass ionomer 44
Goyal et al. (17)	2024 Canada	–	Rotary system 100 Manual files 100 Reciprocating system 20 Protaper Gold 60 Hybrid technique 50	SH EDTA	CH 60 Syringe-needle method	WVC	–	Provisional 80 Cavit + GIC 40 Definitive 30 GIC 20

DS: Dental schools, EAL: Electronic apex locator, EDTA: Ethylenediaminetetraacetic acid, SH: Sodium hypochlorite, CHX: Chlorhexidine, CH: Calcium hydroxide, CLC: Cold lateral compaction, WVC: Warm vertical compaction, CBG: Carrier-based gutta-percha, GIC: Glass-ionomer cement, PC: Pre-clinical

For determining working length in clinical practice, electronic apex locators together with periapical radiographs are used in most of the dental schools (1, 10, 16, 30, 31, 37).

Instrumentation is taught using NiTi rotary files in almost all dental schools in Europe (15) and Canada (17), being Protaper Gold the system used in two thirds of dental schools (1, 10, 17). An earlier study carried out twenty years ago, including 16 French undergraduate dental schools (13), showed that rotary NiTi files were already used in endodontic teaching in 81% of French schools. However, in other countries NiTi rotary files were used only in about half of dental schools (32, 36).

Step-back technique was taught in most of schools (15, 17, 30–32).

Sodium hypochlorite, at different concentrations, was the irrigating solution used by most schools in endodontic clinical practice. EDTA was also used in a large percentage of schools as a second irrigating solution (1, 10, 16, 31). In PC practices some dental schools use chlorhexidine as an irrigating solution (15).

Calcium hydroxide was the most used intracanal medicament around the world, being used as an intracanal medicament in all dental schools in the United Kingdom (10), Spain (1), Italy (16) and Malaysia (31), in more than 80% in Austria, Germany and Switzerland (15) and in 60% of schools in Saudi Arabia (32) and Canada (17).

Regarding the obturation technique taught, cold lateral compaction was the root-filling technique trained in most dental schools (1, 15, 30–32). Warm vertical compaction was the second technique taught, being the most widely taught technique in Canadian dental schools (17). The single cone technique is rarely taught, being used by less than 30% of schools (1, 10, 16, 31, 32). The data show that cold lateral compaction technique remains the standard root filling technique in most dental schools. Despite widespread commercial support for gutta-percha transport systems, these are rarely used in endodontic teaching.

Taking together the results of these studies, it can be concluded that the clinical protocol followed for RCT worldwide is quite homogeneous, differing especially in the type of technique used for obturation of the root canal system. As regards European dental schools in particular, the clinical protocols for RCT followed in the countries from which data have been found, show greater convergence than that found in a previous study conducted fifteen years ago (24).

The definitive restoration of the treated tooth was carried out interchangeably by the student himself or by another in most dental schools (1, 10, 15).

Use of Contemporary Materials and Technologies in Endodontic Training

The use of modern technologies and materials in endodontics teaching was addressed by ten studies (1, 10, 15–17, 31, 32, 35, 36, 38) (Table 5).

TABLE 5. Using contemporary materials and technologies in endodontic training

Authors	Year & Country	CSBC (% of DS)	Ultrasonic (% of DS)	Magnification (% of DS)	CBCT (% of DS)
Al Raisi et al. (10)	2019 UK	40 in pre-clinical 80 in clinical	PC training 53 Clinical training 80	Not used 20 Used 33 Loupes in PC training 20 Loupes in clinical training 27	Used in clinical training (to determine WL) 7
Brown et al. (35)	2020 UK & Ireland	–	–	PC training Loupes 13; Operating microscope 53 Clinical training Loupes 13; Operating microscope 100	–
Baharin & Omar et al. (31)	2020 Malaysia	–	–	–	Used 22
da Costa-Ferreira et al. (36)	2021 Brazil	–	In cavity access 37 In calcified canals 47 In broken instruments 42 In retreatments 21	Operating microscope 30	–
Sacha et al. (15)	2021 Austria, Germany and Switzerland	PC practice Biodentine 18 MTA 27	In irrigation 18	PC training Not used 18 Operating microscope 48	–
Segura-Egea et al. (1)	2021 Spain	Yes 95 Biodentine 60 MTA 40	Not used 70 In cavity access 25 In instrumentation 5 In irrigation 20	Not used 90 Loupes 10 Operating microscope 10	–
Mergoni et al. (16)	2022 Italy	–	PC training 36 Clinical training 84	PC training Not used 36 Operating microscope 21 Clinical training Operating microscope 32	–
Algahtani et al. (32)	2023 Saudi Arabia	Used 92	Not used 76 Used to remove post and broken instruments 12 Used in cavity access 5	Operating microscope 32	Used 44
Coelho & Rios (38)	2023 Brazil	–	–	–	–
Goyal et al. (17)	2024 Canada	Bioceramic sealers 20 MTA 50%	In cavity access 30	Dental loupes 50 Operating microscope 10	Used 20

DS: Dental schools, CSBC: Calcium silicate based cements, CBCT: Cone beam computed tomography, MTA: mineral trioxide aggregate, WL: Working length, PC: Pre-clinical

Five studies reported data on the use of calcium silicate-based cements (CSBC) (1, 10, 15, 17, 32). Although the use of CSBC in preclinical practices was uncommon (10, 15), probably because of its high price, in clinical practices CSBC was used in most dental schools (1, 10, 32). The use of bioceramic sealers in undergraduate endodontic teaching only is reported in the study carried out in Canada (17), being used in 20% of Canadian dental schools.

Regarding the use of cone beam computed tomography (CBCT), based on the data provided by the studies that have investigated its use in teaching endodontics (10, 17 ,31, 32, 38), it can be concluded that CBCT is used in less than 50% of dental schools. This result indicates that CBCT has not yet been incorporated into the undergraduate teaching of endodontics. So, strategies must be considered to allow the integration of CBCT in clinical training use. A study carried out in Brazil showed that the minority of the dental schools (34%) owned a CBCT machine (38). This result contrasts with those of dental schools in the U.S.A. and the U.K., which in 2012 already had CBCT in 89% and 63% of cases, respectively (42). However, when asked if training in the acquisition of CBCT scans is provided to predoctoral students, the same study showed that none of the dental schools surveyed in the U.K. provided training to dental students to acquire the scan during the BDS curriculum and only five dental schools (33%) in the U.K. provided training to dental students to interpret a 3D volume acquired by the CBCT machine (42).

Magnification, and especially the use of the operating microscope, represents another addition to the practice of endodontics that has substantially improved its quality and results. However, the results of the review show that, in most countries, it has not yet been incorporated into undergraduate teaching of endodontics. Less than 50% of dental schools use magnification (1, 10, 15–17, 32, 36). On the contrary, in the United Kingdom and Ireland operating microscope is used in undergraduate endodontic clinical training in all dental schools (35). The high cost and lack of staff training could explain, at least in part, these results (35).

Finally, seven studies reported data about the use of ultrasonic devices in undergraduate endodontic teaching (1, 10, 15–17, 32, 36). The results of these studies show that ultrasound is rarely used in teaching endodontics in Spain (1), Austria, Germany, and Switzerland (15), Canada (17) and Saudi Arabia (32). On the contrary, the studies carried out in the United Kingdom (10) and Italy (16) found a high percentage of ultrasound use, around 80%, in undergraduate endodontic clinical practices. Again, these results indicate the need to review programs and increase the budgets of dental schools to be able to incorporate ultrasonic devices into the undergraduate endodontics program.

Assessment Methodology in Endodontic Training

As a final point, seven studies (1, 10, 15–17, 30, 33) reported data on the methods used to evaluate the learning of undergraduate students in endodontics (Table 6). As indicated in the undergraduate curriculum guidelines for Endodontology, recently published by the ESE (3), the competence of students to reach the correct diagnosis and perform vital pulp therapies and root canal treatment on uncomplicated anterior and posterior teeth should be formally assessed before allowing them to graduate. The assessment of theoretical content was carried out by means of short questions in half of the dental schools in Saudi Arabia and Canada (17, 30). In contrast, in Austria, Germany and Switzerland, oral examinations are used by one third of the schools (15).

For the evaluation of pre-clinical practices, the practical competency exam was used in Saudi Arabia (33) and Canada (17). Most dental schools required a minimum number of RCT in preclinical practices (1, 10, 15, 33).

Clinical training was evaluated by clinical competency exams (17, 33), and more than 50% of dental schools also required a minimum number of treatments (1, 10, 16). However, for students to achieve the appropriate level of competence in endodontics, the evaluation of the quality and consistency of student performance is more important than the number of treatments performed.

While traditional assessments, such as written exams and competency-based clinical requirements, remain central, educational innovation is steering toward more struc-

TABLE 6. Assessment methodology in endodontic training

Authors	Year & Country	Theoretical content (% of DS)	Preclinical practices (% of DS)	Clinical practices (% of DS)	Minimum number of teeth / treatments required in pre-clinical practice (% of DS)	Minimum number of teeth / treatments required in clinical practice (% of DS)
Narayanaraopeta & AlShwaimi (30)	2015 Saudi Arabia	Multiple choice questions 50 Multiple choice questions & short answer questions 50	Orally examination 50 Identification of instrument 67 Submission of assignments 50 Presentation of cases front faculty 17	–	–	–
Al Raisi et al. (10)	2019 UK	–	–	–	Yes 87	Yes 67
Sacha et al. (15)	2021 Austria, Germany and Switzerland	Objective Structured Oral Examination 15 Simple oral examination 33	Objective Structured Clinical Examination 30	–	Yes 100 (3-4 teeth) 32	–
Segura-Egea et al. (1)	2021 Spain	–	–	–	Yes 100	Yes 60
Algahtani et al. (33)	2022 Saudi Arabia	–	Practical competency exam Yes 92	Clinical competency test Yes 84	Yes 92	–
Mergoni et al. (16)	2022 Italy	–	–	–	Yes 39 Mean 7.5±3.3	Yes 25 Mean 12.7±9.5
Goyal et al. (17)	2024 Canada	Essay 30 Requirements 40 Short answer question 50 Student self-assessment 50 Portfolio (work samples) 50	Practical laboratory exam 90	Clinical competency exam 40	–	–

DS: Dental schools

tured and meaningful evaluation strategies. In line with the growing emphasis on competency-based education in health professions, recent developments such as the implementation of Entrustable Professional Activities (EPAs) are gaining traction in dental education (43). EPAs are units of professional practice that can be fully entrusted to a student once sufficient competence has been demonstrated, thus providing a practical framework for assessing readiness for independent clinical work. In the context of endodontics, EPAs may include activities such as performing a root canal treatment on anterior or posterior teeth, managing endodontic emergencies, or conducting pulp vitality assessments. Integrating EPAs into undergraduate curricula can help align learning outcomes with real-world expectations, enhance assessment transparency, and promote accountability among students and educators. Furthermore, frameworks such as CanMEDS and the ADEA Competencies for the New General Dentist also advocate for holistic, outcome-based educational strategies that could be adapted to support structured, progressive learning in endodontics (44, 45). The incorporation of these frameworks may be instrumental in standardizing competency thresholds globally and in advancing the pedagogical rigor of undergraduate endodontic training.

CONCLUSION

This narrative review aimed to show the current situation of undergraduate endodontic teaching worldwide. The data found in the published studies show great consistency and, compared with the data found in studies carried out decades ago, allow us to conclude that the quality of endodontic teaching in dental schools around the world has increased substantially. However, there is still room for improvement in some aspects, especially the incorporation of new technologies and materials into the teaching of endodontics at the undergraduate level. This is the case of magnification, ultrasound and CBCT. The publication by the European Society of Endodontology of the Undergraduate Curriculum Guidelines for Endodontology (3), with numerous recommendations on the scope of endodontic education, may be the appropriate instrument to continue improving and homogenizing undergraduate teaching of endodontics throughout the world.

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