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Cone-Beam Computed Tomography Prescriptions in Pediatric Dentistry

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ABSTRACT

Introduction: Cone Beam Computed Tomography (CBCT) is increasingly used in pediatric dentistry for better diagnostics and treatment, but concerns about its potential harm to children remain. This study evaluates CBCT indications and the appropriateness of the Field of View (FOV) in pediatric patients at Mashhad Dental School.

Materials and Methods: This retrospective study analyzed CBCT radiographs and patient records of individuals aged 18 years or younger who visited the Radiology Department of Mashhad Dental School from April 2018 to the end of 2022. Patients were categorized into three age groups: under 6 years, 7-12 years, and 13-18 years. The study recorded patient age, gender, CBCT indication, anatomical region examined, and FOV used. The appropriateness of the FOV was assessed based on SEDENTEX-CT guidelines.

Results: Out of 4285 patient records, 199 pediatric patients (102 girls and 97 boys) with a mean age of 13.42±3.59 years were included. The most common indication for CBCT was dental impaction (48.2%), particularly of the canine teeth, followed by pathological lesions (19.6%). The majority of CBCT scans used a medium-sized FOV (8x5 cm), which was appropriate in 67.8% of cases. There was a significant relationship between the indication for CBCT and the appropriateness of the FOV (p<0.001).

Conclusion: CBCT is a valuable diagnostic tool in pediatric dentistry, particularly for evaluating dental impactions and pathological lesions. However, careful consideration of the FOV is crucial to minimize radiation exposure. Adherence to guidelines can enhance the safe and effective use of CBCT in pediatric patients.

Keywords: Cone beam computed tomography (CBCT); Pediatric dentistry; Field of view (FOV); Dental impaction; Pathological lesions.

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Introduction

Cone Beam Computed Tomography (CBCT) has revolutionized dental radiology by providing three-dimensional imaging capabilities, which are crucial for accurate diagnosis and treatment planning [1]. Initially developed for use in adults, CBCT has increasingly been applied in pediatric dentistry due to its ability to offer detailed images of craniofacial structures [2]. CBCT is particularly beneficial for diagnosing complex dental conditions, planning orthodontic treatments, and assessing traumatic injuries [3]. However, the application of CBCT in children raises concerns due to their higher sensitivity to ionizing radiation, necessitating a careful evaluation of its indications and usage [4].

The use of CBCT in pediatric dentistry is guided by several guidelines aimed at minimizing radiation exposure while maximizing diagnostic benefits. One of them is the SEDENTEXCT project, which provides evidence-based recommendations for the appropriate use of CBCT in dental practice [5]. Despite these guidelines, there is still a need for more specific criteria tailored to pediatric patients, who are more susceptible to the adverse effects of radiation. This underscores the importance of studies that investigate the indications and outcomes of CBCT use in children. In the context of pediatric dentistry, CBCT is often indicated for various clinical scenarios, including the assessment of impacted teeth, evaluation of pathological lesions, planning for dental implants, and investigation of traumatic injuries [6]. Each of these indications requires a thorough understanding of the patient's clinical history and a careful consideration of the potential benefits and risks associated with CBCT imaging. The prescription of CBCT adheres to the principle of ALARA (As Low As Reasonably Achievable) to minimize radiation exposure [7].

The importance of addressing the use of CBCT in pediatric patients cannot be overstated. Children are more vulnerable to the harmful effects of ionizing radiation due to their developing tissues and higher cell division rates. Additionally, the long-term risks such as carcinogenesis, are more significant in children [8]. Despite this, the use of CBCT in pediatric dentistry is sometimes unavoidable due to its superior diagnostic capabilities [9]. While several studies have explored the application and appropriation of the prescription of CBCT in specific clinical scenarios [10,11], others have been focused on the FOV [12,13]. This gap highlights the need for the study to identify the most common reasons for CBCT referrals in children, assess the appropriateness of the field of view (FOV) selected for each indication, and evaluate the relationship between CBCT indications and dentomaxillofacial pathologies. As it is the aim of this study.

Material and Methods

Study Population

The study included pediatric patients aged 18 years or younger who underwent CBCT imaging at the Radiology Department of Mashhad Dental School. The sample size included all CBCT images taken from April 2017 to the end of 2018 for patients aged 18 years or younger. The patients were categorized into three age groups: under 6 years (primary dentition group), 7-12 years (mixed dentition group), and 13-18 years (permanent dentition group).

Data Collection

Data were collected from the CBCT radiographs and patient records. The variables recorded included patient age, gender, indication for CBCT, the anatomical region examined, and the Field of View (FOV) used. The appropriateness of the FOV was assessed based on SEDENTEX-CT guidelines, which consider an FOV appropriate if it fully encompasses the area of interest without unnecessary exposure [5].

Study Variables

- Indications for CBCT: These included impacted teeth, pathological lesions, implants, trauma, TMJ evaluation, cleft palate, root canal treatment, sinus evaluation, foreign bodies, missing teeth, and orthodontic assessments.

- FOV Classification: The FOV was Categorized in to half jaw (small) maxilla or mandible (medium), both jaws (large), and teeth.

- Appropriateness of FOV: The FOV was deemed appropriate if it was necessary and sufficient for the clinical indication, based on SEDENTEX-CT guidelines.

CBCT Imaging Protocol

CBCT images were obtained using a Planmeca Promax Classic (Finland, Helsinki) with an 8x8cm FOV and an output range of 54 to 84 KVP. Exposure parameters were adjusted according to the patient's characteristics and the clinical indication for imaging.

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Statistical Analysis

Data were analyzed using SPSS version 16. The normality of data distribution was assessed using the Kolmogorov-Smirnov test. The relationship between age, gender, and FOV in CBCT indications was analyzed using T-tests and Spearman correlation for continuous variables, and Chi-square tests for categorical variables. A significance level of 0.05 was used for all statistical tests.

Results

This study reviewed radiographic data from 4,285 patients, including 199 individuals aged 3 to 18 years (102 females and 97 males, with a mean age of 13.42±3.59 years). The variables assessed were indication, involved jaw, appropriateness of FOV, and FOV size (Table 1). The most common indication was impaction at 48.2% (96 cases), followed by lesions at 19.6% (39 cases), with the least common indications being sinus evaluation, foreign body, lateral tooth absence, and central tooth absence, each with one case. Among impactions, canines were the most frequent at 34.4% (33 cases), followed by centrals at 16.7% (16 cases), premolars at 15.6% (15 cases), mesiodens at 13.5% (13 cases), and impacted wisdom teeth at 11.5% (11 cases), with other areas having frequencies below 10% (Table 2). Table 2 shows that dental impaction was the most common indication for both genders, with lesions and trauma following in boys, and implants and lesions in girls. This distribution was statistically significant (p<0.001). Table 4 indicates that in the upper jaw, the most common indications were impaction and implants; in the lower jaw, impaction and lesions; and in both jaws (large FOV), TMJ and lesions, with a significant distribution (p<0.001). Table 3 reveals that FOV was 100% appropriate for trauma, cleft palate, sinus, and foreign body, but varied for other indications, showing a significant relationship with indication type (p<0.001). Table 3 shows medium FOV was mostly used for impaction, lesions, implants, and cleft palate; large FOV for trauma and TMJ; and small FOV for endodontics. The most frequent large FOV was used for TMJ evaluation, and medium and small FOV for impaction, with a significant relationship between FOV size and indication type (p<0.001).

Table 4 shows that dental impaction, implants, TMJ, and endodontics were more common in individuals over 12 years old, while sinus, foreign body, orthodontics, and missing upper anterior were only seen in this age group. Lesions and cleft palate were more frequent in the 7-12 age group. Lesions were most common in those under 7, and dental impaction was most frequent in those 7-12 and over 12. Out of 96 impaction cases, canines had the highest frequency (35.4%, 34 cases), followed by centrals (17.7%, 17 cases) and premolars (15.6%, 15 cases), with molars and laterals being the least frequent (1%, 1 case each). A glossary of results can be seen in Figure 1.

Table 1. Frequency distribution of Jaw Involvement, FOV appropriateness, and FOV size.

Variable		Number (Percentage)
Jaw Involvement	*Maxilla*	*115 (57.8%)*
	Mandible	*60 (30.2%)*
	Both	*24 (12.1%)*
FOV Appropriateness	*Appropriate*	*135 (67.8%)*
	Inappropriate	*64 (32.3%)*
FOV Size	*8*8cm (large)*	*24 (12.1%)*
	*5*8cm (medium)*	*138 (69.3%)*
	*4*4cm (small)*	*37 (18.6%)*

Table 2. Relationship between indication, gender, and involved jaw.

Variable		Gender		Total	Maxilla	Mandible	Both	Total
		Male	Female					
Tooth impaction	N (percentage)	40 (41.2%)	56 (54.9%)	96 (48.2%)	63 (54.8%)	33 (55.0%)	0 (0.0%)	96 (48.2%)
Lesion	N (percentage)	28 (28.9%)	11 (10.8%)	39 (19.6%)	11 (9.6%)	20 (33.3%)	8 (33.3%)	39 (19.6%)
Implant	N (percentage)	4 (4.1%)	15 (14.7%)	19 (9.5%)	16 (13.9%)	3 (5.0%)	0 (0.0%)	19 (9.5%)
Trauma	N (percentage)	7 (7.2%)	1 (1.0%)	8 (4.0%)	3 (2.6%)	0 (0.0%)	5 (20.8%)	8 (4.0%)
TMJ	N (percentage)	5 (5.2%)	7 (6.9%)	12 (6.0%)	2 (1.7%)	0 (0.0%)	10 (41.7%)	12 (6.0%)
Cleft palate	N (percentage)	5 (5.2%)	5 (4.9%)	10 (5.0%)	10 (8.7%)	0 (0.0%)	0 (0.0%)	10 (5.0%)
Endodontics	N (percentage)	5 (5.2%)	3 (2.9%)	8 (4.0%)	5 (4.3%)	3 (5.0%)	0 (0.0%)	8 (4.0%)
Sinus	N (percentage)	0 (0.0%)	1 (1.0%)	1 (0.5%)	0 (0.0%)	0 (0.0%)	1 (4.2%)	1 (0.5%)
Foreign body	N (percentage)	1 (1.0%)	0 (0.0%)	1 (0.5%)	1 (0.9%)	0 (0.0%)	0 (0.0%)	1 (0.5%)
Orthodontics	N (percentage)	1 (1.0%)	2 (2.0%)	3 (1.5%)	3 (2.6%)	0 (0.0%)	0 (0.0%)	3 (1.5%)
Maxillary Anterior Tooth Absence	N (percentage)	1 (1.0%)	1 (1.0%)	2 (1.0%)	1 (0.9%)	1 (1.7%)	0 (0.0%)	2 (1.0%)
Total	N (percentage)	97 (100.0%)	102(100.0%)	199(100.0%)	115(100.0%)	60(100.0%)	24(100.0%)	199(100.0%)
Fisher›s exact test			P<0.001*			P<0.001*		

Table 3. Relationship between indication, gender and involved jaw.

Variable		FOV		Total	FOV size			Total
		Appropriate	Inappropriate		8*8	5*8	4*4	
Tooth impaction	N (percentage)	55 (40.7%)	41 (64.1%)	96 (48.2%)	1 (4.2%)	77 (55.8%)	18 (48.6%)	96 (48.2%)
Lesion	N (percentage)	33 (24.4%)	6 (9.4%)	39 (19.6%)	8 (33.3%)	28 (20.3%)	3 (8.1%)	39 (19.6%)
Implant	N (percentage)	14 (%)	5 (%)	19 (9.5%)	0 (0.0%)	10 (7.2%)	9 (24.3%)	19 (9.5%)
Trauma	N (percentage)	8 (%)	0 (0.0%)	8 (4.0%)	5 (20.8%)	3 (20.2%)	0 (0.0%)	8 (4.0%)
TMJ	N (percentage)	3 (%)	9 (%)	12 (6.0%)	10 (41.7%)	2 (1.4%)	0 (0.0%)	12 (6.0%)
Cleft palate	N (percentage)	10 (%)	0 (0.0%)	10 (5.0%)	0 (0.0%)	9 (6.5%)	1(2.7%)	10 (5.0%)
Endodontics	N (percentage)	7 (%)	1 (%)	8 (4.0%)	0 (0.0%)	2 (1.4%)	6(16.2%)	8 (4.0%)
Sinus	N (percentage)	1 (%)	0 (0.0%)	1 (0.5%)	0 (0.0%)	1 (0.7%)	0 (0.0%)	1 (0.5%)
Foreign body	N (percentage)	1 (%)	0 (0.0%)	1 (0.5%)	0 (0.0%)	1 (0.7%)	0 (0.0%)	1 (0.5%)
Orthodontics	N (percentage)	2 (%)	1 (%)	3 (1.5%)	0 (0.0%)	3 (2.2%)	0 (0.0%)	3 (1.5%)
Maxillary Anterior Tooth Absence	N (percentage)	1 (%)	1 (%)	2 (1.0%)	0 (0.0%)	2 (1.4%)	0 (0.0%)	2 (1.0%)
Total	N (percentage)	135(100.0%)	64(100.0%)	199(100.0%)	24(100.0%)	138 (100.0%)	37(100.0%)	199 (100.0%)
Fisher›s exact test			P<0.001*			P<0.001*		

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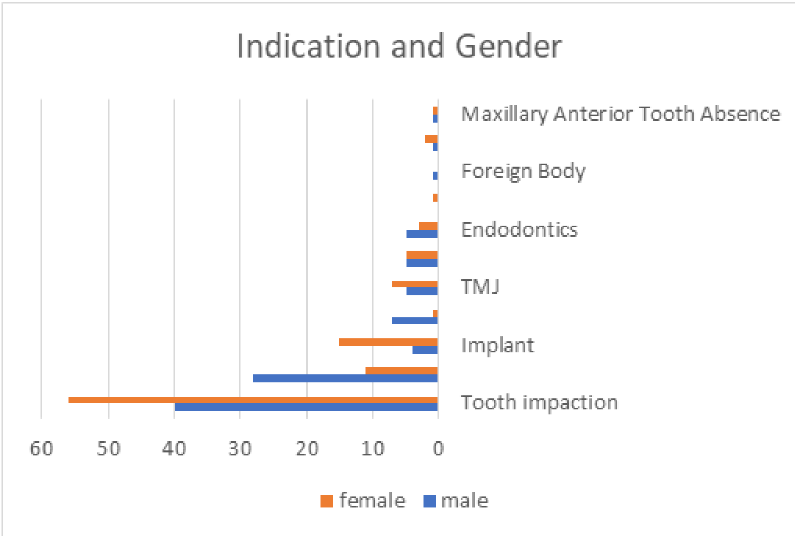
Table 4. Relationship between indication and age grouping by years.

Variable		*Age range (years)*			*Total*
		≤6	*7-12*	*≥13*	
Tooth impaction	*N (percentage)*	*1 (12.5%)*	*35 (49.3%)*	*60 (50.0%)*	*96 (48.2%)*
Lesion	*N (percentage)*	*4 (50.0%)*	*22 (31.0%)*	*13 (10.8%)*	*39 (19.6%)*
Implant	*N (percentage)*	*0 (0.0%)*	*1 (1.4%)*	*18 (15.0%)*	*19 (9.5%)*
Trauma	*N (percentage)*	*2 (25.0%)*	*3 (4.2%)*	*3 (2.5%)*	*8 (4.0%)*
TMJ	*N (percentage)*	*0 (0.0%)*	*2 (2.8%)*	*10 (8.3%)*	*12 (6.0%)*
Cleft palate	*N (percentage)*	*0 (0.0%)*	*6 (8.5%)*	*4 (3.3%)*	*10 (5.0%)*
Endodontics	*N (percentage)*	*1 (12.5%)*	*2 (2.8%)*	*5 (4.2%)*	*8 (4.0%)*
Sinus	*N (percentage)*	*0 (0.0%)*	*0 (0.0%)*	*1 (0.8%)*	*1 (0.5%)*
Foreign body	*N (percentage)*	*0 (0.0%)*	*0 (0.0%)*	*1 (0.8%)*	*1 (0.5%)*
Orthodontics	*N (percentage)*	*0 (0.0%)*	*0 (0.0%)*	*3 (2.5%)*	*3 (1.5%)*
Maxillary Anterior Tooth Absence	*N (percentage)*	*0 (0.0%)*	*0 (0.0%)*	*2 (1.7%)*	*2 (1.0%)*
Total	*N (percentage)*	*8 (100.0%)*	*71 (100.0%)*	*120 (100.0%)*	*199(100.0%)*
Fisher›s exact test			*P<0.001**		

A



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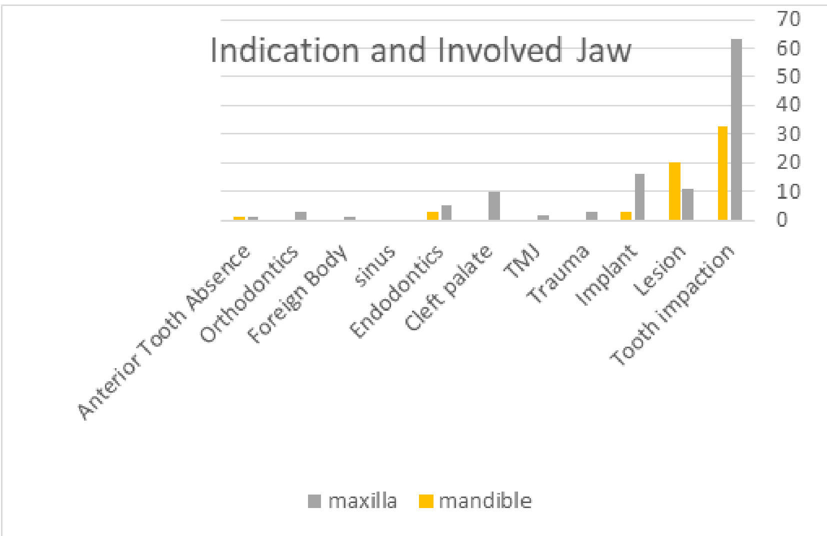

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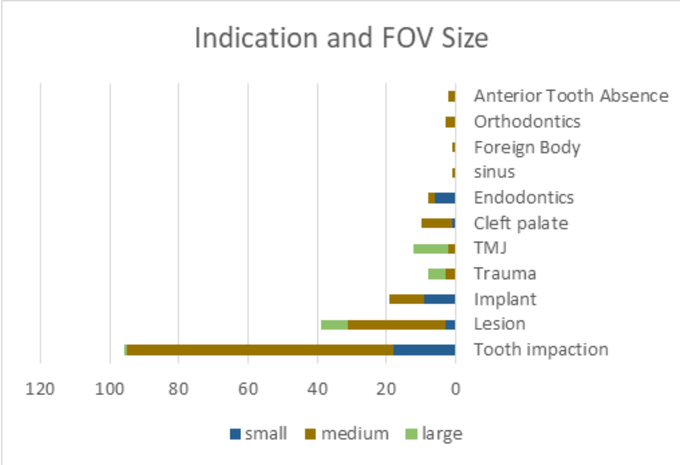

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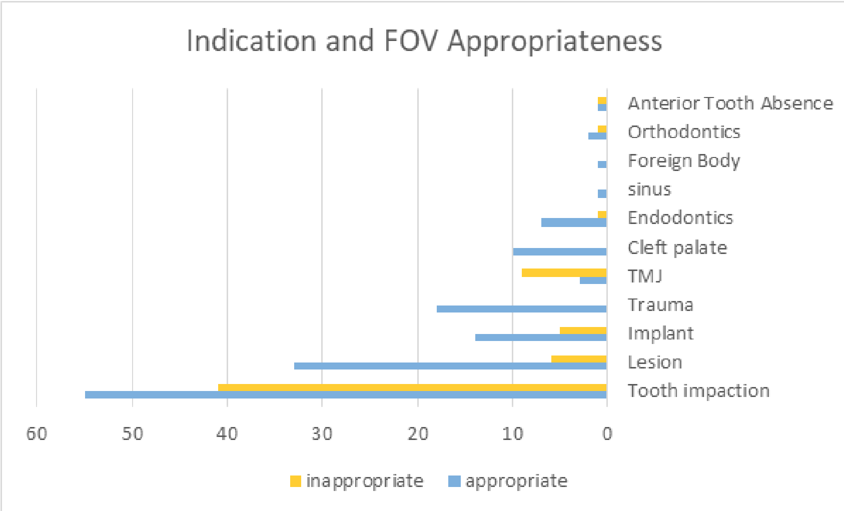

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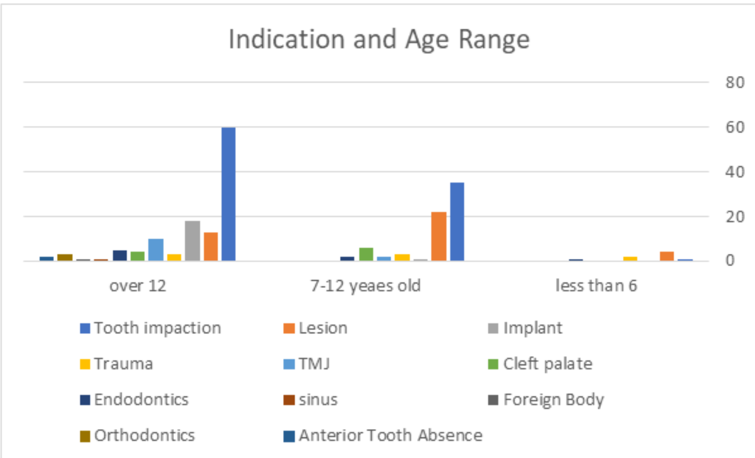

Figure 1. Relationship Between Indication and Gender (A), Involved Jaw (B), FOV Size (C), FOV Appropriateness (D) and Age Range (E).

Discussion

This survey revealed that the most common indication for CBCT in children was dental impaction (48.2%), particularly of the canine teeth, followed by pathological lesions (19.6%). The majority of CBCT scans utilized a medium-sized FOV (8*5cm), deemed appropriate in 67.8% of cases. This research is novel in its comprehensive approach to evaluating CBCT use in a pediatric population. It considers a variety of factors together, including age, gender, clinical indications, FOV size, and appropriateness. Gender distribution was almost equal between females and males. The mean age of the patients was 13.42±3.59 years, which is similar to previous studies [10,12,14-19]. The association between gender and CBCT indication was significant despite previous studies [10,18,19]. The higher frequency of CBCT usage in patients over 12 years old is consistent with findings that reported increased CBCT use in older pediatric patients [2,10,15,16,19,20]. This trend can be attributed to the higher complexity of dental and orthodontic conditions [21] that emerge during adolescence, as well as the cumulative effect of dental issues that may have developed over time. Followed by those aged 7-12 years (35.7%) and those under 6 years old (4.0%). In our study, certain CBCT indications were observed exclusively in patients over 13 years old, such as sinus issues, foreign bodies, orthodontics, and missing upper anterior teeth. This trend may be attributed to the onset of orthodontic treatments typically beginning at this age, as well as the natural progression of dental development, which makes certain conditions more apparent or problematic in older children. Additionally, older patients are generally more cooperative during imaging procedures, which might influence clinicians' decisions to use CBCT for these indications.

Dental impaction, implants, TMJ issues, and endodontic cases were more common in patients over 12 years old, while lesions were most prevalent in children under 7. Dental impaction was frequent across all age groups, particularly in those aged 7-12 and over 12. The most prevalent indication for CBCT in our study was dental impaction (48.2%), with canines being the most frequently impacted teeth (34.4% of impaction cases), similar to what Hajem et al. [15] reported. The prevalence of dental impaction aligns with previous studies [16,22] that reported a high application of CBCT for purpose. The predominance of canine impactions is expected, given their late eruption and complex path. Pathological lesions were the second most common indication (19.6%) [16,22,23], but S. Göksel et al. [2] showed it was the first requested indication. This underscores the importance of CBCT in providing detailed 3D imaging for accurate diagnosis and treatment planning of pathological conditions in pediatric patients. Interestingly, our study found lower frequencies for indications such as sinus issues, foreign body detection, and tooth absence, which align with previous studies [2,16,18,19]. This coordination could be due to similarities in referral patterns, clinical protocols, or the Asian patient population served in these surveys. The results of our study demonstrated a statistically significant relationship between FOV size and indication type, which has important implications for both radiation exposure and image quality in pediatric CBCT imaging [24]. Medium FOV was predominantly used for impactions, lesions, implants, and cleft palate cases. This choice aligns with the principle of using the smallest FOV necessary to capture the region of interest while providing sufficient anatomical context. For instance, in cases of canine impactions, which were the most common in our study, a medium FOV allows for visualization of the impacted tooth and its relationship to adjacent structures, crucial for effective treatment planning [25]. Small FOV was primarily used for endodontic cases, aligning with the principle of limiting radiation exposure to the smallest area necessary. Endodontic issues typically involve a limited number of teeth, making small FOV ideal. This practice is supported by R. Ismayılov et al. [19] and also Hajem et al. [15], which emphasized the effectiveness of small FOV CBCT in endodontic diagnosis and treatment planning. Contrary Hidalgo Rivas et al. [20] and S. Hajem et al. [15] showed that most of their CBCTs were at small FOV.

Large FOV was most frequently employed for trauma and TMJ cases. This is logical given the need to visualize extensive areas in trauma cases and to image TMJ disorders. This practice is consistent with Z. M. Semerci and S. Günen Yılmaz, who noted that larger FOVs are often necessary for comprehensive evaluation of craniofacial trauma and TMJ pathologies [26]. These differences between our results and others could be due to which we classified FOV size despite others. The significant relationship between FOV size and indication type underscores the need for case-specific FOV selection to minimize radiation exposure, as highlighted by Oenning et al. [27]. This approach ensures optimal imaging while adhering to the ALARA principle, particularly important in pediatric populations. Our study revealed significant findings regarding the Field of View (FOV) size and its appropriateness across different indications.

The appropriateness of FOV selection varied across indications, with 100% appropriateness for trauma, cleft palate, sinus, and foreign body cases. This suggests that clinicians are well-versed in selecting the correct FOV for these specific conditions. However, the varying appropriateness for other indications indicates room for improvement in FOV selection practices. The variation in FOV appropriateness across different indications could be due to the complexity of the case, clinician experience, and technology limitations. Our study found distinct patterns in CBCT indications based on jaw location. Impaction and implants were most common in the maxilla, likely due to frequent canine impactions and aesthetic implant needs. The mandible saw more impactions (especially third molars) and lesions, potentially linked to odontogenic cysts and tumors. Cases involving both jaws frequently presented with TMJ issues and lesions, suggesting a relationship between indication and jaw involved. This result could be aligned with S. Göksel et al. [2] which differently categorized indications. N. Gallichan et al. [14] who report most of CBCTs assessed developing dentition, mainly in the upper anterior sextant (68%). We observed more mandibular lesions compared to maxillary focus. This highlights the need for detailed CBCT imaging in complex cases, especially those involving both jaws, TMJ disorders, and extensive lesions. Clinicians should consider anatomical location and potential conditions when deciding on CBCT use.

Several factors could be influencing these patterns:

1. Maxillary anatomical complexity and proximity to vital structures may necessitate more frequent CBCT scans for precise planning.

2. A higher prevalence of specific conditions like impacted canines (maxilla) and third molars (mandible) naturally increases CBCT use in those areas.

3. Treatment planning, particularly for aesthetically sensitive implant placement in the anterior maxilla, often requires detailed 3D imaging.

Understanding these patterns can contribute to developing more targeted CBCT guidelines for pediatric patients, promoting more efficient and judicious use. Generally, these similarities or differences between the studies could be due to the populational factors or genetical factors. Given the higher sensitivity of children to radiation, it is imperative that CBCT scans are reserved for cases where conventional radiography is insufficient. The adherence to SEDENTEX-CT guidelines, which advocate for the smallest possible FOV that adequately covers the area of interest, was observed in approximately 67.8% of cases in our study. This highlights a need for continual education and adherence to these guidelines to further reduce unnecessary radiation exposure in pediatric patients. While our study provides valuable insights into the use of CBCT in pediatric dentistry, it has several limitations. The retrospective nature of the study may introduce selection bias, and the data is limited to a single institution, which may not be generalizable to other settings. Additionally, the study did not evaluate the long-term outcomes of patients undergoing CBCT, which could provide further insights into the utility and impact of CBCT imaging in pediatric dentistry. Future studies should aim to include a larger and more diverse sample size across multiple institutions to enhance the generalizability of the findings.

Conclusion

In conclusion, CBCT imaging is a valuable tool in pediatric dentistry for diagnosing dental impactions, pathological lesions, and other dentomaxillofacial conditions. However, its use must be carefully considered, especially in children, to balance the diagnostic benefits against the potential risks of radiation exposure. Adherence to evidence-based guidelines for FOV selection is crucial in minimizing unnecessary radiation doses. This study highlights the need for ongoing education and adherence to guidelines to ensure the safe and effective use of CBCT in pediatric patients.

Conflict of Interest

There is no conflict of interest to declare.

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