BMC Oral Health

RESEARCH

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Awareness of Cone Beam Computed Tomography (CBCT) use and radiation safety among dentists and specialists

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Abstract

Background Cone Beam Computed Tomography (CBCT) is widely used in dentistry; however, many practitioners have limited knowledge regarding its appropriate indications and radiation safety protocols. Optimizing CBCT use is essential for both patient safety and diagnostic efficacy. This study aimes to evaluate Turkish dentists' and dental specialists' awareness, attitudes, and practices regarding CBCT usage, radioprotection, and dose-reduction measures.

Methods A nationwide cross-sectional study was conducted from November 2021 to February 2024, involving 306 volunteer dentists with 1 to 51 years of clinical experience. Participants completed an 18-item questionnaire covering CBCT usage frequency, imaging indications, technical parameter selection, radiation protection and training. Statistical analysis included Chi-square and Kruskal-Wallis tests.

Results Implant planning, lesion evaluation, and root morphology assessment were the most common reasons for CBCT use. Oral and maxillofacial radiologists used CBCT more frequently than other specialists. A significant relationship was observed between frequency of CBCT use and the selection of technical parameters (voxel size, field of view) ($p < 0.001$). While lead apron usage was common, thyroid collar usage varied and showed a significant relationship with scan frequency ($p = 0.001$). Most participants relied on automatic settings and did not consistently consult a radiologist either before or after imaging.

Conclusions The study reveals knowledge gaps in CBCT usage and radiation protection practices among dental professionals. Ongoing professional education and clearer guidelines are essential to ensure safe and effective use of CBCT technology.

Highlights

- A total of 306 dentists and dental specialists participated in this nationwide survey.
- Implant planning, pathology, and root morphology were the top reasons for CBCT use.
- A significant correlation was found between CBCT frequency and technical parameter selection.
- Thyroid collar usage was significantly associated with CBCT acquisition frequency.
- Knowledge gaps remain regarding radiation protection and consultation with radiologists.

Keywords Dental volumetric tomography, Dental radiology, Awareness, Radiation protection, Imaging parameters, Education

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Background

Cone Beam Computed Tomography (CBCT) is utilized across various fields in dentistry. It is a widely adopted imaging modality in dentomaxillofacial radiology for numerous purposes, such as preoperative implant and third molar surgery planning, assessing lesions, identifying impacted teeth and their proximity to anatomical structures, diagnosing temporomandibular joint disorders, examining paranasal sinus pathologies, evaluating fractures in trauma cases, assessing preoperative alveolar bone resorption, and analyzing cleft lip and palate cases [1].

The X-ray beam passes through the patient, the remaining beam is captured by a 2-D planar detector, which records a cylindrical or spherical volume of data within a field of view (FOV) ranging from 4 to 30 cm. The voxels are isotropic, with sizes typically varying between 0.08 and 0.4 mm^3 [2, 3].

In clinical practice, the quality of CBCT images depends on multiple technical factors such as the scanning unit type, FOV and voxel size. Additionally, scan duration, tube voltage and current, and the characteristics of the examined object also influence the ability to visualize anatomical structures and pathologies [4].

A voxel's size is determined by its height, width, and depth, and CBCT voxels are typically isotropic, meaning all three dimensions are equal [5].

Voxel size depends on the CBCT device and exposure protocols. Smaller voxel sizes enable detailed radiological assessments in cases that require high-resolution imaging, such as root canal system disorders and periapical pathologies [6].

Although smaller voxel sizes produce sharper images, they may not necessarily improve diagnostic outcomes and may increase the radiation dose [7–9].

FOV or scan volume is determined by the size of the detector and the beam projection geometry (such as source-object distance and object-detector distance). The FOV should be minimized as much as possible by adjusting it to match the size of the region being imaged [6].

The FOV can be categorized into four subgroups based on size: dentoalveolar (FOV < 8 cm), maxillo-mandibular (FOV: 8–15 cm), skeletal (FOV: 15–21 cm), and head and neck (FOV > 21 cm). A smaller image volume results in higher image resolution and a reduced effective radiation dose [10, 11].

In large FOV images, image quality decreases due to an increase in both scatter and beam divergence [6, 12]. Large FOV devices necessitate a bigger detector size and higher kilovoltage, making them less suitable for use in dentoalveolar region applications [13, 14].

Dentists should adhere to radiation protection and safety principles throughout their careers. All necessary precautions should be understood and applied appropriately to ensure radiation protection and safety during dental imaging. In CBCT devices, the radiation dose received by the patient can be reduced through adjustments to the kVp, mAs, exposure time, and the use of radiation protection equipment [15–17]. Radiologist involvement in CBCT decision-making supports appropriate indication selection, optimizes technical parameters, and enhances radiation safety, as emphasized in international guidelines [18, 19].

This study aims to evaluate dentists' awareness regarding the use of CBCT, the distribution of CBCT usage among dental specialties, whether imaging is performed with the correct indications, the use and importance of radioprotective tools, and measures to reduce radiation dose in radiographic techniques.

Methods

The cross-sectional study protocol was approved by the Scientific Research Ethics Committee of Lokman Hekim University (2021/147) and the Declaration of Helsinki. Volunteer dentists were included in the study. This study was conducted on 306 individuals experienced in dentistry 1 to 51 years in Türkiye. This study was conducted for a period of approximately 3 years from November 2021 to February 2024.

This study was conducted by the dentists and dental specialists who agreed to participate in the study and provided informed consent.

The questionnaire used in this study was developed by the authors based on current literature and expert input in the field of oral and maxillofacial radiology. The survey consisted of a total of 18 questions. (Supplementary File 1) Demographic information was collected from the participants using a structured questionnaire. Seven questions addressed the use of CBCT including frequencies, indications, factors taken into account in dose adjustment, training received on the use of CBCT and interpretation. This was followed by questions related to technique features among taking radiographic images (2 questions), questions related to use of radioprotective devices (2 questions) were asked.

Statistical analyses

Descriptive statistics for continuous variables in the study were presented as mean and standard deviation when the assumption of normal distribution was met, and as median with minimum and maximum values when it was not. For categorical variables, descriptive statistics were expressed using frequency (%) values.

The Chi-square test was used to examine relationships between categorical variables. The Kruskal-Wallis test was employed to assess differences between groups, and in cases where a significant difference was found, pairwise comparisons were conducted to identify the

groups responsible for the variation. A significance level of $p < 0.05$ was considered statistically significant.

Results

A total of 306 dentists with varying professional experience participated in the study (191 females, 115 males). The distribution of dentists by specialty was as follows: no specialty ($n = 147$), oral and maxillofacial radiology ($n = 34$), oral and maxillofacial surgery ($n = 51$), prosthodontics ($n = 66$), endodontics ($n = 54$), periodontology ($n = 46$), restorative dentistry ($n = 28$), pediatric dentistry ($n = 36$) and orthodontics ($n = 23$).

A significant difference was found in the multiple group comparison of specialty and CBCT utilization frequency, with all specialties showing a statistically significant variation in CBCT acquisition frequency ($p < 0.05$). The frequency of CBCT acquisition among participants, categorized as less than twice per month, 2–10 times per month, and more than 10 times per month, is presented in Fig. 1. The distribution of CBCT acquisition frequency among participants from different specialties varied. The number of practitioners who perform less than 2 CBCT acquisitions per month includes 70 dentists, 4 oral and maxillofacial radiology specialists, 4 oral and maxillofacial surgery specialists, 19 endodontists, 17 pediatric dentists, 5 periodontists, 23 prosthodontists, 17 restorative dentists, and 7 orthodontists. The number of practitioners who perform between 2 and 10 CBCT acquisitions per month includes 29 dentists, 1 oral and maxillofacial radiology specialist, 17 oral and maxillofacial surgery specialists, 6 endodontists, 0 pediatric dentists, 11 periodontists, 12 prosthodontists, and 0 restorative dentists. The number of practitioners who perform more than 10 CBCT acquisitions per month includes 9 dentists, 24 oral and maxillofacial radiology specialists, 13 oral and maxillofacial surgery specialists, 1 endodontist, 1 pediatric dentist, 6 periodontists, 3 prosthodontists, 1 restorative dentist, and 1 orthodontist.

Participants were asked whether they had received training on the use of CBCT in dentistry and its technical aspects, as well as where they received this training if applicable. The distribution of training status is presented in Fig. 2.

The consultation with a radiology specialist before acquiring 3D radiological images varies according to the participants' specialties. Among dentists, 20 individuals (18.5%) consult a radiology specialist, 51 individuals (47.2%) do not, and 37 individuals (34.3%) consult

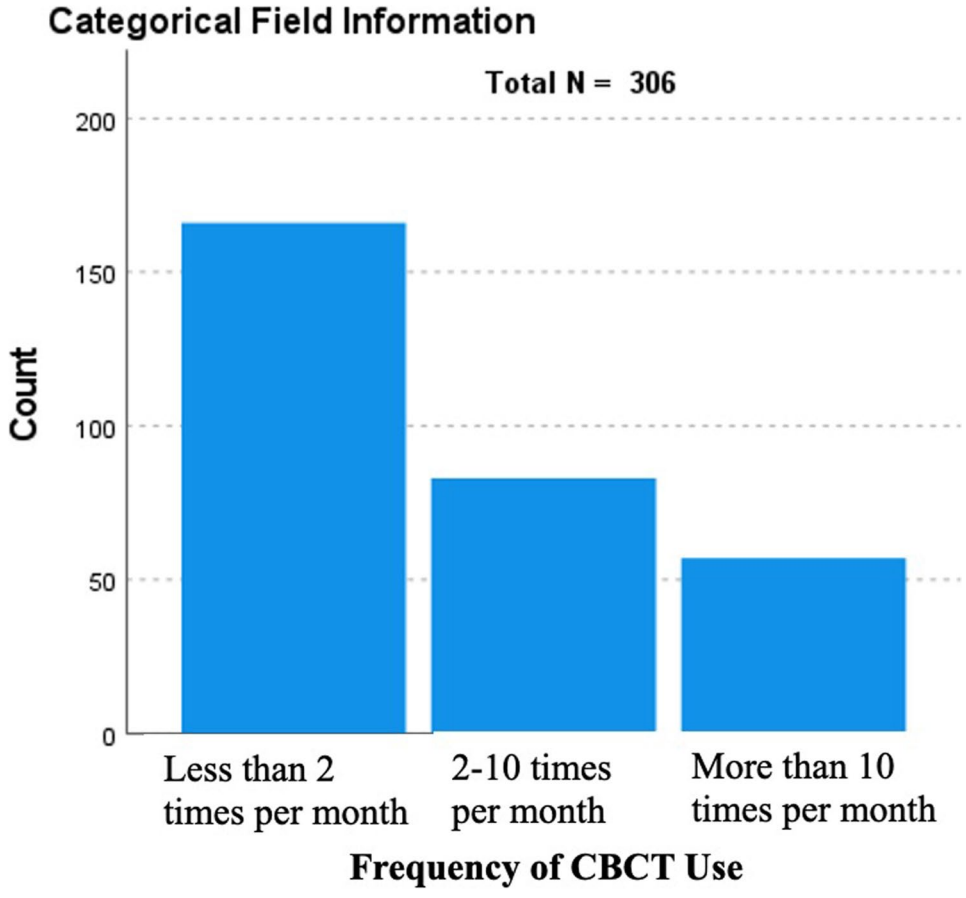


Fig. 1 Bar graph showing the frequency of CBCT acquisition

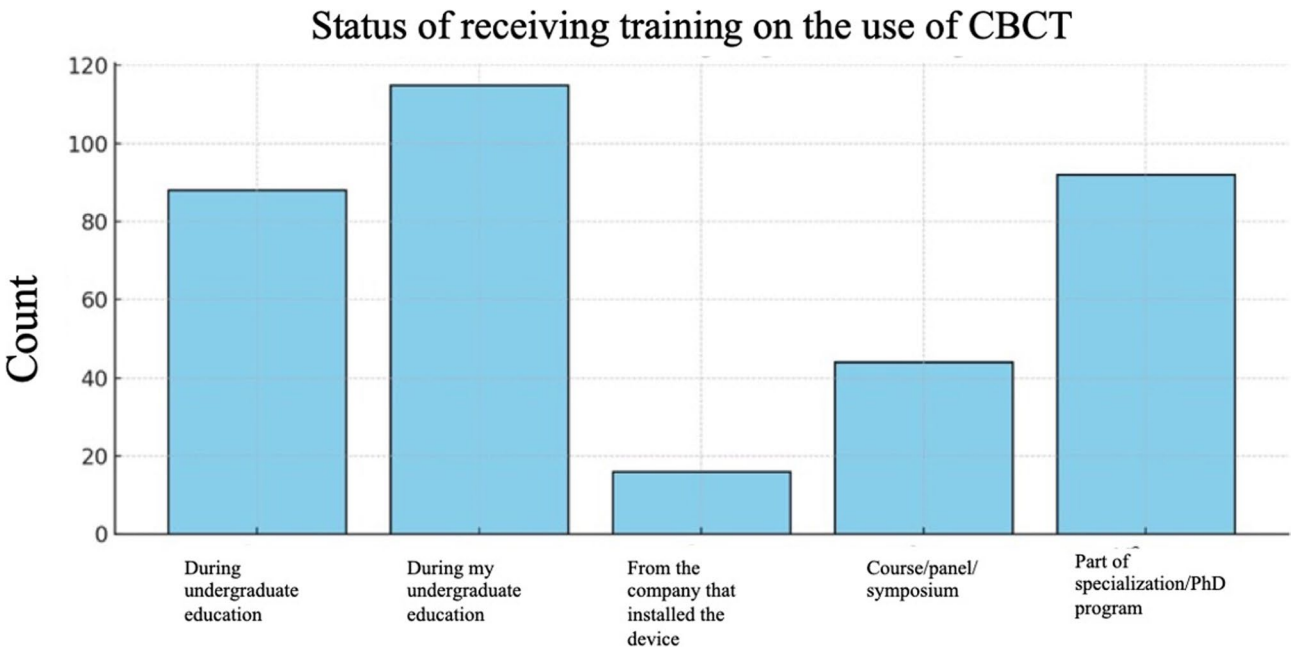


Fig. 2 Bar graph showing the distribution of training on CBCT utilization

sometimes. In oral and maxillofacial surgery specialists, no one consults a radiology specialist. Among endodontists, 6 individuals (24%) consult a radiology specialist, 12 individuals (48%) do not, and 7 individuals (28%) consult sometimes. In pediatric dentistry, 7 individuals (38.9%) always consult, 4 individuals (22.2%) never consult, and 7 individuals (38.9%) consult sometimes. Among periodontists, 7 individuals (31.8%) always consult, 12 individuals (54.5%) never consult, and 13 individuals (13.6%) consult sometimes. In prosthodontics, 21 individuals (55.3%) always consult, 10 individuals (26.3%) never consult, and 7 individuals (18.4%) consult sometimes. In restorative dentistry, 6 individuals (33.3%) always consult, 7 individuals (38.9%) never consult, and 5 individuals (27.8%) consult sometimes. Finally, in orthodontics, 3 individuals (21.4%) always consult, while 11 individuals (78.6%) never consult a radiology specialist.

The distribution of CBCT acquisition before and after treatment across different specialties was analyzed, and the results are presented in Table 1.

Table 1 The distribution of the frequency of tomography according to specialties

The distribution of the frequency of tomography before treatment according to specialties									
	Dentists	**Maxillofacial Radiology**	**Maxillofacial Surgery**	**Prosthodontics**	**Endodontics**	**Periodontology**	**Operative Dentistry**	**Pedondotics**	**Orthodontics**
Mean	3,1667	4,1034	4,2059	3,7632	3,1200	4,4091	2,5556	3,7222	2,7857
N	108	29	34	38	25	22	18	18	14
Std Deviation	1,50078	,93,903	1,09488	1,32408	1,71561	1,14056	1,68810	1,40610	1,42389
Median	3,0000	4,0000	5,0000	4,0000	3,0000	5,0000	2,0000	4,0000	2,5000
Min	1,00	2,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Max	5,00	5,00	5,00	5,00	5,00	5,00	5,00	5,00	5,00
The distribution of the frequency of tomography after treatment according to specialties									
	Dentists	**Maxillofacial Radiology**	**Maxillofacial Surgery**	**Prosthodontics**	**Endodontics**	**Periodontology**	**Operative Dentistry**	**Pedondotics**	**Orthodontics**
Mean	2,1667	2,4643	2,5294	2,2632	2,2917	2,5000	1,7222	1,3333	1,6429
N	108	28	34	38	24	22	18	18	14
Std Deviation	1,23425	1,13797	1,10742	1,22329	1,48848	1,22474	1,17851	,68,599	1,15073
Median	2,0000	2,0000	2,5000	2,0000	1,5000	2,0000	1,0000	1,0000	1,0000
Min	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Max	5,00	5,00	5,00	5,00	5,00	5,00	4,00	3,00	4,00

When examining the reasons for requesting CBCT imaging according to specialty, it is found that dentists most commonly requested imaging for implant region evaluation, with a mean of 3.56 ± 1.37. Oral and maxillofacial radiologists most frequently requested imaging for the evaluation of radiographic lesions in jaw bones, with a mean of 4.27 ± 0.84. Oral and maxillofacial surgeons most commonly requested imaging for implant region evaluation, with a mean of 4.02 ± 1.29. Prosthodontists most commonly requested imaging for implant region evaluation, with a mean of 4.02 ± 1.21. Endodontists most frequently requested imaging for situations related to root canal therapy (resorption, extra canals, abnormal root curvature, etc.), with a mean of 3.56 ± 1.58. Periodontists most commonly requested imaging for implant region evaluation, with a mean of 4.59 ± 0.95. Restorative dentists most frequently requested imaging for situations related to root canal therapy (resorption, extra canals, abnormal root curvature, etc.), with a mean of 2.83 ± 1.68. Pediatric dentists most commonly requested imaging for the evaluation of radiographic lesions in jaw bones, with a mean of 3.00 ± 1.37. Orthodontists most frequently requested imaging for orthodontic malocclusions, with a mean of 2.71 ± 1.20.

When considering all participants ($n = 306$) regardless of their specialty, the most common reasons for requesting CBCT imaging were for pre-treatment evaluation (3.50 ± 1.47), implant region evaluation (3.38 ± 1.55), and suspicion of cysts/tumors (3.16 ± 1.48).

When evaluating the attitude toward selecting the field of view (FOV) and voxel size during CBCT acquisition, the distribution by specialty is presented in Table 2.

Of the 306 participants, only 91 indicated that they consulted a radiology specialist before acquiring CBCT imaging. When asked whether they consulted a radiology specialist for the interpretation of the CBCT images after the imaging, 91.2% ($n = 83$) answered yes, 3.3% ($n = 3$) answered no, and 5.5% ($n = 5$) stated that they sometimes consulted a specialist.

Of the 306 participants, 130 indicated that they did not consult a radiology specialist before acquiring CBCT imaging. When asked whether they consulted a radiology specialist for the interpretation of the CBCT images after the imaging, 17.7% ($n = 23$) answered yes, 44.6% ($n = 58$) answered no, and 37.7% ($n = 49$) stated that they sometimes consulted a specialist.

Of the 306 participants, only 85 indicated that they did not consult a radiology specialist before acquiring CBCT imaging. When asked whether they consulted a radiology specialist for the interpretation of the CBCT images after the imaging, 34.1% ($n = 29$) answered yes, 1.2% ($n = 1$) answered no, and 64.7% ($n = 55$) stated that they sometimes consulted a specialist.

The relationship between years of experience in the profession and CBCT acquisition frequency was evaluated using the Independent-Samples Kruskal-Wallis Test, and no statistically significant difference was found. (p=,126).

When examining the relationship between the frequency of CBCT acquisition per month and voxel selection, as well as the selection of the field of view (FOV), a statistically significant relationship was found. ($p < 0{,}001$) (Table 3).

A descriptive statistical analysis was conducted to evaluate attitudes toward the use of lead aprons and thyroid collars for patient radiation protection based on specialty. When examining the distribution of attitudes towards radiation protection measures according to specialties,

Table 2 The distribution of individuals in selecting the appropriate field of view (FOV) and voxel size in CBCT

		Dentists	Maxillofacial Radiology	Maxillofacial Surgery	Prosthodontics	Endodontics	Periodontology	Operative Dentistry	Pedondotics
FOV AREA	Choose it myself	26 (%24,1)	9 (%26,5)	8 (%21,1)	5 (%20)	6 (%27,3)	2 (%11,1)	4 (%22,2)	5 (%35,7)
	Consult with an Oral and Maxillofacial Radiology Specialist	46 (%42,6)	19(%55,9)	24 (%63,2)	17 (%68)	9 (%40,9)	4 (%22,2)	9 (%50)	8 (%57,1)
	Have no idea	36 (%33,3)	6 (%17,6)	6 (%15,8)	3 (%12)	7 (%31,8)	12 (%66,7)	5 (%27,8)	1 (%7,1)
VOXEL	Choose it myself	15 (%13,9)	7 (%20,6)	3 (%7,9)	5 (%20)	4 (%18,2)	1 (%5,6)	2 (%11,1)	2 (%14,3)
	Consult with an Oral and Maxillofacial Radiology Specialist	47(%43,5)	19 (%55,9)	25 (%65,8)	15 (%60)	8 (%36,4)	4 (%22,2)	11 (%61,1)	8 (%57,1)
	Have no idea	46 (%42,6)	8 (%23,5)	10 (%26,3)	5 (%20)	10 (%45,5)	13 (%72,2)	5 (%27,8)	4 (%28,6)

Table 3 The correlation between the selection of FOV range and voxel size and the frequency of tomography acquisition

FOV AREA			Choose it myself	Consult with an Oral and Maxillofacial Radiology Specialist	Have no idea	
	The frequency of CBCT usage	Less than 2 times per month	29 (%17,5)	86 (%51,8)	51 (%30,7)	
		2–10 times per month	22 (%26,5)	43 (%51,8)	18 (%21,7)	
		More than 10 times per month	33 (57,9%)	16 (28,1%)	8(14,0%)	
						Pearson Chi-Square ,000
VOXEL SIZE			Choose it myself	Consult with an Oral and Maxillofacial Radiology Specialist	Have no idea	
	The frequency of CBCT usage	Less than 2 times per month	19 (11,4%)	88 (53,0%)	59 (35,5%)	
		2–10 times per month	10 (12,0%)	42 (50,6%)	31 (37,3%)	
		More than 10 times per month	29 (50,9%)	16 (28,1%)	12 (21,1%)	
						Pearson Chi-Square ,000

the use of lead aprons shows variability among dentists and various specialists. Among dentists, 67 individuals (62.0%) always use a lead apron, 21 individuals (19.4%) use it sometimes, and 20 individuals (18.5%) do not use it. In oral and maxillofacial surgery specialists, 14 individuals (48.3%) always use a lead apron, 8 individuals (27.6%) use it sometimes, and 7 individuals (24.1%) do not use it. In prosthodontics, 19 individuals (55.9%) always use a lead apron, 10 individuals (29.4%) use it sometimes, and 5 individuals (14.7%) do not use it. Among endodontists, 27 individuals (71.1%) always use a lead apron, 8 individuals (21.1%) use it sometimes, and 3 individuals (7.9%) do not use it. In periodontics, 13 individuals (52.0%) always use a lead apron, 9 individuals (36.0%) use it sometimes, and 3 individuals (12.0%) do not use it. In restorative dentistry, 10 individuals (45.5%) always use a lead apron, 11 individuals (50.0%) use it sometimes, and 1 individual (4.5%) does not use it. In pediatric dentistry, 12 individuals (66.7%) always use a lead apron, 3 individuals (16.7%) use it sometimes, and 3 individuals (16.7%) do not use it. In orthodontics, 14 individuals (77.8%) always use a lead apron, 2 individuals (11.1%) use it sometimes, and 2 individuals (14.3%) do not use it.

Regarding the use of lead collars, among dentists, 61 individuals (56.5%) always use a lead collar, 26 individuals (24.1%) use it sometimes, and 21 individuals (19.4%) do not use it. In oral and maxillofacial surgery specialists, 6 individuals (20.7%) always use a lead collar, 11 individuals (37.9%) use it sometimes, and 12 individuals (41.4%) do not use it. In prosthodontics, 16 individuals (47.1%) always use a lead collar, 13 individuals (38.2%) use it sometimes, and 5 individuals (14.7%) do not use it. Among endodontists, 30 individuals (78.9%) always use a lead collar, 6 individuals (15.8%) use it sometimes, and 2 individuals (5.3%) do not use it. In periodontics, 12 individuals (48.0%) always use a lead collar, 9 individuals (36.0%) use it sometimes, and 4 individuals (16.0%) do not use it. In restorative dentistry, 7 individuals (31.8%) always use a lead collar, 13 individuals (59.1%) use it sometimes, and 2 individuals (9.1%) do not use it. In pediatric dentistry, 9 individuals (50.0%) always use a lead collar, 4 individuals (22.2%) use it sometimes, and 5 individuals (27.8%) do not use it. In orthodontics, 15 individuals (83.3%) always use a lead collar, 1 individual (5.6%) uses it sometimes, and 2 individuals (14.3%) do not use it.

No statistically significant relationship was found between CBCT acquisition frequency and the use of lead aprons for radiation protection ($p = 0.213$). However, a significant relationship was found between CBCT acquisition frequency and the use of thyroid collars ($p = 0.001$) (Table 4).

No significant relationship was found between receiving training on CBCT use and consulting a radiology specialist before acquiring CBCT imaging ($p = 0.10$). However, a statistically significant relationship was found between receiving training and consulting a radiology specialist after acquiring CBCT imaging ($p = 0.043$) (Table 5).

A statistically significant relationship was found between training on CBCT use and knowledge of technical parameters, specifically in the selection of field of view (FOV) and voxel size. (p=,000) (Table 6). Conversely, no statistically significant relationship was found between receiving training on CBCT use and attitudes toward using radiation protection measures for patient safety (Table 7).

Participants were asked about the criteria they consider when adjusting the dose parameters (kVp, mAs, and exposure time) during CBCT acquisition. They were given options including age, gender, weight, general health status, use of the device's automatic settings, not paying attention, and other factors, and were asked to select one or more applicable criteria. The results indicated that participants most frequently relied on the device's automatic settings to determine the patient's

Table 4 The relationship between the use of radiation protection measures and the frequency of tomography acquisition

		Use of Lead Apron			
		Always	**Sometimes**	**Never**	
The frequency of CBCT usage	Less than 2 times per month	106 (63,9%)	35 (21,1%)	25 (15,1%)	
	2–10 times per month	51 (61,4%)	22 (26,5%)	10 (12,0%)	
	More than 10 times per month	27 (47,4%)	19 (33,3%)	11 (19,3%)	
					Pearson Chi-Square ,213
		Use of Thyroid Collar			
		Always	**Sometimes**	**Never**	
The frequency of CBCT usage	Less than 2 times per month	99 (59,6%)	38 (22,9%)	29 (17,5%)	
	2–10 times per month	48 (57,8%)	23 (27,7%)	12 (14,5%)	
	More than 10 times per month	16 (28,1%)	27 (47,4%)	14 (24,6%)	
					Pearson Chi-Square , 001

exposure dose, followed by consideration of the patient's age (Fig. 3).

When comparing the criteria considered by participants who received training on CBCT use and those who did not regarding the radiation dose the patient is exposed to, it was observed that both groups exhibited inadequate attitudes in this regard (Tables 8 and 9). However, a statistically significant difference was found between the two groups in terms of age and weight. (p=,003; p=,009, respectively)

Discussion

The implementation of CBCT in dental practice has considerably enhanced diagnosis and treatment planning [19]. CBCT has numerous advantages over two-dimensional imaging techniques, leading to its extensive utilization in dentistry. Specifically, CBCT has been utilized in implantology, endodontics, orthodontics, and pathology evaluation, owing to its capacity to observe structures in multiplanar perspectives [20, 21]. This study included a total of 306 dentists (191 females, 115 males) with

Table 5 The crosstab showing the correlation between consultation with an oral and maxillofacial radiology specialist and the status of receiving training

			Consultation with an Oral and Maxillofacial Radiology Specialist for Indication Before Acquiring a CBCT Scan			**Total**
			Yes	**No**	**Sometimes**	
Status of Receiving Training	Individuals Who Received Training	Count	57	97	63	217
		Expected Count	64,7	91,8	60,5	217,0
		% within Individuals Who Received Training	26,3%	44,7%	29,0%	100,0%
	Individuals Who Did Not Receive Training	Count	34	32	22	88
		Expected Count	26,3	37,2	24,5	88,0
		% within Individuals Who Did Not Receive Training	38,6%	36,4%	25,0%	100,0%
Asymptotic Significance (2-sided) p=,100						
			Consultation with an Oral and Maxillofacial Radiology Specialist for Indication After Acquiring a CBCT Scan			**Total**
			Evet	**Hayır**	**Bazen**	
Status of Receiving Training	Individuals Who Received Training	Count	88	42	87	217
		Expected Count	95,3	44,1	77,6	217,0
		% within Individuals Who Received Training	40,6%	19,4%	40,1%	100,0%
	Individuals Who Did Not Receive Training	Count	46	20	22	88
		Expected Count	38,7	17,9	31,4	88,0
		% within Individuals Who Did Not Receive Training	52,3%	22,7%	25,0%	100,0%
Asymptotic Significance (2-sided) p=,043						

Table 6 The crosstab showing the relationship between training status and the selection of appropriate field of view (FOV) and voxel size in CBCT

Crosstab						
			Selection of the Appropriate Field of View (FOV) in CBCT			Total
			I select it myself	Consultate an Oral and Maxillofacial Radiology Specialist	Have no idea	
Status of Receiving Training	Individuals Who Received Training	Count	72	105	40	217
		Expected Count	59,8	102,5	54,8	217,0
		% within Individuals Who Received Training	33,2%	48,4%	18,4%	100,0%
	Individuals Who Did Not Receive Training	Count	12	39	37	88
		Expected Count	24,2	41,5	22,2	88,0
		% within Individuals Who Did Not Receive Training	13,6%	44,3%	42,0%	100,0%
Asymptotic Significance (2-sided) *p*=,000						
			Selection of the Appropriate Voxel size in CBCT			Total
			I select it myself	Consultate an Oral and Maxillofacial Radiology Specialist	Have no idea	
Status of Receiving Training	Individuals Who Received Training	Count	52	106	59	217
		Expected Count	41,3	103,2	72,6	217,0
		% within Individuals Who Received Training	24,0%	48,8%	27,2%	100,0%
	Individuals Who Did Not Receive Training	Count	6	39	43	88
		Expected Count	16,7	41,8	29,4	88,0
		% within Individuals Who Did Not Receive Training	6,8%	44,3%	48,9%	100,0%
Asymptotic Significance (2-sided) *p*=,000						

Table 7 The crosstab showing the relationship between the status of receiving training and attitudes toward the use of radiation protection measures during CBCT acquisition

			Use of Lead Apron			**Total**
			Always	**Sometimes**	**Never**	
Status of Receiving Training	Individuals Who Received Training	Count	134	56	27	217
		Expected Count	130,9	53,4	32,7	217,0
		% within Individuals Who Received Training	61,8%	25,8%	12,4%	100,0%
	Individuals Who Did Not Receive Training	Count	50	19	19	88
		Expected Count	53,1	21,6	13,3	88,0
		% within Individuals Who Did Not Receive Training	56,8%	21,6%	21,6%	100,0%
Asymptotic Significance (2-sided) *p*=,124						
			Use of Thyroid Collar			**Total**
			Always	**Sometimes**	**Never**	
Status of Receiving Training	Individuals Who Received Training	Count	119	66	32	217
		Expected Count	115,3	62,6	39,1	217,0
		% within Individuals Who Received Training	54,8%	30,4%	14,7%	100,0%
	Individuals Who Did Not Receive Training	Count	43	22	23	88
		Expected Count	46,7	25,4	15,9	88,0
		% within Individuals Who Did Not Receive Training	48,9%	25,0%	26,1%	100,0%
Asymptotic Significance (2-sided) *p*=,062						

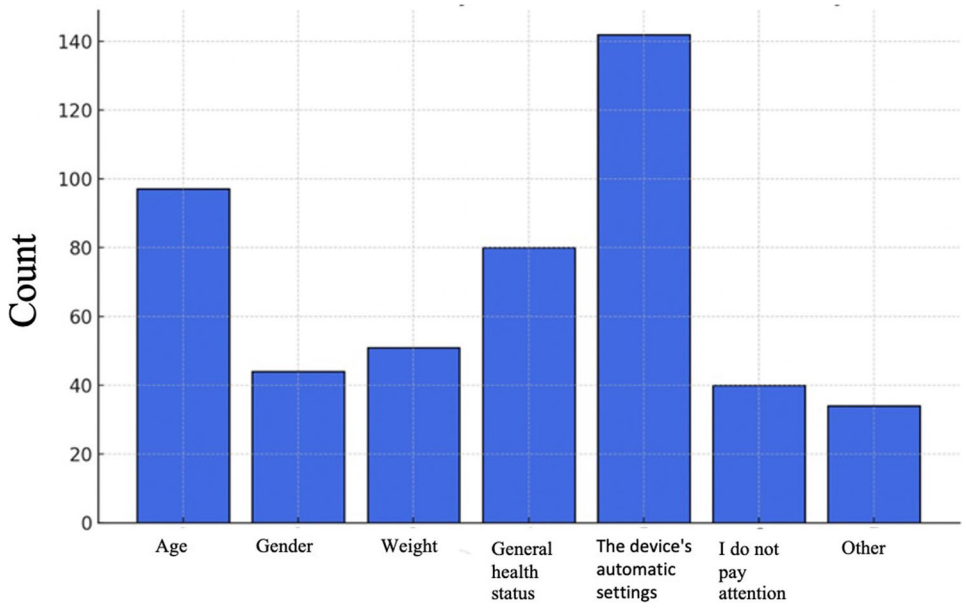


Fig. 3 Bar graph showing the distribution of criterias considered when adjusting CBCT dose

Table 8 The crosstab showing the relationship between the status of receiving training and the criteria considered regarding patient radiation dose during CBCT acquisition

		Criteria Considered Regarding the Patient's Radiation Dose							
		Age		Gender		Weight		General Health Condition	
		Yes	No	Yes	No	Yes	No	Yes	No
Individuals Who Received Training	Count	82	35	182	135	44	173	63	154
	Expected Count	71,1	32,0	185,0	145,9	36,3	180,7	59,1	157,9
	% within Individuals Who Received Training	37,8%	16,1%	83,9%	62,2%	20,3%	79,7%	29,0%	71,0%
Individuals Who Did Not Receive Training	Count	18	10	78	70	7	81	20	68
	Expected Count	28,9	13,0	75,0	59,1	14,7	73,3	23,9	64,1
	% within Individuals Who Did Not Receive Training	20,5%	11,4%	88,6%	79,5%	8,0%	92,0%	22,7%	77,3%
,003				,288		,009		,262	

varying levels of professional experience across different specialties.

However, the negative aspects of CBCT must be acknowledged, including inferior contrast and increased radiation exposure, in comparison to 2 dimensional conventional radiographic methods. Consequently, it is essential that its application is confined to circumstances where it is appropriate, with the advantages of CBCT utilization above the possible risk factors [20, 21].

A significant difference was found in the multiple group comparison between specialty areas and the frequency of CBCT use, with a statistically significant change in the frequency of CBCT imaging observed across all specialties ($p < 0.05$). Masyte et al. [22] evaluated CBCT use and knowledge among lithuanian dentists. In contrast to this study, no relationships were identified between the dentist's specialization and the frequency of CBCT scans.

The frequency of CBCT imaging varied across different specialties. General dentists were the most common group among those who obtained fewer than two CBCT scans per month. Those who performed between 2 and 10 scans per month were predominantly general dentists and oral and maxillofacial surgeons. Meanwhile, radiology specialists and oral and maxillofacial surgeons were the primary groups performing more than 10 CBCT scans per month. In this study, the most common reasons for requesting CBCT were pre-treatment evaluation (3.50 ± 1.47), assessment of the implant site (3.38 ± 1.55), and suspicion of cysts/tumors (3.16 ± 1.48). Cojocaru et al. [23] reported that, while implant planning is the most

Table 9 The crosstab showing the relationship between the status of receiving training and the criteria considered regarding patient radiation dose during CBCT acquisition

		Criteria Considered Regarding the Patient's Radiation Dose			
		Use of the device's automatic settings		I don't pay attention	
		Yes	No	Yes	No
Individuals Who Received Training	Count	99	117	24	193
	Expected Count	100,9	115,1	28,5	188,5
	% within Individuals Who Received Training	45,8%	54,2%	11,1%	88,9%
Individuals Who Did Not Receive Training	Count	43	45	16	72
	Expected Count	41,1	46,9	11,5	76,5
	% within Individuals Who Did Not Receive Training	48,9%	51,1%	18,2%	81,8%
,631				,095	

common application of CBCT imaging in dentistry, its utilization is progressively expanding to encompass additional diagnostic functions, including periodontics and endodontics. In around 20% of instances, the initial diagnosis and/or treatment strategy was modified subsequent to CBCT assessment. Additionally, in the study conducted by Masyte et al. [22], similar to the present study, when investigating the frequency of CBCT indications, they identified dental implant placement, pathology assessment, and root canal evaluation among Lithuanian dentists.

Cojocaru et al. [23] compared to physicians with more than five years of experience, younger physicians were more likely to select this technique. Contrary to this study, when the relationship between years of professional experience and the frequency of CBCT scans was evaluated using the Independent Samples Kruskal-Wallis Test, no statistically significant difference was found ($p = 0.126$).

CBCT exceeds conventional 2D dental imaging in terms of radiation exposure. Therefore, in accordance with radiation safety principles, the necessity of CBCT usage should be carefully evaluated [24]. In the current study, participants were asked whether they had received training on CBCT use and technical specifications in dentistry and where they had obtained this training. Aditya et al. [25] evaluated participants knowledge, attitude, and perspective regarding CBCT utilization. Similar to this study, the researchers firmly support the integration of CBCT training at both undergraduate and postgraduate levels to rectify these knowledge deficiencies and guarantee competence in employing this essential imaging technology. Qirresh et al. [26] conducted a study to evaluate the knowledge, attitudes, and awareness of Palestinian dentists concerning the utilization of CBCT. The study's results demonstrated a substantial gap in the knowledge of dental professionals regarding the applications of CBCT, despite its ubiquitous acceptance among dental specialists. In the study by Masyte et al. [22], where information and expectations regarding CBCT usage were queried, a lack of knowledge was observed. A significant majority of practitioners ($n = 67$, 81.7%) expressed a desire to enhance their CBCT knowledge and skills.

In this study, as shown in Tables 1 and 2, the frequency of CBCT scans and the selection of FOV and voxel size in CBCT scanning vary according to the participants' specialty. Furthermore, the consultation with a radiologist before obtaining three-dimensional radiological images differs by specialty. Among the dentists, 20 individuals (18.5%) consult a radiologist, 51 individuals (47.2%) do not, and 37 individuals (34.3%) sometimes consult a radiologist. When the reasons for requesting CBCT scans according to specialty were examined, oral and maxillofacial surgeons and prosthodontists most frequently requested CBCT for implant site evaluation (4.02 ± 1.29 and 4.02 ± 1.21). Despite the frequent use of CBCT for implant planning and pathology assessment, radiologist consultation prior to imaging was notably lacking among oral and maxillofacial surgeons. Moreover, the significant association between CBCT scan frequency and the selection of voxel size and FOV ($p < 0.001$) highlights the importance of technical knowledge in optimizing image acquisition. Proper selection of FOV and voxel size based on clinical indications requires sufficient knowledge of CBCT technical parameters. However, only a limited number of participants reported consulting a radiologist prior to image acquisition, whereas the majority (91.2%) sought radiological interpretation post-imaging.

Abdalla-Aslan et al. [27] evaluated knowledge and responsibility in CBCT practice among general and specialized Israeli dentists. They researched technical features such as FOV, voxel, and ROI, as well as consultation with oral and maxillofacial radiologists and the request for their reports. Similar to this study, it has been found that CBCT images are primarily obtained for implant planning (27%). However, in contrast to this study, nearly all (94.5%) respondents expressed interest in a service that provides a radiologic interpretation of CBCT reports by a radiologist.' Furthermore, most (71.8%) respondents were aware that the FOV and ROI may vary depending on the specific clinical needs.

Ionizing radiation is a recognized carcinogenic factor and has the potential to induce alterations in an individual's DNA. To mitigate the risk of stochastic biological effects, it is essential to carefully estimate the effective radiation dose. Consequently, it is advisable to consult a radiologist prior to radiological imaging to appropriately

adjust the FOV and voxel settings, assess the suitability of the indication, and implement necessary radiation protection measures during the imaging process [28].

Radiologist involvement in CBCT procedures is essential for both image justification and the selection of appropriate technical parameters, such as voxel size and field of view. This collaboration enhances radiation protection and supports low-dose imaging without compromising diagnostic quality. Furthermore, post-imaging consultation is vital for accurate interpretation and supports clinical decision-making, thereby enhancing both patient safety and diagnostic reliability. Radiologist involvement in CBCT decision-making supports appropriate indication selection, optimizes technical parameters, and enhances radiation safety. As highlighted by Ploussi and Efstathopoulos [18], integrating radiologists into CBCT workflows fosters a radiation safety culture and minimizes unnecessary exposure. The low consultation rate found in this study highlights a critical gap in adherence to best practices.

This study revealed variability in radiation protection practices across specialties. While the use of lead aprons was not significantly associated with CBCT imaging frequency ($p = 0.213$), a significant relationship was observed for thyroid collar use ($p = 0.001$), indicating selective awareness of sensitive anatomical regions. Training on CBCT use did not influence pre-imaging consultation with radiologists ($p = 0.10$), yet those who received training were more likely to seek post-imaging interpretation ($p = 0.043$). Although nearly half of the participants relied on automatic exposure settings, only a minority adequately considered patient-specific factors such as age ($p = 0.003$), with gender having no significant effect ($p = 0.288$).

Masyte et al. [22] found that, a majority of responders ($n = 43$, 52.4%) were unable to specify the specific exposure factor settings. Similar to this study, Thirty-nine dentists (47.6%) utilized pre-programmed settings for various patient groups before CBCT imaging. The usage of lead thyroid shields and lead aprons during CBCT among practitioners was moderate. Specifically, 24.4% of practitioners abstained from utilizing lead thyroid shields, whilst 19.5% refrained from employing lead aprons.

This study relied on self-reported questionnaire responses, which may be subject to recall bias or social desirability bias, potentially affecting the accuracy of reported practices and attitudes. Due to its cross-sectional design, the study cannot establish causal relationships between training, radiologist consultation, and improved CBCT practices. Although the sample included dentists from various specialties, the voluntary nature of participation and the limited sample size may limit the generalizability of the findings to the broader population of Turkish dentists. Additionally, the study did not include objective evaluations of clinical CBCT use or radiation protection behavior, as all findings were based on self-assessment and reported frequencies.

Conclusions

This study demonstrates that CBCT is most frequently utilized for implant surgery, pathology assessment, and the evaluation of root canal morphology. However, findings indicate that practitioners have insufficient knowledge regarding CBCT usage and the criteria necessary to minimize patient radiation exposure. Consulting a radiology specialist before imaging is crucial for verifying indications, selecting appropriate imaging parameters, and reducing radiation dose. Additionally, post-imaging consultation with a radiologist is essential for accurate interpretation. The use of protective equipment for radiation safety remains limited among practitioners. To enhance radiation health and safety, continuous education and regulatory oversight on CBCT utilization and practitioner attitudes should be prioritized.

Abbreviations

CBCT	Cone Beam Computed Tomography
FOV	Field of view
ROI	Region of Interest
DNA	Deoxyribonucleic acid

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12903-025-06754-0.

Supplementary Material 1.

Acknowledgements

Not applicable.

Authors' contributions

S.C.A. and Ö.S.Ö. contributed to conceptualization, data curation, investigation, methodology, and resources.S.C.A. and Ö.S.Ö. were responsible for writing—review and editing.S.C.A. performed supervision, validation, and writing—original draft preparation. All authors reviewed and approved the final version of the manuscript.

Funding

Not applicable.

Data availability

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request. The English version of the questionnaire is available as Supplementary File 1.

Declarations

Ethics approval and consent to participate

The protocol of this cross-sectional study was approved by the Scientific Research Ethics Committee of Lokman Hekim University (Approval No: 2021/147) and was conducted in accordance with the principles of the Declaration of Helsinki. Volunteer dentists were included in the study. All participants were informed about the purpose of the study, and their

participation was entirely voluntary. Informed consent was obtained from all participants prior to their inclusion in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Received: 7 July 2025 / Accepted: 6 August 2025
Published online: 26 September 2025

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