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ORIGINAL ARTICLE

CBCT of Swedish children and adolescents at an oral and maxillofacial radiology department. A survey of requests and indications

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ABSTRACT

Objectives: This retrospective study investigated requests and indications for cone-beam computed tomography (CBCT) in children and adolescents over a 3-year period at one oral and maxillofacial radiology department. Specific aims were to determine what technical settings were used, which caregivers write the referrals, and how often and for what reasons re-exposure was necessary.

Materials and methods: Patients <19 years of age who had been referred to the department and undergone a CBCT scan during 2015–2017 were included in the study.

Results: CBCT were made in 617 of the 3847 eligible referrals. The most common referral was from general practice dentists (GPD) (43%). Mean age of the patients was 12.5 years (range: 6–18). Nineteen different types of requests were identified. The most common request was assessment of an ectopic canine with a question about potential resorption of adjacent teeth (38.6%). Forty (6.5%) of the CBCT needed to be re-taken due to patient motion artefacts.

Conclusions: The most common request and indication for CBCT examination of children and young adults were to assess an ectopic canine and determine the presence of resorption of adjacent teeth. Referrals from GPDs were the most frequent and the largest age group was the 11- to 15-year olds. The reason for re-exposures was motion artefacts. High scanning speed to reduce motion artefacts and a half rotation (180°) to reduce the radiation dose to the patient should be preferred. The need for continuous work with quality and systematic monitoring of radiographic procedures at any radiology department should be given high priority.

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Introduction

Cone-beam computed tomography (CBCT) is a newer radiological technique used in dental and maxillofacial radiology giving high diagnostic quality [1–3]. It is based on volumetric tomography and yields images in three dimensions: in the axial, sagittal and coronal planes. However, the technique delivers a relatively high radiation dose to the patients compared to traditional dental radiographic techniques but less than medical tomography, CT. The European Commission has established guidelines and regulations [4] for CBCT use in European Union (EU) member countries. Studies have evaluated various CBCT examinations to verify the need for this technique [5–7]. Studies have also investigated CBCT units from various manufacturers to measure radiation doses to patients. It was found that, due to the numerous technical settings, such as field of view (FOV), tube voltage (kV), and tube current (mA), the delivered radiation dose can vary greatly between units [8–10]. The advantage of CBCT compared with conventional dental radiography, however, is a greater amount of information, which is expected to allow more accurate radiographic evaluation.

Some countries allow only licensed specialists in oral and maxillofacial radiology to authorize CBCT examinations and interpret the resulting images.

Radiographic examinations are valuable diagnostic tools in child and adolescent dental care. To reduce unnecessary radiation exposure to the patient, no radiographic examination should be done before a thorough assessment of the patient history and a clinical examination have been made, and evidence-based indications found. Availability and use of CBCT in child and adolescent care has grown in recent years. Each exposure to ionizing radiation carries with it the risk of permanently modifying human genetic material (DNA) and causing mutations, which could induce cancer [11]. The latency period between exposure to ionizing radiation and the clinical development of a tumour is estimated to be between 20 and 45 years [10]. Children have a longer expected life span than adults; because their tissue cells undergo a more rapid rate of division during growth, they are 2–10 times more radiosensitive than adults and, thus, suffer a higher risk of stochastic effects [10].

Justification and optimization of the examinations are important tools for cancer risk reduction and radiation

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protection in the field of child and adolescent dentistry. Patient benefit should exceed the potential risk of inducing cancer. Effective optimization, also known as the As Low As Reasonably Achievable (ALARA) principle [10], includes quality assurance, assessment of techniques and equipment, and the lowest radiation doses that will reasonably deliver the necessary diagnostic information.

To minimize the radiographic dose to young patients, guidelines for when and why examinations should be performed must be developed. In order to do this, it is important to determine how CBCT is presently being used. Thus, the general aim of the present study was to investigate why CBCT examinations are made, that is, the indications being used for recommending a CBCT examination of children and adolescents, during a 3-year period. Specific aims were to discover the types of caregivers sending referrals, the characteristics of the patients, and the technical parameters and necessity of a second exposure in CBCT exams.

Materials and methods

The Regional Ethics Committee for Human Research at Lund, Sweden approved the present study (Dnr [Daybook no.] FO 4.2-2017/556). All patients who were 18 years old and younger and had been imaged with a CBCT unit during 2015–2017 were included. The CBCT unit at the Department of Oral and Maxillofacial Radiology at Skåne university hospital was a 3D Accuitomo 170 (J. Morita Corporation, Kyoto, Japan). Referrals and reports were retrieved from the Radiology Information System (Sectra RIS, Sectra AB, Linköping, Sweden) and examination parameters were retrieved from the Morita i-Dixel workstation. One author (SH) analysed all data received from the hospital RIS system and the i-Dixel workstation, respectively. If previous images existed, these were routinely evaluated before the decision to perform a CBCT.

Besides the total number of referrals in the study age group, we recorded these data for those who underwent CBCT imaging: who sent the referral (dental specialist or general practice dentist [GPD], private or public health care), age at the time of examination (years), gender, requests and indications, technical settings (FOV dimensions, mA [tube current] and kV [tube voltage], exposure time, and rotation angle), and whether a scan was repeated the same day. These data were organized in a Microsoft® Office Excel 2016 spreadsheet for further processing.

After data collection, we divided the patients into four age groups: 0–5, 6–10, 11–15 and 16–18 years.

Results

During the study period, 3847 referrals for children and adolescents under the age of 19 years were sent to the

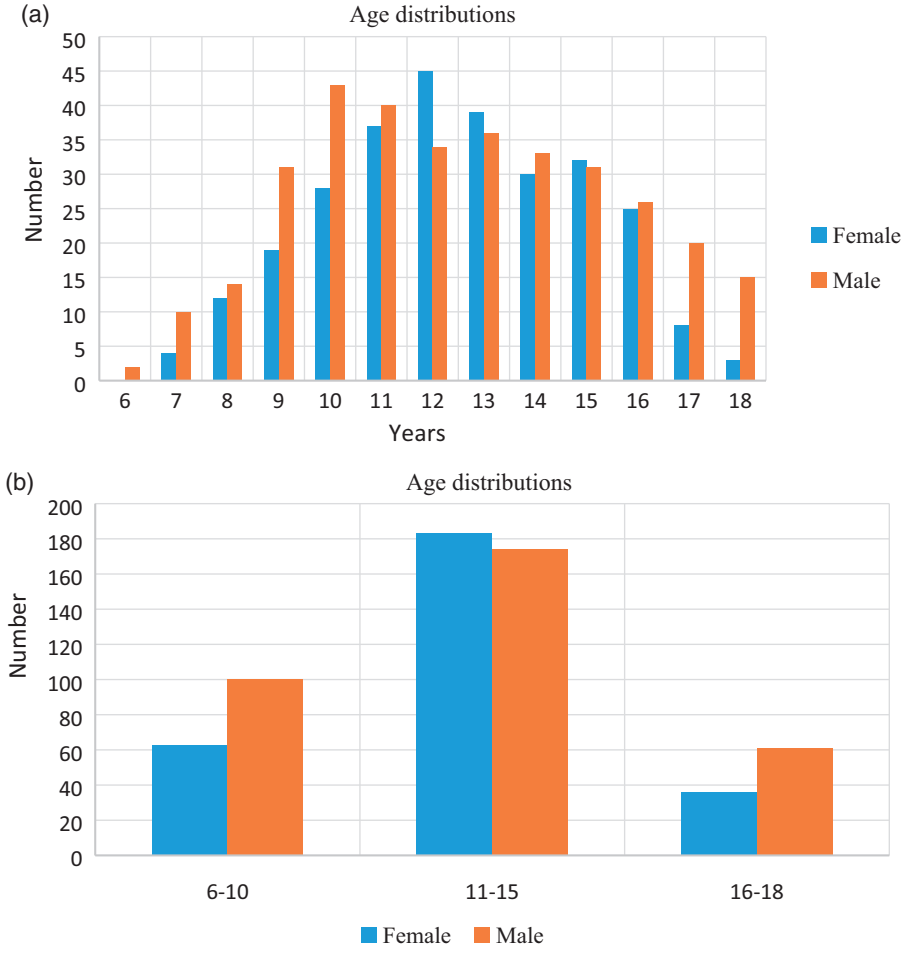

Figure 1. Age distribution in the study group ($n = 617$) according to gender: (a) per year and (b) per age group.

Table 1. Distribution of requests for a CBCT scan by age group (6–10 years, $n = 163$; 11–15 years, $n = 357$; 16–18 years, $n = 97$; total $N = 617$).

	Age group (years)		
Requests	6–10 *n* (%)	11–15 *n* (%)	16–18 *n* (%)
Absence of a tooth?		1 (0.3)	
Bony pathosis?	5 (3.1)	21 (5.9)	13 (13.4)
Cleft palate assessment	34 (20.9)	20 (5.6)	8 (8.2)
Delayed tooth eruption	9 (5.5)	22 (6.2)	8 (8.2)
Dental trauma (after previous or resent accidents)	14 (8.6)	9 (2.5)	2 (2.1)
Ectopic mandibular canine. Resorption of adjacent teeth?	3 (1.8)	5 (1.4)	0
Ectopic maxillary canine. Resorption of adjacent teeth?	45 (27.6)	171 (47.9)	14 (14.4)
Impacted second premolar. Resorption of adjacent teeth?	11 (6.7)	50 (14.0)	6 (6.2)
Localization of impacted mesiodens	7 (4.3)	7 (2.0)	
Pathologic conditions of the maxillary sinus	1 (0.6)		1 (1.0)
Periapical disease?	1 (0.6)	8 (2.2)	5 (5.2)
Post-operative complications following dental extractions			1 (1.0)
Pre-extraction assessment[a]	4 (2.5)	7 (2.0)	10 (10.3)
Pre-operative implant planning		1 (0.3)	11 (11.3)
Presence of resorption both external and internal	8 (4.9)	13 (3.6)	5 (5.2)
Salivary stone?		2 (0.6)	
Supernumerary tooth position?	18 (11.0)	9 (2.5)	7 (7.2)
Temporomandibular joint	1 (0.6)	4 (1.1)	3 (3.1)
Tooth anatomy	1 (0.6)	4 (1.1)	1 (1.0)
Tooth ankylosis	1 (0.6)	1 (0.3)	2 (2.1)
Tooth autotransplantation		2 (0.6)	

[a]Evaluation of anatomy of a tooth and its surroundings when planned to be removed.

department; licensed specialists recommended a CBCT exam for 617. Mean participant age was 12.5 years (range: 6–18; 282 females [45.7%] and 335 males [54.3%]). The largest age group was the 11- to 15-year olds ($n = 357$; Figure 1). Nineteen types of requests were made in the referrals. The most frequent request was to assess an ectopic canine and determine the presence of resorption of adjacent teeth to the impacted canine.

Table 1 lists the various reasons for requesting a CBCT investigation. The requests are in alphabetic order, according to age group.

The two most common reasons for referral – (i) assessment of an ectopic canine and (ii) localization of an impacted second premolar; along with the presence of resorption on the teeth adjacent to these – were most frequent in the 11- to 15-year age group. Re-exposure was required in 40 cases (6.5% of the included 617 scans). Primary reasons were all motion artefacts caused by anxiety, lack of patient cooperation or just accidental movement, such as swallow. Artefacts occurred most frequently in the 11- to 15-year age group, but correlations between age and re-take frequency were non-significant. All re-examinations were made in connection with the first examination.

The 617 patients included in this study had been referred from general practice and specialized caregivers: GPDs (43%), orthodontists (26%), oral and maxillofacial surgeons (20%), paediatric dentists (7%), endodontists and prosthodontists (2.6%), and medical doctors (1.4%).

Two scout images, one frontal and one lateral image, were made for all patients. These images were produced with a radiation dose equal to one intra-oral radiographic image, such as a bitewing. The scout images were used to determine the best FOV and rotation angle for each examination. Figure 2(a,b) illustrate the distribution among the examinations of the four rotation scenarios (two angles, each possible at two speeds) and the 15 possible FOVs. The clinical standard at the department was a voltage of 90 kV and a current of 5 mA. The distribution of volume sizes for each indication is given in Table 2.

Discussion

CBCT has been available for about 20 years in dental care. Previous studies [11,12] have found this technique to be useful and provide detailed images in comparison to intraoral and panoramic radiographic imaging. CBCT has been found to be superior for cases which demand images in three planes, for instance, Guerrero et al. [3] found that CBCT images improved scores for subjective image quality and surgical confidence levels when estimating the length of implants at posterior locations of the jaws. However, studies have also concluded that CBCT investigations are not always necessary in order to give a high diagnostic accuracy and a high benefit for the patients [7,13,14]. The backside is that the radiation dose to the patient is higher than with intraoral imaging. However, CBCT is easy to administer, and in some countries, reimbursement is considerably higher than for intraoral imaging, which can encourage a too frequent use of this modality. This is a concern in child and adolescent dental care. Even though the ICRP has published guidelines [14] for a restricted use of CBCT, the number of referrals and performed examinations have unfortunately been on the rise since their introduction. In Sweden, CBCT regulations state that a licensed specialist in oral and maxillofacial radiology must decide when CBCT is justified and then supervise the examination [15].

A limitation of this retrospective survey was that patients from only one clinic were included. The sample, however, was rather large and extended over 3 years; thus, it should be representative for dental radiology in Swedish hospitals. Unfortunately, we did not have any information about the

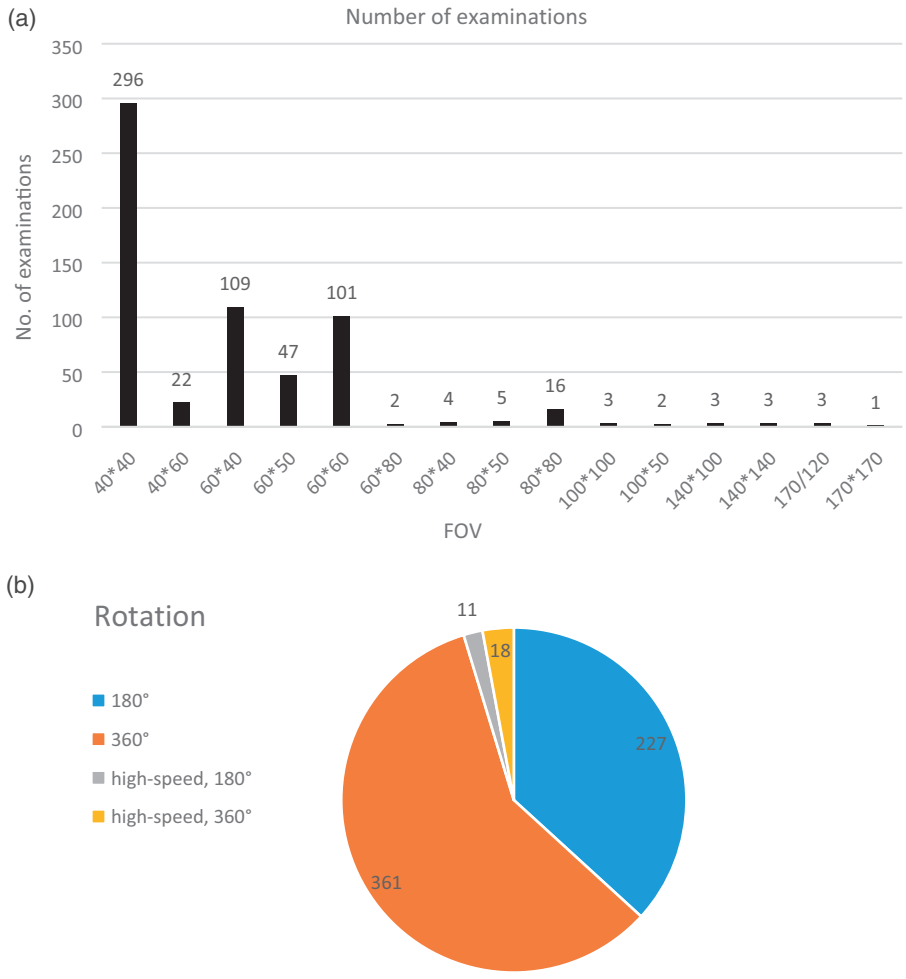

Figure 2. (a) Distribution of the various fields of view (FOVs) in the cone-beam computed tomography (CBCT) ($n = 617$ examinations); (b) number of CBCT using rotation settings of 180° or 360° at normal or at high speeds ($n = 617$ examinations).

rest of the referrals in this group of patients. In the future, a full analysis of all referrals in this age group would be interesting to carry out. The main concern, possibly, is that only one specialist in oral and maxillofacial radiology evaluated the requests and determined whether a CBCT examination was warranted. The referring dentists ask a question they want an answer to and usually, they do not specify the kind of examination they would prefer.

The present study found many indications for recommending a CBCT examination. This reflects the diversity of child and adolescent care and the need for detailed investigations with 3D imaging. Unsurprisingly, most investigations (58%) were made in the 11- to 15-year age group. Assessment of an ectopic maxillary canine was most common in this group, as it was in all age groups. An impacted second premolar was the second most common indication in the 11- to 15-year group while various cleft palate indications took second place in the youngest, 6- to 10-year group. This could be because the hospital has a cleft palate specialist centre. The second most common referral among the oldest children, the 16- to 18-year group, concerned bone changes due to pathology.

A previous study [6] found that CBCT does not always improve diagnostic accuracy compared with other imaging methods, such as panoramic imaging. Wriedt et al. [1] evaluated CBCT accuracy for indications concerning impacted ectopic canines and resorption on adjacent teeth. They concluded that small volume CBCT may be justified as a supplement to intraoral radiography when root resorption of adjacent teeth is suspected or when the canine apex is not clearly discernible in the panoramic X-ray, implying dilaceration of the canine root. Christell et al. [16] concluded that not all patients benefit from a CBCT examination if the primary outcome is a change in treatment plans. Christell et al. [16] also found no support for routine control of maxillary canine eruption disturbance.

The quality of the investigations was, in general, acceptable. The motion artefacts which resulted in an inferior image quality and therefore resulted in a re-exposure were found to be, in our opinion, not alarmingly high. In a systematic review [17], they found that prevalence of movement during CBCT investigations could be approximately 20%. However, no analysis was made of the artefacts resulted in re-examinations of the patients. This study did not include any analysis of the amount of movement artefacts in the investigations which were not subject to re-exposure. Spin-Neto et al. [18], have in a previous study, concluded that all kinds of movement give artefacts in CBCT images. They also concluded that movement of young patients during CBCT examination not always resulted in inferior image quality

Table 2. Distribution of fields of view for the different indications of CBCT exams.

Indication	40 × 40	40 × 50	40 × 60	60 × 40	60 × 50	60 × 60	60 × 80	80 × 40	80 × 50	80 × 80	100 × 50	100 × 100	140 × 100	140 × 140	170 × 120	170 × 170	Total
Assessment of ectopic mandibular canine. Resorption of adjacent teeth?	3			4		1											8
Assessment of ectopic maxillary canine. Resorption of adjacent teeth?	109		2	29	18	60	2	2	1	6		1					230
Assessment of periapical disease	5			1	4	4											14
Assessment of the presence or absence of resorption of adjacent tooth	16		1	3	2	2		1		1							26
Bony pathosis	10			10	2	8			1		1	1	2	3	1		39
Cleft palate assessment	20			12	13	16			1								62
Dealyed tooth eruption	22			5	4	6				2							39
Dental trauma	11		2	2	1	5		1	2	1							25
Impacted second premolar position. Resorption of adjacent teeth?	44			9	2	12											67
Localization of impacted mesiodens	8	1				4				1							14
Pathologic conditions of the maxillary sinus															1	1	2
Post-operative complications following dental extractions															1		1
Pre-extraction assessment	12			6		3											21
Preoperative implant planning	5			2		3				2							12
Salivary stone?										1	1						2
Supernumerary tooth position	18			4	2	9				1							34
Temporomandibular joint	8																8
To determine the presence or absence of the teeth														1			1
Tooth anatomy	2			1	1	1				1							6
Tooth ankylosis	3											1					4
Tooth autotransplantation	1					1											2
Total	297	1	5	88	49	135	2	4	5	16	2	3	2	4	3	1	617

and it was the number and duration of the movement which affected the image quality [19].

The largest group of referrals came from GPDs. GPDs do much dental work in child care and, thus, in the developing dentition, so the diagnostics of permanent tooth eruption is important. A favourable eruption position of the maxillary canine is a palpable buccal bulge in the primary canine apical area. If a permanent tooth cannot be palpated by the age of 9–11 years, an eruption disturbance is possible and would be an indication for a radiographic investigation [20]. As discussed, the most frequent query in the 11- to 15-year group was how the canines were situated and whether adjacent teeth had any degree of resorption. This is an area needing more research to determine whether and what proportion of the examinations supported a change in patient treatment plans, the underlying question being whether the examinations was warranted on a cost–benefit basis. The cost of any investigation and the actual benefit should always be included in guidelines for any clinical investigation. Previous studies [11,21,22] have been made in an effort to make clinicians and researchers aware of the costs involved in health care. The study [11] regarding CBCT and its clinical efficacy regarding removal of the third molar concluded that the costs involved should be analysed. Another study [21] concluded the involving costs for a CBCT examination was approximately four times the costs for panoramic imaging also regarding removal of the third molar in the mandible. However, one study [23] has concluded that it is not possible to generalize the cost involved in radiographic examinations due to different types of health care system in different countries.

The Swedish National Board of Health and Welfare [24] estimates that approximately 11% of all practicing dentists are licensed specialists. Unsurprisingly, however, specialists wrote the majority of the referrals, with orthodontists and oral and maxillofacial surgeons submitting more referrals than other specialists.

In any radiographic investigation, the query should determine the modality and number of images. Due to high cost and high radiation dose to the patient, CBCT must be done using optimal settings and follow the ALARA principle. Thus, scan settings, that is, all technical settings including FOV, must be customized for each patient. New CBCT units are commonly equipped with automatic exposure control, which is favourable for reducing patient exposure. The scout images made before the CBCT could be a reason for why the present study found that re-exposures were low (6.5%).

Conclusion

The most common request and indication for CBCT examination of children and young adults were to assess an ectopic canine and determine the presence of resorption of adjacent teeth. Referrals from GPDs were the most frequent and the largest age group was the 11- to 15-year olds. The reason for re-exposures was motion artefacts. High scanning speed to reduce motion artefacts and a half rotation (180°) to reduce the radiation dose to the patient should be preferred. The need for continuous work with quality and systematic monitoring of radiographic procedures at any radiology department should be given high priority.

Disclosure statement

No potential conflict of interest was reported by the authors.

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