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Current situation of cone beam computed tomography in dentomaxillofacial radiology education.

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Abstract

Little is known regarding to what extent Cone Beam Computed Tomography (CBCT) has been incorporated into the curriculum of dental schools or to which degree the students are being exposed to it. The objectives of this study were to evaluate the current situation of CBCT in Dentomaxillofacial Radiology (DMFR) education and review the established competences on dentists and DMFR residents on CBCT in Turkey, Europe and United States.

In order to define the situation in Turkey, DMFR educators were asked to complete a form, which consisted of 11 questions on the didactic and practical teaching of CBCT technique to undergraduate and postgraduate students. They were also asked to indicate their opinion about expected level of competence of dental students on CBCT upon graduation. Besides, competences that were determined for the undergraduate and postgraduate CBCT education in Turkey, Europe and United States were discussed. Fifty-four educators from 20 dental schools in Turkey responded the survey. Sixteen (80%) dental schools presently had a CBCT machine, and most of them had courses on higher-level use of CBCT for postgraduate students. Twenty-nine educators (53.7%) thought that a dental student should be familiar with the CBCT technique, whereas only 2 (3.7%) of them thought that they should be competent in using and interpreting CBCT upon graduation.

A large number of dental schools in Turkey had CBCT machine. Although, the competences regarding CBCT were specifically determined in Turkey, there is a need for updating national and international competences in order to define the responsibilities and limitations of the dental practitioners and DMFR specialists.

Keywords: CBCT, Dental radiology curriculum, Competences, Radiation protection, Implant.

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Introduction

Dentists have the tendency to use the technologies that they were exposed to and worked with during their dental training [1]. Dental educators update themselves on new developments to ensure that dental students acquire the ability to give patients the highest quality of care. The need of education of the educator himself or the high cost may lead to difficulties in incorporating new technologies into the curriculum [1].

Dental students are expected to be competent in taking and diagnosing intraoral radiographs, as well as diagnosing on panoramic radiographs upon graduation [2]. However, Cone Beam Computed Tomography (CBCT), which is among the many recent and costly technological innovations in the field of dentistry [3], is not a basic radiographic examination. It applies a much higher radiation dose, which makes proper indication and justification much more sensitive. The information obtained from CBCT imaging also requires a substantial level of expertise for interpretation [4]. Most of the current dentists have received insufficient or no training in the application and interpretation of cross-sectional 3D imaging. Despite the reasons like the need of education or the high cost, there is a growing concern for a rapidly increasing use of CBCT worldwide, which might lead to an uncritical, unjustified and incorrect use and to a significant increase in the radiation burden of patients. It is well recognized that medical imaging has come to represent the largest man-made source of ionizing radiation in developed countries over recent years [5]. As cross-sectional images are provided, image reading, interpretation and diagnosis must be based on intensive, repeated training and highly skilled experience. Moreover, the process of analyzing CBCT images is highly time consuming which cannot be performed simultaneously with any other treatment of patients [6].

Since it is a rather new technology, until now, the main concentration of education for this technology has been for the deficiencies of general dentists in the interim period with continuing education programs. Previous studies on the current status of awareness and knowledge regarding CBCT and radiation protection amongst the general dentists, dental students and dental specialists other than Dentomaxillofacial Radiology (DMFR) revealed that there is a need to design a

curriculum for training of all these groups of people on CBCT [7,8]. There are differences in depth, extent and structure within the DMFR curriculum for undergraduate dentistry and in most countries throughout Europe, CBCT is generally available to all dentists [5,9].

With the introduction of CBCT, dental radiology has matured to DMFR, which must be considered as a specialty for which a special education must be created. Even though, DMFR is a registered specialty with formal training curriculum in a few countries, including Turkey, CBCT has started gaining popularity as preferred imaging modality by the general dentists also in Turkey. Today the competence of the dentists for the usage of CBCT and the need of curriculum of the dental schools to be modified accordingly is being questioned. There are previously established competences on dental radiology and differences exist among countries in incorporating competences regarding CBCT [2,9-12]. Recently, Turkish dental radiology curriculum was set by the authorities throughout the country and the topic of CBCT is included in both undergraduate and postgraduate education [2,9].

Little is known regarding to what extent CBCT has been incorporated into the curriculum of dental schools or to which degree the students are being exposed to it. In the literature, there is only one published report by Parashar et al. on the integration of CBCT education in US, UK and Australian dental schools [13]. The objectives of this study were to evaluate the current situation of CBCT in DMFR education and review the established competences on CBCT.

Materials and Methods

This study was approved by the Institutional Review Board of the faculty and has been carried out in accordance with the Declaration of Helsinki. The project consisted of collecting and analyzing information regarding current educational trends without reporting any identifiable private information about individual members, employees, or staff of an organization. The purpose of the study was communicated to the participants, and the rules of ethics were explained. Since participation was voluntary and all participants remained anonymous, no ethical approval was obtained. An 11-question survey form, modified from the original one, created by Parashar et al. [13] was used. The survey form was delivered to the dental educators responsible for teaching DMFR curriculum, during the recent congress of Turkish Association of DMFR. The questionnaire was formulated to be short and informative with options to choose Yes, No, or Not Applicable as answers. Question 1 assessed the uptake of CBCT equipment within the school. Questions 2, 3, 4, 6, and 8 assessed the integration of CBCT to the undergraduate curriculum, including image orientation and the inclusion of CBCT images in the schools' courses, as well as acquisition and interpretation of the images and application of implant planning software. Questions 5, 7, and 9 assessed the inclusion of CBCT acquisition, interpretation, and implant software application in postgraduate DMFR curriculum. These questions had an option of Not Applicable as an answer in case there are no postgraduate students. Additionally we inserted two more questions to the survey. Question 10 assessed the rate of CBCT usage prior to implant placement. Finally, the educators were asked how they think about the level of competence on CBCT of a dental student should be upon graduation in Question 11, which was also an additional question to the original survey form and the answer options for this question were: -be familiar with CBCT technology and have a basic knowledge on CBCT technology, -have complete didactic knowledge but a limited clinical experience on CBCT, or -be competent and have a complete theoretical knowledge and clinical experience on CBCT.

Results

Fifty-four educators (18 professors, 16 associate professors, 13 assistant professors and seven lecturers) from 20 dental schools (four schools and 14 educators in Ankara; four schools and 12 educators in Istanbul; three schools and 12 educators in Izmir; nine schools and 16 educators from nine different cities) responded the survey. Out of 20 schools 16 (80%) had CBCT machine. The educators from the remaining schools mentioned that their schools were actively in the process of having CBCT equipment.

In terms of undergraduate dental radiology education, it was found that 21 (38.8%) educators taught 3D image orientations, whereas 30 (55.5%) educators included CBCT images in their lectures. When asked if they provided training in acquisition of cone-beam scans, 12 (22.2%) of the educators responded positively. When asked if they educated undergraduate students in the interpretation of CBCT scans, 21 (38.8%) of the educators responded positively. Only three (5.5%) educators from different dental schools provided training to undergraduate students to apply implant planning software. A large number of dental schools did not provide training to undergraduate students to manipulate 3D CBCT images for planning implant treatment. In terms of the level of competence of a dental student upon graduation, 29 (53.7%) educators thought that the student should be familiar with this modality and have a basic knowledge on it, whereas 23 (42.5%) of them thought that the student should have complete didactic knowledge but a limited clinical experience. Only two (3.7%) of the educators thought that students should be competent to have a complete didactic knowledge and clinical experience on CBCT.

Forty-eight (88.8%) educators had at least one postgraduate student in their dental school. For postgraduate education in DMFR, out of 48 educators 46 (95.8%) was teaching the acquisition of CBCT scan. The remaining two (4.2%) educators do not have CBCT machine in their dental school. All the educators (100%) provided training in the interpretation of 3D images acquired with CBCT. Out of 48 educators from 15 dental schools, which have postgraduate students, 36 (75%) provide training to postgraduate students to apply implant-planning software. It was found that if there is no CBCT machine they do not provide training. Otherwise, at least one

lecturer in each dental school teaches implant planning on CBCT.

Preoperative implant planning is one of the major indications for acquisition of CBCT scan in dental practices. Among all the educators, eight (14.8%) indicated that 0-50% of implant placements were performed by utilizing CBCT imaging. On the other hand, 37 (68.5%) indicated that CBCT imaging was performed prior to 51-100% of implant placements. Nine (16.6%) of them did not know the percentage of implant placements performed by utilizing CBCT imaging.

Discussion

A combination of low radiation dose, high-quality bony definition, and compact design requiring minimum space has made CBCT desirable as an in-office imaging system for the examination of pathologies in the head and neck, extracranial, paranasal, and temporal bone regions [14]. Additionally, CBCT units have rapid scan time, limit the beam to the head and neck, and have interactive display modes that offer maxillofacial imaging and multiplanar reformation, making them more suitable for use in dental practices [15,16]. The 3D information offers the potential of improved diagnosis for a wide range of clinical applications [17]. CBCT was initially introduced for its indispensable role in the field of dental implantology [16]. Currently, the utility of CBCT encompasses field of dental implantology, oral surgery, orthodontics, endodontics, sleep apnea, temporomandibular joint disorders, and periodontics, and it is expanding its range in the field of ear, nose, and throat medicine [14].

Universities are increasingly applying CBCT technology for academic and research purposes, which in turn motivates general dentists to use CBCT on their patients. In Switzerland, three CBCT machines (two in universities, one in private practice) were accredited in 2004, whereas in 2013, the number of accredited CBCT machines increased to 279 (six in university, 273 in private practice) [6]. If the fact that the dose of ionizing radiation delivered by CBCT is higher than conventional 2D radiographic imaging is not taken into account, this could be considered as a great improvement in the dental field. However, patient safety is a compelling reason to seriously discuss how the future of CBCT should evolve in dentistry. Besides, the level of knowledge among dentists may not always be sufficient to meet the considerable demands imposed on performing justification, acquisition and, particularly, interpretation of CBCT images. This discrepancy is mainly owing to the relative novelty of the technique and the lack of education received during undergraduate studies. Kamburoğlu et al. suggested that efforts should be made to improve students' knowledge regarding CBCT and that the curriculum should devote more time to this new technology [7]. EADMFR recognizes that the educational situation and knowledge on CBCT will change with time [5].

Parashar et al. performed a school-based survey in order to evaluate CBCT teaching in both undergraduate and postgraduate training other than DMFR in US, UK, and Australia [13]. Findings of Parashar et al. and the present study was compared as seen on Table 1 [13]. Less than half of the educators in our study had a role in teaching interpretation of the CBCT images to undergraduate students. Similarly, only a few educators teach using implant treatment planning software, that many graduating dental students will have limited exposure and experience in implant planning. The data imply that educational experiences in CBCT technology and interpretation are not yet as widespread as they should be. Since there are basic differences in the methods of these two studies, it is hard to make an accurate comparison of the findings.

Table 1. *Findings of the previously published study of Parashar et al. [13] and this study.*

	Parashar et al. [13] (school-based)			This study (educator-based)
Undergraduate education	**U.S.**	**U.K.**	**Australia**	**Turkey**
CBCT uptake (school-based)	89%	63%	14%	80%
3D image orientation	84%	67%	100%	38.80%
3D CBCT images	91%	80%	71%	55.50%
Acquisition of CBCT scans	18%	0%	29%	22.20%
Interpretation of CBCT images	48%	33%	57%	38.80%
Apply implant planning software	32%	7%	29%	5.50%
Postgraduate education	**Education in residencies other than DMFR**			**Education in DMFR residency**
Acquisition of CBCT scans	43%	7%	29%	95.80%
Interpretation of CBCT images	81%	53%	57%	100%
Apply implant planning software	58%	40%	57%	75%

Implementing changes in the curriculum takes time and it may be challenging for full-time dental school faculty members to keep up with new technologies while maintaining full-time academic responsibilities. Dental school educators must be

calibrated in the content of their courses to provide students a consistent learning environment and all faculty members should uniformly teach the curriculum content [18]. In our study, we found that each educator had different levels of contribution to the CBCT education in both undergraduate and postgraduate level. This finding might be attributed to the fact that this is a new technology and not all the instructors may have had previous education on this subject.

Brownstein et al. aimed to identify the penetration of emerging dental technologies into the undergraduate curricula of US dental schools [18]. They reported that there was a high penetration of CBCT into dental curricula and it was included in preclinical and clinical didactic courses in 73% of 33 responding dental schools, whereas in 85% they included it in clinical practices. Parashar et al. reported that the rate of uptake of this technology in US, UK and Australian dental schools were 89%, 63% and 14%, respectively [13]. In our study, we found that 80% of the dental schools incorporated this technology, which is considered to be consistent to the rate of schools in US.

Considering that higher radiation doses are used when CBCT examinations are performed [19,20], it is even more important that anyone using this technique understands the justification of patient exposure, optimization of patient dose and protection for staff from radiation [5]. In terms of radiation protection, ADEE stated that the student must be competent at managing and avoiding the hazards of ionizing radiation, implementing the ionizing radiation regulations including leading the dental team on radiation protection measures. In the meantime, the student should have knowledge on the hazards of ionizing radiations and their effects on biological tissues, together with the regulations relating to their use, including leading the team on radiation protection measures [11]. ADEA stated that the dentist must be competent at imaging safety protocols [12]. According to the Commission on Dental Accreditation (CODA), postgraduate students must have an in-depth knowledge of radiation protection upon graduation [10]. In Turkey, principles of radiation protection are included in the curriculum, but there are no stated competences on radiation protection neither in undergraduate nor postgraduate DMFR dental radiology curriculum [2,9], which apparently should be considered for revision in terms of the inclusion of competences for radiation protection.

Regarding the CBCT imaging, neither Association for Dental Education in Europe (ADEE) nor American Dental Education Association (ADEA) stated any specific competences [11,20]. ADEE stated that the student must be competent at taking and interpreting radiographs of relevance to dental practice, whereas must have knowledge of other methods of medical imaging of relevance to dentistry. However, it is not clear if CBCT was regarded as radiographs of relevance to dental practice or other imaging techniques [11]. ADEA stated that the graduate must be competent at selecting, obtaining, and interpreting diagnostic images for the individual patient [12]. In Turkey, undergraduate core curriculum program was revised in 2014 and regarding the undergraduate radiology education, it was stated that the student must have didactic knowledge on how to acquire CBCT images and be able inform the patient on the results of interpretation as the minimum standard upon graduation [9]. In our study, even though the uptake of CBCT machines are considerably high, the integration of CBCT in dental education is low, which could be attributed to the fact that the revisions were made very recently, without sufficient time to revise the curriculum.

It is recognized that DMFR specialists have undergone substantial further training, which includes CBCT imaging. There is variation among countries in the availability of specialists in DMFR. Few European countries have established such dental specialty postgraduate programs [5]. CODA proposed revision on the DMFR residency program and stated that the graduates must be competent in the procedures performed in oral and maxillofacial radiology including CBCT [10]. In this revision, they proposed to indicate each of the radiological techniques separately instead of referring them as routine and special procedures performed in oral and maxillofacial radiology [10]. In Turkey, DMFR was accepted as a specialty in the field of dentistry in 2011 [9]. In the core curriculum report revised and released by the authorities in 2014, the minimum standard was briefly stated as upon graduation regardless of the complexity of the cases the resident must be able to perform application of CBCT for each cases when necessary, and report on the resultant CBCT examination [9]. Procedures related to CBCT and reporting are considered as advanced applications and are not accepted to have priority over many other DMFR applications.

Treatment planning will benefit from 3D imaging for correct implant placement with regard to function and esthetics. For treatment planning in implantology, dentists are increasingly disposed to apply 3D imaging due to the supposed advantage of obtaining superior results in the final treatment outcome [6]. 3D imaging may be necessary in all cases where clinical and standard radiographic findings are insufficient to assess the bone volume with required certainty. The frequency of implant surgeries is continuously rising. Since CBCT is used particularly in oral implantology, it may well be assumed that the frequency of CBCT images will increase with the increasing number of oral implant surgeries [6]. Since general dentists routinely send patients to imaging centers for CBCT diagnostics in implant treatment planning, learning about this technology while in dental school is useful [18].

In this study, 68.5% of the DMFR educators indicated that 51-100% of implant placements performed by utilizing CBCT imaging. ADEE and DentEd stated that graduates must have knowledge of the basic radiographic and other imaging techniques relevant to implant dentistry, being competent to interpret the results and be familiar with other forms of medical imaging that are of relevance to implant dentistry [21]. Again, there may be discrepancies in the understanding of the competence on CBCT according to which definition will be used for this technology. For the DMFR residency program, CODA did not state any competences specifically to the imaging for implant surgery [10]. The competences regarding

the implant education were also determined in undergraduate and postgraduate dental radiology curriculum in Turkey [2,9]. Upon graduation, undergraduate students must have didactic knowledge on treatment planning for implant surgery with the data gathered from CT images and be able inform the patient on the result of the interpretation [2]. For postgraduate DMFR education in Turkey, which includes education on implant planning, imaging procedures prior to, during and after implant surgery and reporting of the interpretation, it was stated that upon graduation the resident must be able to establish diagnosis and refer for the implant treatment [9]. Similar to the procedures related to CBCT, implant planning and post-op follow-up procedures are considered as advanced applications and are not accepted to have priority over many other DMFR applications. We recommend revisions for the competences on implant planning for postgraduate DMFR education, in which the meaning of establishing diagnosis indicated clearly and implant planning is also included.

A survey of the existing literature shows that there is yet no study evaluating the status of CBCT in dental radiology education in Turkey. The results generally reveal that although educators support the view that basic knowledge should be instilled in terms of CBCT during dental education, practical experience in the field is not necessary or should be limited to a certain degree. They generally agree that CBCT usage and interpretation should be performed by specialists. Furthermore, the majority of the dental schools have a CBCT device, which shows the increasing interest in the implementation of this useful technology. Once every school obtains the CBCT device, then follow-up studies can be done to evaluate whether there has been any change in the overall opinion of educators. Although it is difficult to predict when this will occur, a five-year elapse for the second evaluation may be suitable. It is anticipated that the demand for CBCT will increase with the release of further scientific evidence supporting the benefits of this innovative technology.

Conclusion

The survey was educator-based and investigated the role of each educator in CBCT education. More research should be conducted into the reasons why the curricula differed among dental schools and in order to understand what should be done to standardize the curriculum.

Within the limitation of this study, we concluded that a large number of dental schools in Turkey had CBCT machine and the remaining schools are in the process of acquiring one. In order to define the responsibilities and limitations of the dentists and specialists, it is essential that, CBCT education standardized and the competences regarding this technology determined relying on the updated national and international guidelines, in which the use of CBCT technique is stated clearly. Since CBCT is a recent technology, the former education and experience of dental radiology educators on CBCT should also be questioned.

The present study serves as a tool to determine the existing status, so that the dental curriculum can be enhanced by a general analysis. It is also expected that with the more widespread utilization of CBCT in general dental practice, instructors will also feel the necessity to adjust themselves in the emerging technology and attempt to instil more sophisticated knowledge and skills in dental students.

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