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ORIGINAL RESEARCH ARTICLE

Assessment of Dental Anomalies in a Pediatric Population: A World Health Organization-Based Approach

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Abstract

Purpose: Dental anomalies refer to congenital, developmental, or acquired deviations from normal tooth development. The present study aims to evaluate the prevalence of dental anomalies and associated factors in a pediatric population using panoramic radiography.

Materials and Methods: In this retrospective cross-sectional study, panoramic radiographs obtained from patients aged 6–15 years were evaluated. The number and localization of teeth affected by anomalies within the jaws, as well as the patients' age, sex, and anomaly type were recorded during the evaluation conducted based on dental anomalies in the International Classification of Diseases-11. Data analyses were performed using IBM SPSS V23. Group comparisons of categorical variables were conducted using Chi-Square and Fisher's exact tests, with significance set at $p<0.05$.

Results: A total of 1505 panoramic radiographs were included in the analysis. The results revealed that at least one dental anomaly was present in 26.3% of the patients. Among the dental anomalies identified, dilaceration of tooth (13.16%) and hypodontia (5.65%) were determined to be the most prevalent. While no significant difference was observed between sexes regarding the presence of dental anomalies, the overall prevalence of dental anomalies was significantly higher in the 12–15 age group compared to other age groups, and in the maxilla compared to the mandible (both $p<0.001$).

Conclusions: Dental anomalies are often asymptomatic and detected during routine examinations. Nevertheless, they can significantly compromise oral health and quality of life. This study highlights their high prevalence and underscores the need for methodological consistency to facilitate accurate global comparisons.

Keywords: Dental anomalies; Dilaceration of tooth; Growth and development; Hypodontia; Pediatric dentistry

Introduction

Dental anomalies (DAs) are defined as developmental, congenital, or acquired disorders that arise during the development of teeth. These anomalies can manifest as isolated, simple defects affecting a single tooth or as a component of a broader systemic condition or syndrome.[1,2] The etiologies of DAs have not been fully understood; however, they are thought to be multifactorial, primarily driven by genetic factors, as well as congenital, developmental, and environmental factors.[3,4]

DAs are generally asymptomatic and are detected during routine clinical and radiographic examinations.[5,6] However, their clinical effects may negatively impact chewing and speech functions, aesthetics, and overall oral health, and may also lead to conditions such as malocclusions, periodontal problems, and a reduced quality of life.[5–7] These effects highlight the importance of careful diagnostic assessment for ensuring that such anomalies are not overlooked.

Panoramic radiographs are a cost-effective and easily accessible tool for diagnosing DAs.[1,4] In addition, the use of a globally accepted, standardized, and generalizable classification system is crucial for ensuring consistent interpretation and comparability in the diagnosis of these anomalies. Although different approaches exist in this field, the International Classification of Diseases (ICD) published by the World Health Organization (WHO) provides a fundamental framework for the standardization of DAs and their consistent documentation in health records.[8]

The nature and significance of DAs necessitate population-specific prevalence studies that provide clinicians with reliable information and utilize up-to-date classification and coding systems. In this context, the present study aims to evaluate the prevalence of DAs diagnosed using panoramic radiography and classified according to the ICD-11 system, as well as their associated factors,

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in a group of Turkish children. The null hypotheses tested in this study were that the prevalence of DAs in children did not differ significantly by jaw location (maxilla vs. mandible), sex, or age group.

Material and Methods

Ethical approval

The protocol of this retrospective cross-sectional study was approved by the Ethics Committee of the university that the author is affiliated with (Approval No: 2024/05-26, Date: 04.22.2024), and this study was carried out in line with the guidelines laid out in the Declaration of Helsinki.

Study population

Panoramic radiographs of patients who presented to the pediatric dentistry clinic for routine examination between 3 January 2022 and 28 March 2024 were retrospectively evaluated, and patients aged 6-15 years with diagnostically adequate panoramic radiographs were included in this study. Exclusion criteria consisted of congenital craniofacial anomalies or syndromes, history of head or neck surgery, and tooth loss of unknown etiology. Third molars were also excluded from the study due to their high prevalence of DAs.

Radiographic evaluation

Panoramic radiographs of the included patients were evaluated to identify DAs in the permanent and primary teeth of both jaws. To ensure diagnostic reliability, the evaluations of DAs were performed by two independent and calibrated researchers experienced in pediatric dentistry. The classification of DAs was performed according to the codes listed in the ICD-11 under the categories "Disorders of tooth development or eruption (DA07)", "Anomalies of tooth position (DA0E.3)", and "Structural developmental anomalies of the teeth and periodontal tissues (LA30)".[8] Among the anomalies defined under these headings and detectable radiographically, a total of 15 DA subtypes were evaluated in this study: dilaceration of tooth, supernumerary root, short root, transposition, hypodontia, oligodontia, hyperdontia, macrodontia, microdontia, fusion of teeth, gemination of teeth, taurodontism, dens invaginatus, talon cusp, and conical teeth.

During the evaluation process, (i) a total of 15 DAs were assessed according to the affected jaw (maxilla or mandible), the affected tooth type, and demographic variables (sex and age group), age category into three groups (6-8, 9-11, and 12-15 years) based on developmental and dentition periods,[9] (ii) completion of tooth maturation was taken into account during the assessment of root-related anomalies (e.g., dilaceration of tooth, short root), and (iii) the relationships among the most prevalent DAs were evaluated. While the prevalence of DAs and their associations with variables such as sex and age group were evaluated at the patient level, the number of teeth affected by the anomalies was determined, and their distribution across the jaws was assessed at the tooth level. In addition, since more than one type of DA could be observed in a single patient, these data were also recorded. Table 1 presents the diagnostic criteria and ICD classification of DAs evaluated in this study, while Figure 1 illustrates representative cases diagnosed accordingly.

Statistical Analysis

Data analyses were conducted using IBM SPSS version 23 software. Intra- and inter-observer reliability was assessed utilizing the Kappa test. Prevalence rates of DAs were calculated at the patient level; additionally, since a patient could present with multiple DAs, the total number of affected teeth was also documented. Fisher's Exact Test (with and without Monte Carlo correction), Yates' Correction, and Pearson's Chi-square Test were employed to compare anomalies by categorical variables and among anomalies themselves. Pairwise comparisons were performed using the Z-test with Bonferroni Correction. The Kolmogorov–Smirnov Test was employed to assess the normality of data distribution and the Mann-Whitney U Test to compare ages between sexes in case of non-normally distributed data. Results were presented as frequencies (percentages) for categorical variables, and as mean ± standard deviation and median (minimum–maximum) for quantitative variables. The level of statistical significance was set at $p<0.05$.

Results

A total of 1505 panoramic radiographs were included in the analysis, and the mean age of the patients was found to be 9.7 ± 2.4 years. The study group consisted of 774 (51.43%) girls and 731(48.57%) boys. The Kappa values indicated almost perfect agreement, ranging between 0.922 to 1.00.

Overall, more than a quarter of the patients (26.3%) had at least one DA. One type of anomaly was detected in 21.4% of patients, two types in 4.0%, three types in 0.8%, and four types in 0.1%. Among the observed DAs, dilaceration of tooth was the most common, occurring in 198 patients and affecting a total of 341 teeth, followed by hypodontia in 85 patients (144 teeth) and taurodontism in 38 patients (71 teeth). Examining the distribution of DAs by jaw, it was determined that the maxilla had a significantly higher frequency ($p<0.001$). Dilaceration of tooth was the most common finding in both the maxilla and mandible, followed by taurodontism in the maxilla and by hypodontia in the mandible. Short root, transposition, microdontia, gemination of teeth, and dens invaginatus did not differ significantly between the jaws ($p>0.05$). The detailed distribution of DAs by jaws and affected teeth is presented in Figure 2 and Table 2, respectively.

When evaluating the DAs on a tooth-specific basis, dilaceration of tooth and short root were found most frequently in maxillary permanent first molars (n=65 and n=7, respectively) and supernumerary root in maxillary second premolars (n=19). Transposition was most frequently observed between maxillary permanent lateral incisors and canines (n=4), hypodontia in mandibular second premolars (n=57), hyperdontia as mesiodens in the maxilla (n=36), macrodontia in mandibular permanent lateral incisors (n=8), microdontia, dens invaginatus, and conical teeth in maxillary permanent lateral incisors (n=18, n=6 and, n=17, respectively), fusion of teeth in mandibular deciduous lateral incisors and canines (n=3), taurodontism in maxillary permanent first molars (n=54), and talon cusps in maxillary permanent central incisors (n=13).

Regarding the distribution of DAs between sexes, a total of 203 girls (26.2%) and 193 boys (26.4%) were found to have anomalies. Dilaceration of tooth was statistically significantly more common in girls ($p<0.021$), while hyperdontia was more common in boys ($p=0.001$). Hypodontia, microdontia, taurodontism, dens invaginatus, and talon cusp were more prevalent in girls, and supernumerary root, transposition, macrodontia, fusion of teeth, and gemination of teeth were more prevalent in boys; however, the differences were not statistically significant. The detailed association between sexes and DAs is presented in Table 3.

Considering the age distribution of the patients, 676 patients were aged 6-8 years, 528 were aged 9-11 years, and 301 were aged 12-15 years. The frequency of DAs differed significantly by the age groups, and the highest frequency was observed in the 12-15 age group ($p<0.001$). When evaluating the types of anomalies separately, there were significant differences between age groups in dilaceration of tooth ($p<0.001$), supernumerary root ($p<0.001$), short root ($p<0.001$), oligodontia ($p=0.045$), and taurodontism anomalies

Table 1. Diagnostic criteria and ICD classification of DAs evaluated in the study

ICD Codes /Category	ICD Codes/ Subcategory	ICD Codes/DAs	Diagnostic Criteria
DA07 Disorders of tooth development or eruption	DA07.3 Disturbances in tooth formation	Dilaceration of tooth	Dilaceration of tooth was diagnosed when an angulation or curvature of 20° or greater from the normal longitudinal axis of the tooth was observed radiographically. [10,11]
	DA07.4 Root anomaly	Supernumerary root	A supernumerary root was diagnosed when an additional root, not part of the normal anatomy of the tooth, was identified radiographically. [2]
		Short root	A short root was diagnosed in teeth having a root-to-crown length ratio of 1:1 or less. [2]
DA0E.3 Anomalies of tooth position	-	Transposition	A transposition was diagnosed when two adjacent permanent teeth were interchanged in position within the same quadrant of the dental arch. [2]
LA30 Structural developmental anomalies of teeth and periodontal tissues	LA30.1 Hypodontia	Hypodontia	Tooth agenesis was diagnosed when there was no sign of crown calcification on the radiograph and no evidence or history of loss due to orthodontic treatment, caries, periodontal disease, or trauma. [12] For second premolars, an age threshold of 8 years was applied; in patients aged 8 years and older, the absence of radiographic evidence of crown calcification for the second premolar was recorded as agenesis. [12–15]
	LA30.2 Oligodontia	Oligodontia	Oligodontia was diagnosed when agenesis of more than six teeth is present. [2]
	LA30.3 Hyperdontia	Hyperdontia	Hyperdontia was diagnosed an increase in the normal number of permanent teeth due to the development of additional teeth. [2]
	LA30.4 Abnormalities of size or form of teeth	Macrodontia	Macrodontia was diagnosed when the tooth crown was larger than the typical size for that particular tooth. [16]
		Microdontia	Microdontia was diagnosed when the tooth crown was smaller than the typical size for that particular tooth. [17]
		Fusion of teeth	Fusion was diagnosed when two separate tooth buds were united during development involving the crowns and/or the roots. [18]
		Gemination of teeth	Gemination was diagnosed when a single tooth germ showed incomplete division resulting in two partially or completely separated crowns with one root and one root canal. [2]
		Taurodontism	Taurodontism was diagnosed according to Shifman and Chanannel's classification. [19]
		Dens invaginatus	Dens invaginatus was diagnosed when radiolucent pocket-like structures were observed beneath the cingulum and incisal edges of affected teeth, often surrounded by radiopaque enamel and confined either to the crown or extending into the pulp. [20]
		Talon cusp	Talon cusp was diagnosed when a cusp-like protuberance arising from the cingulum on the lingual surface of a maxillary incisor was identified. [2]
		Conical teeth	Conical teeth were diagnosed when the teeth with an incisal mesio-distal width smaller than their cervical width. [21]

DAs: Dental anomalies, ICD: International Classification of Diseases

Table 2. Distribution of DAs by number of patients and affected teeth

ICD Codes	Associated DAs	Number of patients	Number of affected teeth
DA07.3 Disturbances in tooth formation	Dilaceration of tooth	198	341
DA07.4 Root anomaly	Supernumerary root	39	52
	Short root	12	19
DA0E.3 Anomalies of tooth position	Transposition	5	16
LA30.1 Hypodontia	Hypodontia	85	144
LA30. 2 Oligodontia	Oligodontia	4	29
LA30. 3 Hyperdontia	Hyperdontia	32	43
LA30. 4 Abnormalities of size or form of teeth	Macrodontia	9	14
	Microdontia	22	24
	Fusion of teeth	3	6
	Gemination of teeth	1	2
	Taurodontism	38	71
	Dens invaginatus	7	8
	Talon cusp	15	22
	Conical teeth	16	17

DAs: Dental anomalies, ICD: International Classification of Diseases

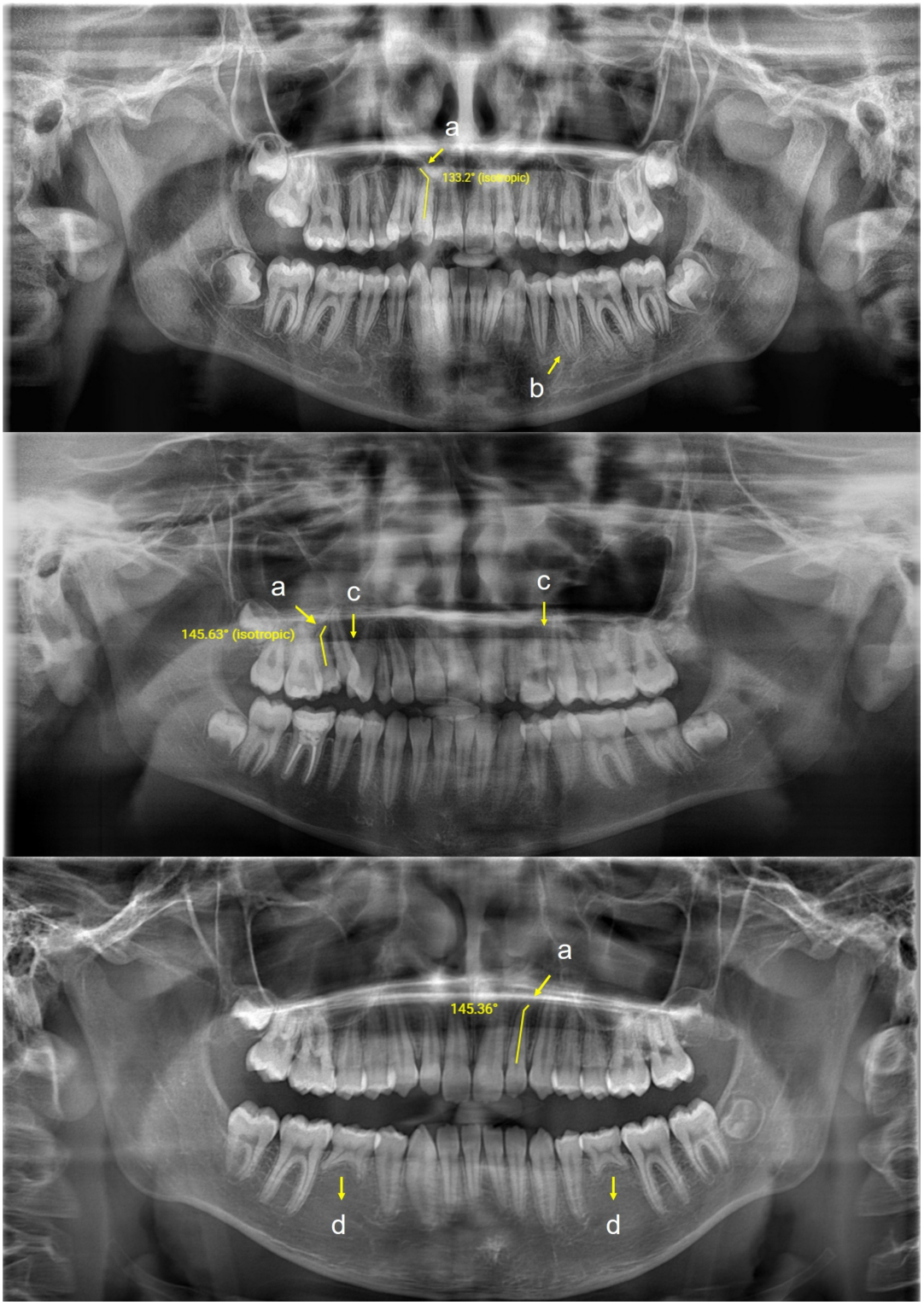

Figure 1. Representative diagnosed anomalies are indicated by yellow arrows on the panoramic radiographs; a: dilaceration of tooth, b: supernumerary root and taurodontism, c: transposition, d: hypodontia

(p=0.003). The detailed relationship between age groups and DAs is presented in Table 4.

When evaluating the relationships among DAs, as the two most frequently observed types, there was no significant relationship between dilaceration of tooth and hypodontia (p=0.917). However, significant relationships were found between hypodontia and microdontia and between hypodontia and conical teeth (both p<0.001).

Discussion

Studies on DAs not only determine their prevalence in the population but also enable rapid diagnosis and optimal treatment planning, thereby helping to reduce complications associated with delayed treatment. [6,22] In recent years, many studies aimed to analyze the frequency of DAs in different populations by using panoramic radiographs. [4,6,23–29] Panoramic radiographic examination has been preferred in previous studies because it allows for comprehensive

Table 3. Association between sexes and DAs

DAs	Sex		Total n (%)	p
	Girl n (%)	Boy n (%)		
Dilaceration of tooth	117 (15.1)	81 (11.1)	198 (13.2)	**0.021**[x]
Supernumerary root	17 (2.2)	22 (3)	39 (2.6)	0.406[y]
Short root	6 (0.8)	6 (0.8)	12 (0.8)	1.000[y]
Transposition	2 (0.3)	3 (0.4)	5 (0.3)	0.679[z]
Hypodontia	45 (5.8)	40 (5.5)	85 (5.6)	0.774[x]
Oligodontia	2 (0.3)	2 (0.3)	4 (0.3)	1.000[z]
Hyperdontia	7 (0.9)	25 (3.4)	32 (2.1)	**0.001**[y]
Macrodontia	3 (0.4)	6 (0.8)	9 (0.6)	0.330[z]
Microdontia	13 (1.7)	9 (1.2)	22 (1.5)	0.610[y]
Fusion of teeth	1 (0.1)	2 (0.3)	3 (0.2)	0.614[z]
Gemination of teeth	0 (0)	1 (0.1)	1 (0.1)	0.486[z]
Taurodontism	21 (2.7)	17 (2.3)	38 (2.5)	0.753[y]
Dens invaginatus	5 (0.6)	2 (0.3)	7 (0.5)	0.453[z]
Talon cusp	8 (1)	7 (1)	15 (1)	1.000[y]
Conical teeth	8 (1)	8 (1.1)	16 (1.1)	1.000[y]
Total	203 (26.2)	193 (26.4)	396 (26.3)	0.939[x]

DAs: Dental anomalies, [x]Pearson's Chi-square test; [y]Yates' correction; [z]Fisher's exact test. Significant values are denoted in bold ($p<0.05$).

Table 4. Association between age groups and DAs

DAs	Age			Total n (%)	p
	6-8 n (%)	9-11 n (%)	12-15 n (%)		
Dilaceration of tooth	7 (1)[a]	77 (14.6)[b]	114 (37.9)[c]	198 (13.2)	**<0.001**[x]
Supernumerary root	6 (0.9)[a]	11 (2.1)[a]	22 (7.3)[b]	39 (2.6)	**<0.001**[y]
Short root	0 (0)[a]	3 (0.6)[a]	9 (3)[b]	12 (0.8)	**<0.001**[y]
Transposition	1 (0.1)	2 (0.4)	2 (0.7)	5 (0.3)	0.297[y]
Hypodontia	29 (4.3)	33 (6.3)	23 (7.6)	85 (5.6)	0.079[y]
Oligodontia	0 (0)	4 (0.8)	0 (0)	4 (0.3)	**0.045**[y]
Hyperdontia	16 (2.4)	11 (2.1)	5 (1.7)	32 (2.1)	0.815[y]
Macrodontia	5 (0.7)	3 (0.6)	1 (0.3)	9 (0.6)	0.909[y]
Microdontia	6 (0.9)	9 (1.7)	7 (2.3)	22 (1.5)	0.177[y]
Fusion of teeth	2 (0.3)	1 (0.2)	0 (0)	3 (0.2)	1.000[y]
Gemination of teeth	1 (0.1)	0 (0)	0 (0)	1 (0.1)	1.000[y]
Taurodontism	7 (1)[a]	20 (3.8)[b]	11 (3.7)[b]	38 (2.5)	**0.003**[y]
Dens invaginatus	4 (0.6)	2 (0.4)	1 (0.3)	7 (0.5)	0.889[y]
Talon cusp	5 (0.7)	8 (1.5)	2 (0.7)	15 (1)	0.350[y]
Conical teeth	5 (0.7)	7 (1.3)	4 (1.3)	16 (1,1)	0.546[y]
Total	82 (12.1)[a]	158 (29.9)[b]	156 (51.8)[c]	396 (26.3)	**<0.001**[x]

DAs: Dental anomalies, [x]Pearson's Chi-square test; [y]Fisher's exact test with Monte Carlo correction; [a–c]: Groups with the same letter are not significantly different. Significant values are denoted in bold ($p<0.05$).

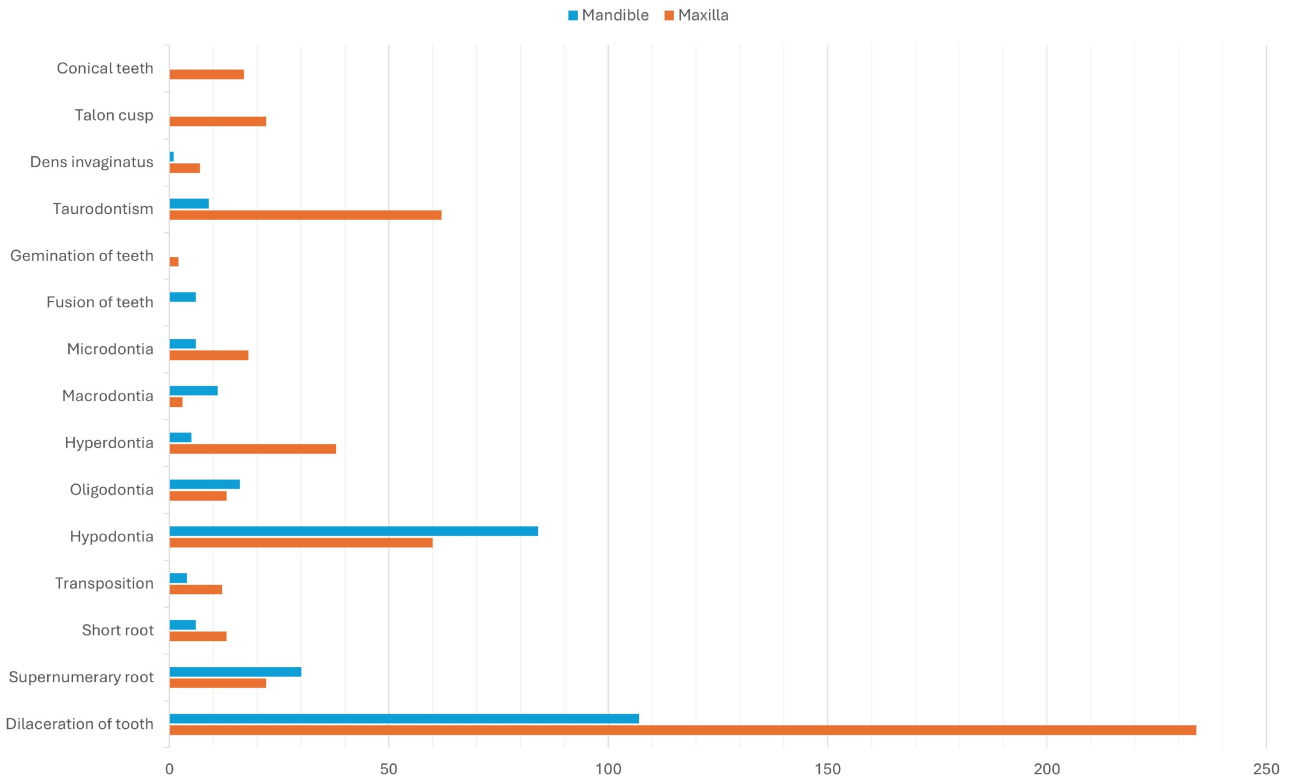

Figure 2. Distribution of DAs observed in the maxilla and mandible

simultaneous assessment of the teeth and jaws, facilitates the detection of anomalies that may not be observable during physical examination, particularly hypodontia or the presence of hyperdontia, and is an inexpensive and easily applicable method.[22,29,30] In this study, children aged 6–15 years in the Kütahya population were evaluated using panoramic radiographs to determine the prevalence of DAs. To the best of our knowledge, this is the first study in the Turkish pediatric population in which DAs were classified according to ICD codes and one of the few studies in which the diagnostic criteria were clearly defined in accordance with the literature (Table 1).

A review of the literature indicates that classification systems vary across studies. DAs have commonly been evaluated under the categories of number, size, shape, structure, position, eruption, and root anomalies; however, these categories have not been consistently assessed across all studies. While most studies have focused on number, size, and shape anomalies,[4,6,23,26,31,32] some have additionally included position,[4,6,23,26] eruption,[4,26,27] structure,[6,26,32,33] and/or root anomalies[4] into their analyses. In some studies, instead of the main categories mentioned, subcategories (such as taurodontism or hypodontia) were identified and evaluations were conducted based on them.[25,28,34] In this study, however, the WHO classification system was used, as it provides a standardized and internationally recognized framework and is considered to enable consistent reporting and comparability compared with systems based solely on morphological or clinical criteria.[8] Moreover, to strengthen the methodology of the present study: (i) only anomalies identifiable on panoramic radiographs were included, while those requiring clinical findings (such as amelogenesis imperfecta or dentinogenesis imperfecta) were excluded;[2,22,26,35] and (ii) to minimize observer bias, anomalies more susceptible to intra- and/or inter-observer variation, such as taurodontism, were evaluated in a standardized manner based on objective criteria and threshold values defined in the literature.[2,10,11,19]

Considering the obtained findings, significant differences were observed among the age groups and between jaws in terms of the overall prevalence of DAs, whereas no significant difference was found between sexes. Accordingly, the study's null hypothesis was partially rejected. The results achieved in this study indicate that the evaluated anomalies affected approximately one in four children, demonstrating that DAs are not uncommon in the pediatric population in the region where this study was carried out. Recent studies focusing on the Turkish pediatric population also reported similar findings. In this context, Daldal et al.[25] reported an anomaly prevalence of 16.3% among 1500 children aged 5–14 years, whereas Bodrumlu et al.[34] reported 26.7% among 4105 children aged 3–18 years. Correspondingly, Bag[31] found a prevalence of 24.7% among 1287 children and Eymirli et al.[26] reported 23.7% among 1921 children. In addition, Alanzi et al.[23] reported an anomaly prevalence of 20.1% among 546 children aged 8–12 years in the Kuwaiti population. Similarly, Lagana et al.[28] found a prevalence of 20.9%, and Pallikaraki et al.[36] reported a rate of 18.67% among 1200 children aged 7–17 years in the Greek population. However, there are also studies in which prevalence was reported to be remarkably lower or higher. Nahir et al.[6] reported an anomaly prevalence of 2.1% in Tokat. In contrast, Hoyte et al.[27] reported a prevalence of 75.2% among 536 children aged 5–16 years in the Trinidad and Tobago population. Similarly, Wagner et al.[22] reported DAs in 61.3% of 512 children aged 6-12 years in a Latin American population. Factors contributing to differences in the reported prevalence percentages of anomalies across populations include ethnic differences, variations in cultural and socioeconomic profiles, and the rate of access

to oral health services in childhood.[22,27,29,37] Hoyte et al.[27] emphasized that the genetic pool of the Trinidad and Tobago population is heterogeneous due to its marked ethnic diversity.

In addition to these unmodifiable external factors, selection bias in patient recruitment across studies, differences in the DAs examined, evaluation of the same anomaly under different classification headings, and ambiguities in diagnostic criteria for anomalies also contribute to these variations.[22,25–27,34] With regard to diagnostic criteria for anomalies, only a limited number of studies described the diagnostic criteria for the anomalies examined in detail.[22,23,26–28,30,33] Moreover, even in those studies, the threshold values used for diagnosis were often not explicitly stated.[22,26,27] Besides, there are differences among studies regarding the inclusion of third molars, in which DAs are frequently observed, in the evaluation.[6,22,27,30]

The most frequently detected anomaly in the present study was dilaceration of tooth, followed by hypodontia, supernumerary root, and taurodontism. Dilaceration of tooth was reported as the most common anomaly in the study carried out by Wagner et al.,[22] whereas it was not detected by Hoyte et al.[27] Even though the definition was similar in both studies, the threshold value considered "abnormal" was not explicitly stated. In the present study, the definitions proposed by Chohayeb et al.[10] and Schneider et al.[11] were adopted, and an angulation of 20° or higher relative to the normal axis was considered dilaceration of tooth. Differences in prevalence among studies are thought to be influenced not only by population-related factors and the effects of distortion on panoramic radiographs, particularly in the molar region, but also by the lack of standardization of the diagnostic threshold for dilaceration of tooth among researchers.[38]

Hypodontia, which was the second most frequently detected anomaly in this study, was also commonly reported among the top two anomalies in studies carried out in pediatric populations. However, the reported prevalence rates seem to vary across a wide range.[6,22,26,27] This variability is thought to be largely attributable to the diagnostic threshold (age) used when assessing second premolar agenesis. Even though agenesis was defined in literature most commonly as the absence of radiographic evidence of crown calcification in relation to the chronological age of tooth eruption, the age considered as the threshold for second premolars was not explicitly stated in every study. In this study, an age threshold of 8 years was adopted for the second premolars in accordance with some studies in the literature;[12–15] in individuals aged 8 years and older, the absence of radiographic evidence of crown calcification in the second premolar was considered agenesis.

Taurodontism, which was among the frequently observed anomalies in this study, was also identified as another anomaly affected by variability related with the diagnostic threshold. Taurodontism was diagnosed by using the criteria introduced by Shifman and Chanannel;[19] the ratio of pulp chamber height to total root length was calculated, and a threshold value of 20% was adopted. However, the fact that the diagnostic threshold is not explicitly stated in most studies in the literature may have contributed to differences in reported results.[6,22,23] Indeed, taurodontism was reported at relatively high rates (6.6% by Alanzi et al.[23] and 9.7% by Daldal et al.[25]) whereas much lower prevalences were reported by Karataban et al.[39] (0.2%) and Hoyte et al.[27] (0.75%). In the present study, in line with the literature, the least frequently detected anomaly was gemination, followed by fusion, transposition, dens invaginatus, and macrodontia. However, in the study carried out by Nahir et al.,[6] the prevalences of gemination, fusion, and dens invaginatus were reported to be higher than those reported by other studies in the literature.[22,23,26,27,34] The higher reported rates are thought to be associated with sample characteristics and environmental and ethnic factors, rather than the diagnostic threshold.

When examining the distribution of anomalies by the jaws, a higher number of anomalies were detected in the maxilla. Even though there are studies in the literature consistent with this finding,[6,23] there are also studies reporting no significant difference between the jaws.[22,26] These differences among studies are thought to be closely related not only with population characteristics but also with the types of anomalies included in the assessment. The anomalies included in our assessment (conical teeth, microdontia, talon cusp, and taurodontism) are frequently reported in the literature as being more prominent in the maxilla, and this largely explains the higher overall anomaly prevalence observed in the maxilla.[2,23,40,41]

Another finding achieved in this study was that there was no significant difference in the overall prevalence of DAs between sexes, which is consistent with the current literature.[22,23,26,27] However, anomaly-specific analyses yielded two notable results: the prevalence of dilaceration of tooth was significantly higher in girls, whereas the prevalence of hyperdontia was significantly higher in boys. A higher frequency of dilaceration of tooth in girls was also reported by Wagner et al.[22] In their study, the authors suggested that this finding may be better explained by sex-related genetic factors rather than hormonal differences during childhood. A higher prevalence of hyperdontia in boys was also reported by Shen et al.[29] in a Chinese pediatric population. The authors emphasized that boys may be more predisposed to the development of hyperdontia, and they proposed that autosomal or sex chromosome-linked genetic mechanisms may play a role. In this context, it was noted that the EDA gene located on the X chromosome plays an important role in tooth development, and transgenic mouse models revealed that increased EDA expression is associated with the formation of hyperdontia.[42–45]

DAs being evaluated across three different age groups is considered another important aspect of this study. In the present study, the overall prevalence of anomalies was significantly higher in the 12-15 age group compared with the other age groups. Wagner et al.[22] reported that hyperdontia were more common in younger patients, whereas other anomalies were observed at higher rates in older children. Similarly, in the present study, even though the difference was not significant, hyperdontia was more frequently observed at younger ages. This age-related difference is thought to have two possible explanations: (i) dilaceration of tooth, supernumerary root, short root, and taurodontism can be identified more reliably after completion of root development;[2,41,46] therefore, these anomalies were detected more frequently in the age group of 12-15 years. Since these were the most commonly observed anomalies in the present study, this was also reflected in the higher overall anomaly prevalence in the older age group; (ii) hyperdontia was most commonly observed as mesiodens, which may cause complications such as delayed eruption and lead to earlier clinical presentation; this may have contributed to the more frequent detection of hyperdontia in the younger age group.[22,29]

This study also contributes by evaluating the associations among DAs. In line with previous studies, a relationship was found in this study between hypodontia and microdontia and between hypodontia and conical teeth; this finding supports the role of hereditary factors in the etiology of these anomalies.[27,47,48]

This study is considered to make important contributions to the literature through its large-scale pediatric sample, its efforts to reduce methodological bias using a WHO-based classification system and diagnostic criteria supported by the literature, and its evaluation of anomalies across different age groups. Nevertheless, these findings should be interpreted within the limitations of the study. First, this study is limited by the inherent constraints of panoramic radiography, which, although one of the principal methods used in the diagnosis of DAs, represents three-dimensional anatomy in two dimensions.[38] Cone-beam computed tomography (CBCT) enables three-dimensional evaluation and can provide important information for early diagnosis; however, since radiation dose is a primary consideration in pediatric patients, the use of CBCT is recommended only when conventional radiographs are insufficient. Therefore, the feasibility of a CBCT-based assessment for the diagnosis of DAs in

children is limited.[49,50] Second, when interpreting the prevalence of DAs, it should be noted that not every anomaly can be assessed in every tooth at every stage of development. In younger children, several anomalies cannot be reliably evaluated because the relevant teeth may not yet have reached the developmental stage required to apply the diagnostic criteria, such as root-related anomalies before root development is completed.[9] This creates a denominator problem since the total number of screened patients does not correspond to an equally evaluable tooth set for each anomaly. Therefore, an anomaly-specific prevalence calculated on the basis of the relevant tooth group (only the teeth for which the diagnostic criteria can be applied) could not be generated in the present study; instead, consistent with common practice in the literature, prevalence was reported at the patient level. Finally, as this study was conducted in a faculty hospital and included only patients presenting for dental examination, it should be kept in mind that the results may have been influenced by referral bias.

Conclusion

In this study, which aims to reduce potential bias related with the criteria used to identify DAs, anomalies were detected in at least one in four children in Kütahya. Epidemiological studies across populations are important for understanding population-level differences and for highlighting the direct clinical implications of timely and accurate identification of DAs. Nevertheless, given inherent genetic, environmental, and ethnic variability across populations, methodological consistency is essential when interpreting how these factors influence anomaly prevalence. Accordingly, standardization is suggested in the following areas:

- The diagnostic adequacy of panoramic radiographs varies depending on the type of the anomaly. While some anomalies can be reliably assessed on panoramic radiographs, reliance on panoramic radiographs alone may introduce methodological uncertainty for anomalies in which clinical examination is decisive. Therefore, clear differentiation between anomalies that can be assessed using panoramic radiography and those requiring clinical examination is important.
- A lack of common terminology and coding for anomaly classification remains a concern. To facilitate consistent comparisons across populations, a reporting framework aligned with international classifications, particularly the WHO ICD-11 coding approach, should be adopted.
- For anomalies with threshold-dependent diagnoses, diagnostic boundaries should be defined using objective and reproducible criteria. Researchers should explicitly report the index used for taurodontism or the cutoff angulation for dilaceration of tooth.
- In addition to patient-based prevalence, future studies should consider tooth-based analyses and reporting using the evaluable tooth group specific to each anomaly.

Ethical Approval

The protocol of this retrospective cross-sectional study was approved by the Ethics Committee of the university that the author is affiliated with (Approval No: 2024/05-26, Date: 22.04.2024), and this study was carried out in line with the guidelines laid out in the Declaration of Helsinki.

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AI Statement

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Conflict of Interest

The authors declare that they have no conflict of interest.

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