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Indications for CBCT examination in pediatric patients: a cross-sectional study

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ABSTRACT

Objectives: This study aims to portray the characteristic of cone beam computed tomography (CBCT) indication on pediatric patients based on age, gender, specialist field, clinical indications, and radiation doses.

Materials and Methods: CBCT images of 55 pediatric patients were investigated retrospectively. CBCT images were obtained with three categories field of view (FOV). CBCT indications were categorized as dental anomalies, impacted teeth, orofacial cleft, orthodontic needs, endodontics, osseous pathological lesion, dentoalveolar trauma, and temporo mandibular disorder. The effect of age, sex, and FOV were evaluated.

Results: The most common indication for using CBCT is impacted teeth (45%), osseous pathological lesion (17%), and dentoalveolar trauma (11%). There were not significant association between sex, age group, and FOV to CBCT indication.

Conclusion: CBCT examination at Dental Hospital of Hasanuddin University is needed in pediatric patients mainly to diagnose oral pathology, impacted teeth, and dentoalveolar trauma. Determining CBCT for pediatric patients should be indicative-oriented suitably with as low as diagnotically achievable being indication-oriented and patient-specific (ALADAIP) principles.

Keywords: *Cone-beam computed tomography, pediatric dentistry, radiation dose, ALADAIP*
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INTRODUCTION

Cone beam computed tomography (CBCT) is a medical imaging technique used in the 1990s and has become very popular since 2002. CBCT is an exceptional technique for imaging dense tissues, such as bone and teeth. It provides a three-dimensional (3D) perspective on extensive anatomical regions and employs greater energy and radiation intensities than conventional two-dimentional (2D) radiography.[1,2] The dose of radiation generated by the CBCT is greater than that of traditional dental X-rays. Nevertheless, this method produces 3D digital imaging at a lower cost and with a reduced radiation exposure to the patient in comparison to conventional Computed Tomography (CT) examinations.[3–5] In comparison to conventional radiological examinations, CBCT induces a substantial increase in x-ray scatter and results in higher absorbed doses. Consequently, it is imperative to meticulously spot the areas of application in children.[3,6]

This study aims to portray the characteristics of CBCT indication on pediatric patients based on age, gender, specialist field, clinical indications, and radiation doses. It is crucial to restrict the exposure of children to ionizing radiation to a relatively low level, as they are susceptible to its effects.[3,6] The use of CBCT is a topic of controversy due to the radiation dosage and the increased susceptibility to radiation-induced harm in minors compared to adults, which is a result of their underdeveloped anatomical and biological components. The development of children's organs and the growth of their cells are particularly susceptible to radiation.[5]

The effective dose range is considerably influenced by the specific CBCT device, the available protocol options, and the size or position of the field of view (FOV) as it considers radiosensitivity.[7] CBCT images have been utilized in children for various purposes including airway analysis, periodontal and endodontic treatments, anchoring device treatment, assessment of maxillofacial morphology in orthodontics, diagnosis of root resorption and fractures, evaluation of impacted teeth, identification of oral pathology, orofacial cleft, dentoalveolar trauma, and caries diagnosis.[5,8,9] Justification for establishing the precise FOV for pediatric patients in order to prevent overexposure to CBCT radiation and to serve as a guide when CBCT is prescribed for pediatric exams.[9,10] Furthermore, some specific

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diagnostic tasks may require greater image resolution, and thus a higher exposure setting, than others. For example, imaging of root canals or fracture lines in teeth need a higher level of image quality than the dose needed for detection of the presence or absence of a tooth. This is why the ALADAIP (As Low As Diagnostically Achievable being Indication oriented and Patient-specific) principles has been introduced more recently.[11]

MATERIALS AND METHODS

This study was approved by the Health Research and Professional Law of Ethics Commission of the Faculty of Dentistry, Hasanuddin University (No. 0087/PL.09/KEPK FKG-RSGM UNHAS/2023). This study included CBCT images archives of Dental Hospital Hasanuddin University in July 2022 to November 2023. The datas were analyzed retrospectively.

The data were collected using a purposive sampling method. The total of 213 CBCT scans were recorded during the study period that include 55 (26%) patients under 17 years old, however, two patients had to be excluded because the refferal forms did not provide required clinical diagnoses. The total samples met all the inclusions criteria were 53 patients, patients younger than 17 years old who were referred to Hasanuddin University Dental Hospital between July 2022 and November 2023. The CBCT data were recorded in SIMpel Advance Ver.1.4. 5. Referral forms without clinical diagnoses were excluded.

All patients included were exposed to The Pax-i3D Green CBCT device (Vatech Co., Gyeonggi-do, Korea). The clinical diagnosis for CBCT examination, the exposure protocol (milliamperage – mA, seconds – s, kilovoltage– kV, FOV), the age at exposure were collected for each examination. The diagnoses are in line with the CBCT indication category and measures by Jensen et al (2021): dental anomalies, impacted teeth, orofacial cleft, orthodontic needs, endodontics, osseous pathological lesion, dentoalveolar trauma, and TMD.[12] Further, the indications category and measures of the recorded CBCT indication were evaluated using IBM SPSS Statistic 28 to quantify, summarize, and analyze the quantitative. The chi-square test was used to determine the relationship between indications to sex, age groups, and FOV.

RESULTS

Our study shows that out of 53 pediatric patients 23 (43%) were male and 30 (57%) were female (Table 1). These age group categories: toddlers (between 0-5 years) by 2 (4%), children (between 6-11 years) by 18 (34%), and adolescence (between 12-17 years) as many as 33 (62%) (Table

Table 1. The indications of CBCT by gender

Indication	Males		Females		Total		*p*
	n	%	n	%	n	%	
Dental anomalies	1	4,3	3	10	4	7,5	0.05
Impacted teeth	9	39,1	15	50	24	45,3	
Orofacial cleft	0	0	3	10	3	5,7	
Orthodontic needs	0	0	2	6,7	2	3,8	
Endodontics	2	8,7	2	6,7	4	7,5	
Osseous pathological lesion	5	21,7	4	13,3	9	17,0	
Dentoalveolar trauma	6	26,1	0	0	6	11,3	
TMD	0	0	1	3,3	1	1,9	
Total	**23**	**43,4**	**30**	**56,6**	**53**	**100**	

p: p value for chi-square test
*: Statiscally significant at p<0,05

Table 2. The indications of CBCT by age group

Indication	Age 0-5years		Age 6-11 years		Age 12-16 years		Total		*p*
	n	%	n	%	n	%	n	%	
Dental anomalies	1	50	0	0	3	9,1	4	7,5	0.599
Impacted teeth	0	0	8	44,4	16	48,5	24	43,3	
Orofacial cleft	0	0	2	11,1	1	3	3	5,7	
Orthodontic needs	0	0	1	5,6	1	3	2	3,8	
Endodontics	0	0	1	5,6	3	9,1	4	7,5	
Osseous pathological lesion	1	50	3	16,7	5	15,2	9	17,0	
Dentoalveolar trauma	0	0	3	5,6	3	9,1	6	11,3	
TMD	0	0	0	0	1	3	1	1,9	
Total	**2**	**3,8**	**18**	**34**	**33**	**62,2**	**53**	**100**	

p: p value for chi-square test
*: Statiscally significant at p<0,05

Table 3. The indications of CBCT by FOV

Indication	FOV						Total		*p*
	Small		Medium		Large				
	n	%	n	%	n	%	n	%	
Dental anomalies	0	0	2	8	2	10,5	4	7,5	
Impacted teeth	2	22,2	16	64	6	31,6	24	45,3	
Orofacial cleft	0	0	0	0	3	15,8	3	5,7	
Orthodontic needs	1	11,1	0	0	1	5,3	2	3,8	
Endodontics	2	22,2	2	8	0	0	4	7,5	0.05
Osseous pathological lesion	1	11,1	4	16	4	21,1	9	17,0	
Dentoalveolar trauma	3	33,3	1	4	2	10,5	6	11,3	
TMD	0	0	0	0	1	5,3	1	1,9	
Total	**9**	**17**	**25**	**47,2**	**19**	**35,8**	**53**	**100**	

p: p value for chi-square test
*: Statiscally significant at p<0,05

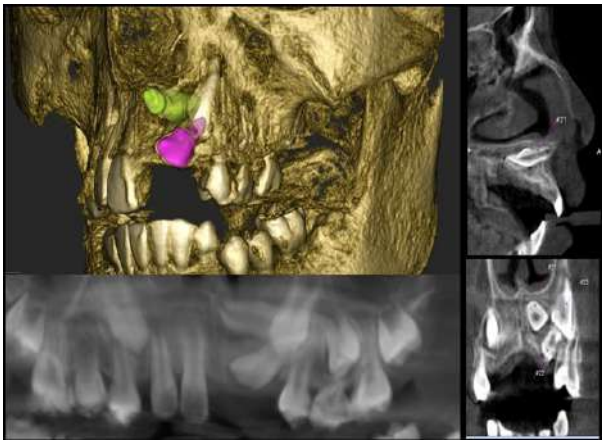

Figure 1. 3D reconstruction, panoramic reconstruction, sagittal and coronal view of 3D CBCT images with medium FOV of 8-year-old male patient showing location and inclination of impacted teeth #21 and #22

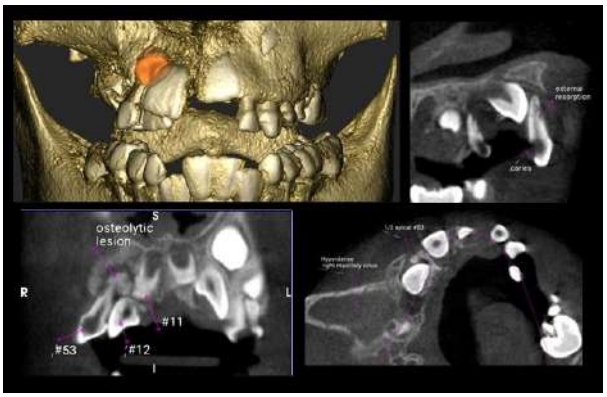

Figure 2. 3D reconstruction, axial, sagittal and coronal view of 3D CBCT images with small FOV of 9-year-old female patient showing #53 with osteolytic lesion because of infection from the caries and the right maxillary sinus shows condition of inflammation

2). These categories were based on age group category by the Ministry of Health of the Republic of Indonesia in 2009.[13] The average patient age was 12,07 years old (range 5 -17 years).

The indication for CBCT includes dental anomalies, impacted teeth, orofacial deformity, orthodontic requirements, endodontics, osseous pathological lesions, dentoalveolar trauma, and TMD. [11,12] Impacted teethwere the most prevalent indication for CBCT examination, as they were present in 24 referrals (45%). These referrals covered incisive, paramolar, and canine impacted teeth (see figure 1). In 10 referrals (19%), oral osseous pathological lesions were observed (Figure 2). Consequently, six referrals (11%) were received for dentoalveolartrauma (Figure 3).

Based on all the referrals of CBCT, the FOV used 3 categories of FOV. The most pediatric patients exposed to FOV medium (80x80mm and 120x90mm) 25 (47%) and large (170x150mm)

Figure 3. 3D reconstruction, sagittal and coronal view of 3D CBCT images with medium FOV of 8-year-old female patient with trauma history showing root fracture at #31 and #41

were 19 (36%) patients each, small (80x50mm) 9 (17%) patients (Table 3).

DISCUSSION

The purpose of this retrospective study was to evaluate the appropriateness of CBCT in pediatric patients, with a particular emphasis on the indications as specified in the dental CBCT guidelines.[14] The most frequently referenced diagnosis categories were impacted teeth (45%) as a result of the results of panoramic imaging. These patients are typically provided with more detailed information about the location, especially if they are scheduled for surgery or orthodontic treatment (Figure 1.). The most prevalent orthodontic indications, according to Isman et al (2017), were malocclusions and dentomaxillofacial anomalies, with localization of impacted teeth following in second place.[5]

For treatment planning purposes, diagnosing impacted teeth requires high radiographic accuracy. A CBCT provides the best localization and visualization for teeth that are impacted compared to panoramic, occlusal, and periapical radiographs. When determining the position of impacted teeth in the palatal-buccal region, panoramic radiographs were found to be the most sensitive among the conventional radiography. Comparing CBCT to conventional radiographs, the former's localization, detection, and capacity to measure the extent of root resorption associated with affected canines was 63% higher. It has been shown that increasing the diagnostic precision of ectopic canines can shorten treatment times and increase orthodontic treatment success. In most cases, panoramic, periapical, and bitewing radiographs can be used to diagnose acute dental infections; however, when conventional radiographic evaluations cannot provide a precise diagnosis, CBCT may help.[12]

The effective dose of a CBCT is affected by the FOV, at Dental Hospital of Hasanuddin University the FOV size used is medium size (47,2%) (120x90mm and 80x80mm), large size (35,8%) (170x150mm) and small size (80x50mm) of all CBCT pediatric patient cases. FOV is a key factor in pediatrics to optimize the selection of the FOV according to the indication for CBCT.[11] It is recommended that the narrowest FOV that still covers the region of interest be chosen to reduce radiation exposure in children.[15,16] The effective dose range for CBCT is considerably influenced by factors such as the size or position of the FOV in relation to radiosensitive organs, as well as the particular protocol options selected.[7] Kühnisch et all (2020) explained about workflow during dental radiographs that prescribed for children and adolescents in accordance with the principles of radiation protection justification, optimization, and limitation. They emphasized that exposure should not be performed on uncooperative pediatric patients. Nevertheless, when prescribing intraoral or extraoral radiographs, the following recommendations should be considered. CBCT is restricted to a small number of clinical scenarios in which 2D imaging modalities are insufficiently effective in terms of diagnostic efficacy and adheres to accurate indications.[11]

The safety and efficacy of a new and emerging dental x-ray modality (SEDENTEXCT) demonstrated that the effective dose in children exposed to CBCT could be greater than the dose from conventional radiographs, and the FOV should be defined according to the region of interest.[1,8] The radiation dose is directly proportional to the FOV, which is why it is recommended that the FOV be as small as feasible. The image should be clinically adequate by utilizing the smallest FOV, exposure time, resolution, and milliamperage while maintaining a sufficient therapeutic value resulting in adherence to the ALARA (as low as reasonably achievable) principle.[1,5,12] A well-reasoned justification of CBCT examinations based on selection criteria could reduce the number of dental radiological exposures in children. Optimization protocols by minimizing FOV could improve radiation safety in CBCT exposures.[17]

In 2017, new guidelines for pediatric use of CBCT

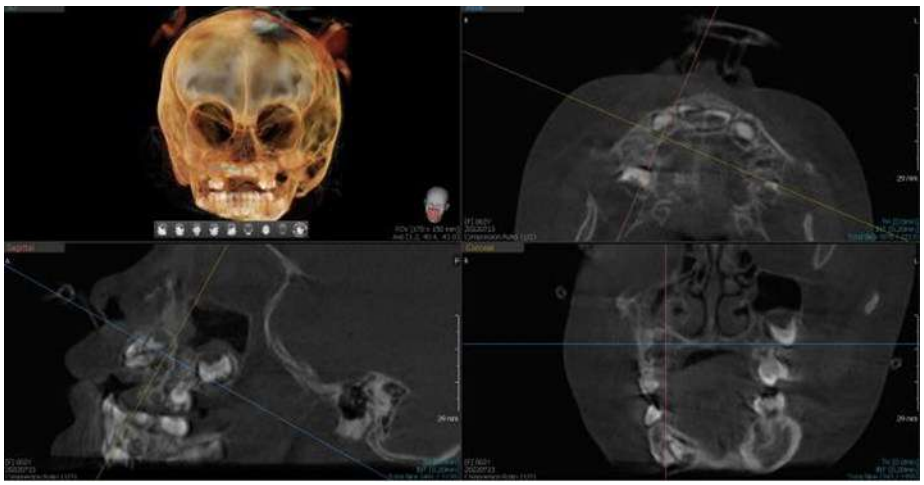

Figure 4. CBCT images of a 2 year old patient under general anesthesia, show hypodense area in #53 extending to the right maxillary sinus

were proposed through a Dentomaxillofacial Pediatric Imaging: An investigation towards low-dose radiation-induced risks (DIMITRA) focused on optimizing doses and potential biological effects of radiological exposures in pediatric dentistry.[7,15,17] This position statement provided indication-oriented, patient-specific guidelines focused on optimizing pediatric doses. It proposed moving from ALARA and ALADA (as low as diagnostically acceptable) to ALADAIP.[7,18] Careful justification is necessary when employing a substantial quantity of CBCT. Additionally, it was evident that there were numerous significant voids in the quantification of the benefit to the patient's outcome, which was consistent with the previous guidelines.[19] Based on current evidence for the use of CBCT in perdiatric dentistry Jensen et al (2018) categorized into indication, potential indication, and not currently indicated. Impacted canines, root resorption, orthonagnatic surgery, autotransplantation and TMJ disorder are including indication for the use CBCT. Potential indications include dental trauma, dental infection, dental anomalies, oral pathology, cleft lip and palate, and baseline orthodontic assessment. Caries and periodontal pathology are not currently indicated.[8]

The clinician may need to find an alternative treatment plan or postpone the radiographs until a more appropriate time, such as when the patient is under general anesthesia (Figure 4). The CBCT images of a 2-year- old child with a clinical diagnosis of an abscess on her right maxilla that required a CBCT examination were obtained, but the patient's behavior was poor, necessitating the use of the necessary techniques to obtain high-quality images. A CBCT examination was conducted by the clinician to evaluate the extent of the lesion while the patient was under general anesthesia for a medical procedure.[5] The technique used during exposure was to position the patient with a headrest to prevent movement.

The shortcoming in this study is that the number of paediatric patient samples is still insufficient. In the future, we hope other researchers can correlate the indication and clinical diagnosis with radiation dose for more.

CONCLUSION

CBCT examination at Dental Hospital of Hasanuddin University is needed in pediatric patients mainly to diagnose impacted teeth, osseous pathology lesion, and dentoalveolar trauma. Determining CBCT for pediatric patients should be indicative-oriented suitably with ALADAIP principles.

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FOOTNOTES

All authors have no potential conflict of interest to declare for this article. All procedures conducted were in accordance with the ethical standards.

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