RESEARCH

The usage of digital radiography and cone beam computed tomography among Turkish dentists

S Dölekoğlu*, E Fişekçioğlu, M İlgü and D İlgü

Department of Oral Diagnosis and Radiology, Faculty of Dentistry, Yeditepe University, Istanbul, Turkey

Objectives: The aim of this study was to determine the prevalence of the use of digital radiography and report how it was used by Turkish dentists.

Methods: The survey was based on 383 dentists who were present at the sixteenth International Congress organized by the Turkish Dental Association. A questionnaire which consisted of 19 questions was given to the dentists who participated in the study. Data were assessed according to frequency distribution and the χ^2 test was used to determine the significance of differences between two independent groups.

Results: 376 questionnaires were analysed. The mean age of the dentists who participated in the study was 37.14 ± 9.6 years (range: 20–63 years). The distribution of the dentists according to the 7 regions of Turkey were: Marmara 58%, Aegean 13% and Mediterranean 10%, Central Anatolia 8%, Black Sea 7%, Southeastern Anatolia 3%, Eastern Anatolia 1%. 124 dentists (33%) said they did not work with digital radiography. 95 dentists indicated that they did not use digital radiography owing to cost (60%). 252 dentists (67%) said they used digital radiography. 40% of the participants noted that the repetition of periapical radiographs was due to digital radiography. 166 dentists (55.9%) and 79.1% academicians had knowledge about cone beam CT (CBCT).

Conclusion: Digital radiography users are increasing in Turkey and levels of knowledge of CBCT and awareness of radiation safety has also increased.

Dentomaxillofacial Radiology (2011) **40**, 379–384. doi: 10.1259/dmfr/27837552

Keywords: dental digital radiography; cone beam computed tomography

Introduction

In dental practice, digital radiography is increasingly used as a new imaging technology.

An increasing number of dental practitioners worldwide have preferred digital imaging to conventional film radiography.¹

The main advantages of digital intraoral radiography systems are time saving, radiation dose reduction, eliminating developing process and chemicals, image enhancement, data storage, communication with other practitioners and that it is easier to view an image on a monitor for the patient. A number of reviews have been published since the 1990s describing these advantages with digital systems and future prospects of digital

radiography.^{1–11} Although digital radiographic systems were introduced as an alternative to conventional radiography, it could take time to get a desirable level of usage.

In general dental practice, such inspections seem to be inconsistent and knowledge about how digital radiography is used in general dental practice is scarce.¹² Dedicated cone beam CT (CBCT) scanners for the oral and maxillofacial region were pioneered in the late 1990s independently by Arai et al¹³ and Mozzo et al.¹⁴ Since then, there has been an explosion of interest in this new imaging technique in the oral and maxillofacial region by different research groups.¹⁵ CBCT provides a lower dose, lower cost alternative to conventional CT that promises to revolutionize the practice of oral and maxillofacial radiology.¹⁶

The aim of this study was to determine the prevalence of the use of digital radiography and CBCT and report how they were used by Turkish dentists.

*Correspondence to: Dr Semanur Dölekoğlu, Faculty of Dentistry, Yeditepe University, Bağdat Street No: 238 34728, Göztepe, İstanbul, Turkey; E-mail: semanur.dolekoglu@yeditepe.edu.tr

Received 15 July 2010; revised 1 September 2010; accepted 13 September 2010

Materials and methods

The survey was administered to a sample of 383 dentists who were present at the sixteenth International Congress about general dentistry organized by the Turkish Dental Association in Istanbul. All participants had a questionnaire which consisted of 19 questions (Table 1). The questionnaire comprised four sections. These were:

- (1) (a) demographic characteristics of dentists, (b) clinical features such as academican, general practitioner, public dental service or student (five questions);
- (2) digital radiographic system (six questions). The first question in this section (question 6) asks the dentists whether or not they used digital radiography. If the answer was "no", the dentist was asked to go to question 11 which was about the reasons why they choose not to work with digital radiography;
- (3) CBCT (five questions). The second question in this section (question 13) asks whether or not the dentists have knowledge of CBCT. If the answer

was "no" the dentist was asked to go to the last question of the survey (question 19); and

- (4) radiation safety (three questions).

The statistical analysis was performed by the Graph Pad Prism V.3 Pocket program (GraphPad Software Inc., San Diego, CA). Data were assessed according to frequency distribution and the χ^2 test was used to determine the significance of differences between two independent groups. The level of significance was set at 5%.

Results

7 respondents out of 383 who participated in the study were excluded owing to respondents' errors while filling out the questionnaire. In total, 376 questionnaires were analysed. The mean age of the dentists who participated in the study was 37.14 ± 9.6 years (range: 20–63 years). The distribution of the dentists participating the congress according to geographic location (7 regions of

Table 1 The questionnaire form

1. Age:	2. Gender
3. Student ( ) General practitioner ( ) Public dentist ( ) Academican ( )	
4. Location:	5. Year of draduation:
6. Do you use digital imaging techniques in your clinics?	
(a) ( ) Yes (b) ( ) No	
If you answered 6th question No please go to 11th question	
7. For which kind of radiography do you use digital imaging?	
(a) ( ) Panoramic (b) ( ) Intraoral (periapical...)	
(c) ( ) Cephalometric (d) ( ) All	
8. Please check the reasons of using digital imaging techniques:	
(a) ( ) Radiation dose is much less (b) ( ) It takes a short time to perform	
(c) ( ) There is no developing process (d) ( ) There is no wastage in developing process and does not cause pollution	
(e) ( ) It is easy to store images (f) ( ) Adjustments and measurements can be done on images	
(g) ( ) There are no artefacts related to developing process	
9. Are you satisfied with digital imaging?	
(a) ( ) Not at all (b) ( ) A little	
(c) ( ) No idea (d) ( ) Satisfied (e) ( ) Very satisfied	
10. Does the usage of digital imaging increase the radiographic repetitions?	
(a) ( ) Yes (b) ( ) No	
11. Please check the reasons of not using digital imaging techniques:	
(a) ( ) Expensive (b) ( ) Poor image quality (c) ( ) I do not have essential equipments	
(d) ( ) I do not know how to use computer (e) ( ) I have no idea (f) ( ) Hard to perform	
(g) ( ) Image area is too narrow (h) ( ) Some technical problems might occur during the storage of images	
12. Which one do you prefer when you need three-dimensional (3D) imaging of neck and head region?	
(a) ( ) Computerized tomography (CT)	
(b) ( ) Dental volumetric tomography (DVT)/cone beam computed tomography (CBCT)	
13. Have you ever heard about CBCT/DVT?	
(a) ( ) Yes (b) ( ) No	
If you answered 13th question No please go to 17th question	
14. Have you ever referred your patients for CBCT imaging?	
(a) ( ) Yes (b) ( ) No	
15. In which situations do you prefer CBCT imaging?	
(a) ( ) Trauma (b) ( ) Cyst-tumour (c) ( ) Implant planning (d) ( ) Dental caries	
(e) ( ) Periodontologic diseases	
16. What is the difference between CT and CBCT?	
(a) ( ) Radiation dose for CBCT is less than CT (b) ( ) Radiation dose for CBCT is same as CT (c) ( ) Radiation dose for CBCT is higher than CT	
17. How long is your exposure time for intraoral digital radiography?	
(a) Anterior teeth ..... seconds (b) Posterior teeth ..... seconds	
(c) ( ) I do not know (d) ( ) I do not make any adjustments	
18. Do you have periodic controls and calibrations of your radiography equipments?	
(a) ( ) Yes (b) ( ) No	
19. Do you usually attend to seminars and meetings about radiology?	
(a) ( ) Yes (b) ( ) No	

Table 2 Distribution of gender and practice types between digital users and non-users

	Digital users	Non-digital users
Male	128 (67%)	63 (33%)
Female	124 (67%)	61 (33%)
Academician	42 (96%)	2 (5%)
General practitioner	182 (62%)	115 (39%)
Student	21 (84%)	4 (16%)
Public dental service	7 (70%)	3 (30%)

Turkey) were as follows: Marmara 223 (58%), Aegean 48 (13%), Mediterranean 38 (10%), Central Anatolia 31 (8%), Black Sea 28 (7%), Southeastern Anatolia 10 (3%) and Eastern Anatolia 5 (1%). 252 (67%) said they used digital radiography. There were 124 (33%) dentists who did not work with digital radiography. The results in terms of gender, working as an academician, a general practitioner, a student and working in public dental service can be seen in Table 2, age in Table 3 and years in dentistry in Table 4. On the basis of responses, the dentists were categorized as digital users (DU) or non-digital users (NDU). Table 2 shows that the group of academicians had the highest score among DU. There were no significant differences between the DU and NDU for gender and age ($P > 0.05$). Among the digital systems, periapical radiography was the most preferred system (69%). 179 (79%) general practitioners said they used digital periapical radiography. Table 5 shows the reasons to use or not to use the digital systems. According to age groups and practice types, significant differences were found ($P = 0.0001$, $P = 0.02$), respectively.

Owing to high cost, general dentists (69%) and those in their 40s (77%) and 50s (72%) did not prefer the digital imaging systems. The number of the dentists who said that the repetition of periapical radiographs was due to digital radiography was 98 (40%). There was a correlation between years in dentistry and repetition of periapical radiographs ($P < 0.05$). According to the number of years, repetition of radiographs were 1–9, 10–19, 20–29, >30 and 31 (34%), 37 (51%), 20 (51%) and 4 (22%). 66 (29%) of the respondents said that they did not make any time adjustment while they were taking periapical radiographs. 131 (53%) of the respondents reported that they did not get any periodic controls of radiographic equipment.

166 dentists (56%) had knowledge about CBCT. Correlations were found between practice types, gender and awareness of CBCT. The academicians and male dentists had the highest results with 34 (79%) ($P < 0.05$) and 96 (67%) ($P < 0.05$), respectively. 82 dentists (30%) said they referred their patients to CBCT

Table 3 The age ranges among digital users

Age range	Digital users
20–29	73 (70%)
30–39	94 (72%)
40–49	53 (58%)
>50	32 (63%)

Table 4 The number of years in dentistry among digital users

Years	Digital users
1–9	92 (71%)
10–19	78 (65%)
20–29	41 (53%)
>30	20 (83%)

imaging. The most common reasons for prescribing CBCT were implant planning (70%) and diagnosing cyst-tumours (54%). According to gender, male dentists referred their patients to CBCT (40%) 2 times more than female dentists (20%) ($P = 0.0001$).

115 (82%) respondents knew that radiation dose for CBCT is less than CT. 57 female dentists (91%) gave the right answer compared with 58 male dentists (74%) ($P < 0.05$).

The number of dentists who performed implant surgery was 128 (43%). There were statistically significant differences according to gender and age groups ($P = 0.0001$; $P = 0.01$). 81 male dentists (54%) performed implant surgery compared with 47 female dentists (31%). The results of age groups were: 20–29 years: 26 (29%); 30–39 years: 56 (51%); 40–49 years: 30 (47%); and >50 years: 16 (46%).

After graduation, dentists who were joining meetings and seminars was 137 (44%). A significant difference was found between years of practice and joining meetings and seminars for continuing education ($P < 0.05$). Table 6 shows the results for years of practice.

Discussion

The number of dentists who have converted from conventional film radiography to digital radiography continues to grow.¹⁷

In the present study, 67% of the participants used digital radiography. Wenzel *et al*¹⁸ found that 14% of dental practitioners in their study had chosen to use digital radiography. This study was conducted in 2001 and since then there has been an increasing trend to adopt digital radiography. According to Ilgüy *et al*'s¹⁹ study, which had been reported in 2005, 14% of dentists used digital radiography in Turkey. The percentage of the usage of digital radiography in Turkey was higher than the usage reported by Jacobs,²⁰ Gijbels,²¹ Brian²² and Aps²³ previous publications. A significant difference was found between DU and NDU according to practice types ($P < 0.05$). Academicians were in the group that had the highest DU score. It seems that the higher rate of digital radiography utilization among academicians and students may be owing to the pioneering role of universities in terms of technological advances.

Because of the location of the congress, the majority of dentists who joined the congress were from the Marmara region. A minor portion of dentists from Eastern regions attended this congress. The number of dentists who practice in the eastern region of Turkey is relatively less and these regions are a long distance

Table 5 The reasons to use or not to use the digital systems

<i>Reasons for using digital imaging techniques</i>	<i>%</i>	<i>Reasons for not using digital imaging techniques</i>	<i>%</i>
Less radiation dose	79	Expensive	60
Short time to perform	80	Poor image quality	9
No developing process	86	I do not have essential equipments	26
No wastage in developing process and does not cause pollution	70	I do not know how to use computer	2
Easy to store images	83	I have no idea	3
Adjustments and measurements can be done on images	75	Hard to perform	3
No artefacts related to developing process	68	Narrow image area	3
		Technical problems of the archive	8

away from Istanbul, a metropolis located in the west. This may clarify why there was such a low number of participants from the eastern region. These kinds of congresses about general dental practice must also be held in eastern cities of the country to reach more dentists. It is true that the present results may rather reflect the status of dental practitioners in the urbanized region; however, one must remember that the concentration of dentists is higher in those areas compared with the rural areas in the east. Parallel to this, the attendance of dentists from the urbanized regions is more likely. It is mainly related with the frequency of dental practitioner population.

In our study, no correlation was found with the DU and NDU according to gender and age ($P > 0.05$). Also, Wenzel *et al*¹⁸ and Sogur *et al*²⁴ found that gender and age were not significant determining factors when using digital radiography.

According to the study of Gijbels,²¹ male dentists use digital imaging more often (37%) than their female (19%) colleagues.

179 (79%) general practitioners stated that they used periapical radiography, making it the most preferred system among the digital systems.

Other studies along with our own show that the most preferred digital radiography method is periapical radiography.^{21,22}

60% of the respondents did not use the digital system because of the cost. Many researchers have found that the major reason dentists choose not to use digital radiography is the high cost associated with using this technology.^{18,22,25–27} A significant difference was found between age groups and practice types ($P = 0.0001$ and $P = 0.02$, respectively). Digital imaging systems were rejected more often by general dentists (69%) in their 40s (77%) and 50s (72%) owing to high costs and general ignorance of the technology. The reasons given for not using digital radiography are similar to the

findings in other publications.²² Alternative payment conditions may be offered to the dentists by companies.

Digital radiography is potentially an area where large savings in dose may be achieved owing to the sensitivity of the image receptor and ability to manipulate the image to optimally display the subject of interest. Other benefits may accrue from the facility of electronic storage with no limit on numbers of copies that can be made, as well as the avoidance of photographic processing.^{27,28}

The major reasons for using digital radiography were elimination of the developing process (86%), easy to store images (83%), shorter performance time (80%) and reduced radiation dose (79%). In the Brian *et al*²² study, the most highly rated assets were time saving (87%) and eliminating processing problems. Some of these factors were also cited in a Norwegian survey but not in the same percentage or order.¹⁸ Berkhout *et al*²⁹ reported that the total number of radiographs taken by general dental practitioners using digital radiography was significantly higher than the number of radiographs taken by film users. The need for more certainty about the planned or ongoing treatment as well as better diagnosis were the most important reasons for taking more radiographs. More solid-state users than phosphor plate users mentioned these reasons. For 17% of general dental practitioners using digital radiography, the idea that digital radiography requires less radiation than conventional film-based radiography was reason enough to take more radiographs. The mistakes were also an important cause for taking more radiographs (10%). The general dental practitioners using digital radiography were asked whether or not deciding to take or re-take a radiograph was easier after the conversion of digital radiography.²⁹ In our study, 40% of the participants noted that the repetition of periapical radiographs was due to digital radiography. Also, repetition of periapical radiographs may be related to whether direct or indirect digital radiography is being used. A significant correlation pattern was discovered between the years in dentistry and the repetition of periapical radiographs. Older dentists had less repetition owing to their experience in dentistry.

166 (56%) dentists had general knowledge about CBCT. There was a correlation between practice types, gender and awareness of CBCT. The academicians and male dentists had the most awareness of CBCT. 30% of the dentists referred their patients to CBCT imaging.

Table 6 The prevalence of joining meetings and seminars

<i>Years</i>	<i>Joining the meetings and seminars</i>
1–9	38 (33%)
10–19	45 (46%)
20–29	30 (51%)
>30	13 (72%)

The main reasons for CBCT referrals were dental implant planning (40%), suspected surgical pathology (24%) and temporomandibular joint analysis (16%).³⁰ CBCT is now the most commonly used imaging modality for implant assessment.^{31,32} In this study, implant planning and diagnosing of cyst-tumours were the most common reasons for prescribing CBCT and the results of our study are supported by the findings from Arnheiter et al's³⁰ study.

Chau et al³¹ compared typical patient radiation doses delivered in implant imaging with spiral CT, conventional spiral tomography and CBCT in their study. They reported that CBCT delivers the lowest radiation dose to the organs, whereas spiral multislice CT delivers the highest dose.³¹ In our study, 115 (82%) respondents knew that CBCT requires lower radiation dose than CT.

Of the 252 dentists, 66 (29%) respondents did not adjust the exposure time according to location of the tooth while they were taking periapical radiographs. 70.3% of the dentists reported that they set the exposure time in our study that was performed in 2005.¹⁹ Both studies' results about exposure time are exactly the same.

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