Submitted: 26 July, 2025 Accepted: 30 September, 2025 Published: 03 January, 2026 DOI:10.22514/jocpd.2025.120

Journal of Clinical Pediatric Dentistry

ORIGINAL RESEARCH

Investigation of incidental findings in CBCT images of pediatric patients: a retrospective study

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Abstract

Background: Cone beam computed tomography (CBCT) allows detailed imaging of teeth and jaw structures in children. These scans may reveal findings that are unrelated to the initial reason for imaging. This raises questions about how common such findings are in pediatric patients. The aim of this study was to determine the type and frequency of incidentally detected findings in the maxillofacial region in CBCT images of patients in the pediatric and adolescent age group. **Methods**: Incidental findings detected in six regions, including air spaces, dental, bone, jaw lesions, temporomandibular joint (TMJ), and soft tissue calcifications, were recorded in 194 CBCT images obtained in 3 different field of view (FOV) sizes. The relationship between incidental findings and gender was examined using the chi-square test, and the relationship between age and incidental findings was examined using Spearman correlation analysis. **Results**: A total of 1187 incidental findings were identified in 189 (97.4%) of 194 paediatric patients on CBCT images. The most common findings were inferior concha hypertrophy (59.8%), maxillary sinus septa (58.2%), and root dilaceration (55.7%). Dental findings were observed in 89.2% of patients, and airway findings in 76.8%. Incidental findings in the bony structures and temporomandibular joint regions were significantly more prevalent among girls (p = 0.04). A positive correlation was found between age and the number of incidental findings. The number of findings was influenced by FOV size and imaging region. **Conclusions**: Incidental findings, especially dental and airway anomalies, are common in pediatric CBCT scans. Early detection of TMJ and airway issues is important, but routine CBCT use in children for these alone is not advised due to radiation exposure.

Keywords

Incidental finding; Cone-beam computed tomography; CBCT; Pediatric patient

1. Introduction

Cone beam computed tomography (CBCT) was developed in the late 1990s as a novel imaging modality for the oral and maxillofacial region. The first commercial CBCT device, the NewTom 9000 (Quantitative Radiology, Verona, Italy), was introduced by Mozzo *et al*. [1] in 1998. Since its then, CBCT technology has undergone significant advancements, leading to improved image quality and functionality [1]. CBCT overcomes limitations inherent to two-dimensional radiographs, such as distortion and superimposition, by providing three-dimensional images [2]. Additionally, CBCT offers high-contrast visualization of bone and dental structures with lower radiation exposure and cost compared to conventional computed tomography (CT). The field of view (FOV) in CBCT imaging can be adjusted in parallel with the clinical requirement; small FOVs are typically used for localized regions such as a single jaw or a group of teeth, whereas larger FOVs allow for the examination of extensive anatomical areas including the paranasal sinuses and airways [3]. Therefore, CBCT has become an essential tool for a variety of clinical indications, including assessment of impacted teeth, endodontic lesions, temporomandibular joint (TMJ) disorders, trauma, infections, maxillofacial pathologies, and airway evaluations [4].

The expanding use of CBCT in dentistry raises important questions regarding the responsibility clinicians in image interpretation. Although sometimes overlooked, guidelines prepared by the American Academy of Oral and Maxillofacial Radiology and the European Academies of Dentomaxillofacial Radiology emphasize that all anatomical structures captured within the scan should be thoroughly evaluated [5, 6]. This necessitates dentists to have comprehensive knowledge of dentoalveolar and adjacent anatomical structures to ensure accurate assessment [5, 6].

Incidental findings (IFs) are unexpected abnormalities detected during radiographic examinations that are unrelated to the original diagnostic purpose. These findings may range from benign anatomical variations to clinically significant benign or malignant lesions [7]. Careful and comprehensive image evaluation is very important to identify such IFs, because failure to recognize and manage them appropriately may have adverse consequences for patient health [7]. In traditional two-dimensional radiography, IFs are often missed due to the inherent limitations in tissue visualization. In contrast, CBCT provides three-dimensional imaging, allowing for improved detection of IFs and previously hidden lesions. This facilitates appropriate clinical management, enabling targeted treatment when necessary and avoiding unwarranted advanced imaging when treatment is not indicated [8].

The prevalence of IFs on CBCT varies considerably by patient age, population demographics, and the specific category of findings. IFs are mostly related to developmental variations and tooth eruption anomalies in pediatric patients, whereas findings are more commonly associated with degenerative changes, cystic or neoplastic lesions in adults [9]. Early diagnosis of these IFs in pediatric patients can ensure that orthodontic, surgical, or restorative interventions are planned minimally invasive and more successfully, preventing potential future malocclusion, loss of function, aesthetic issues, and psychosocial effects [10]. Most of previous studies focused on adults with a wide age range [3, 11]. The present study aims to investigate the type and frequency of IFs in the maxillofacial region on CBCT images with varying FOV sizes in patients aged 18 years and younger. The null hypothesis posits that there is no significant difference in the frequency of IFs between different anatomical regions in pediatric patients, nor any association between patient age and the number of IFs.

2. Materials and methods

2.1 Sample size calculation

The required sample size was calculated as 194 patients using a goodness-of-fit test, with a significance level (α) of 0.05, a statistical power of 90%, and an effect size of 0.232 [12].

2.2 Study design and population

CBCT images of patients aged 18 years and younger, who underwent scanning on various clinical indications for diagnostic or therapeutic purposes at the Tokat Gaziosmanpaşa University Faculty of Dentistry between May 2022 and July 2024, were retrospectively analyzed. CBCT indications included cysts, dental anomalies, foreign bodies, impacted teeth, implants, orthognathic surgery, root resorption, residual roots, supernumerary teeth, and trauma. Patients with complete clinical and radiographic records and CBCT scans of sufficient diagnostic quality were included. Exclusion criteria were motion artifacts, image quality insufficient for diagnosis, previous maxillofacial surgery, or severe craniofacial deformities that could alter the anatomy, and the presence of extensive metallic restorations or orthodontic appliances causing significant artifacts.

2.3 CBCT imaging protocol

CBCT scans were acquired using the Kavo OP 3D Vision system (Imaging Sciences International LLC, Hatfield, PA, USA) with the following parameters: tube current of 5 mA, exposure time between 8.9 and 17.8 seconds, and tube voltage of 90 kVp. Voxel sizes ranged between 200 and 300 μm. The FOV size of the CBCT scan was 6 × 16 cm and 11 × 16. A thyroid shield with a thickness equivalent to 0.25 mm lead was firmly placed around the patient's neck before CBCT scanning.

2.4 Image evaluation

Images were assessed on 27-inch Dell Precision T3620 medical monitors (Dell, Round Rock, TX, USA) with a resolution of 1920 × 1200 pixels and 64-bit color support, using OnDemand3D software (CyberMed, Seoul, Republic of Korea). A single experienced oral and maxillofacial radiologist (MÇ) with 9 years of expertise performed all evaluations. The evaluator calibrated the classification criteria and ensured consistency in application through sample cases. Cases where uncertainty arose during evaluation were discussed with a second specialist, and a final decision was reached by consensus. Images were reviewed in batches of 10 per session. To assess intraobserver reliability, 20 CBCT images (10% of the total sample) were re-evaluated after a three-week interval.

2.5 Assessment and classification of IFs

CBCT images were examined in coronal, sagittal, and axial planes. IFs were categorized into six groups: air space, teeth, bone structure, jaw lesions, TMJ, and soft tissue calcifications. Images were further classified according to FOV into maxilla (6 × 16), mandible (6 × 16), and large FOV (11 × 16) groups.

Airspace, teeth, bone structures (excluding mandibular torus), jaw lesions, TMJ, and soft tissue calcifications (excluding arterial and triticeous cartilage calcification) were recorded in maxillary FOV images, whereas teeth, bone structures (excluding palatal torus), jaw lesions, and soft tissue calcifications (excluding stylohyoid ligament ossification, rhinolith, and antrolith) were recorded in mandible FOV images. All IFs observed in the six groups were recorded in the large FOV images. Since not all anatomical structures were fully captured in every CBCT scan, the prevalence of each incidental finding was calculated using only the scans in which the relevant structure was obvious. For certain structures with limited visualization in specific FOVs (*e.g.*, Nasal septum deviation (NSD), TMJ components, selected bone structures), prevalence was calculated relative to the total study population, and these restrictions are specified for each FOV.

2.5.1 Air space findings

NSD: Defined by an angle less than 150° between three anatomical points: the point where the nasal septum crosses the nasal cavity floor, the crista galli, and the most convex part of the septum in the coronal plane (Fig. 1A) [13].

Inferior concha hypertrophy: Defined radiographically (Fig. 1B).

Bullous concha: A well-defined area of air density in the middle concha [14].

Paradoxical concha: The convex surface of the concha faces the lateral side.

Septal pneumatization: Well-defined, air-filled spaces

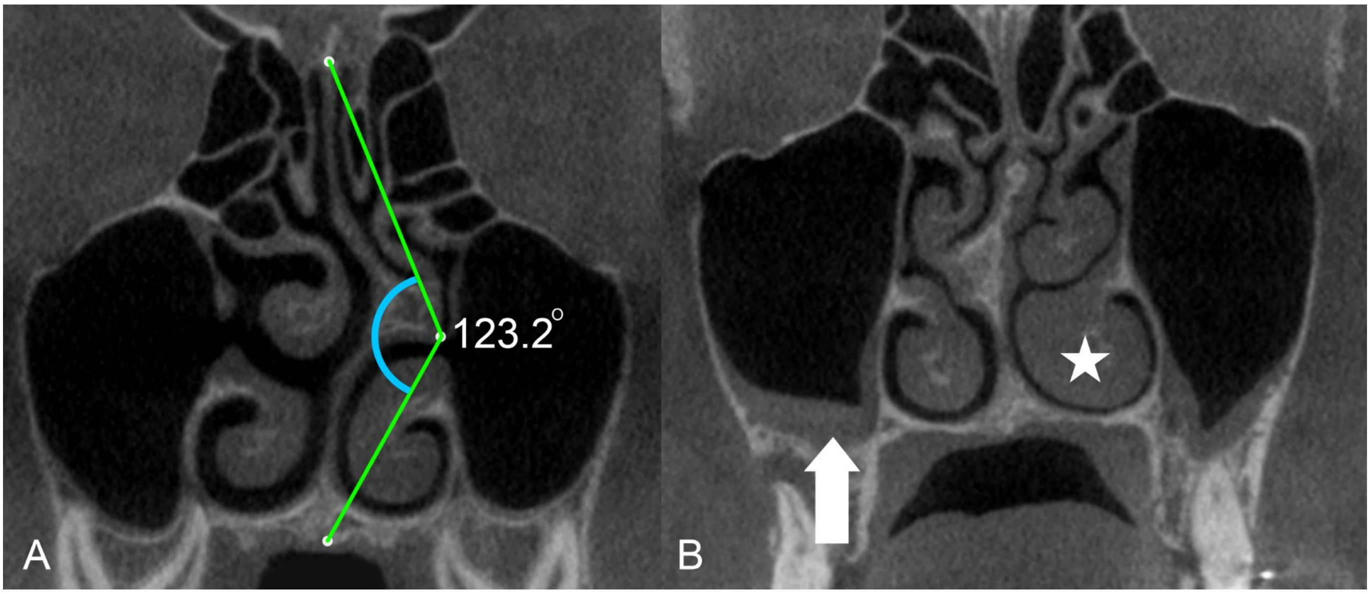

FIGURE 1. In the coronal cone beam computed tomography (CBCT) images. (A) For Nasal Septum Deviation (NSD), measuring the angle is defined as the one formed between three anatomical points: the point where the nasal septum crosses the floor of the nasal cavity, the crista galli, and the most convex part of the septum in the coronal plane. (B) The arrow shows mucosal thickening in the right maxillary sinus, and the asterisk shows left inferior concha hypertrophy.

within the nasal septum.

Septa in the maxillary sinus: Defined radiographically.

Maxillary sinus pneumatization: Defined radiographically.

Mucosal thickening: The maxillary sinus mucosa, known as the Schneiderian membrane, normally ranges.

between 0.8 and 1 mm in thickness. Mucosal thickening was recorded if thickness was ≥2 mm (Fig. 1B) [15].

Mucous retention cyst/polyp: Soft tissue density, dome-shaped lesions on the sinus floor or wall [16].

Nasal polyp: A well-circumscribed, polypoid mass with soft tissue density in the nasal cavity [17].

Total opacification of the maxillary sinüs: Defined radiographically.

Acute sinusitis: Presence of mucosal thickening, fluid level and opacity in the sinus.

Oroantral communication: Defined radiographically.

2.5.2 Dental anomalies

Tooth rotation, supernumerary teeth, agenesis, pulp calcification (Fig. 2A), taurodontism, enamel pearls, root fractures, root remnants, external root resorption (excluding physiological root resorption), furcation lesions, root number anomalies, dens in dente (Fig. 2B), and endo-perio lesions: No threshold, defined radiographically.

Root dilaceration: Root dilaceration was noted if there was an apical deviation of 50° or more between the root and crown axes (Fig. 2C) [18].

Impacted teeth: Teeth failing to erupt within the expected chronological period were classified as impacted [19].

2.5.3 Bone structure abnormalities

Rarefying osteitis, condensing osteitis, osteosclerosis, palatal torus, mandibular torus, and exostoses (Fig. 3A–C): No threshold; defined radiographically.

2.5.4 Jaw lesions

Encompassed odontogenic and non-odontogenic cysts, tumors, and pseudocysts. (No threshold; defined radiographically).

2.5.5 TMJ findings

Osteophytes: A bony growth developing on the surface or margin of the mandibular condyle (Fig. 4A) [20].

Flattening: The normal convex structure of the condyle surface is disrupted and becomes flat [20].

Subcortical sclerosis: Increased bone density (sclerotic area) below the cortical bone [20].

Erosion: Irregularity or discontinuity of cortical bone.

Subchondral cysts: A well-circumscribed radiolucent area below the cortex, distinct from the surrounding trabecular bone.

Bifid condyle: Two separate protrusions or notches at the tip of the condyle.

2.5.6 Soft tissue calcifications

Stylohyoid ligament ossification: The styloid process was considered elongated if its length was ≥30 mm [21].

Antroliths, rhinoliths (Fig. 4B), sialoliths, lymph node calcifications, triticeous cartilage calcifications, and osteoma cutis: No threshold; defined radiographically.

Tonsilloliths: Small, irregular, radiopaque calcifications in the oropharynx region, medial to the mandibular ramus, near the lateral pharyngeal wall [22].

Arterial calcifications: Near the mandibular angle, at the C3–C4 intervertebral disc level, within soft tissue, single or multiple radiopaque lesions.

Moreover, the season in which the CBCT scan was performed was recorded.

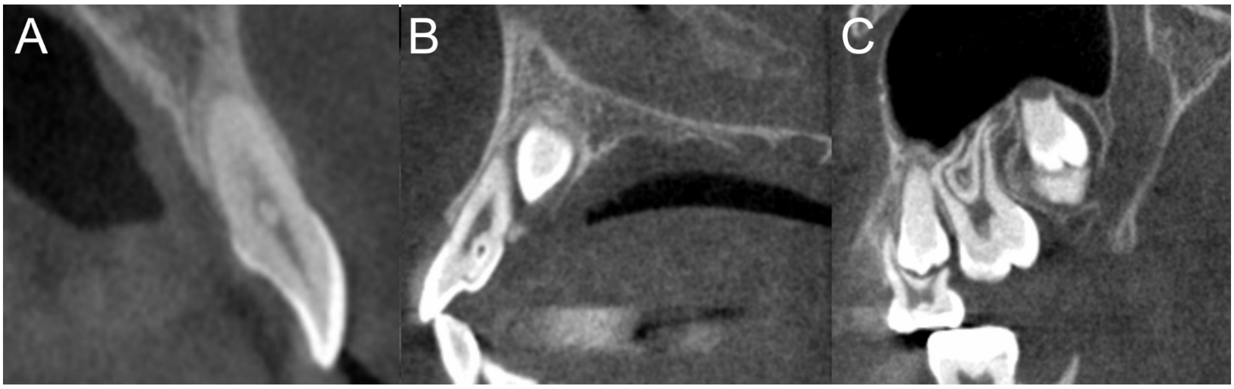

FIGURE 2. In the cross-sectional cone beam computed tomography (CBCT) images. (A) Pulp calcification is observed in tooth number 21. (B) Dens in dente is observed in tooth number 22. (C) The mesiobuccal root of tooth number 26 shows dilaceration.

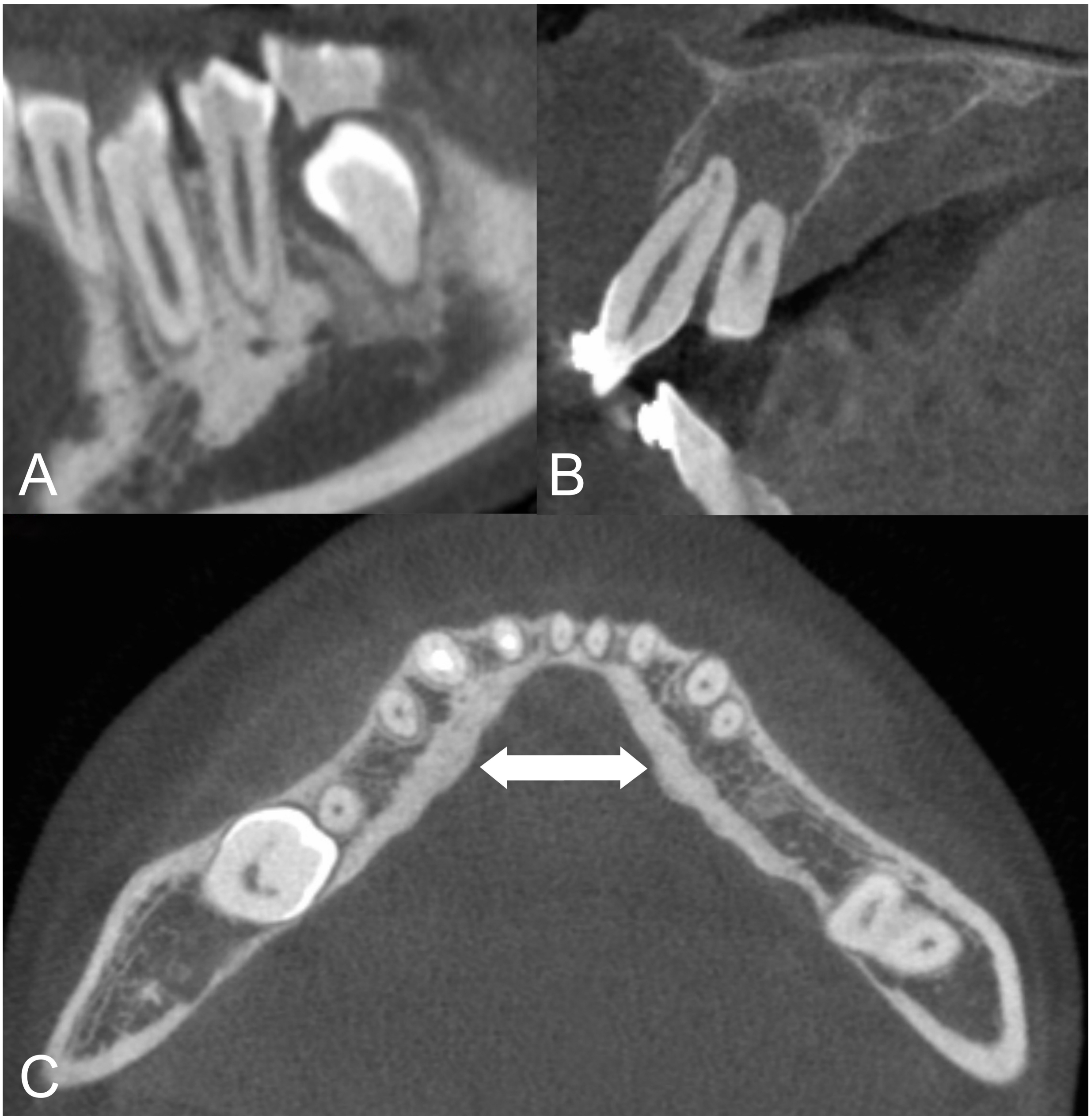

FIGURE 3. Representative cone beam computed tomography (CBCT) findings of bone structure and jaw lesions. (A) In the sagittal CBCT image; osteosclerosis is apparent in the area around teeth 33 and 34. (B) In the sagittal CBCT image, a radicular cyst is seen in tooth 21. (C) The axial CBCT image shows bilateral multiple mandibular torus.

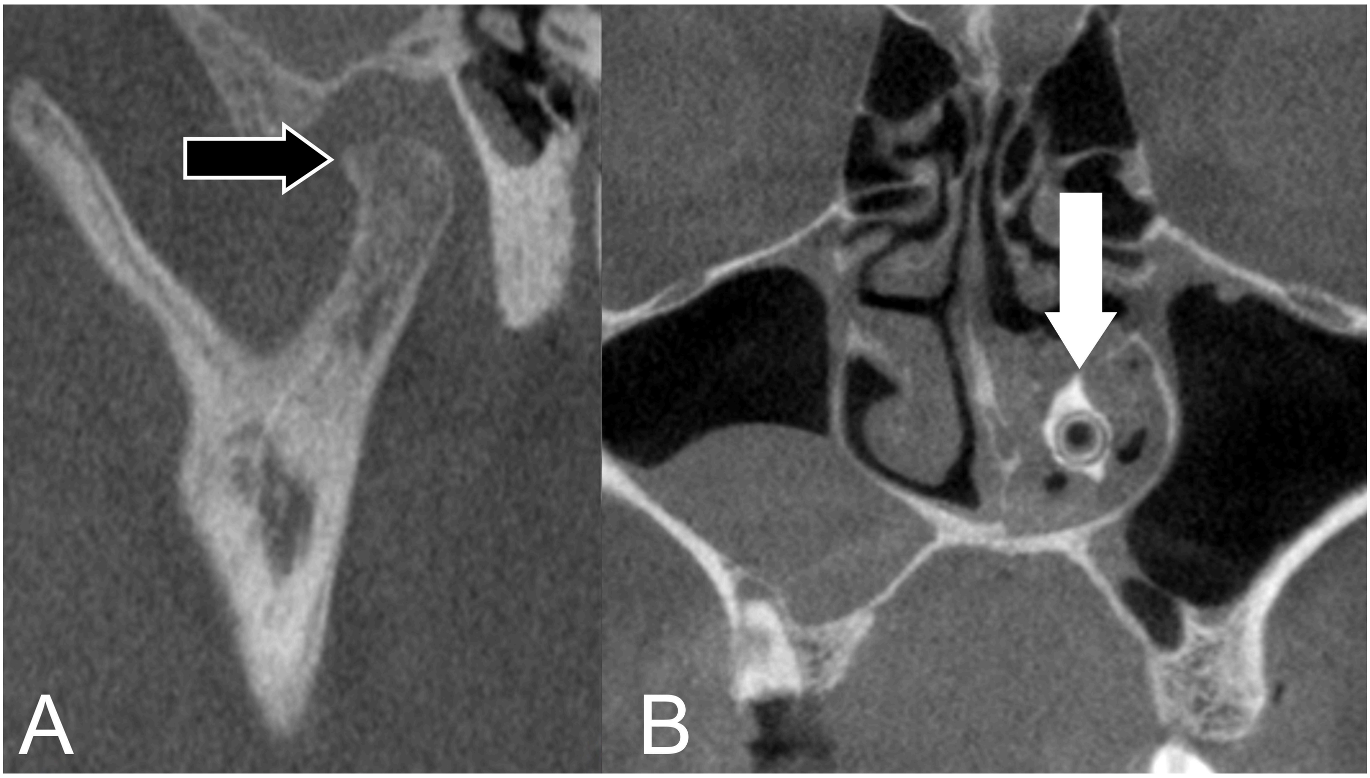

FIGURE 4. Representative cone beam computed tomography (CBCT) findings of temporomandibular joint and nasal cavity. (A) In the sagittal CBCT image, the arrow indicates the osteophyte of the condyle. (B) In the coronal CBCT image, the arrow indicates the rhinolith in the left nasal cavity.

2.6 Statistical analysis

Statistical analyses were conducted using SPSS version 27 (IBM Corp., Armonk, NY, USA). Descriptive statistics for demographic data were presented as mean ± standard deviation, and median (range). Frequency and percentage values were used to describe IFs. Relationships between IFs and gender were evaluated using the Chi-Square test. Correlations between age and IFs were analyzed via Spearman's rank correlation. Intraobserver agreement was quantified using Cohen's Kappa coefficient. Statistical significance was set at $p < 0.05$.

3. Results

Intra-observer agreement between the first and second assessments was found to be high; the kappa coefficient was found to be 1.00 (95% CI: 1.00–1.00, $p < 0.001$) and 0.86 (95% CI: 0.59–1.00, $p < 0.001$). A total of 194 pediatric patients, aged between 6 and 18 years, were included in the analysis. The mean age was 13.82 ± 3.35 years, and 53.1% (n = 103) of patients were girls and 46.9% (n = 91) were boys. The mean age of girls was 14.25 ± 3.07 years, while that of boys was 13.34 ± 3.59 years; this difference was not statistically significant ($p = 0.110$). The most common clinical indications for CBCT imaging include impacted teeth (34.5%), cystic lesions (22.2%), and unerupted teeth (11.3%) (Table 1).

TABLE 1. The distribution of indications for CBCT requests.

	n (%)
Cyst	43 (22.2)
Dental anomaly	3 (1.5)
Foreign object	1 (0.5)
Impacted teeth	67 (34.5)
Implant	15 (7.7)
Orthognathic surgery	15 (7.7)
Root resorption	9 (4.6)
Residual root	2 (1.0)
Supernumerary teeth	22 (11.3)
Trauma	17 (8.8)

IFs were detected in 189 patients (97.4%), with a total of 1187 findings identified. The average number of IFs per patient was 6.12 ± 3.16, ranging between 0 and 13. Dental findings were observed in 89.2% of patients, and airway findings in 76.8%. Among all IFs, airway findings accounted for 48.5%, and dental findings for 38.1% (Table 2).

No significant difference was found in the overall presence of IFs between genders ($p = 0.130$). However, IFs related to bone structures and TMJ findings were significantly more prevalent among girls ($p = 0.040$). There was no gender difference in the total number of IFs ($p = 0.563$).

The most frequently observed IFs were inferior concha hypertrophy (59.8%), maxillary sinus septa (58.2%), and root dilaceration (55.7%) (Table 3). Within specific categories, rarefying osteitis was the most common bone finding (57.1%), osteophytes predominated in the TMJ region (36.2%), and

TABLE 2. The frequency and number of IF.

	n (%)	Total (%)
Airway	149 (76.8)	576 (48.5)
Dental	173 (89.2)	452 (38.1)
Bone	61 (31.4)	70 (5.9)
Jaw Lesion	4 (2.1)	4 (0.3)
TMJ	37 (19.1)	57 (4.8)
Soft Tissue Calcification	26 (13.4)	28 (2.4)

TMJ: temporomandibular joint.

tonsilloliths were the most frequent soft tissue calcifications (85.7%). Radicular cysts were the only jaw lesions detected, identified in four patients (Table 3).

The distribution of IFs by FOV sizes is presented in Table 4. Fewer IFs were noted in CBCT scans focusing on the mandible. There was a significant positive correlation between patient age and the number of IFs (Table 5).

Further analysis revealed that mucous retention cysts and supernumerary teeth were more common in boys, whereas rarefying osteitis developed more frequently among girls ($p = 0.040$, $p = 0.030$, and $p = 0.040$, respectively). Seasonal variation did not significantly affect the frequency of maxillary sinus findings.

4. Discussion

The increasing use of CBCT has led to a rise in the detection of IFs through three-dimensional imaging [23]. Although IFs rarely necessitate emergency intervention, thorough examination of CBCT scans to identify these findings is essential [23]. Dentists bear the responsibility of evaluating the entire scan and informing patients about any detected abnormalities [5, 6]. Proper interpretation of CBCT images is crucial to fulfill this duty, and it is recommended that oral and maxillofacial radiologists (OMFRs) or adequately trained dentists perform this task [5, 6, 24]. Supporting this recommendation, previous studies demonstrated that endodontists and orthodontists may overlook a substantial proportion of IFs identified by OMFRs—up to 59.4% and 67%, respectively—with many false positives reported [25, 26].

The FOV size influences the anatomical regions visualized in CBCT and affects the number of detectable IFs, which tend to increase with larger FOVs [27]. Consistent with this, the present study revealed a higher number and frequency of IFs in scans with larger FOVs. However, since many IFs lack significant clinical relevance, it is advisable to select the smallest FOV that adequately covers the area of interest rather than using large FOVs merely to detect more IFs [28].

Pediatric patients are particularly sensitive to radiation due to their high mitotic activity and cumulative exposure effects [29]. Despite the high prevalence of IFs in children, cases requiring urgent intervention are uncommon; thus, routine CBCT imaging for IF detection is not recommended in this population [28]. CBCT indications in pediatric patients should align with established guidelines and principles such as ALADAIP (As Low As Diagnostically Acceptable being Indication-oriented and Patient-specific) to minimize radiation exposure [28].

Previous studies assessing IFs in CBCT scans often included broad age ranges. For example, Lopes *et al.* [3] reported IFs in 92% of patients aged between 8 and 91 years, distributed across dental (27.3%), airway (24.4%), soft tissue calcifications (20.5%), TMJ (16.4%), bone (7.3%), and jaw cysts (1.9%). In contrast, Kadkhodayan *et al.* [30] observed a lower IF prevalence (39.8%) among patients aged between 7 and 90 years, with predominant findings in cervical vertebrae, TMJ, airway, dental, and soft tissue calcifications. Studies focusing on large and medium FOV CBCT scans have reported IF rates up to 100%, highlighting a high prevalence of nasal cavity and paranasal sinus findings [11]. The number of studies specifically targeting pediatric populations under 18 years is limited. Doğramacı *et al.* [31] identified IFs in 83% of small FOV CBCT scans of patients averaging 18 years, primarily comprising airway findings, dental anomalies, caries, and cysts. Similarly, Kocsis *et al.* [32] reported 500 IFs in large FOV scans of 16.3-year-old patients, mostly dental and sinus finding. Other pediatric-focused studies have documented IF prevalence ranging between 44.7% and 66%, varying by anatomical region and population characteristics [33, 34]. In this study, with a mean age of 13.82 years, 97.4% of patients exhibited at least one IF. Dental and airway findings were notably frequent (89.2% and 76.8%, respectively), followed by bone lesions, TMJ findings, soft tissue calcifications, and jaw lesions. This incident surpasses that reported in similar age cohorts, potentially due to differences in CBCT scan volumes, definitions of IFs, or racial/ethnic variations. Consistent with adult populations, a positive correlation was observed between patient age and the number of IFs.

In the literature, which includes studies evaluating the Turkish population, varying prevalence rates have been reported for NSD, bullous concha, mucosal thickening, and sinusitis as sinonasal findings [31, 32, 34, 35]. The results achieved in this study aligned closely with Etemad *et al.* [34], indicating high frequencies of NSD (47.4%), inferior concha hypertrophy (59.8%), and mucosal thickening (45.9%). Differences among studies may reflect methodological inconsistencies, including varying criteria for mucosal thickening, NSD assessment, and FOV size. NSD can contribute to upper airway obstruction and frequently coexists with bullous concha, potentially impacting maxillary morphology and palate depth during growth [36]. The clinical significance of IFs varies and is commonly categorized as mild (no intervention required), moderate (follow-up/referral needed), or severe (prompt intervention necessary). This study included pediatric patients with ongoing jaw growth. Considering the impact of NSD and bullous concha on jaw development, the clinical significance can be moderate or severe depending on the severity of IFs. Mucosal thickening's clinical significance similarly ranges between mild and severe, particularly when multiple sinuses are involved [37]. Although they are usually asymptomatic in children, symptoms can increase their importance. Mucous retention cysts, which are more common in males and often seasonal in incidence, typically regress spontaneously and have low clinical significance [16, 38]. In this study, mucous retention cysts were more frequent in boys, but no seasonal

TABLE 3. Distribution of IF frequency by region.

		n	Region (%)	Total (%)
Airway				
	Nasal septum deviation	92	16.0	47.4
	Inferior concha hypertrophy	116	20.2	59.8
	Bullous concha	56	9.7	28.9
	Paradoxical concha	6	1.0	3.1
	Pneumatized nasal septum	34	5.9	17.5
	Maxillary sinus septa	113	19.7	58.2
	Mucosal thickening	89	15.5	45.9
	Mucous retention cyst/polyp	50	8.7	25.8
	Nasal polyp	1	0.2	0.5
	Total opacification	3	0.5	1.5
	Sinusitis	13	2.3	6.7
	Oroantral communication	2	0.3	1.0
Dental				
	Tooth rotation	82	18.1	42.3
	Supernumerary tooth	10	2.2	5.2
	Agenesis	12	2.7	6.2
	Pulp stone	105	23.2	54.1
	Taurodontism	7	1.5	3.6
	Root dilaceration	108	23.9	55.7
	Enamel pearl	3	0.7	1.5
	Root remnant	12	2.7	6.2
	External root resorption	43	9.5	22.2
	Impacted tooth	17	3.8	8.8
	Furcation lesion	10	2.2	5.2
	Root number anomalies	22	4.9	11.3
	Dens in dente	21	4.6	10.8
Bone				
	Rarefying osteitis	40	57.1	20.6
	Condensing osteitis	4	5.7	2.1
	Osteosclerosis	22	31.4	11.3
	Mandibular torus	4	5.7	2.1
Jaw Lesion	Radicular cyst	4	100.0	2.1
TMJ				
	Osteophytes	21	36.2	10.8
	Flattening	20	34.5	10.3
	Subcortical sclerosis	8	13.8	4.1
	Erosion	8	13.8	4.1
	Subchondral cyst	1	1.7	0.5
Soft Tissue Calcification				
	Stylohyoid ligament calcification	1	3.6	0.5
	Antrolith	2	7.1	1.0
	Rhinolith	1	3.6	0.5
	Tonsillolith	24	85.7	12.4

TMJ: temporomandibular joint.

TABLE 4. The distribution of IF frequency in 3 FOVs.

	Maxilla (n = 79)		Mandible (n = 39)		Large FOV (n = 71)	
	Patient n (%)	Total IF n (%)	Patient n (%)	Total IF n (%)	Patient n (%)	Total IF n (%)
Airway	78 (52.3)	291 (50.5)	0	0	71 (47.7)	285 (49.5)
Dental	69 (39.9)	164 (36.3)	36 (20.8)	78 (17.3)	68 (39.3)	210 (46.5)
Bone	13 (21.3)	14 (20)	16 (26.2)	17 (24.3)	32 (52.5)	39 (55.7)
Jaw Lesion	1 (25)	1 (25)	1 (25)	1 (25)	2 (50)	2 (50)
TMJ	17 (45.9)	24 (42.1)	0	0	20 (54.1)	33 (57.9)
Soft Tissue Calcification	2 (7.7)	2 (7.1)	6 (23.1)	6 (21.4)	18 (69.2)	20 (71.4)

TMJ: temporomandibular joint; IF: incidental finding; FOV: field of view.

TABLE 5. The correlation between age and number of IFs in regions.

	Age	
	r	*p**
Airway	0.059	0.415
Dental	0.319	<0.001
Bone	0.230	0.001
Jaw Lesions	0.070	0.330
TMJ	0.201	0.005
Soft Tissue Calcification	0.217	0.002

**Pearson correlation. TMJ: temporomandibular joint.*

variation was found. The clinical significance of nasal polyps was reported in the literature as mild [3, 27], moderate [39] and severe [40]. These lesions can cause symptoms such as nasal obstruction, loss of smell and sleep disturbance. In this study, only one patient had nasal polyps. The clinical significance of nasal polyps may vary depending on the size of the lesion, the presence of asthma in the patient, and the symptoms, considering the low prevalence. Total sinus opacification's clinical significance is debated, often deemed moderate or severe; however, in children, it should be interpreted in the context of symptoms due to its nonspecific radiologic nature [3, 11, 41]. Oroantral communications, though infrequent (1% in this study), represent a severe condition requiring urgent management to prevent chronic sinus disease [11, 42]. Given the lack of clinical symptom data in this retrospective study, recommendations for referral should be cautious. Referral may be prudent in symptomatic patients, those with coexisting NSD and bullous concha potentially affecting jaw growth, or individuals with sinusitis planned for surgical intervention.

Multiple studies investigated dental anomalies and maxillofacial findings in pediatric and adolescent populations, revealing varied prevalence rates that are influenced by differences in study design, patient age, and reporting methods. For instance, Drage *et al*. [33] reported enamel pearls in 10% of patients (mean age 14.5 years), root remnants in 20%, root resorption in 10%, root anomalies in 10.8%, and dens in dente in 6.6%. In contrast, Kocsis *et al*. [32], studying a slightly older cohort (mean age 16.3 years), observed supernumerary teeth in 2%, aplasia in 27.2%, hypoplasia in 3.5%, oligodontia in 2%, and taurodontism in 0.3%. Similarly, Doğramacı *et al*. [31] analyzed patients with a mean age of 18 years, identifying supernumerary teeth at 1.1%, hypodontia at 0.3%, pulp stones at 3.5%, dilaceration at 25%, enamel pearls at 0.3%, root remnants at 1.7%, impacted teeth at 0.3%, dens in dente at 0.8%, and root fractures at 0.3%. In a group of people aged 13 to 18, Etemad *et al*. [34] reported ectopia in 1.5%, transposition in 1.2%, supernumerary teeth in 4.5%, hypodontia in 11.6%, dilaceration in 0.4%, root resorption in 0.8%, impacted third molars in 43%, microdontia in 0.8%, and pericoronitis in 0.4%. Methodological disparities among these studies—particularly the variation in whether dental findings were reported per IF or per patient—complicate direct comparisons. To address this, the present study presents data using both reporting methods (Table 3), revealing dental findings such as tooth rotation (18.1% per finding/42.3% per patient), supernumerary teeth (2.2%/5.2%), hypodontia (2.7%/6.2%), pulp stones (23.2%/54.1%), taurodontism (1.5%/3.6%), root dilaceration (23.9%/55.7%), enamel pearls (0.7%/1.5%), root remnants (0.7%/1.5%), root resorption (2.7%/6.2%), external root resorption (9.5%/22.2%), impacted teeth (3.8%/8.8%), and dens in dente (4.6%/10.8%). When compared to previous studies, the prevalence of supernumerary teeth, pulp stones, dilaceration, and enamel pearls in the cohort of the present study was notably higher, whereas hypodontia and impacted teeth were less frequent. The clinical significance of these findings varies. Pulp stones and root dilacerations generally present mild clinical challenges but may complicate endodontic treatment [3, 24, 31, 34]. Supernumerary teeth warrant moderate clinical concern due to their potential to cause eruption disturbances, root resorption, crowding, and cyst formation [43]. Hypodontia, particularly in pediatric patients, can lead to aesthetic and functional deficits; however, retention of primary teeth may mitigate bone loss and preserve jaw development. Root remnants and impacted teeth also carry moderate clinical importance due to their potential complications [3, 11, 31]. Root resorption ranges in clinical severity depending on its type: superficial resorption is often benign, whereas internal and cervical resorption pose significant risks of tooth loss [44]. Dens in dente increases vulnerability to caries and pulp infections but can be managed effectively with preventive care.

Regarding bony findings, previous studies reported rarefying osteitis rates ranging between 0.6% and 12.5% [31, 33], condensing osteitis between 0.3% and 4.2% [31, 33], osteosclerosis at 0.8% [34], and mandibular torus at 0.4% [34]. This study revealed higher incidences: rarefying osteitis at 20.6%, condensing osteitis at 2.1%, osteosclerosis at 11.3%, and mandibular torus at 2.1%. Given that rarefying osteitis reflects localized inflammatory bone destruction with potential progression to infection if untreated, it is generally regarded as having moderate clinical significance [31, 33]. Similarly, condensing osteitis indicates an underlying inflammatory process requiring intervention [45] and is also considered to have moderate clinical importance. Osteosclerosis, characterized by localized bone density increase without infection, is variably classified as mild or moderate in clinical significance [3, 34]. The authors of this study also suggested mild clinical significance.

In terms of jaw lesions, previous studies have reported odontogenic cysts in 1.2–1.4% of cases [32, 34], incisive canal cysts at 0.5% [33], odontomas in 0.8–2% [31, 34], radicular cysts at 1.1%, dentigerous cysts at 2.9%, odontogenic keratocysts at 0.3%, and lateral periodontal cysts at 0.3% [31]. In this study, 2.1% of patients had only radicular cysts as jaw lesions. Etemad *et al.* [34] emphasized the severe clinical significance of odontogenic cysts. However, detailed comments on cysts' distribution and clinical significance could not be provided because the term "odontogenic cyst" was used as a comprehensive term. As stated by Doğramacı *et al.* [31], odontogenic keratocysts are of severe clinical significance, whereas other cysts are of moderate importance. Odontogenic keratocysts have aggressive clinical features and a high recurrence rate. Although odontogenic keratocysts are currently classified as cysts [46], there was ongoing disagreement about whether these lesions are cysts or tumors [47, 48], due to tumor suppressor gene mutations [49]. These characteristics of the cyst justify its severe clinical significance.

TMJ findings also demonstrate variable prevalence across studies of broad age ranges. Joint space narrowing has been reported in 12.7% of cases [11], flattening and erosion in 12.0–40.7% [11, 50], osteophytes in 1.3–12.3% [11, 50], ankylosis in 0.7% [11], subchondral pseudocysts in 8.5% [50], condylar hyperplasia in 1.2% [50], condylar hypoplasia in 1.9–3.8% [40, 50], and bifid condyle in 2.6% [50]. In adolescent populations, Etemad *et al.* [34] found osteoarthritis in 1.2%, bifid condyle in 3.3%, flattening in 3.3%, and erosion in 1.6% [33]. The present study reported osteophytes in 10.8%, flattening in 10.3%, subcortical sclerosis in 4.1%, erosion in 4.1%, and subchondral cysts in 0.5%. The inclusion of minimal TMJ changes as positive findings are likely to contribute to these relatively higher rates. Notably, subcortical sclerosis was significantly more frequent in patients over 16 years (p = 0.040), aligning with literature indicating that degenerative TMJ changes and related symptoms increase with age [50]. Gender differences in TMJ pathology remain inconsistent; while Edwards *et al.* [40] reported a higher prevalence in females, others found no gender disparity [50]. There was no difference between genders in this study. The inclusion of the pediatric population may have prevented the formation of differences between genders. Bone changes may become more noticeable in females with age. Moderate clinical significance is generally attributed to TMJ findings such as osteophytes, flattening, and erosion [3, 34]. Accurate identification of TMJ changes in children is very important for early diagnosis and management of conditions like juvenile idiopathic arthritis (JIA), in which delayed treatment can result in growth disturbances and facial asymmetry [51].

Soft tissue calcifications such as stylohyoid ligament ossification vary widely with age, with prevalence reported between 9.3% and 54.6% in general populations [3, 11], but only 0.1% in a pediatric study group [34]. In this study, stylohyoid ligament calcification was observed in 0.5%. Maxillary antroliths are detected in 3.2–3.5% of adults, increasing with age [52, 53], while pediatric prevalence is lower (≈1.3%) [33]; this study's findings (1%) align with this. The clinical relevance of antroliths remains unclear and is generally considered low unless symptomatic, large, or located near critical structures [3, 11]. Tonsilloliths, with a reported prevalence of 0.6–15.8% [3, 34]. In this study, tonsilloliths were present in 12.5% of patients, similar to the literature. Although usually asymptomatic and requiring no intervention in children, the lesion's size, symptomatology, and patient comorbidities—such as neuromuscular disorders increasing aspiration risk [54]—should guide management decisions.

The present study has several limitations. Primarily, as it is a retrospective study, there are limitations in the data collection and evaluation process, such as not being able to get access to the patients' clinical information. The analysis of CBCT images with different FOV sizes has increased the frequency of some findings while decreasing others. Furthermore, the single-center nature of this study may restrict the generalization of the findings to the general population. Potential biases related to the referral history of patients included in this study should also be considered. Finally, the lack of longitudinal follow-up data limits the ability to assess changes in IFs over time and their clinical implications.

5. Conclusions

This study detected a high rate of IFs in CBCT images of pediatric patients aged 18 years and younger. The most common findings included dental and airway anomalies, with an observed increase in their frequency as age advanced. Early diagnosis of these findings can directly influence patient management: for example, unerupted teeth may prompt timely orthodontic planning, airway anomalies may necessitate referral for respiratory evaluation, and TMJ abnormalities may benefit from early functional monitoring. Although routine CBCT solely for detecting IFs is not recommended due to radiation exposure, careful review of all anatomical regions beyond the primary indication is essential, and clinically significant findings should guide follow-up and intervention to prevent potential complications.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

MÇ—planning the study, interpretation of images, statistical analysis, interpretation of results, writing of manuscript, supervision of manuscript. YMS—planning the study, organization of data, writing of manuscript. Both authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Human rights statements: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Ethics Committee Approval: The Non-Interventional Scientific Research Ethics Committee of Tokat Gaziosmanpaşa University Faculty of Medicine, 25-MOBAEK-019.

Informed consent was obtained from the parents of all patients to be included in the study.

ACKNOWLEDGMENT

Not applicable.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Mesude Çitir, Yeliz Mısra Solmaz. Investigation of incidental findings in CBCT images of pediatric patients: a retrospective study. Journal of Clinical Pediatric Dentistry. 2026; 50(1): 265-275. doi: 10.22514/jocpd.2025.120.