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Use of Cone-Beam Computed Tomography in Pediatric Patients in a Turkish Dental School

Bir Türk Diş Hekimliği Fakültesinde Çocuk Hastalarda Konik-Işınlı Bilgisayarlı Tomografi Kullanımı

ABSTRACT

Objective:

The purpose of the present study was to provide information that might help in planning cone-beam computed tomography (CBCT) imaging in pediatric patients. This study focused on the evaluation of indications for CBCT in pediatric patients in a Turkish dental school.

Material and Methods:

Six-hundred-seven CBCT scans belonging to patients under the age of 16 were included in this study. The following data were recorded from an electronic patient database: Age, gender, indication for referral (impacted teeth, supernumerary teeth, trauma, cysts/tumors, clefts, temporomandibular joint, and other reasons), dispersion of referrals by departments, external or internal referral.

Results:

Mean age was 12.39 years [range: 4-16; 260 females (42.8%) and 347 males (57.2%)]. The most frequent and largest age group (54.2%) was 13- to 16-years old. The most frequent request was to assess an impacted tooth and its localization (38.2%). Examining the FOVs, the maxilla was the most frequently imaged area (27.2%). Four-hundred sixty-six patients (76.8%) had been referred from departments of the dental school while 141 (23.2%) patients were referred from external clinics. Re-exposure was required in 52 cases (8.6%) due to patient-motion artefacts.

Conclusion:

The results of the present study can help dental professionals make the decision to refer for CBCT when extra three dimensional imaging is necessary for a pediatric patient. It is proper that an oral and maxillofacial radiologist decides when CBCT is necessary and then supervises the CBCT scanning protocol to minimize the radiation dose to pediatric patients.

Key Words:

Cone-beam computed tomography, Indication, Maxillofacial radiology, Pediatric dentistry

ÖZ

Amaç:

Bu çalışmanın amacı, çocuk hastalarda konik-ışınlı bilgisayarlı tomografi (KIBT) görüntülemenin planlanmasına yardımcı olabilecek bilgiler sağlamaktır. Bu çalışma, bir Türk diş hekimliği fakültesindeki çocuk hastalarda KIBT endikasyonlarının değerlendirilmesini amaçlamaktadır.

Gereç ve Yöntemler:
Bu çalışmaya 16 yaş altı hastalara ait 607 KIBT taraması dahil edildi. Aşağıda sıralanan veriler, elektronik hasta veri tabanından kaydedildi: Yaş, cinsiyet, sevk endikasyonu (gömülü dişler, süpernümere dişler, travma, kistler/tümörler, yarıklar, temporomandibular eklem ve diğer nedenler), sevklerin bölümlere göre dağılımı, dış veya iç sevkler.

Bulgular:
Ortalama yaş 12,39 idi [Yaş aralığı: 4-16; 260 kadın (%42,8) ve 347 erkek (%57,2)]. En sık ve en büyük yaş grubu (%54,2) 13-16 yaş aralığıydı. En sık talep nedeni gömülü diş ve lokalizasyonunun değerlendirilmesiydi (%38,2).
FOV'lar incelendiğinde en sık görüntülenen alan maksillaydı (%27,2). Dört yüz altmış altı hasta (%76,8) diş hekimliği fakültesi bölümlerinden, 141 hasta (%23,2) dış kliniklerden sevk edilmişti. Hasta hareket artefaktları nedeniyle 52 olguda (%8,6) yeniden çekim yapılmıştı.

Sonuç:
Bu çalışmanın sonuçları, diş hekimlerinin çocuk hastada ekstra üç boyutlu görüntüleme gerektiğinde KIBT'ye başvurma kararını vermelerine yardımcı olabilir. Bir oral ve maksillofasiyal radyoloğun KIBT'nin ne zaman gerekli olduğuna karar vermesi ve ardından çocuk hastalarda radyasyon dozunu en aza indirmek için KIBT tarama protokolünü denetlemesi uygun olacaktır.

Anahtar Sözcükler:
Konik-ışınlı bilgisayarlı tomografi, Endikasyon, Maksillofasiyal radyoloji, Çocuk diş hekimliği

INTRODUCTION
Cone-Beam Computed Tomography (CBCT) is an advanced imaging technique that provides three-dimensional imaging of dental and maxillofacial tissues. CBCT, which ensures a lower dose and a lower-cost alternative to conventional computed tomography (CT), is increasingly used in oral and maxillofacial radiology practice, especially in dental schools (1-3).
Paediatric patients refer to the dental clinics with various complaints and in specific conditions radiological examinations are needed to diagnose the source of the problems. To avoid unnecessary radiological applications, the radiological examination should not be requested without taking the patient's anamnesis and detailed clinical examination. In some cases where a complete diagnosis cannot be made with conventional x-ray techniques, it may be necessary to resort to advanced imaging methods such as CBCT.
Children are more susceptible to ionizing radiation risks because their tissues grow at a faster rate. Therefore they are more undefended to DNA damage and other changes (4,5). The European DIMITRA Project (dentomaxillofacial paediatric imaging: an investigation toward low-dose radiation induced risks- www.dimitra.be) is part of a project for the development of patient-specific and indication-oriented recommendations for the use of CBCT in pediatric dentistry. DIMITRA project is focused on optimizing pediatric doses. The DIMITRA consortium has recently proposed to move from ALARA (As Low as Reasonably Achievable) and ALADA principles (As Low as Diagnostically Acceptable) to ALADAIP principle (As Low as Diagnostically Acceptable being Indication-oriented and Patient-specific) (6). So a convenient CBCT-scanning protocol must be developed to minimize the radiation dose to pediatric patients. In turn to do this, it is important to determine why CBCT is currently being used.
In the literature, there are many studies on the reasons for the requests of CBCT including all age groups (7-10). However, only a few studies were found related to indications of CBCT utilization in paediatric dentistry (11-13). The main aim of the present study was to investigate the indications being used for recommending a CBCT examination of pediatric patients in a Turkish dental school. Other aims were to determine the dispersions of departments sending referrals for CBCT imaging, the ages and genders of the patients, fields of view (FOV) size of the CBCT scans, and presence of a repeated x-ray exposure.

MATERIAL and METHODS
The Ethical Committee of Cukurova University's Medical School approved the study (approval number: 89/14.06.2019-77). CBCT scans of 607 patients under the age of 16 who underwent CBCT imaging in the Oral and Maxillofacial Radiology Department of Cukurova University's Dental School during May 2015- December 2019 composed the study sample.
CBCT unit was a Planmeca® ProMax 3D Mid (Helsinki, Finland). Pediatric patients' CBCT images were scanned at six sets of FOV (width x height in mm): For face (200 x 170); for jaws (maxilla and mandible) (200 x 100); for maxilla (200 x 60); for mandible (200 x 60); for teeth (100 x 60) and for tooth (40 x 80). All of CBCT scans were archieved in the Romexis® database, and there was no possibility for missing/lost data.
Referrals (internal-from the departments of dental school or external-outer special clinics) and tomography reports written by an oral and maxillofacial radiologist were obtained from the Hospital Information Management System (Enlil, Eroglu Information Systems LLC, Eskisehir, Turkey). The following data were retrieved from the Romexis® database and the general electronic patient database: Age, gender, indication for referral (impacted teeth, supernumerary teeth, trauma, cysts/tumors, clefts, temporomandibular joint, and other reasons), and CBCT FOVs. Repeated exposures due to patient-motion artefacts which were written to patients' charts by radiology technicians were recorded.
The study inclusion criteria were fine visibility of all structures, including abnormalities or pathologies, with no imaging-artefacts due to patient movement or metal objects. In case of multiple CBCT scans per patient, only the first CBCT scan was included.
One author (BE) with 12 years experience analysed all data. After data collection, the patients were divided into three age groups, similar to the Isman et al.'s study: 4–6, 7–12, and 13–16 years based on primary, mixed, and permanent dentition, respectively (13).

IBM® SPSS 25.0 (Armonk, NY, USA) version was used for the statistical analysis. The significance level was set at 5% ($p<0.05$). The chi-square test was performed to determine the relationship between age groups, gender, CBCT indications, and FOV dimensions.

RESULTS

Mean participant age was 12.39 (SD=2.63) years [range: 4-16; 260 females (42.8%) and 347 males (57.2%)]. A hundred CBCT scans (16.5%) were taken in children aged between 4 to 6 year olds, 178 scans (29.3%) in children aged between 7 to 12 year olds and 329 scans (54.2%) in children aged between 13 to 16 year olds.

CBCT indications for referral were recorded, which could afterwards be subdivided into 7 categories, based on the represented cases (Table I). Two-hundred thirty-two reasons (38.2%) were for impacted teeth, 100 (16.5%) for pathological findings such as cyst/tumors, 88 (14.5%) for alveolar clefts, 76 (12.5%) for supernumerary teeth, 52 (8.5%) for other reasons (dental anomalies (2.0%), syndromes (1.6%), orthognathic surgery (1.2%), delayed eruption (1.1%), undetermined swelling (0.7%), external resorption (0.6%), sialolithiasis (0.5%), soft tissue calcification (0.5%), follow-up autotransplant (0.3%)); 41 (6.8%) for dentoalveolar trauma, and 18 (3.0%) were for the visualization of the temporomandibular joint (TMJ).

A significant relationship was found between age groups and CBCT indications (p=0.003) (Table I).

According to the referrals the most frequent and the largest age group was 13 to 16 year olds (54.2%). In all age groups, the most frequent request was to assess an impacted teeth and its localization. In the 4-6 and 7-12 age groups, the second most common reason was the supernumerary tooth (17%, 16.3%) respectively, while in the 13-16 age group that was cyst/tumor (19.2%). In the 4-6 age group, the third most frequent reason was trauma (15.0%), while that was clefts in the 7-12 (15.7%) and 13-16 age (14.3%) groups.

The distribution for the FOVs was listed as: 165 CBCT scans (27.2%) had a FOV of 200 x 60 mm (maxilla), 156 (25.7%) a FOV of 200 x 100 mm, 124 (20.4%) a FOV of 200 × 60 mm (mandible), 82 (13.5%) a FOV of 100 x 60 mm, 69 (11.4%) a FOV of 200 X 170 mm, and 11 CBCT scans (1.8%) were taken with a FOV of 40 × 80 mm (Table II). The maxilla was the most frequently imaged area in both 4-6 (49.0%) and 7-12 (35.4%) aged groups. In the 13-16 aged group, the most commonly imaged area was the mandible (25.5%) (Table II).

Table I. Distribution of indications for CBCT by age groups.

	IT	ST	PF	AC	DT	TMJ	OR	Total
4-6	32	17	11	13	15	3	9	100
	32%	17%	11%	13%	15%	3%	9%	100%
	13.8%	22.4%	11%	14.8%	36.6%	16.7%	17.3%	16.5%
7-12	61	29	26	28	13	3	18	178
	34.3%	16.3%	14.6%	15.7%	7.3%	1.7%	10.1%	100%
	26.3%	38.2%	26%	31.8%	31.7%	16.7%	34.6%	29.3%
13-16	139	30	63	47	13	12	25	329
	42.2%	9.1%	19.1%	14.3%	4%	3.6%	7.6%	100%
	59.9%	39.5%	63%	53.4%	31.7%	66.7%	48.1%	54.2%
Total	232	76	100	88	41	18	52	607
	38.2%	12.5%	16.5%	14.5%	6.8%	3%	8.6%	100%
	100%	100%	100%	100%	100%	100%	100%	100%
				p*=0.003				

IT: Impacted teeth, ST: Supernumerary teeth, PF: Pathological findings, AC: Alveolarcleft, DT: Dentoalveolar trauma, TMJ: Temporomandibular joint, OR: Other reasons. The results are expressed as the frequency (%). Chi-square test (*$p< 0.05$).

Table II. Distribution of FOV dimensions by age groups.

	200X170 (Face)	200X100 (M-M)	200X60 (Max)	200X60 (Mand)	100X60 (Teeth)	40X80 (Tooth)	Total
4-6	25	26	49				100
	25%	26%	49%	-	-	-	100%
	36.2%	16.7%	29.7%				16.5%
7-12	20	49	63	40	6		178
	11.2%	27.5%	35.4%	22.5%	3.4%	-	100%
	29%	31.4%	38.2%	32.3%	7.3%		29.3%
13-16	24	81	53	84	76	11	329
	7.3%	24.6%	16.1%	25.5%	23.1%	3.3%	100%
	34.8%	51.9%	32.1%	67.7%	92.7%	100%	54.2%
Total	69	156	165	124	82	11	607
	11.4%	25.7%	27.2%	20.4%	13.5%	1.8%	100%
	100%	100%	100%	100%	100%	100%	100%
				p*=0.000			

The results are expressed as the frequency (%). Chi-square test (*$p< 0.05$). FOV: Field of view; FOV dimensions are presented as width x height in mm. M-M: maxilla and mandible; Max: maxilla; Mand: mandible.

There was no significant difference between gender and CBCT indications (p=0.140) (Table III). The most frequent request was to assess an impacted teeth in both females (37.7%) and males (38.6%). While the second most common reason of CBCT requests in females was cyst/tumor (18.1%); in males, supernumerary teeth (15.3%) and cyst/tumor (15.3%) ranked second with the same rate (Table III).

Table III. Distribution of indications for CBCT by gender.

	IT	ST	PF	AC	DT	TMJ	OR	Total
Female	98	23	47	38	16	10	28	260
	37.7%	8.8%	18.1%	14.6%	6.2%	3.8%	10.8%	100%
	42.2%	30.3%	47%	43.2%	39%	55.6%	53.8%	42.8%
Male	134	53	53	50	25	8	24	347
	38.6%	15.3%	15.3%	14.4%	7.2%	2.3%	6.9%	100%
	57.8%	69.7%	53%	56.8%	61%	44.4%	46.2%	57.2%
Total	232	76	100	88	41	18	52	607
	38.2%	12.5%	16.5%	14.5%	6.8%	3%	8.6%	100%
	100%	100%	100%	100%	100%	100%	100%	100%
					p=0.140			

IT: Impacted teeth, ST: Supernumerary teeth, PF: Pathological findings, AC: Alveolar cleft, DT: Dentoalveolar trauma, TMJ: Temporomandibular joint, OR: Other reasons. The results are expressed as the frequency (%). Chi-square test (*p< 0.05).

Fifty-two (8.6%) of the CBCT scans were re-taken due to patient-motion artefacts.

Four-hundred sixty-six patients (76.8%) were referred from various departments (orthodontics (51.9%), paediatric dentistry (27.5%), and oral and maxillofacial surgery (20.6%)) of the dental school, while 141 (23.2%) patients were referred from the external clinics. The dispersion of these 141 patients was as follows: private dental clinics (63.8%) and medical clinics (36.2%) (Figure 1).

DISCUSSION

For decision of maxillofacial imaging in pediatric patients it should be taken into consideration how much it is really required and which structures need to be visualized. CBCT technology which has been available for about 20 years in dentistry became a convenient method for oral and maxillofacial diagnostic imaging. CBCT allows images to be acquired using a low dose of radiation, shorter patient examination time and lower costs than conventional computerized tomography (CT), which makes its usage preferable for specific indications of oral and maxillofacial imaging (3,14-16). However, a few studies have appointed that CBCT applications are not always necessary for a high benefit for the patients (17,18). This study focused on the evaluation of indications for CBCT in oral and maxillofacial imaging in pediatric patients. The purpose was to provide information that might help in planning CBCT imaging in pediatric patients.

Mean age was 12.39 years, this is similar with the age distribution in previous studies (11,19,20). A lower mean age of 8.3 years was shown in the study of Suzuki et al. (21). According to the referrals the most frequent and the largest age group was the 13- to 16-year olds (54.2%) in the present study. Hajem et al. reported 58% of the investigations were made in 11- to 15- year olds age group in their study on Swedish children and adolescents (11). There were more males (57.2%) than females in this sample, in similar with the study by Van Acker et al. (19) and in contrast to the study by Hidalgo-Rivas et al. (20).

There are several studies in the literature regarding the use of CBCT in pediatric patients. In the study of M. Marcu et al. the most common indication for CBCT scans in children was the evaluation of dental anomalies (12). The main clinical indication was for tooth localisation and assessment of resorption of adjacent tooth roots, typically concerning ectopic maxillary canine impaction in previous studies (11,20). In a Japanese survey, Suzuki et al. reported 51% of CBCT examinations were performed for impacted supernumerary teeth and 28% for disorders of tooth eruption (21).

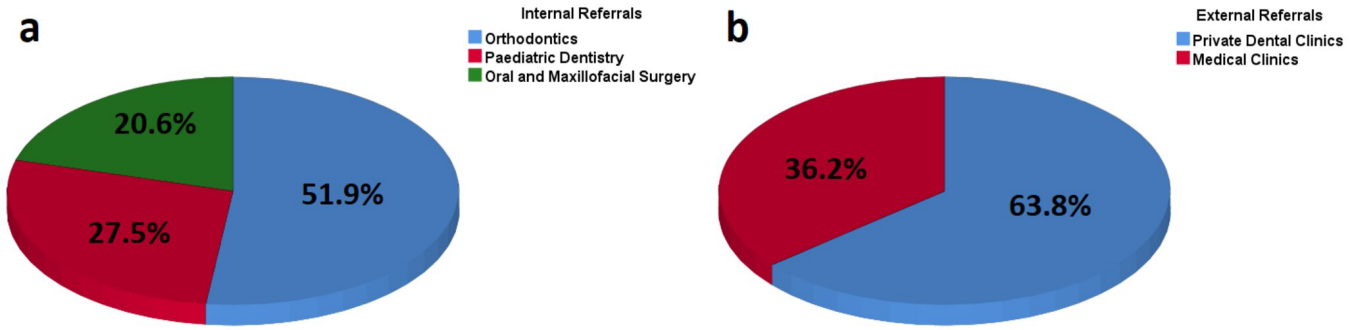

Figure 1. Distribution of internal and external referrals for CBCT scans.

The same study also reported that 9.2% of examinations were made for the TMJ. In our study, 3.0% of CBCT scans were for the visualization of TMJ. Thirty-six % of reasons were for developing dentition-localized and 1.0% was for TMJ in the study of Van Acker et al. (19). In accordance with the literature, the most frequent request was to assess an impacted tooth and its localization (38.2%) in our study. Since it is not possible to determine the positions of impacted or/and supernumerary teeth with conventional x-ray techniques that offer a two-dimensional view, CBCT is favored as much more beneficial method for the evaluation of impacted teeth. It is also clear that there is a variety in the presence and reaches to CBCT imaging and it should be taken into account in terms of culture and ethnicity while evaluating the literature from different regions of the world.

Field of view (FOV) is a parameter that determines the scan volume of the CBCT device. FOV limits the radiation exposure to a specific region of interest. In the present study, the distribution of different FOVs were investigated. Since larger FOVs results with higher radiation doses, it is crucial to choose the appropriate FOV for the area of interest. It would be appropriate to use a smaller FOV to examine one or two teeth (22). In the study of Isman et al., the most frequently used FOV was the face, because of the most common CBCT indication in their study was malocclusion and dentomaxillofacial anomalies (13). Examining the CBCT FOVs in this study, the maxilla was the most frequently imaged area (27.2%), followed by the jaws (maxilla and mandible; 25.7%), the mandible (20.4%), teeth (13.5%), face (11.4%) and tooth (1.8%). The CBCT scans with the two smallest FOV values specified in the study (100 x 60 and 40 x 80) accounted for only 15.3% of all scans. When making a CBCT request in a pediatric patient, the area to be examined is usually specified by a general or pediatric dentist. According to our findings, general dentists and paediatric dentists should be informed about the use of suitable FOVs to avoid the higher radiation doses. It might be proper that an oral and maxillofacial radiologist decides when CBCT is necessary and then supervises the examination.

Spin-Neto and Wenzel found that prevalence of movement during CBCT investigations could be approximately 20% in a systematic review (23). Movements and motion artefacts of patients underwent CBCT is more common in pediatric patients (11,24-26). In present study 52 (8.6%) of the CBCT scans were re-taken due to patient-motion artefacts. For avoiding image repetition it is important to provide that pediatric patient can cooperate for the radiological practice remaining motionless for a prolonged period.

In the current study, internal referrals (76.8%) from departments of dental school were much more common. Departments of orthodontics (51.9%), paediatric dentistry (27.5%), and oral and maxillofacial surgery (20.6%) referred the pediatric patients for CBCT imaging. In Hajem et al.'s study the largest group of referrals came from general practice dentists (43%) (11). In the study of Van Acker et al., 48.1% of patients received treatment in the local university dental out-patient hospital, while 49.4% of CBCT scans were external referrals (19).

A limitation of this retrospective survey was that patients from only a dental school were included in the study. In further studies, it will be interesting to perform a full analysis of all referrals of pediatric patients from various dentistry fields.

CBCT should be performed with following the ALADAIP principle and be used where the pediatric patient's benefit would outweigh potential risks. It may be recommended that an oral and maxillofacial radiologist decides when CBCT is necessary and then supervises the CBCT-scanning protocol to minimize the radiation dose in pediatric patients.

CONCLUSIONS

The results of the present study can help dental professionals make the decision to refer for CBCT when extra three dimensional imaging is necessary for a pediatric patient. The most frequent and the largest age group was the 13- to 16-year olds in the present study. The most frequent CBCT request was to assess an impacted tooth and its localization, and the maxilla was the most frequently imaged area. 8.6% of the CBCT scans were re-taken due to patient-motion artefacts. The majority of CBCT scans were consisted of requests from the dental school's departments.

Ethics Committee Approval:

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee (approval number: 89/14062019-77) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent:

All the participants' rights were protected and written informed consents were obtained before the procedures according to the Helsinki Declaration.

Author Contributions:

Concept – B.E., H.D., I.G.A, A.U.; Design – B.E., H.D., Supervision – B.E.; Resources – B.E.; Materials – B.E.; Data Collection and/or Processing – H.D., I.G.A, A.U.; Analysis and/ or Interpretation – H.D., I.G.A, A.U.; Literature Search – I.G.A, A.U.; Writing Manuscript – B.E., H.D., Critical Review – B.E.

Conflict of Interest:

The authors have no conflict of interest to declare.

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