Evaluation of cone beam computed tomography referral profile: Retrospective study in a Turkish paediatric subpopulation



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Abstract

Aim Increasing use of cone beam computed tomography (CBCT) for dentomaxillofacial diagnosis raises concerns about radiation dose which is known to be higher compared to conventional dental imaging methods. This retrospective study investigated the CBCT referrals in a Turkish paediatric subpopulation in terms of referring department, field of view (FOV), and findings.

Materials and methods A total of 8,880 CBCT images were reviewed retrospectively and images of paediatric patients (≤14 years old) were selected. In paediatric patients; data related to patient age and gender, referring department, FOV, region of interest for localised applications, and reason for CBCT referral were recorded. FOVs of CBCT scans were classified as face, jaws (maxilla and mandible), maxilla, mandible, and tooth. CBCT indications were categorised based upon an adaptation of the European DIMITRA (dentomaxillofacial paediatric imaging: an investigation towards low-dose radiation induced risks) multicenter and multidisciplinary project recommendations as impacted teeth, trauma, orofacial clefts, dental anomalies, bone pathology, syndromes, and other. Patients undergoing consecutive CBCT examinations for follow-up were also recorded. In order to record the incidental findings noticed in the CBCT evaluation, the radiological report prepared by the radiologist was used. The results were analysed statistically with a significance level set at $p<0.05$.

Results Four hundred forty-nine of the 8880 CBCT scans were taken from paediatric patients under the age of 14, representing approximately 5% of all scans. Most of the referrals were from Department of Paediatric Dentistry (36.3%), followed by Department of Orthodontics (25.6%). The most frequently imaged region was the maxilla (33.4%), followed by the face (20.5%). The most common region of interest for localised applications was the maxillary canine/incisor region (85.55%). The most common indication was impacted teeth (41.4%) followed by bone pathology (31%) and dental anomalies (29.6%); 11.6% of the patients underwent follow-up CBCT examinations especially for orofacial clefts and syndromes.

Conclusions This retrospective study investigating CBCT indications in a Turkish paediatric subpopulation and comparing existing applications with DIMITRA project recommendations can guide dental professionals in referring paediatric patients for CBCT.

KEYWORDS Cone beam computed tomography; Paediatric population; Field of view; Indication; DIMITRA project guidelines.

Introduction

Providing high-quality three-dimensional images of the maxillofacial region, cone beam computed tomography (CBCT) has become a widely used imaging technique in dentistry in the past decade. All of the different CBCT models available from various manufacturers, which have different design, operating procedures, field of view (FOV) options, and image quality, generate a set of cross-sectional image data with multiplanar reconstruction facility originating from a single scan with a much lower effective patient dose compared to multislice computed tomography [Silva et al., 2008; Okano et al., 2009; Aps, 2013; Hidalgo-Rivas et al., 2014; Jaju & Jaju, 2015].

The arising popularity of CBCT in all dentistry branches, including paediatric applications, results in growing concerns regarding the dose of radiation known to be higher compared to conventional dental imaging modalities [Silva et al., 2008; Okano et al., 2009; Aps, 2013; Horner et al., 2015; Ludlow et al., 2015; Hedesiu et al., 2018]. Since ionising radiation exposure in children is associated with greater risk, proper use with regard to justification, optimisation, and protection respecting the ALARA (as low as reasonably achievable) principle while ensuring adequate diagnostic yield is essential in paediatric dentistry [Theodorakou et al., 2012; Ludlow et al., 2015].

Although the SEDENTEXCT Guideline Development Panel proposed evidence-based guidelines for CBCT usage, current information for significant patient outcome efficacy in paediatric dentistry is insufficient [Radiation Protection No. 172, 2012]. Recently, a literature review concerning CBCT in paediatric dentistry came to the conclusion that the indications of CBCT in paediatric dentistry have not yet been exactly identified and its use should only be limited to the patients

where benefits clearly dominate the potential risks [Aps, 2013].

Case reports, case series, and review articles that emphasise the potential advantages of CBCT in paediatric dentistry and orthodontics have been published [Kapila et al., 2011; Nervina, 2012; Dobbyn et al., 2013; Kapila & Nervina, 2015]. However, the number of studies investigating the CBCT indications in this age group is scarce. A thorough search of the relevant literature yielded only four studies that have attempted to explore the common CBCT referral reasons in paediatric dentistry [Suzuki et al., 2006; Hidalgo-Rivas et al., 2014; Van Acker et al., 2016; İşman et al., 2017]. More recently, as a part of the OPERRA research (Open Project for European Radiation Research Area), the European DIMITRA project (dentomaxillofacial paediatric imaging: an investigation toward low-dose radiation induced risks) aimed to establish recommendations specified to patient and oriented to indication for the appropriate use of CBCT in paediatric dentistry. In the published position statement, principles and clinical guidelines for the major CBCT indications in paediatric dentistry are offered [Oenning et al., 2018].

Based on this information, this CBCT-based retrospective study was aimed to investigate the CBCT referrals in a Turkish paediatric subpopulation, and to compare the existing applications with DIMITRA European multicenter and multidisciplinary project recommendations.

Materials and methods

The records of children (≤14 years old) with CBCT images obtained using the Planmeca ProMax® 3D Mid unit (Planmeca Oy, Helsinki, Finland) between January 2013 and January 2019 in the Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Marmara University, Istanbul, Turkey were analysed retrospectively in this study. The study design was examined and approved by the Ethics Committee of Marmara University Faculty of Dentistry (protocol number: 2019-292).

All examinations performed on children were assigned for further analysis. For each CBCT examination, the following data were collected from the Planmeca Romexis® database (Planmeca Oy, Helsinki, Finland) and the electronic patient database: patient age at the time of the CBCT examination, gender, referring department, FOV dimensions of the CBCT scan, and reason for referral.

FOV dimensions of the CBCT scan was recorded as face, jaws (maxilla-mandible), maxilla, mandible, and regional. For regional CBCT scans, the region of interest was recorded as 4 different sextants as maxillary molar-premolar, maxillary canine-incisor, mandibular molar-premolar, and mandibular canine-incisor regions. The reasons for CBCT referrals were categorised and recorded based upon an adaptation of the European DIMITRA project recommendations [Oenning et al., 2018]. An additional heading of "other" was enclosed for unanticipated reasons of referral not classified in DIMITRA. When multiple referral indication for a CBCT was encountered, each was recorded. In order to record the incidental findings noticed in the CBCT evaluation, the radiological report prepared by the radiologist was used. Findings that were not relevant to referral reason of the CBCT examination were accepted as incidental findings. Patients undergoing consecutive (follow-up) CBCT examinations were also recorded, however only the first CBCT was taken into consideration. In addition, when CBCT retake was encountered, only the retake was regarded valid for evaluation.

All data were collected by a dentomaxillofacial radiologist with 20 years of experience (B.G.) and checked twice. The same medical monitor (NEC MD242C2 24-inch monitor, 1920×1200 resolution, Hiliex Advanced Medical Technologies, California, USA) was used for all analyses with a black background and dim lighting.

For statistical analysis, IBM® SPSS Statistics 22 (IBM SPSS, Turkey) was used. In addition to descriptive statistics (mean, standard deviation, frequency), quantitative data were compared using the Mann Whitney U test, the qualitative data were compared using chi-square test, Fisher Freeman Halton test, and continuity (Yates) correction. The significance level was set at $p<0.05$.

Results

Study subject characteristics

Of the 8,880 CBCT scans evaluated retrospectively, 449 (5.1%) were obtained from paediatric patients aged ≤14 years: 185 (41.2%) from girls and 264 (58.8%) from boys. The mean age of the entire paediatric sample was 11.15±2.33 (range 3–14).

Referring departments and FOV dimensions

In our patient group, CBCT referrals were from Department of Paediatric Dentistry in 36.3%, Department of Orthodontics in 25.6%, Department of Oral and Maxillofacial Surgery in 25.4%, Department of Oral and Maxillofacial Radiology in 11.4%, and Department of Endodontics in 1.3% of the patients (Table 1).

FOV Dimension	Referring Department						p
	Orthodontics 115 (25.6%)	Oral and Maxillofacial Radiology 51 (11.4%)	Paediatric Dentistry 163 (36.3%)	Oral and Maxillofacial Surgery 114 (25.4%)	Endodontics 6 (1.3%)	Total 449 (100%)	
Face	44 (38.3%)	12 (23.5%)	11 (6.7%)	25 (21.9%)	0 (0%)	92 (20.5%)	[1]0.000*
Jaws (maxilla and mandible)	19 (16.5%)	4 (7.8%)	4 (2.5%)	12 (10.5%)	0 (0%)	39 (8.7%)	
Maxilla	48 (41.7%)	13 (25.5%)	57 (35%)	30 (26.3%)	2 (33.3%)	150 (33.4%)	
Mandible	4 (3.5%)	21 (41.2%)	8 (4.9%)	44 (38.6%)	1 (16.7%)	78 (17.4%)	
Regional	0 (0%)	1 (2%)	83 (50.9%)	3 (2.6%)	3 (50%)	90 (20%)	

[1]*chi-square test* *$p<0.05$

TABLE 1 Distribution of CBCT FOV dimensions in regard to referring departments.

Region	Referring Department					
	Orthodontics n (%)	Oral and Maxillofacial Radiology n (%)	Paediatric Dentistry n (%)	Oral and Maxillofacial Surgery n (%)	Endodontics n (%)	Total n (%)
Maxillary molar-premolar	0 (0%)	0 (0%)	3 (3.6%)	1 (33.3%)	0 (0%)	4 (4.4%)
Maxillary canine-incisor	0 (0%)	0 (0%)	74 (89.2%)	1 (33.3%)	2 (66.7%)	77 (85.6%)
Mandibular molar-premolar	0 (0%)	1 (100%)	2 (2.4%)	1 (33.3%)	1 (33.3%)	5 (5.6%)
Mandibular canine-incisor	0 (0%)	0 (0%)	4 (4.8%)	0 (0%)	0 (0%)	4 (4.4%)
Total	0 (0%)	1 (100%)	83 (100%)	3 (100%)	3 (100%)	90 (100%)

TABLE 2 Distribution of region of interest for localised exposures in regard to referring departments.

Regarding the CBCT FOV dimensions, the most frequently requested area was maxilla (33.4%), followed by face (20.5%), regional (20%), mandible (17.4%), and jaws (maxilla and mandible) (8.7%) (Table 1). The majority of regional CBCT examinations (85.6%) included maxillary canine-incisor region with other sextants having a much lower frequency (Table 2).

Statistically significant differences were observed in the distribution of FOV dimensions between referring departments (p: 0.000; p<0.05) (Table 1). The rate of face FOV dimension requests from the Department of Orthodontics (38.3%) was found to be significantly higher in comparison to the other departments (p: 0.000; p<0.05). The rate of maxilla FOV dimension requests from the Department of Paediatric Dentistry (35%) was significantly higher in comparison to Departments of Oral and Maxillofacial Radiology (25.5%) and Oral and Maxillofacial Surgery (26.3%) (p: 0.000; p<0.05). Additionally, the rate of mandibular FOV dimension requests from the Department of Endodontics (16.7%) was detected to be significantly lower compared to the Departments of Oral and Maxillofacial Radiology (41.2%) and Oral and Maxillofacial Surgery (38.6%) (p1: 0.005; p2: 0.002; p<0.05). The distribution of regional FOVs by referring departments is shown in Table 2.

Indications for CBCT examinations

The distribution of the reasons for CBCT referrals are presented in Table 3. The total number of indications was found to be higher than the total number of patients, because CBCT requests were for more than one clinical situation in some patients. Assessment of the radiological reports demonstrated a wide variety of incidental findings, including maxillary sinus and temporomandibular joint pathologies, and soft tissue calcifications such as tonsillolith and sialolith in 149 (33.2%) study subjects.

No statistically significant relationship was detected between gender and CBCT indications (p>0.05). The referring department and the indications revealed statistically significant differences (p:0.000; p<0.05). The most common orthodontic indication was cleft lip and palate (59.1%), while the most common paedodontic indication was impacted teeth (54.6%). For Departments of Oral and Maxillofacial Radiology, Oral and Maxillofacial Surgery, and Endodontics, the most common indication was bone pathology (52.9%, 52.6%, and 66.7%, respectively) (Table 3).

Except syndromes, a statistically significant difference was noted between the CBCT FOV and indications (p<0.05). In orofacial cleft patients, the most frequently referred CBCT FOV was face (37%). Regional FOV was preferred for dental anomalies (51.1%) followed by impacted teeth (43.3%) (Table 4).

More than one CBCT scan was performed in 52 of 449 patients (11.6%). Fourty-three received 1, eight received 2, and one received 3 follow-up CBCT examinations. Most of these were for orofacial clefts and syndromes.

Discussion

The use of CBCT in paediatric dentistry is limited since its radiation dose is higher and scanning time is longer. Consequently, CBCT studies in paediatric patients have been restricted to review articles or case reports/series, and in this

Indication	Referring Department						p
	Orthodontics n (%)	Oral and Maxillofacial Radiology n (%)	Paediatric Dentistry n (%)	Oral and Maxillofacial Surgery n (%)	Endodontics n (%)	Total n (%)	
Impacted teeth	29 (25.2%)	21 (41.2%)	89 (54.6%)	47 (41.2%)	0 (0%)	186 (41.4%)	[1]0.000*
Trauma	1 (0.9%)	3 (5.9%)	14 (8.6%)	5 (4.4%)	2 (33.3%)	25 (5.6%)	[1]0.002*
Orofacial clefts	68 (59.1%)	1 (2%)	1 (0.6%)	4 (3.5%)	0 (0%)	74 (16.5%)	[1]0.000*
Dental anomalies	10 (8.7%)	9 (17.6%)	85 (52.1%)	27 (23.7%)	2 (33.3%)	133 (29.8%)	[1]0.000*
Bone pathology	4 (3.5%)	27 (52.9%)	44 (27%)	60 (52.6%)	4 (66.7%)	139 (31%)	[1]0.000*
Syndromes	1 (0.9%)	0 (0%)	0 (0%)	1 (0.9%)	0 (0%)	2 (0.4%)	[2]0.498
Other	9 (7.8%)	4 (7.8%)	2 (1.2%)	7 (6.1%)	0 (0%)	22 (4.9%)	[1]0.076

[1]*chi-square test* [2]*Fisher Freeman Halton test* **p<0.05*

TABLE 3 Distribution of the indications for CBCT referrals categorised based upon an adaptation of the European DIMITRA project recommendations in regard to referring department.

Indication	FOV Dimension					p
	Face n (%)	Jaws (maxilla and mandible) n (%)	Maxilla n (%)	Mandible n (%)	Regional n (%)	
Impacted teeth	24 (26.1%)	14 (35.9%)	74 (49.3%)	35 (44.9%)	39 (43.3%)	[1]0.008*
Trauma	3 (3.3%)	4 (10.3%)	5 (3.3%)	3 (3.8%)	10 (11.1%)	[1]0.046*
Orofacial clefts	34 (37%)	14 (35.9%)	26 (17.3%)	0 (0%)	0 (0%)	[1]0.000*
Dental anomalies	16 (17.4%)	7 (17.9%)	55 (36.7%)	9 (11.5%)	46 (51.1%)	[1]0.000*
Bone pathology	20 (21.7%)	8 (20.5%)	37 (24.7%)	50 (64.1%)	24 (26.7%)	[1]0.000*
Syndromes	2 (2.2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	[2]0.219
Other	12 (13%)	3 (7.7%)	3 (2%)	3 (3.8%)	1 (1.1%)	[2]0.001*

*[1]chi-square test [2]Fisher Freeman Halton test *p<0.05*

TABLE 4 Distribution of the indications for CBCT in regard to FOV dimensions.

context there are only a few original research articles [Suzuki et al., 2006; Hidalgo-Rivas et al., 2014; Van Acker et al., 2016; İşman et al., 2017].

In the first study available on this subject in the literature by Suzuki et al. [2006], the most common reasons for CBCT referral in children and adolescents in Japan were reported as impacted supernumerary teeth (51%), disorders of tooth eruption (28%), and investigation of temporomandibular joint (9.2%).

In a subsequent study, Hidalgo-Rivas et al. [2014] provided useful information about CBCT use in children and adolescents in United Kingdom hospital practice. CBCT scans obtained using three different units (NewTom VG, 3D Accuitomo 170, and i-Cat Next Generation) were examined and it was reported that CBCT use in this age group constituted only a small percentage (13.7%) of the total workload of CBCT devices. Their paediatric sample comprised of 53.1% female and 46.9% male subjects, and the mean age was reported to be 13.1 years (n=294, age range: 5–17 years, SD=2.6 years). Of the CBCT examinations, 81.5% were classified as regional examinations, and the majority of them (63.4%) included maxillary anterior region. The main clinical indication was reported as unerupted teeth localisation (especially canines) and detection of adjacent root resorption followed by bone pathology. Incidental findings, most of which were inflammatory sinonasal diseases, were revealed in more than a quarter of the radiological reports of study subjects (26.4%).

In another study, Van Acker et al. [2016] reviewed the causes of CBCT referral of paediatric patients under the age of 18 at a university hospital in Belgium. In this study, CBCT scans taken using Planmeca Promax® 3D Max were evaluated. The mean age of the paediatric sample consisting of 44.3% female and 55.7% male subjects, was reported as 12.35 years (n=79, range: 7-17 years, SD=2.75 years); 81% of the CBCTs were reported to be obtained with a small FOV (50×55 mm), and the most common reason for referral was reported as impacted canines and adjacent root resorption followed by atypical tooth morphology.

A retrospective study by İşman et al. [2017] investigated CBCT indications in accordance with the guidelines for dental CBCT in a Turkish paediatric subpopulation. The mean age of the paediatric sample, which consisted of 46.5% female and 53.5% male subjects, was 13.42 years (n=329, range: 2–17 years). CBCT scans obtained using Planmeca Promax® 3D Mid having five different FOVs (face, jaws, maxilla, mandible, and regional) were evaluated and the most commonly requested FOV was reported to be face (74%), followed by the jaws (12.2%), whereas the least frequently used FOV was reported as regional (0.9%). The most frequent indication for CBCT in their study was malocclusion and dentomaxillofacial anomalies in the primary dentition and permanent dentition groups, and impacted teeth localisation in the mixed dentition group.

The comparison of the findings of our study with the previous studies is difficult due to different methodologies and equipment used.

Our dental faculty, which includes all specialist departments in the field of dentistry, provides undergraduate and postgraduate education and also delivers dental treatment to the public. Since the faculty is located in Istanbul with a combination of all social classes and dental health demands, it can be assumed that the profiles of patients admitted to the hospital show uniform distribution.

Although all of the aforementioned similar studies were performed using CBCT scans of patients under the age of 18, CBCT scans of patients under the age of 14 years were assessed in our study as patients younger than 14 years are regarded as paediatric patients in our faculty. As a result, the mean age of the paediatric population in our study was 11.15 ± 2.33 years (range 3–14) which is slightly lower compared to the mean age reported by Hidalgo-Rivas et al. [2014], Van Acker et al. [2016], and İşman et al. [2017], however Suzuki et al. [2006] reported a lower mean age of 8.3 years. The youngest patient in our paediatric sample was 3 years old and was admitted as a result of trauma similar to that reported in the study by İşman et al. [2017]. The proportion of males (58.8%) was higher than females (41.2%) in our study group, similar to the sample of Van Acker et al. [2016] and İşman et al. [2017], on the contrary to Hidalgo-Rivas et al. [2014] who reported a quite higher female proportion (53.1%).

The first finding of interest in our study was that CBCT referrals of children constituted a small minority of the patients (5.1%) and most of them were from the Department of Paediatric Dentistry (36.3%). Regarding the CBCT FOV dimension, the most commonly requested area was maxilla (33.4%), followed by face (20.5%), and regional (20%). The

prevalence of regional referrals was lower compared to the studies of Hidalgo-Rivas et al. [2014] and Van Acker et al. [2016], but fortunately higher in comparison to the other study from Turkey by İşman et al. [2017].

The second finding of interest was that most of the CBCT referrals from the Department of Paediatric Dentistry were localised CBCT examinations (50.9%) showing the greater awareness of paediatric dentists about the potential ionizing radiation-related risks compared to other speacialist groups. The most frequently referred region was the anterior maxilla (85.55%), similar to the findings of Hidalgo-Rivas et al. [2014].

To the authors' knowledge, this is the first study classifying the CBCT indications according to an adaptation of the European DIMITRA project recommendations [Oenning et al., 2018]. The most common indication was impacted teeth (41.4%), which accorded with previous studies by Hidalgo-Rivas et al. [2014] and Van Acker et al. [2016], followed by bone pathology and dental anomalies (31% and 29.8%, respectively).

In radiology, it is inevitable to encounter incidental findings that are not relevant to the reason for which imaging was performed [Hidalgo-Rivas et al., 2014]. Assessment of the reports prepared by the radiologists exhibited a wide collection of incidental findings, namely maxillary sinus and temporomandibular joint pathologies, and soft tissue calcifications such as tonsillolith and sialolith in 33.2% of the study subjects. Inflammatory sinonasal disease was determined to be the most common incidental finding similar to the study of Hidalgo-Rivas et al. [2014].

A variety of CBCT units are on the market and make it difficult to compare the findings of the studies [Van Acker et al., 2016]. In the present study, images obtained using a Planmeca Promax® 3D Mid CBCT unit were evaluated. Different results might be achieved if another device with different technical properties or settings varying by manufacturer was used [Van Acker et al., 2016].

In addition, while evaluating the studies carried out in different regions of the world, diversity in availability and access to CBCT, and cultural and ethnical characteristics should be taken into consideration [Van Acker et al., 2016]. It should also be pointed out that there may be differences in patterns of radiology usage and the results of this study conducted in a Turkish subpopulation may not reflect the practice in another country.

In conclusion, in case CBCT scanning is needed in paediatric patient population, the European DIMITRA multicenter and multidisciplinary project recommendations should be respected and the most appropriate FOV should be chosen to prevent unnecessary radiation exposure.

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