



Prevalence and Distribution of Size-Related Dental Anomalies in Yemeni Paediatric population: A Panoramic Radiographic Study

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ABSTRACT

Objective: This study aimed to determine the prevalence of size-related developmental dental anomalies (DDAs) Macrodonia and Microdonia and distribution by gender, age, jaw among Yemeni paediatric patients by panoramic radiographs analysis.

Methods: A total of 5006 OPGs collected from a major radiology center in Sana'a City (2021–2024), the OPGs were analyzed from patients aged 10 to 18 years (mean age 13.77 ± 2.71 years). The data were evaluated for Macrodonia and Microdonia (including the peg-shaped subtype). Statistical analysis, including the chi-square test, was performed with significance set at $P \leq 0.05$.

Results: Size-related DDAs were observed in 221 instances, yielding an overall prevalence of 4.41% (CI 95%). Microdonia was the predominant anomaly, accounting for 4% (N=200) of all size-related cases, with the peg-shaped subtype representing 23.5% of microdonia instances. Macrodonia was significantly less common, representing 0.41% (N=21). A statistically significant association was found with gender, with females exhibiting a higher frequency (61.5%), and age peaking in the adolescent (14–18 years) group (62.2%). Furthermore, a highly significant predilection for the maxilla was noted (81.58%, $P < 0.001$).

Conclusion: Microdonia is the dominant type, and the significant distribution across gender, age, teeth group and jaw location suggest the importance of early radiographic screening and timely intervention in this population.

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1. INTRODUCTION

Human odontogenesis is a highly regulated and complex biological process, and any disruption during its stages can lead to significant clinical alterations[1]. Dental developmental anomalies (DDAs) are deviations in the origin of dental tissue that result in variations in the number, size, form, or positioning of teeth[2, 3]. These anomalies are not merely morphological variations; they are distinct clinical entities that can significantly impact the function and aesthetics of the stomatognathic system[3]. In the pediatric population, the presence of these anomalies often serves as a primary indicator of underlying developmental disturbances [4].

The etiology and pathogenesis of DDAs are multifactorial, arising from an intricate interplay between genetic and environmental factors [4, 5]. Most disturbances in tooth size and shape occur during the morphodifferentiation stage of development, in which the final form of the tooth is established [1, 2]. Genetic variations have been linked to the activity of specific homeobox genes, such as PAX and MSX, which regulate tooth morphogenesis [2, 4]. Environmental stressors, including exposure to toxins, prenatal or postnatal systemic diseases, and aggressive medical treatments, such as radiation or chemotherapy at a young age, can further interrupt normal dental development [1, 4].

Size-related dental anomalies are primarily catego-



alized as macrodontia (teeth larger than normal) and microdontia (teeth smaller than normal) [1, 4]. Both conditions are subdivided into three clinical types: true generalized, often linked to systemic conditions such as pituitary dwarfism or gigantism; relative generalized, appearing due to jaw size discrepancies; and localized, affecting isolated teeth [4]. These anomalies have a substantial clinical impact, leading to aesthetic concerns, crowding, malocclusion, and an increased risk of dental caries and periodontal disease due to abnormal morphology and plaque accumulation [1, 6].

Global and regional epidemiological reports have demonstrated that the prevalence of these anomalies varies significantly across different ethnic and geographical groups [3, 7]. Regionally, a study in Ajman, United Arab Emirates, reported microdontia in 4.6% and macrodontia in 2.3% of their sample [3]. Furthermore, meta-analyses suggest that microdontia, particularly the "peg lateral" incisor, shows a consistent predilection for females [1, 7].

Microdontia is generally more common in females and occurs in approximately 1.5–2% of the population, with reported rates of 1.8% in India, 2% in Iran, and regional variances in Saudi Arabia ranging from 0.05% in Riyadh to 4% in the Western region [1, 4, 8–11]. Macrodontia is typically rarer, affecting 1.1–1.9% of permanent dentitions, with specific incidences of 0.02% in India, 0.10% in Riyadh, and 2.8% in Western Saudi Arabia [4, 9–11]. Regarding TSD, which measures arch harmony, significant anterior discrepancies affect 20–30% of the population, with rates reaching 22.7% in Brazil, 21.3% in Turkey, and up to 50% in mixed samples from the United States [12, 13]. Furthermore, research indicates that Caucasians tend to exhibit higher overall tooth size variances and discrepancies than the Chinese population [12].

Orthopantomograms (OPGs) are essential tools for diagnosing dental anomalies [3]. They allow for the detection of anomalies that are not clinically observable, such as impacted macrodont teeth (molarization: an extreme form of this condition is the 'molarization' of premolars, where the premolars become so large that they resemble molars) and abnormal root structures [1]. OPGs provide a comprehensive view of the maxilla and mandible, facilitating the evaluation of tooth size, eruption patterns, and arch relationships [3, 6]. This radiographic modality is particularly favored in pediatric dentistry because it offers a broad diagnostic range with reduced radiation exposure compared to a full series of intraoral films [3].

Despite the wealth of international data, a significant research gap remains because of the heterogeneity and inconsistency of the current evidence [3]. Most existing studies are limited by selection bias, as they often focus on orthodontic patients rather than the general pediatric population [5]. Furthermore, there is a notable lack of local pediatric data specifically for the Yemeni population, making it difficult to establish a regional baseline

or to understand the unique genetic and environmental influences affecting Yemeni children.

The rationale and objective of the current study are based on the necessity of early detection to prevent the long-term functional and aesthetic complications of the disease. Understanding the local prevalence of size anomalies is vital for effective multidisciplinary treatment planning and improving the quality of pediatric dental care [1]. Therefore, this study aimed to investigate the prevalence and distribution of size-related dental anomalies (Macrodontia and Microdontia) among Yemeni pediatric patients through radiographic evaluation, providing essential data to guide early intervention strategies for this specific population. Furthermore, this study investigated the distribution of these anomalies in relation to sex, age group, tooth group, and jaw location.

2. MATERIALS AND METHODS

2.1. STUDY DESIGN AND SETTING

This study employed a retrospective cross-sectional research design to assess the prevalence and distribution of dental anomalies in a pediatric population. This study was conducted in Sana'a City, Yemen, utilizing a large dataset of OPGs collected over a four-year period (2021–2024) from the Alpha Radiology Center.

2.2. ETHICAL APPROVAL

The study protocol was reviewed and approved by the Ethics Committee of the Faculty of Dentistry at Sana'a University (n= 698) on August 6th, 2024. This study adhered to all ethical guidelines regarding patient data confidentiality. Given the retrospective nature of the study, direct patient contact was not required, and all data were anonymized to ensure patient privacy and security.

2.3. STUDY POPULATION AND SAMPLE SELECTION

The initial dataset consisted of 33762 OPGs. A multi-stage filtration process was applied: first, duplicate entries and records of OPGs outside the 10–18 age range were removed. After applying specific clinical inclusion and exclusion criteria, a final sample of 5006 radiographs was established for analysis. The PRISMA flow diagram of the study selection and filtration process shows in **Figure 1**

2.4. SELECTION CRITERIA

Inclusion Criteria:

Yemeni patients aged 10–18 years [10, 14]. High-quality panoramic radiographs are suitable for diagnostic interpretation. based on the National Radiological Protection Board (NRPB) quality standards. Only radiographs

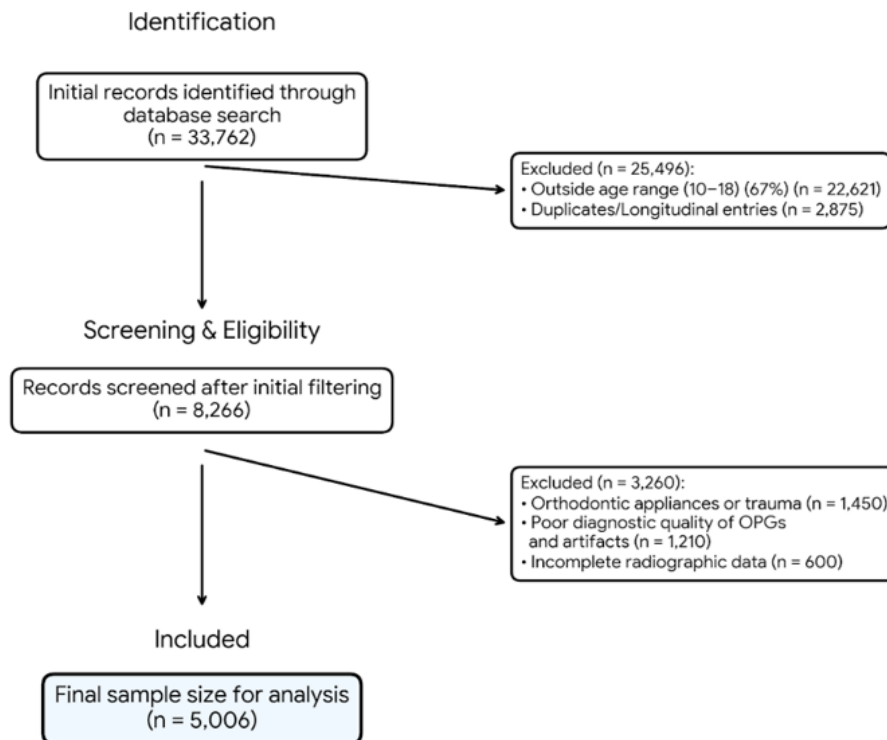


Figure 1. PRISMA flow diagram of the study selection and filtration process

graded as 'excellent' or 'diagnostically acceptable, characterized by optimal positioning (absence of ghost images and spine superimposition), absence of movement blur, adequate density and contrast, minimal artifacts, and clear anatomical representation were included in the study sample.

availability of a complete set of OPG records, including demographic data (age, sex, and nationality). Although patient names and registration dates were recorded during the data collection phase to strictly prevent sample duplication and ensure unique entries, this information was subsequently anonymized to maintain confidentiality of the patients.

Exclusion Criteria:

OPGs with suboptimal diagnostic quality due to distortion, blurring, or artifacts resulting from orthodontic appliances and dental restorations were excluded from the study. Additionally, patients with a history of dental trauma ((as a broken tooth or a tooth pushed into the jaw) can change the shape, position, and size of the dentition. Since your study likely aims to look at developmental anomalies, including trauma cases would confuse developmental issues with accidental damage) or congenital craniofacial anomalies were omitted from the study. Finally, cases with incomplete radiographic records were excluded to ensure the integrity and accuracy of the final analyses.

2.5. RADIOGRAPHIC EQUIPMENT AND IMAGE ACQUISITION

All radiographs were acquired using digital panoramic units at the Alpha Radiology Center, Brazil. To ensure diagnostic consistency, all images were viewed on high-resolution monitors under standardized lighting conditions, allowing clear visualization of the dental structures. Images were acquired using a PCH-2500 Digital X-ray Imaging System (Vatech Co., Ltd.) featuring a Canon D-052SB tube with a 0.5 mm focal spot for high resolution. The beam quality was optimized using a 2.8 mm Al equivalent filtration to minimize low-energy radiation. Consistent parameters of 90 kV, 10 mA, and a 20.2-second exposure were maintained according to the manufacturer's guidelines.

Digital analysis was conducted on a Dell Latitude 7420 workstation (Windows 11) equipped with an Intel Core i7-1185G7 processor and 32 GB RAM to ensure sufficient power for precise radiographic calibration and data processing.

2.6. DIAGNOSTIC CRITERIA

Localized microdontia: Diagnosed when the mesiodistal diameter of a tooth was smaller than the mean value minus two standard deviations (-2SD). Conversely, **Macrodonia:** Diagnosed when the mesiodistal diameter exceeded the mean value plus two standard deviations (+2SD)[15]. **Peg-shaped Teeth:** A specific form of microdontia, diagnosed when the crown (typically the max-



illary lateral incisor) exhibits a reduced, conical shape, tapering incisally from the cemento-enamel junction[3].

In this study, radiographic assessment focused exclusively on identifying localized microdontia and macrodontia through a comparative analysis of mesiodistal tooth dimensions in the same panoramic image. The cases were initially diagnosed by comparing the suspected tooth with its adjacent and contralateral counterparts to ensure proportional accuracy. The diagnosis of dental size anomalies was standardized based on the morphometric measurements of permanent teeth, as defined in Wheeler's Dental Anatomy, Physiology, and Occlusion[16].

An anomaly was recorded if the mesiodistal width of the tooth crown deviated by more than two standard deviations ($\pm 2SD$) from the established mean values. Conversely, generalized forms of these anomalies were deliberately excluded from the analysis because of the inherent magnification and geometric distortion of OPGs. Because patient positioning within the focal trough can uniformly alter the perceived size of the entire dentition, diagnosing generalized size discrepancies without the use of standardized study casts or 3D imaging (CBCT) would be diagnostically unreliable and prone to significant measurement errors.

2.7. RADIOGRAPHIC EVALUATION AND EXAMINER CALIBRATION

The 5006 OPGs were examined in two stages: Initial Examination: The primary author, a trained examiner, performed the evaluation. Consensus Review: Complex or questionable cases were collaboratively reviewed by a senior supervisor. Challenging cases were further validated by an oral and maxillofacial radiology specialist to minimize misclassification bias. The examiner reliabilities were assessed by having them read 10% OPGs and re-read them 2 weeks later. The intra-examiner reliability of two readings was evaluated using the (Cohen's kappa) statistic, showing an almost perfect agreement (0.81). In addition, the inter-reliability test between the examiner and supervisor was substantial (0.75).

2.8. STUDY VARIABLES (OUTCOMES)

The primary outcomes measured were the presence or absence of size anomalies (macrodontia, microdontia, and peg-shaped). These were analyzed in relation to the following variables: 1-age groups: (10-13 years) early teenager, (14 - 18 years) teenager. 2- Gender. 3-anatomical distribution(maxilla vs. mandible). 4-Tooth groups (anterior, premolars, molars).

2.9. STATISTICAL ANALYSIS

Statistical Analysis starts with data screening, which focuses on the way of coding and checking the missing data on SPSS, sample profile, which is data about the patients or subjects characteristics (in tabular and/or graphical forms), and the results of the comparative analysis. The SPSS program, which is the Sciences Statistical package for social version No. 29, was used to conduct the appropriate tests for the study, as the following tests were used:

1. Statistical significance for comparative tests was set at $P \leq 0.05$ for all tests.
2. Chi-Square Test.
3. Frequencies and Percentages A 95% Confidence Interval (CI) was used to estimate the prevalence and precision using the Wilson score method.

3. RESULTS

3.1. DEMOGRAPHIC CHARACTERISTICS OF THE STUDY POPULATION

In this study, 5,006 orthopantomograms (OPGs) were analyzed. The demographic distribution, categorized by gender and age group, is summarized in **Table 3.1**.

3.1.1. Gender Distribution

The study population showed a relatively balanced distribution between the sexes, with a slight predominance of female participants in the study. Of the total sample, 52.1% ($n = 2,607$) were female, while 47.9% ($n = 2,399$) were male.

3.1.2. Age and Dentition Stages

The participants were categorized into two primary age groups reflecting their dental developmental stages:

- Late Mixed Dentition (10–13 years): This group comprised 50.1% ($n = 2,509$) of the total sample.
- Permanent Dentition (14–18 years): This group accounted for the remaining 49.9% ($n = 2,497$) of the population.

3.2. OVERALL PREVALENCE AND DISTRIBUTION OF SIZE ANOMALIES

The investigation into size-related Developmental Dental Anomalies (DDAs) revealed a total prevalence of 4.41% within the study population ($N=5,006$), accounting for 221 cases. The distribution of these anomalies was heavily skewed toward a specific type, as shown in Table 3.2.

Analysis of the size-related anomalies showed a significant disparity between cases of abnormally large and abnormally small teeth.

Table 1. Demographic Characteristics of the Study Population (N=5006)

Characteristic	Group / Category	Frequency (N)	Percentage (%)
Total Patient's OPGs		5006	100.0%
Gender	Female	2607	
	Male	2399	
Age Group	10 to 13 years (Late mixed dentition)	2509	24.9%
	14 to 18 years (Permanent dentition)	2497	35.1%

Table 2. Prevalence and Distribution of size-related Dental Anomalies by Type and Subtype

Group	Frequency (N) Percentage (%)	Type of size dental anomalies	Frequency (N) Percentage (%)	Subtype of Microdontia	Frequency (N) Percentage (%)
Size	N=221 4.41%*	Macrodontia	N=21 0.41%		
		Microdontia	N=200 4%	Non-peg-shaped Microdontia	N=153 76.5%
				Peg-shaped	N=47 23.5%

- Microdontia was the most frequent size anomaly, occurring in 4% of the total population (n=200). This represents over 90% of all size-related anomalies recorded.
- Macrodontia was found to be relatively rare, with a prevalence of only 0.41% (n=21).

Within the Microdontia group (n=200), two distinct morphological subtypes were identified:

1. Non-peg-shaped Microdontia: This prevalent subtype accounted for 76.5% of all microdontia cases (n=153).
2. Peg-shaped Microdontia: This variation, often characterized by a conical crown shape, was observed in 23.5% of the microdontia cases (n=47).

3.3. DISTRIBUTION BY GENDER

In **Table.3** The distribution of dental size developmental anomalies (DDAs) shows a clear predilection based on sex. Of the 221 size-related anomalies, the majority were observed in females (n=136; 61.5%) compared to males

(n=85; 38.5%). This higher prevalence in the female cohort was statistically significant ($P = 0.004$).

When categorizing the anomalies by type, microdontia was significantly more frequent than macrodontia, accounting for 200 of the 221 cases. Within the microdontia group, females were affected more often than males (64.5% vs. 35.5%, respectively), a difference that reached high statistical significance ($P < 0.001$). Conversely, macrodontia was the only anomaly that appeared more frequently in men (66.7%) than in women (33.3%); however, this specific distribution did not reach the threshold for statistical significance ($P = 0.132$).

A further sub-analysis of microdontia revealed distinct patterns between non-peg-shaped and peg-shaped variants. Non-peg-shaped microdontia was significantly more prevalent in females, who accounted for 68.6% of the 153 identified cases ($P < 0.001$). In contrast, the occurrence of peg-shaped microdontia was nearly equally distributed between the sexes, with 51% in females and 49% in males. This balanced distribution for the peg-shaped subtype was not statistically significant ($P = 0.884$), suggesting that while microdontia in general is



Table 3. Gender Distribution of Dental Size Anomalies

Group	Anomaly Type/ Subtype	Male (N & %)	Female (N & %)	total	P value
Total Size Anomalies		N=85 (38.5%)	N=136 (61.5%)	N=221 100%	0.004*
Type of size DDAs	Macrodontia	N=14 (66.7%)	N=7 (33.3%)	N=21 100%	0.132
	Microdontia	N=71 (35.5%)	N=129 (64.5%)	N=200 100%	<0.001*
Microdontia Subtypes	(non-peg-shaped) Microdontia	N=48 (31.4%)	N=105 (68.6%)	N=153 100%	<0.001*
	Peg-shaped	N=23 (49%)	N=24 (51%)	N=47 100%	0.884

value Chi-Square Test, *P ≤ 0.05: Significant

a female-dominant trait in this sample, the peg-shaped variant affects both sexes almost equally.

3.4. DISTRIBUTION BY AGE GROUP

The analysis of dental size anomalies (DDAs) according to age group revealed a significantly higher prevalence in the older teenage cohort. Of the 221 total size anomalies identified, the Teenager group (14–18 years) (late mixed dentition) accounted for 65.2% (n=144), while the Early Teenager group (10–13 years) (permanent dentition) accounted for 34.8% (n=77). This age-based disparity was highly statistically significant ($P < 0.001$), suggesting that these anomalies were more frequently detected or recorded in late adolescence within this study population.

Regarding specific types of size DDAs, both macrodontia and microdontia exhibited a similar trend of increasing prevalence with age. Macrodontia was significantly more common in the older group, with 76.2% of cases found in teenagers aged 14–18 years compared to only 23.8% in early teenagers ($P = 0.016$). Similarly, microdontia showed a significant distribution, with 64% of the 200 cases occurring in the older cohort ($P < 0.001$).

Further investigation into microdontia subtypes, specifically non-peg-shaped and peg-shaped variants, confirmed that this age-related trend was consistent. Non-peg-shaped microdontia was observed in 64.1% of the older group versus 35.9% in the younger group ($P < 0.001$). Peg-shaped microdontia followed a nearly identical pattern, with 63.8% of cases diagnosed in the 14–18 age range ($P < 0.001$). These findings indicate that across all categories and subcategories of dental size anomalies, the frequency of diagnosis was significantly higher in late adolescence than in early teenage years.

3.5. DISTRIBUTION BY JAW LOCATION

The localization of dental size anomalies (DDAs) showed a significant predilection for the maxilla over the mandible. Of the 221 size anomalies identified, the majority were situated in the maxilla (n=161; 3.22%), while the mandible accounted for only 0.82% (n=41), and a small fraction (0.38%) affected both jaws. This uneven distribution across the dental arches was statistically significant ($P < 0.001$).

When analyzing specific types of anomalies, macrodontia was nearly twice as common in the maxilla (0.26%) than in the mandible (0.14%), and this difference was statistically significant ($P = 0.006$). Microdontia followed a similar, even more pronounced trend; of the 200 cases, the maxilla was the most frequent site (2.36%), followed by the mandible (1.36%), and involvement of both jaws (0.28%). This overall pattern for microdontia was statistically significant at $P < 0.001$.

A notable finding emerged during the subanalysis of the microdontia variants. While non-peg-shaped microdontia was distributed relatively closely between the mandible (1.36%) and maxilla (1.42%), the peg-shaped variant was found exclusively in the maxilla (0.94%), with no cases recorded in the mandible or involving both jaws. The localization of peg-shaped microdontia solely to the upper arch contributed to the high statistical significance ($P < 0.001$) observed in its distribution, marking it as a distinct characteristic of this specific subtype within the study population.

Table 4. Distribution of Size Dental Anomalies (DDAs) Across Different Age Groups

Group of size DDAs	Subgroup / Anomaly Type	Early Teenager (10-13) (N / %)	Teenager (14-18) (N / %)	Total	p-value
Size		77 / 34.8%	144 / 65.2%	221	<0.001*
Type of size DDAs	Macrodonia	5 / 23.8%	16/ 76.2%	21	0.016*
	Microdonia	72/36%	128/64%	200	<0.001*
Subtype of microdonia	(non-peg shaped) Microdonia	62 / 35.9%	91/ 64.1%	153	<0.001*
	Peg-shaped	10 / 36.2%	37 / 63.8%	47	<0.001*

value Chi-Square Test, *P ≤ 0.05: Significant

Table 5. Table 3.5 Distribution of Size Dental Anomalies (DDAs) by Jaw Location

Group	Anomaly Subtype	Type /	Mandible (N / %)	Maxilla (N / %)	Both (N / %)	Total	P value
Size (Total DDAs)			41 / 0.82%	161 / 3.22%	19 / 0.38%	221/ 4.41%	< 0.001*
Type of dental anomalies	Macrodonia		7 / 0.14%	13 / 0.26%	1 / 0.02%	21/ 0.42%	0.006*
	Microdonia (Total)		68 / 1.36%	118 / 2.36%	14 / 0.28%	200/ 4.00%	< 0.001*
Subtype of Microdonia	(non-peg-shaped) Microdonia		68 / 1.36%	71 / 1.42%	14 / 0.28%	153/ 3.06%	< 0.001*
	Peg-shaped		0 / 0.00%	47 / 0.94%	0 / 0.00%	47/ 0.94%	< 0.001*

Value Chi-Square Test, *P ≤ 0.05: Significant



3.6. DISTRIBUTION OF DENTAL SIZE ANOMALIES BY TOOTH TYPE

In **Table 3.6** The distribution of dental size anomalies (DDAs) across different tooth types revealed a highly significant predilection for specific teeth ($P < 0.0001$). Of the 221 total anomalies, the maxillary lateral incisors were the most frequently affected, accounting for nearly half of all cases (49.32%; $n=109$). This was followed by molars (28.51%), premolars (15.84%), and central incisors (6.33%).

When analyzed by anomaly type, macrodontia showed a distinct pattern, primarily affecting the central incisors (52.38%). In stark contrast, macrodontia was absent in the maxillary lateral incisors (0.00%). The remaining cases of macrodontia were distributed between molars (28.57%) and premolars (19.05%), with a statistically significant overall distribution ($P = 0.0075$).

Microdontia followed a vastly different trend, with a overwhelming majority of the 200 cases localized to the maxillary lateral incisors (54.50%), while central incisors were rarely affected (1.50%). Among the microdontia subtypes, non-peg-shaped microdontia was the most broadly distributed. Although the maxillary lateral incisors remained the most common site (40.52%), significant occurrences were also noted in the molars (37.25%) and premolars (20.26%).

The most striking finding was observed in the peg-shaped microdontia subtype. This anomaly was found exclusively in the maxillary lateral incisors, accounting for 100% of the 47 identified cases. No peg-shaped teeth were recorded among the central incisors, premolars, or molars, resulting in a highly significant statistical correlation ($P < 0.0001$) between this specific morphology and the maxillary lateral incisor position.

4. DISCUSSION

4.1. OVERALL PREVALENCE OF SIZE ANOMALIES

The present investigation identified a total prevalence of size-related developmental dental anomalies (DDAs) of 4.41% ($n=221$) within a population of 5,006 subjects. This finding aligns with the variable rates reported in the global literature, which often show significant regional and ethnic differences. For instance, our results are comparable to those of studies in Abha, Saudi Arabia, which reported a similar size anomaly prevalence of 4.4% [17] and fall within the intermediate range of findings from Northern Brazil, where rates reached 6.06% [18]. However, our recorded prevalence is higher than that observed in a large Indian population study (2%) [10] and an Iranian sample (1.5%) [19]. These discrepancies are frequently attributed to differences in sampling techniques, diagnostic criteria, and the specific age groups evaluated [20, 21].

A core finding of this study is the pronounced disparity between microdontia (4.0%) and macrodontia (0.41%), with the former representing over 90% of all size-related anomalies. This distribution is strongly supported by the existing literature, which consistently identifies microdontia as the more frequent condition [18, 22]. In an Indian population, researchers reported a microdontia prevalence of 1.8% compared to a nearly non-existent macrodontia prevalence of 0.02% [5, 13]. Similarly, in Turkey, microdontia was recorded in 0.7% of orthodontic patients, while macrodontia was not observed at all in the same sample [20].

The rarity of macrodontia—confirmed by our low rate of 0.41%—is often explained by its association with specific systemic conditions, such as pituitary gigantism, insulin-resistant diabetes, or KBG syndrome [4, 20]. Conversely, the higher frequency of microdontia is frequently linked to an evolutionary trend toward a reduction in both jaw size and the number/size of teeth [10, 21]. Clinically, microdontia is a significant finding, as it often results in diastemas, aesthetic concerns, and functional difficulties such as food retention [4, 8].

Within the microdontia cohort, this study distinguished between non-peg-shaped (76.5%) and peg-shaped (23.5%) variations. Peg-shaped teeth (particularly the maxillary lateral incisor) are widely recognized in the dental literature as the most common form of localized microdontia [4, 9]. 23.5% prevalence of peg-shaped microdontia in our study is significant, as these teeth are frequently identified as a diagnostic marker for other anomalies, such as hypodontia (congenitally missing teeth) and palatally displaced canines [11, 23].

The etiology of these size variations is primarily genetic, occurring during the morpho differentiation stage of the bell stage of tooth development [10]. The higher prevalence of microdontia observed in this study underscores the importance of early radiographic screening, as these anomalies can lead to malocclusion and arch length discrepancies [12]. Early diagnosis is essential for multidisciplinary treatment planning, which may involve orthodontic space closure or restorative procedures, such as composite buildups, veneers, or crowns, to restore proper dental proportions [4, 8, 12].

4.2. DISTRIBUTION BY GENDER

The distribution of size-related dental anomalies in this study revealed a significant female predilection (61.5%, $P=0.004$), which aligns with several global investigations reporting higher incidence rates of developmental anomalies in female cohorts [24, 25]. This overall trend was primarily driven by the microdontia group, in which females were significantly more affected than males (64.5% vs. 35.5%, $P<0.001$). This mirrors the established literature identifying microdontia as a female-dominant trait [4, 21, 23], with specific regional studies

Table 6. Frequency and Percentage of Size-Related Dental Anomalies According to Tooth Group

Group	Anomaly Type / Subtype	Central Incisors (N / %)	Maxillary Lateral Incisors (N / %)	Premolars (N / %)	Molars (N / %)	Total	P Value
Size (Total DDAs)		14 / 6.33%	109/ 49.32%	35 / 15.84%	63/ 28.51%	221/ 100%	< 0.0001
Type of dental anomalies	Macrodontia	11 / 52.38%	0 / 0.00%	4 / 19.05%	6 / 28.57%	21/ 100%	0.0075
	Microdontia (Total)	3 / 1.50%	109/ 54.50%	31 / 15.50%	57 /28.50%	200/ 100%	< 0.0001
Subtype of Microdontia	(non-peg shaped) Mi-crodon-tia	3 / 1.96%	62/ 40.52%	31 / 20.26%	57 /37.25%	153/ 100%	< 0.0001
	Peg-shaped	0 / 0.00%	47/ 100.00%	0 / 0.00%	0 / 0.00%	47/ 100%	< 0.0001

Value Chi-Square Test, *P ≤ 0.05: Significant

in Iran and India similarly recording higher female frequencies of reduced tooth dimensions [10]. The predominance of microdontia in females is often linked to genetic factors during the morphodifferentiation stage of odontogenesis and an evolutionary trend toward reduced jaw and tooth size [4, 10, 26].

Conversely, macrodontia was the only anomaly in this sample showing a male preponderance (66.7%), consistent with the general observation that permanent macrodontia affects 1.1% to 1.9% of populations with a higher reported prevalence in males [4, 25]. The lack of statistical significance for this distribution (P=0.132) likely reflects the rarity of the condition, a common limitation noted in other regional studies where macrodontia cases were too few to reach significance [9, 10]. A notable nuance in our data is the gender-balanced distribution of peg-shaped microdontia (51% female vs. 49% male, P=0.884), which contrasts with the significant female dominance of the non-peg-shaped variant (68.6%, P<0.001). While peg-shaped lateral incisors are frequently identified as a common form of localized microdontia associated with genetic markers for hypodontia [18, 23], our results suggest that the morphological tapering characteristic of the peg-shaped variant may be sex-independent in this population, whereas generalized reductions in tooth size remain predominantly linked to women.

4.3. DISTRIBUTION BY AGE GROUP

The analysis revealed a significantly higher prevalence of dental size anomalies in late adolescence (14–18 years) than in the early teenage group (10–13 years), with the older cohort accounting for 65.2% of all cases (P < 0.001). This age-based disparity is consistent with the existing literature, such as a study on a Turkish population that found that the frequency of dental anomalies was statistically higher in the 13–18 age range than in the 9–12 age group [20]. This trend is likely attributable to the completion of permanent dentition eruption and the increased frequency of comprehensive orthodontic screenings during these years, which often serve as the primary point of detection for size discrepancies [25, 27, 28].

The consistent increase in prevalence across all types including macrodontia (P = 0.016), microdontia, and its peg-shaped variants (P < 0.001) supports the observation that developmental anomalies become more pronounced and "recognizable" as patients age [29]. Although these conditions are ontogenetically established during the morphodifferentiation stage of tooth development [20, 28], their clinical and radiographic visibility is optimized once the crown and root structures mature. These findings highlight the importance of systematic radiographic evaluation in late adolescence to facilitate the timely multidisciplinary management of aesthetic and functional complications, such as crowding or spacing, associated with tooth size discrepancies [3, 28, 30].



4.4. DISTRIBUTION OF DENTAL SIZE ANOMALIES BY JAW LOCATION

The significant maxillary predilection for size-related anomalies (3.22% vs. 0.82%, $P < 0.001$) observed in this study aligns with the established literature, indicating that the upper arch is generally more susceptible to developmental disturbances [26]. This disparity is often attributed to the complex ontogenesis of the maxilla, which involves the fusion of multiple embryonic processes, making it more prone to epigenetic influences than the mandible, which develops as an independent bone [26]. The higher incidence of both macrodontia and microdontia in the maxilla suggests that these genetic disturbances occurring during the morphodifferentiation stage are most impactful in the more developmentally intricate upper arch [26].

A critical finding was the exclusive localization of peg-shaped microdontia to the maxilla (0.94%, $P < 0.001$), a result strongly supported by reports identifying nearly 97% of peg-shaped teeth in the upper jaw [26]. While non-peg-shaped microdontia was distributed more evenly, the maxilla-specific nature of the peg-shaped variant reinforces its role as a distinct diagnostic marker often associated with other localized disturbances, such as palatally displaced canines or maxillary hypodontia [11, 23, 26]. These results underscore the importance of targeted maxillary screening, as these localized forms of microdontia frequently lead to significant aesthetic and spacing complications, requiring multidisciplinary management [8, 26].

4.5. DISTRIBUTION OF DENTAL SIZE ANOMALIES BY TOOTH TYPE

The maxillary lateral incisor emerged as the primary site for size-related disturbances (49.32%), a finding consistent with the literature identifying this tooth as the most frequent location for microdontia [4, 25, 30]. Specifically, the exclusive peg-shaped morphology of the maxillary lateral incisors (100%, $P < 0.0001$) reinforces its status as a definitive marker for localized microdontia, often resulting from developmental instability in the embryonic maxillary fusion zones [20, 26]. This high predilection for the upper anterior segment highlights the susceptibility of this region to genetic and environmental disturbances during the morphodifferentiation stage of odontogenesis [10, 28].

Conversely, macrodontia was significantly rarer (0.41%) and primarily affected central incisors (52.38%), contrasting with the total absence of abnormally large lateral incisors and matching global reports regarding the extreme rarity of macrodont morphology [18, 30]. The broader distribution of non-peg-shaped microdontia, which involves significant molar (37.25%) and premolar (20.26%) occurrences, reflects established evolutionary trends toward

dental reduction and a reduced masticatory surface area [21, 26]. These tooth-specific predilections are clinically critical, as tooth size discrepancies frequently necessitate multidisciplinary interventions to address associated complications such as spacing, crowding, and functional malocclusion [11, 12].

5. LIMITATIONS OF THE STUDY

Despite the statistical power derived from the large sample size ($n = 5006$ panoramic radiographs), this study had certain limitations that should be considered when interpreting the results.

- **Nature of Radiographic Imaging (2D vs 3D):** The study relied exclusively on Orthopantomograms (OPGs), which are two-dimensional representations of three-dimensional structures. This type of imaging can suffer from inherent magnification and geometric distortion depending on the patient's positioning within the "focal trough" of the machine, potentially affecting the accuracy of precise millimetric measurements compared to Cone-Beam Computed Tomography (CBCT).
- **Exclusion of Generalized Cases:** Due to the potential for uniform distortion in tooth size resulting from patient positioning, cases of generalized size anomalies (Generalized Macrodontia/Microdontia) were deliberately excluded, focusing only on localized cases to ensure diagnostic accuracy. This may imply that the overall prevalence of anomalies could be slightly higher than that observed in this study.
- **Geographical Scope:** Data were collected from a single major radiology center in Sana'a City. Despite the large sample size, it may not fully represent the complete geographical and ethnic diversity of rural Yemen.

6. CONCLUSION

This study aimed to assess the prevalence and distribution of size-related developmental dental anomalies (DDAs) among Yemeni pediatric patients aged 10-18 years, utilizing panoramic radiographs. The investigation revealed an overall prevalence of 4.41% for these anomalies in the studied population. A key finding was the pronounced disparity between microdontia and macrodontia, with microdontia being the predominant anomaly, accounting for 4% of the cases, while macrodontia was significantly less common at 0.41%.

The analysis further elucidated significant distributional patterns: females exhibited a higher frequency of size anomalies, particularly microdontia, and the older adolescent cohort (14-18 years) showed a greater prevalence than younger age groups. Geographically within the oral cavity, the maxilla demonstrated a significantly higher incidence of DDAs than the mandible. Notably, peg-shaped microdontia was exclusively observed in the

maxillary lateral incisors, representing 100% of its occurrences. These findings underscore that while the prevalence and distribution of dental size anomalies in the Yemeni pediatric population align with global and regional trends, they also present unique characteristics that necessitate targeted clinical and public health interventions.

7. RECOMMENDATIONS

Based on these findings, this study recommends the following:

- **Early Radiographic Screening:** The findings highlight the importance of targeted radiographic screening in pediatric patients who present with clinical signs of developmental dental anomalies. We recommend incorporating panoramic radiography into the diagnostic protocol when size anomalies are suspected, ensuring early detection while adhering to the ALARA principle for Yemeni children starting from the age of ten to ensure early detection of microdontia or macrodontia cases that may not be clinically evident in their early stages.
- **Integrated Treatment Planning:** Given that maxillary lateral incisors are the most affected, close collaboration between orthodontists and restorative/esthetic dentists is recommended to develop comprehensive treatment plans that ensure early restoration of function and aesthetics, thereby preventing malocclusion or diastema issues.
- **Clinical Awareness:** Raising the awareness level of practicing dentists in Yemen regarding the common distribution patterns of these anomalies, especially the higher predisposition in females and in the maxilla.
- **Future Research:**
 - Conducting longitudinal studies to assess the long-term effects of these anomalies on jaw development.
 - Utilizing three-dimensional imaging techniques (CBCT) in future studies to compare their accuracy with panoramic radiography in diagnosing these conditions.

Investigating specific genetic and environmental factors within the Yemeni community that may contribute to the etiology of these developmental anomalies

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