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Resources Allocated for Undergraduate Education in Oral Radiology in European Dentistry Programmes: A Survey Study

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ABSTRACT

Aims: The Education Committee of the European Academy of DentoMaxilloFacial Radiology should ‘*encourage and support high levels of graduate and postgraduate education in dentomaxillofacial radiology (DMFR) all over Europe*’. For this reason, the committee aimed to formulate a document describing resources allocated for undergraduate education within oral radiology in Europe today that can serve as a benchmark against which dental schools and/or countries with dentistry programmes can relate their undergraduate education.

Materials and Methods: A questionnaire addressing resources allocated for learning oral radiology was distributed to colleagues involved in oral radiology education in 117 dental schools in 29 countries in Europe.

Results: The answers represent approximately 13% of the dental schools in 40% of the countries providing dental education in Europe. There was a large variation regarding qualifications among teachers. There were also large differences in reported time dedicated to oral radiology courses, within some parts the allocated time differed by a factor 16.

Discussion: An ambition to achieve high standards in oral radiology all over Europe should, based on the results of this survey, start with an effort to attain consensus regarding the role of oral radiology in dental education. The involvement of dentists with DMFR specialist training, would support high levels of undergraduate education.

Conclusion: The results of this survey include information that educators and authorities can relate to in planning and implementation of new or revised curriculum. The ambition should be to increase teachers' competence and to work towards more harmonised and extensive courses in oral radiology.

1 | Introduction

Since education ministers of 29 European countries signed the Bologna declaration in 1999, there has been an ongoing effort to converge and harmonise the higher educational systems across

the European countries [1]. The aim has been to make it easier for professionals to move around an integrated Europe and to make it possible for authorities to recognise degrees from different countries. Dental education and degrees are no exceptions, and much work has been done within the Association for Dental

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Education in Europe (ADEE) [2] and the DentEd Thematic Network [3] in order to converge and harmonise the various dental curricula.

DMFR is an integral component of diagnosis and treatment planning for clinical dental practice and many aspects of dentistry cannot be performed without using radiographs. Further, dentists have access to several imaging modalities but technological advances pose challenges for the users of these modalities [4]. A newly qualified dentist should have the range of professional skills required to begin working as part of a dental team where radiography and radiology skills are vital [5]. Dental education needs to ensure that dental graduates have the competency to be safe independent practitioners that can improve and promote the oral health of the population.

Among the objectives of the Education Committee of the European Academy of DentoMaxilloFacial Radiology (EADMFR) are to '*encourage high standards in dentomaxillofacial radiology all over Europe*' and to '*encourage and support high levels of graduate and postgraduate education in dentomaxillofacial radiology all over Europe*'. In addition, the committee should work to '*simplify the European directives concerning the education in dentomaxillofacial radiology within the basic training of dentistry*' [6].

To fulfil these objectives, it is vital to strive towards all dental graduates in Europe having similar core competencies in DMFR needed to work as professionals in different societal contexts. Furthermore, knowledge gained by the students during their undergraduate education, must rely on a common base among colleagues interested in education to be a registered specialist or gaining a certificate in DMFR in countries where DMFR is not a recognised specialty. To establish a base for the work with learning objectives and teaching/learning strategies the EADMFR education committee decided to investigate similarities and differences regarding allocated resources in undergraduate education within DMFR in Europe today. Surveys have shown that significant variations exist in curriculum structure [7, 8], but no survey has focused on DMFR. Therefore, the Education Committee of EADMFR aimed to compile quantifiable information regarding time and resources provided for undergraduate students within the area of oral radiology in European dentistry programmes.

The resulting document is intended to show extent, medians and spread of the time and resources provided, and serve as a benchmark against which individual schools, and/or countries, can relate their undergraduate education when planning and implementing changes and/or evaluating curricula. In this way the document can serve as a valuable tool that can be used to harmonise oral radiology education between the European countries and dental schools.

2 | Material and Methods

During 2017 and 2018 the committee designed questions for the survey with the objective to present a simple and adequate questionnaire that would be easy to fill in for most schools, regardless of differences in curriculum structure. The questionnaire

addressed three parts within oral radiology: basics of radiation theory, how to take radiographs, and interpretation and diagnostics. In addition, the questionnaire requested information regarding the competence of the teachers responsible for different parts of and/or otherwise involved in the teaching of oral radiology. There were also basic questions about annual intake of students, use of European Credit Transfer System (ECTS), extent of the dentistry programme and extent of the oral radiology course(s). The plural form 'courses' was used to include education composed by several minor courses in oral radiology.

The intra- and inter-country variation in reported total time allocated for the three main areas (basics of radiation theory, learning how to take radiographs, and interpretation and diagnostics) was analysed. The variation was determined by calculating the coefficient of variation within each area. This measure relates the standard deviation to the mean value (in per cent). Variation within each main area and country will be related to the mean value within that country. Variation between countries will be related to the mean value for all countries. This means that differences between countries will not influence variations within a country.

Parallel to the construction of the questionnaire the committee also worked with the challenging task to collect contact information for staff at the dental schools with knowledge of the training in oral radiology and could reply to the questionnaire. Colleagues were approached based on membership in EADMFR complemented by personal knowledge of colleagues who were not members of the academy at the time of the survey. The combination of an expedient questionnaire and a well-defined target group was believed to increase the chances of receiving correct information and a high response rate.

During the second part of 2018 a web-based questionnaire was created and a server with an assigned e-mail address at Umeå University, Sweden, was set up for carrying out the web-based survey. In the beginning of 2019, the survey was piloted among the members of the committee to test the functionality of the survey and to refine the questionnaire. In May 2019 the survey was distributed to colleagues at 117 different dental schools in 29 countries. As a result, close to 80% of the countries in Europe that provide dental education and just over 53% of all European dental schools were invited to participate in the survey.

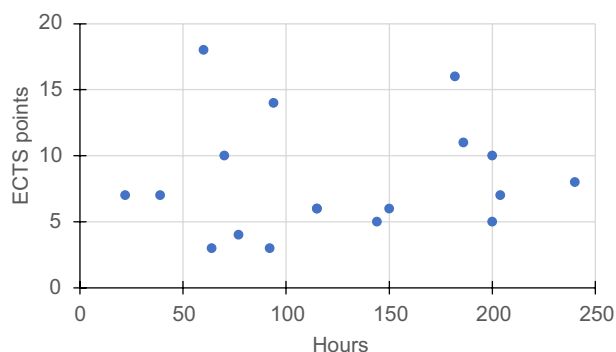
Since the questionnaire was rather extensive, a slight reluctance to respond could be anticipated from the approached schools. To encourage and facilitate a high response rate, the time for completion of the questionnaire was generous and two reminders were sent out with an interval of 4 months, one in July and one in late October. The survey was closed in the beginning of December 2019.

3 | Results

Despite a challenging questionnaire the respond rate was good. Close to 26% ($n = 30$) of the approached schools in 52% ($n = 15$) of the countries responded (Table 1). This means that approximately 13% of all European dental schools from close to 42% of the countries with dental education have contributed to the

TABLE 1 | Number of responding schools by country.

Country	Number of responding schools per country
Belgium	1
Finland	2
Greece	1
Iceland	1
Latvia	1
Lithuania	2
The Netherlands	2
Norway	3
Poland	3
Portugal	2
Russia	1
Sweden	3
Switzerland	1
Türkiye	3
United Kingdom	4
Total	30

**FIGURE 1** | Total scheduled time for the Oral Radiology course(s) in hours plotted against number of ECTS points for the Oral radiology course(s). Eighteen schools in 12 countries. (Two schools reported the same number of hours and ECTS points, resulting in 17 visible data points representing the 18 schools).

result. The participating schools varied in size with the intake of students each year varying between 40 and 160. Eighty per cent of the schools reported that their dentistry programme was 5 years and 20% had a 5.5 or a 6-year dentistry programme.

The total reported scheduled time dedicated to oral radiology course(s), varied between 22 and 240 h with a median of 101 h. Eighteen respondents in 12 countries stated that they used the European Credit Transfer and accumulation System (ECTS) both for the whole dentistry programme and for the oral radiology course(s). The ECTS for the oral radiology course(s) varied between 3 and 18 ECTS, which means that the course(s), measured as ECTS points, constituted between 1% and 5.5% of the

whole dentistry programme. A weak correlation was seen between the declared total time for oral radiology in hours and ECTS points (Figure 1).

The declared time reserved for students to learn basics of radiation theory, to learn how to take radiographs and to learn how to interpret radiographs varied considerably between the schools (Figures 2–4).

3.1 | Basics of Radiation Theory

All respondents could identify members of staff responsible for the teaching of basics of radiation theory. A DMFR specialist or teacher stating corresponding postgraduate education within DMFR was responsible in 57% of the schools and a medical physicist in 32%. In 29% a general dentist was responsible and in 18% a radiographer/technician was responsible (Table 2).

In total, 96.4% of the respondents declared that they had stated learning outcomes on the basics of radiation theory that the students were expected to have achieved at the end of the course(s).

In all schools, the students' knowledge and competence in the basics of radiation theory was assessed and a written exam was the most common way of assessment (85%) followed by oral exam (36%) and continuous clinical examination (28%). Objective Structured Clinical Examination (OSCE) was used for assessment in 10% of the schools, and other unspecified methods in 10%.

The longest stated total time dedicated to radiation theory was approximately 10 times longer than the shortest dedicated time declared. Within basic radiation theory, the time dedicated for radiation protection specifically, differed with a factor 16 between the shortest and longest declared time (Figure 2).

3.2 | Learning How to Take Radiographs

In total, 96.5% of the respondents declared that they could identify a member of staff *responsible* for teaching the theoretical part of how to take radiographs. In 63% of the responding schools, this was a dentist. In 52% it was a DMFR specialist or teacher stating corresponding post graduate education within DMFR, in 44% a radiographer/technician, and in 4% a nurse, assistant or dental hygienist.

The extent to which different professions among the staff were involved in the *practical education* of taking radiographs was as follows; general dentists (75%), DMFR specialists or teacher stating corresponding post graduate education within DMFR (48%), radiographers/technicians (52%), and nurses/assistants/dental hygienists (22%), (Table 2).

Digital radiography was used in 86% of the schools and both digital and analogue radiography was used in 14%.

Altogether, 93% of the respondents had formulated learning outcomes on how to take radiographs that the students were expected to have achieved at the end of the course(s).

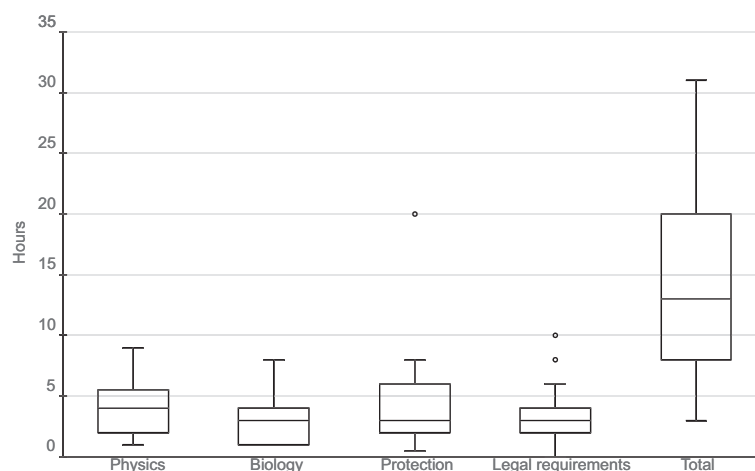


FIGURE 2 | Box-and-whisker plots demonstrating the time reserved for students to learn various parts of the basics of radiation theory.

TABLE 2 | Educational level of teachers responsible for, and/or involved in, the oral radiology education within different parts of radiography/radiology.

Part of radiography/ radiology	DMFR specialist or corresponding postgraduate qualification (%)	Medical physicist (%)	General dentist (%)	Radiographer/ technician + nurse/ assistant or dental hygienist (%)	Postgraduate student (%)
Basics of radiation theory, responsible	57	32	29	18 + 0	
Learning how to take radiographs, responsible theoretical part	52		63	44 + 4	
Learning how to take radiographs, involved in practical training	48		75	52 + 22	
Interpretation and diagnostics, responsible	71	4	61		21
Interpretation and diagnostics, involved in practical training	75	4	7		25

Note: Values are expressed in percentage of reporting schools.

In 93% of the schools, the student's knowledge and competence in how to take radiographs was assessed. Various forms for assessment were used, often in combination; written exam (69%) practical competence testing (65%), continuous clinical assessment (54%), oral examination (35%) and OSCE (27%).

Pre-clinical training in taking radiographs was included in 86% of the schools. The training was carried out with manikins (88%), radiographic simulators for example, Qbion Oral radiology package [9] (13%) and other methods for example, training on classmates without radiation (8%).

Sixty-one per cent of the schools had specified requirements that should be met by the student regarding *pre-clinically performed* radiographic examinations with different radiographic techniques. Of these 61%, 82% had requirements regarding partial dental examinations, 71% regarding full mouth series and

65% regarding panoramic examinations. Requirements regarding both extraoral plane radiographs (anterior-posterior, lateral skull examination, cephalograms etc) and other training (simulator training etc.) were formulated by 6% of the course providers with specified pre-clinical requirements.

In 75% of the schools the education included patient examinations. Of these, 76% had requirements regarding partial dental examinations, 71% panoramic examinations and 65% regarding full mouth series. Extraoral plane radiographs were required by 6% and advanced examinations for example, cone beam computed tomography (CBCT) by 6%.

The longest declared total time dedicated to practising how to perform radiographic examinations was 8 times longer than the shortest dedicated time. Within the subject 'learning radiographic techniques', the time reserved for learning how

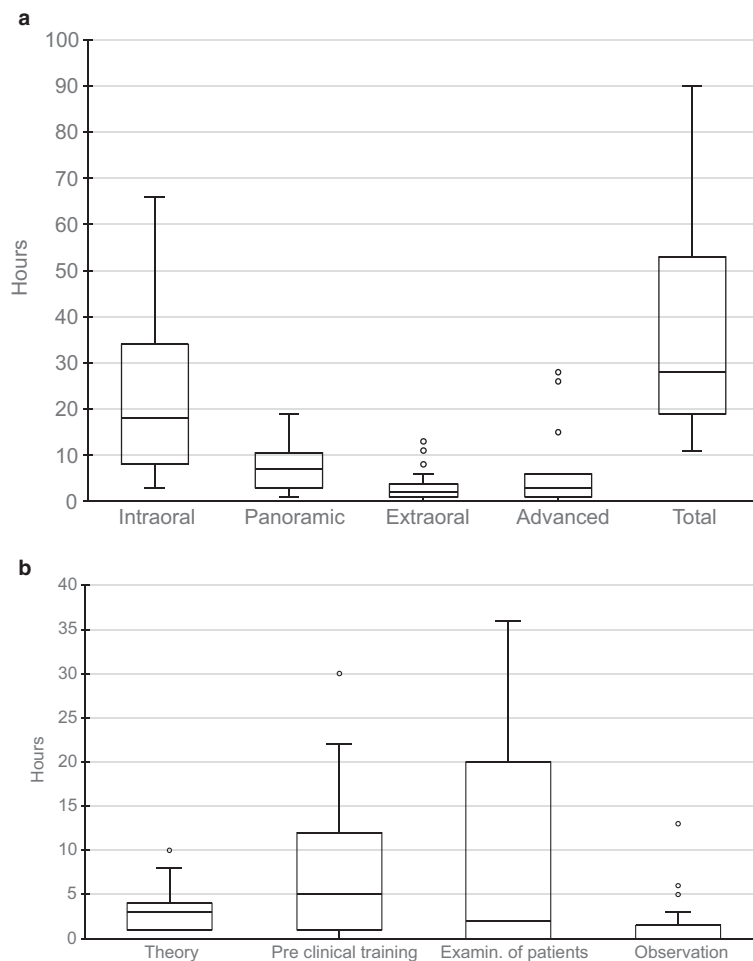


FIGURE 3 | (a) Box-and-whisker plots demonstrating the time reserved for students to learn different radiographic techniques, (b) Box-and-whisker plots (min, max) demonstrating the time reserved for students to learn how to perform intraoral radiographic examinations. ‘Extraoral’: (i.e., anterior–posterior and lateral projection of the skull, e.g., for cephalometric assessment). ‘Advanced’: (i.e., CBCT, CT, MR, Ultrasound).

to perform intraoral examinations differed with a factor 22 (Figure 3a). The largest differences were found in pre-clinical training (min 0 h, max 30 h) and examinations on patients (min 0 h, max 36 h) (Figure 3b).

3.3 | Interpretation and Diagnostics

In 71% of the schools the member of staff *responsible* for teaching radiographic interpretation and diagnostics was a DMFR specialist or a teacher stating corresponding post graduate education within DMFR. In 61% it was a general dentist and in 21% a postgraduate student. In 4% a medical physicist was responsible.

Ninety-three per cent of the respondents had formulated learning outcomes on radiographic interpretation and diagnostics that the students were expected to have achieved at the end of course(s).

The extent to which different professions among the staff was involved in the *practical education* of interpretation and diagnostics was as follows; general dentists (75%), DMFR specialists (75%), postgraduate students (25%) and medical physicists (4%) (Table 2).

Computer-based learning methods was used in 57% of the schools. Among these, 100% used Power point-based methods, 75% used interactive computerised learning tools for example, board games (Go-Fish, Kahoot and Qbion oral radiology package [9]) and 44% used video lectures.

In 93% of the schools, the students’ knowledge and competence in radiographic interpretation and diagnostics was assessed through a combination of tests. Written exams were used in 100%, practical competence testing in 69%, oral examination in 65% and OSCE in 27%.

There was an almost tenfold difference in total time dedicated to learning how to interpret radiographs between the highest and lowest reported number of hours. Within specific subjects that are not only parts of the subject radiology even larger differences were seen. Time dedicated to anatomy differed with a factor of 24 between the shortest and longest. Corresponding factor for caries and periodontal diagnosing was 30, and time dedicated to interpretation of images depicting inflammation of the jaws, tumours, cysts, etc. varied between 3 h and 42 h (Figure 4).

The reported time allocated for the three main areas of education in oral radiology (basics of radiation theory, learning how

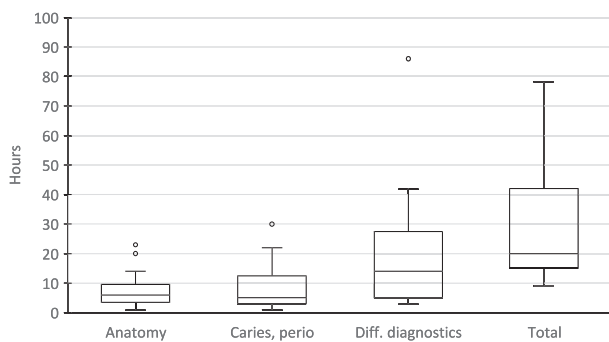


FIGURE 4 | Box-and-whisker plots demonstrating the time reserved for students to learn how to interpret radiographs. 'Perio' refers to periodontal and includes apical and marginal findings. 'Diff diagnostics' relates to differential diagnostics and findings regarding inflammation of the jaws, tumours, cysts etc.

to take radiographs and interpretation and diagnostics) showed a significantly larger variation between countries compared to within countries. The coefficient of variation regarding basics of radiation theory was within countries as a mean 25.5%. When comparing differences between countries, the value was 42.7%. Corresponding values for learning how to take radiographs was within countries as a mean 24.4% and between countries 62.4%. For learning interpretation and diagnostics, the variation within countries was as a mean 32.9% and between countries 60%.

In countries without a recognised specialty, a teacher declaring corresponding post graduate educational level was responsible for the oral radiology education in 50% of the schools. In these schools, the declared total scheduled time for Oral radiology course(s) was 50% higher compared to the 50% of schools where other occupational groups (e.g., dentists, radiographers and dental nurses) were declared responsible.

4 | Discussion

The survey shows a large variation regarding educational level and competence among teachers in undergraduate oral radiology education in Europe. The largest variation in competence appears among teachers who conduct the theoretical parts of the oral radiology education such as radiation theory and diagnostics, but there is also a variation among teachers involved in the practical parts of the oral radiology education, such as how to perform a radiographic examination. The answers regarding responsibility indicate that there can be shared responsibilities (Table 2).

The survey also reveals a large difference in declared time dedicated to oral radiography and oral radiology. With regards to radiation protection specifically, the difference could be described by a factor 16.

Surveys among dentists based on questionnaires about oral radiology is a widely used research method [10], however, it is always a challenge to reach the intended survey population. Currently, there is no data confirming the exact number of dental schools across Europe. The most recent Council of European Chief Dental Officers (CECDO) database recorded 220 'dental'

schools [11]. In the current study we made a significant effort to identify schools and contact people with knowledge of oral radiology in undergraduate dental programmes, and in total we managed to reach 117 dental schools in 29 European countries. The response rate regarding approached countries (52%) corresponds to almost 42% of all countries in Europe with dentistry programmes. Analysing data from 15 European countries may be a representative sample and is similar to samples reported in some other survey studies on dental curricula [12, 13]. Furthermore, for the results of both schools and countries, the response rates in this survey are considered as acceptable within social sciences regarding survey-studies such as the present study [14].

The questionnaire was anonymous, so the responders are likely to be truthful. As it was not possible to identify the non-responders, their reasons for not completing the questionnaire are unknown. Due to data anonymisation there is no reason to assume that there is a high risk of skewed results. It could be anticipated that schools with more well-established radiology education would be more prone to answer the questionnaire. However, the relatively large variation in allocated time for the oral radiology courses indicates that the responding schools do not only represent schools with more extensive radiology education.

One of the most striking findings of this survey is the difference between schools regarding what proportion of the total dentistry programme is constituted by oral radiology course(s). The shortest reported time dedicated to the radiology course(s) was less than a 1/10th of the longest reported time. An ambition to achieve high standards in oral radiology all over Europe and to encourage and support high levels of pre- and postgraduate education in oral radiology should, based on the results of this survey, start with an effort to attain a consensus regarding the role of oral radiology in European dental education. Bearing in mind the importance of and demands on oral radiology in dental care regarding the quality of diagnostics and on justification and documentation, the ambition should be to work towards more extensive courses in oral radiology in the dental education programmes in Europe.

The medians shown in the boxplots, represent aggregated data on resources allocated in the different education areas and could serve as minimum standards when revising courses or planning new courses. This recommendation should, however, be adapted to varying pre-conditions for example, integration in other clinical courses and legal aspects regarding the students' possibilities of performing radiographic examination and diagnostics of patients outside the oral radiology course.

When analysing the result, one should remember that this survey does not include any information regarding the outcome of the education. Furthermore, education in oral radiology can be implemented and integrated in many ways within a curriculum.

At the end of the questionnaire, the respondents had the opportunity to add comments if there was anything else they wanted to share regarding their radiology course(s). This opportunity was used by 13 respondents and 7 of these stated that oral radiology in one, two, or all three specified areas was integrated in

other courses, mainly other clinical courses. This must be seen as positive as it supports continuous learning within oral radiology throughout the undergraduate curriculum in close collaboration with colleagues from relevant clinical disciplines [15]. It is of course difficult to specify the amount of time that the students spend gaining knowledge of oral radiology within other clinical courses. However, one can assume that the students, as a result of integration, assimilate knowledge within oral radiology in addition to what can be expected from the time declared in this questionnaire.

The part of radiology with the largest differences in reported scheduled time for the students was learning how to take radiographs with different radiographic modalities. However, it is difficult to estimate the total resource allocated for this since, based on the answers in the questionnaire, training in performing radiographic examinations can largely be carried out within clinical courses other than oral radiology.

ECTS was initiated for credit transfer and is based on the convention that 60 credits measure the workload of a full-time student during one academic year. The student workload in a full-time study programme in Europe usually amounts to 36/40 weeks per year and in those cases one credit equals 24–28 working hours [16]. Student workload in the ECTS includes the time spent attending lectures, seminars, practical and clinical work, independent studies and preparation for and taking of examinations. The weak correlation between ECTS and allocated time for education in oral radiology in this survey is therefore somewhat surprising. One explanation might be that these values are just a guide, and different schools might include different parts of education within the hours and the exact number of hours included in one ECTS point can differ from country to country. Another explanation for differences in the given ECTS points could be that the educators might have different expectations regarding the amount of time the students spend on independent studies.

An interesting result was the differences that probably have a limiting effect on the learning process during the studies. As an example, differences in regulations can for example, limit the possibilities for students to perform radiographic examinations on patients before they receive their licence, which impedes the learning development of this specific skill during the dental education. In such situations, the knowledge and experiences that clinical training on patients results in, can to some extent be gained by preclinical training on manikins, fellow students (without radiation) and/or interactive computerised learning tools. The experience and knowledge gained from examinations of real patients in an environment with experienced teachers will, in these cases, be achieved after graduation and the speed of this development will be dependent on the environment in which the former students start to practice their profession.

Although many respondents stated that a DMFR specialist was responsible for, and/or involved in, the oral radiology education (Table 2), DMFR is a recognised specialty with national board exams in few European countries (Finland, Norway, Sweden, UK and Türkiye). However, in some European countries, dentists undergo university postgraduate courses of 3 years [17], and these dentists might have knowledge and competence comparable to a recognised DMFR specialist. When answering the

survey, the instructions stated that the category ‘DMFR specialist’ also included teachers with corresponding post graduate education. In the five countries with a recognised DMFR specialty with national board exams, more than one school per country answered the survey and the response rate was higher than in countries without a recognised specialty. As a result, a relatively large proportion of specialists, as defined in the survey, are declared responsible for teaching oral radiology, a proportion that exceeds the proportion of DMFR specialists with national board exams in Europe.

We found that 50% more time was allocated for oral radiology education in schools where a teacher declaring corresponding educational level was responsible in countries *without* recognised specialty. This indicates that there is a correlation between the time spent on oral radiology education and the expertise level of the teachers, which supports the notion that all schools and countries should strive for increased competence in DMFR among the teachers specifically and among dentists in general.

The involvement of dentists in DMFR specialist training, or the equivalent, might encourage and support high quality under- and postgraduate education.

It is difficult to know to what extent this survey can be generalised. However, the results clearly show a significantly larger variation between countries compared to variations between schools within a country, and we draw the conclusion that the reported large variation in allocated resources, do reflect differences between countries.

Although a larger amount of allocated resources can be interpreted as the students receiving a more comprehensive and superior education, especially if the teachers possess a higher competence in the area, it is also important to study the learning outcomes that the students are expected to reach and how these are assessed.

A large body of work within European undergraduate dental education has aimed at developing learning outcomes within various fields, focusing on harmonisation of dental undergraduate education [1, 18]. More than 90% of the respondents in this survey stated that they have formulated learning outcomes within the three areas of oral radiology addressed. In a recent systematic review [19] dealing with the progress and challenges in the harmonisation of European undergraduate dental education, dental education as whole was studied as well as specific subjects within the curriculum. However, no report on oral radiology was found. To further support the objectives of the EADMFR education committee, a subsequent step from this survey could be to formulate general expected learning outcomes for oral radiology education and propose alignments within Europe. It would also be beneficial to study how learning outcomes are assessed and whether the assessments actually measure the formulated expected learning outcomes.

5 | Conclusion

The results from this survey study can be useful for educators and authorities when evaluating their course(s) and/or when

planning for a new or revised curriculum in oral radiology. The document can serve as a benchmark and valuable tool when working towards a common standard of undergraduate education, and for uniformity between countries and schools with dentistry programmes in Europe. The ambition should be to increase teachers' competence in DMFR and work towards more harmonised and extensive courses in oral radiology. This is extremely important as the use of ionising radiation in medical as well as dental imaging is constantly increasing and has implications for radiation protection of medical staff, public and patients.

Author Contributions

All authors contributed to conception, design, collection of contact information and critical revision of the final version of the manuscript. Jan Ahlqvist, Christina Lindh and Eva Levring Jäghagen analysed data and drafted the manuscript.

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Ethics Statement

Participation in the survey was voluntary. By answering the survey, the responders gave their informed consent to participate. The results are based on anonymized answers. No ethical approval for the survey was required.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data is not available. When answering the survey, the informant gave their informed consent to participate under the condition that they were anonymized.

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