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A Two-Year Retrospective Evaluation of Cone Beam Computed Tomography Indications in Pediatric, Adolescent and Adult Patients

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ORIGINAL ARTICLE

A Two-Year Retrospective Evaluation of Cone Beam Computed Tomography Indications in Pediatric, Adolescent and Adult Patients

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ABSTRACT

Objective: The objective was to evaluate cone-beam computed tomography (CBCT) indications and distribution in pediatric, adolescent and adult patients. **Methods:** A total of 1013 CBCT images were reviewed in detail from the electronic patient database. The patient's age, gender, CBCT indications and acquisition sites, referral departments, reason for referral, incidental findings in the imaging field and the presence of artifacts in the CBCT images were all recorded. The European DIMITRA project recommendations were used to categorize CBCT indications in the children and the European Guidelines were used for adults. **Results:** From a total of 1013 images; 5.3% were from children, 9.2% were from adolescents and 85.5% from were adult patients. The most common indication was impacted permanent teeth in children (37%) and adolescents (34%) and impacted 3rd molars (28.7%) and implant dentistry (25.8%) in adults. While the most common regional image was taken from children (37%) and adolescents (43.4%), it was determined that CBCT was taken from the maxilla+mandible (37.7%) in adults. **Conclusion:** Our results show that while attention was paid to use CBCT in children and adolescents in accordance with clinical guidelines and taking into account radiation protection protocols, it was used in the adult patient group in cases where it is not superior to traditional methods.

Key words: artifact, cone-beam computed tomography, CT, dental radiography, diagnosis

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INTRODUCTION

Cone-beam computed tomography (CBCT) provides high-quality three-dimensional imaging of the maxillofacial region, including teeth and craniofacial anatomy, and has become a widely used imaging technique in dentistry in recent years.[1,2] Different CBCT models are available from many manufacturers and they vary in design, operating procedures and field of view (FOV) options. All CBCT provides a cross-sectional image dataset with multi-plane reconstruction from a single scan.[2–4] While CBCT is used to determine the diagnosis and treatment plan, real measurements and images of the maxillofacial region can be taken in the axial, sagittal, and coronal planes and from various angles.[1]

CBCT has a much lower effective radiation dose than computed tomography (CT). It also creates a faster and more detailed image than CT.[2–4] Although the radiation dose of CBCT is lower than that of CT, it has a higher radiation dose than traditional dental imaging methods.[3,5,6] The radiation dose of CBCT depends on the exposure parameters used by the operator. Moreover, the effective dose rates of CBCT differ in children and adults, depending in part on volume size (FOV size).[6,7] The use of CBCT in children and adolescents is common and associated with a greater risk of stochastic effects, especially in children, as the tissues are more susceptible to the harmful effects of radiation.[3,6] Therefore, it is important to use it appropriately in patients of all age groups, especially in pediatric dentistry. The basic principles of using correct CBCT include adjusting the tube voltage (kVp), tube current (mA)-irradiation time to the patient. and limiting the FOV to the area of clinical interest.[3,8] Dentists should adhere to the ALADAIP (Indication As Low As Diagnostically Acceptable And Patient-specific) principle and the radiation dose should be kept at an optimum level in

accordance with the clinical indication.[9] A request for CBCT should be made according to the three basic principles of radiation protection (justification, optimization and limitation).[10] CBCT can be requested for various reasons, including implant planning, evaluation of maxillofacial pathologies, evaluation of the temporomandibular joint (TMJ), determining the localization of mandibular third molars, determining the localization of impacted teeth and their proximity to anatomical structures, and for endodontic and orthodontic considerations.[6,11–13]

To our knowledge, no study has been conducted in Turkey in which the CBCT images of pediatric, adolescent and adult patients were analyzed in detail. The aim of this retrospective study was to analyze the profile, indications and exposure parameters of CBCT in child and adult patients in the Turkish subpopulation by age group, and to thus collect useful information for clinicians regarding the implementation of a strategy for radiological protection.

METHODS

This study was approved by the Ethics Committee of Ankara Yıldırım Beyazıt University (decision number: 2021-551). In this study, the images of patients who attended a large Dental Hospital between January 2020 and January 2022, and whose CBCT images were taken for various reasons, were scanned retrospectively. CBCT images obtained from the Planmeca ProMax® 3D Mid unit (Planmeca Oy, Helsinki, Finland) were evaluated using the Planmeca Romexis® database (Planmeca Oy, Helsinki, Finland). Incidental finding classification and all scans were performed by the same Oral and Maxillofacial radiologist (ZBA), who had six years of experience. The demographic information of the patients and the presence and findings of panoramic images before CBCT were examined from the electronic patient database. The following information obtained from these data was recorded in an Excel table: the patient's age, gender, CBCT indications, CBCT acquisition sites (FOV dimensions), exposure parameters (mA and kVp), referring department, and incidental findings in the imaging field. CBCT images with artifacts for which image analysis could be performed were evaluated, while images with severe artifacts were excluded from the study. In addition, artifacts in these images were grouped as "metal" and "motion" artifacts.

The patients were classified by age as children (≤ 12 years), adolescents (13–18 years), and adults (≥ 19 years). The imaging areas (FOV) of the CBCT scans were evaluated by grouping them as maxilla and mandible, maxilla, mandible, regional, sinus and TMJ. The following dental groups were included in the regional scans: maxilla anterior (canine-incisor), maxilla posterior (molar-premolar), mandible anterior (canine-incisor) and mandible posterior (molar-premolar).

CBCT indications were categorized and recorded by taking into account the classification of dental CBCT uses from the European Guidelines[14] in adults, and an adaptation of the European DIMITRA project[7] in children and adolescents: impacted permanent tooth (except third molar), impacted supernumerary tooth, impacted third molar (adults only), periapical pathology, bone pathologies (cyst-tumors and other lesions), trauma, cleft lip and palate, TMJ, implant dentistry (adults only), dental anomaly, sinus pathology (adults only), endodontics, orthodontics. When multiple exposure indications were encountered for a CBCT, each finding was recorded. In the examination of the CBCT images, findings unrelated to the reason for referral were accepted as incidental findings. Only the first CBCT was considered in patients with a follow-up CBCT image.

Statistical analysis

Statistical analysis was performed using the IBM SPSS (Version 26). Descriptive statistics were used to determine the distributions of patient age, gender, CBCT indications, incidental findings and FOV dimension. The chi-square test was used to evaluate the relationship between age groups and CBCT indications, FOV dimension, artifact types and the relationship between artifact type and FOV size. The level of significance was set at $p < 0.05$.

RESULTS

In this study, CBCT scans from 1013 patients aged between 5 and 93 years (mean age: 38.34) were analyzed retrospectively. Of the 1013 CBCT scans, 460 (45.4%) were from males and 553 (54.6%) were from females. The distribution of the examined computed tomographies according to age group was 54 pediatric patients (5–12 years old) (5.3%), 93 adolescents (13–18 years old) (9.2%) and 866 adults (19–93 years old) (85.5%) (Table 1).

The tomography images of 16 patients (1.5%) were excluded from the evaluation due to the presence of severe artifacts. Table 2 showed the distribution of the indications for CBCT referrals. The total number

Table 1. Distribution of CBCT examinations according to age and gender.

	Children		Adolescents		Adults	
	n	%	n	%	n	%
Female	22	2.2	56	5.5	475	46.9
Male	32	3.1	37	3.7	391	38.6
Total	54	5.3	93	9.2	866	85.5

Table 2. Distribution of the indications for CBCT by age groups.

Indication	Children		Adolescents		Adults	
	n	%	n	%	n	%
Impacted third molars	0	0	0	0	279	28.7
Impacted permanent teeth	27	37.0	32	34.0	52	5.4
Impacted supernumerary teeth	15	20.6	13	13.8	18	1.9
Periapical pathology	0	0	2	2.1	71	7.3
Bone pathology	22	30.1	31	33	199	20.4
Endodontic reasons	0	0	0	0	5	0.5
Orthodontic reasons	3	4.1	6	9.4	1	0.1
Trauma	0	0	2	2.1	4	0.4
TMJ	1	1.4	5	5.3	53	5.4
Implant dentistry	0	0	0	0	251	25.8
Cleft lip and plate	0	0	1	1	1	0.1
Dental anomalies	5	6.8	1	1	2	0.2
Sinus pathology	0	0	1	1	15	1.5
Others	0	0	0	0	22	2.3
Total	73	100	94	100	973	100

of indications was found to be higher than the total number of patients as CBCT requests were made for more than one clinical condition in some patients. The results showed that there were statistically significant differences between age groups and CBCT indications ($p = 0.00$). Impacted permanent teeth were the most common indication in children (37%) and adolescents (34%), while impacted third molars were found most frequently in adults (28.7%).

In addition to the CBCT indications, incidental findings were recorded as a result of retrospective analysis. Nasal region pathology (47.8%) was the most common incidental finding, followed by maxillary sinus pathology (30.2%) and periapical pathology (16.5%) (Table 3).

Table 3. Distribution of the incidental findings for CBCT.

Incidental Findings	n	%
Nasal region pathology	342	47.8
Maxillary sinus pathology	216	30.2
Periapical pathology	118	16.5
Idiopathic osteosclerosis	14	1.9
Odontoma	8	1.2
Impacted teeth	7	1.05
Bone pathology	4	0.6
Pericoronitis	2	0.3
Root resorption	2	0.3
Dental anomaly	1	0.15
Total	714	100

When CBCT requests were examined by region, it was determined that the most frequently requested was regional (37.1%), followed by maxilla+mandible (36.3%) and maxilla (17.2%) (Figure 1). It was determined that there was a statistically significant difference between the regions and age groups requiring CBCT ($p = 0.044$). While CBCT imaging was most frequently performed regionally in children (37%) and adolescents (43.4%), CBCT was obtained most frequently from the maxilla + mandible (37.7%) in adults.

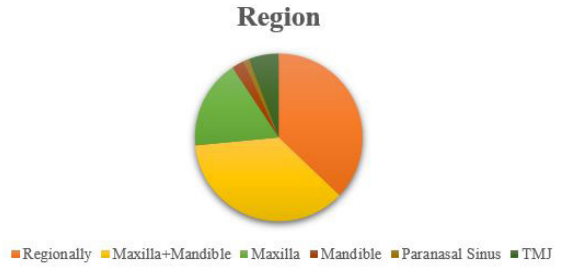

Figure 1. Distribution of CBCT examinations according to region

Considering the exposure parameters, the Kvp values were determined to be the same for each of the images (Kvp=90). The mA values ranged between 9 and 12 in each age group. The mean mA values were found to be 9.74 in children, 10.6 in adolescents and 11.95 in adults.

Artifacts were found in 31.2% of 1013 images and the most frequently detected artifacts were metal-induced (85.4%), followed by motion artifacts (14.2%). It was determined that there was a statistically significant difference between the artifact types and the age group requiring CBCT ($p = 0.00$). While 100% of the artifacts detected in children were motion artifacts, in adults 94% were metal artifacts.

A statistically significant difference was found between artifact type and region ($p = 0.00$). While metal artifacts were detected in 54.6% of images taken from

the maxilla+mandible, they were detected in 23.4% of images taken regionally. Motion artifacts were detected in 45.4% of maxilla+mandible images and 31.8% of regional images.

When the departments requesting CBCT were examined, it was determined that most of the orders were made by Departments of Oral and Maxillofacial Surgery (49.6%), followed by Departments of Oral and Maxillofacial Radiology (45.9%) and Departments of Pediatric Dentistry (5.1%).

With regard to the panoramic radiograph records of the 1013 patients that were examined retrospectively, it was determined that 25.6% of the patients were not referred for panoramic films before CBCT was conducted. In addition, the CBCT indications and panoramic radiograph findings were compatible in 91.4% of the patients who had panoramic radiographs.

DISCUSSION

Since the description and introduction of CBCT for use in dentistry, it has been employed for more than two decades in diagnostic imaging and treatment planning for the maxillofacial and dental area.[15] Today, due to its superiority in imaging, CBCT has become widely available and accessible in both university and dental hospitals. However, due to its high radiation dose, it should only be used for appropriate and necessary indications. In order to ensure the correct use of CBCT, various guidelines have been prepared for different dental disciplines.[9,16,17] However, there is a limited number of studies in the literature examining the knowledge and attitudes of dentists towards dentomaxillofacial imaging with CBCT in pediatric, adolescent and adult patients. Therefore, in the present study, the CBCT indications, intake sites, exposure parameters, referral department and incidental findings in the imaging field of all patients (1013 in total) aged 5–93 years who attended a large dental hospital over a two-year period were retrospectively examined.

Although the ratio of male to female patients was close, a significant difference was found in the age group ratios. Similar to the study of Barba et al.,[5] while most CBCT scans were performed in adults, the percentage in children and adolescents was very low. It was an expected result of the study that CBCT scans were taken less frequently from pediatric patients due to the high radiation dose and limited indications.

The most common indications in both children and adolescents were impacted permanent and supernumerary teeth. This finding is consistent with the results of other previous investigations.[1,3,18–20] It has been stated that the imaging method should include the impacted tooth as well as nearby anatomical structures,[9] and has been reported by the EAPD (European Academy of Pediatric Dentistry) guidelines[10] and The European DIMITRA Project[9] that CBCTs using is more successful and convenient than conventional two-dimensional radiographs in determining the positions of impacted teeth in pediatric patients. It can be concluded that clinicians use CBCTs in pediatric and adolescent patients in appropriate indications. In addition, the indication rate for dental trauma was found to be lower, similar to previous studies (2.1% in children and adolescents).[2,3] It can be thought that clinicians regard conventional radiographic techniques as useful for the diagnosis and treatment of dental trauma. However, it should be remembered that evaluation should be made on a case by-case basis, since CBCT may be beneficial in severe dental trauma and trauma induced-root resorption.

As in previous studies, it was detected that CBCT was mostly requested by Oral and Maxillofacial Surgery Departments (49.6%).[21] When the indications in the adult patient group were evaluated, it was determined that the most common indications for CBCT were impacted third molars and implant dentistry. This reaffirms the findings of other studies, such as Barba et al.[5] and Friedlander-Barenboim et al.,[21] which have reported this. In addition, in survey studies conducted on the subject, it has been stated that the clinicians mostly preferred to use CBCT for implants and third molar surgery.[22,23] This result can be explained by the fact that oral and maxillofacial surgeons requested CBCT to examine the relationship of the surgical field to the anatomical structures in a three-dimensional, cross-sectional manner. The European Radiation Protection Commission states that CBCT has sufficient geometric accuracy for linear measurements in implant dentistry and recommends the use of CBCT in situations where there is a possibility of damaging anatomical structures. At the same time, they emphasized that CBCT is not required for every planned implant, and that clinicians should decide on the use of CBCT according to their clinical judgement and in cases where conventional images are not sufficient.[6,14]

During extraction of the third molar, there is a possibility that the inferior alveolar nerve (IAN) will be damaged, with a 1% chance of permanent sensory loss.[24] In order to avoid this surgical complication, most studies evaluating the relationship between the mandibular canal and the third molar recommend preoperative evaluation with CBCT.[25–27] Although clinicians find preoperative CBCT scans to be helpful in diagnosing and extracting mandibular third molars, especially if there is a close relationship between the roots and the lower alveolar canal, having these images does not necessarily reduce the risk of IAN injury and does not affect prognosis.[14,28–30] Therefore, routine use of CBCT in third molar surgery is not recommended; however, when a close relationship is observed between

tooth roots and the lower alveolar canal on panoramic images, it has been reported that CBCT evaluation is appropriate.[6,14]

In the present study, the most common incidental findings were nasal region pathology (47.8%) and maxillary sinus pathology (30.2%). This result is similar to the results of many studies on this subject.[31–33] The frequency of maxillary sinus and nasal region findings detected in the images show that CBCT can be an effective method in the evaluation of the airway region, and that clinicians should utilize all data collected from CBCT scans regarding the dental areas.

Dental CBCT radiation doses are generally higher than traditional dental radiographs (intraoral and panoramic). The dose is determined by the type of equipment and the exposure parameters used, particularly the FOV chosen.[14] As a result of the current study, it was determined that while more regional images were taken in children (37%) and adolescents (43.4%), more images were taken from the maxilla+mandible in adults (37.7%). This result is similar to the study of Isman et al. and Hidalgo-Rivas et al.[1,3] In addition, the lowest average radiation dose was found in children, while the highest was in adults. These are desirable results demonstrating that attention was paid to radiation protection when taking CBCT from pediatric patients.

One of the most significant drawbacks of CBCT is its susceptibility to artifact generation.[34] In the current study, artifacts were detected at a total rate of 31.2% and 1.5% of the images were excluded from the study due to the presence of severe artifacts. Artifacts caused by implants, crown prosthesis, amalgam fillings and materials used in orthodontic treatments were labeled "metal" in this research. Similar to the results of Nardi et al.,[35] metal artifacts were found to be more common in adults and motion artifacts were more common in the pediatric patient group. It has been reported that motion artifacts in dentomaxillofacial region are caused by head shaking and/or trembling and are seen at a higher rate in anxious patients.[36,37] This may be the reason why there are more motion artifacts in images taken from children. It has been reported that the incidence of metal artifacts increases when the FOV area is wide, and that artifacts occur less frequently at low FOV.[38] Similarly, in this study, metal artifacts were mostly seen in maxilla+mandible scanning (54.6%). Although it has been reported that CBCT images with artifacts are not always of lower quality,[35] it is clear that the presence of artifacts reduced the image quality, causing repetitive acquisitions and therefore more radiation. Therefore, artifacts should be avoided as much as possible by limiting the FOV area to the region to be evaluated.

In this study, it was determined that 25.6% of the patients requested tomography without panoramic films having been taken. CBCT imaging has advantages over panoramic radiographs in that it allows measurement of bucco-lingual bone width, a three-dimensional visualization of the relationship with anatomical structures and provides images of high diagnostic quality. Because of these advantages, although it is superior to panoramic films in many clinic conditions such as trauma, implant surgery and TMD, it is incorrect not to use panoramic radiographs before CBCT examinations in order to protect patients from the high radiation dose.[10,39,40]

CONCLUSION

Nowadays, the use of CBCT in dentistry is becoming more widespread. The most common indications for CBCT in the present study were impacted permanent teeth in children and adolescents, while they were impacted third molar teeth and implant planning in adults. CBCT was taken more regionally in children and adolescents, and more from the maxilla+mandible area in adults. In addition, the prevalence of requesting CBCT in children and adolescents was very low compared to adults. In conclusion, it was observed that CBCT is used in pediatric and adolescent patients with more attention to radiation protection and in indications in accordance with the guidelines, while it is used in adult patients when it is not superior to traditional methods.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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