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Prevalence of delayed tooth eruption of permanent maxillary anterior teeth among Ukrainian children: retrospective radiographic study using CBCT data

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Abstract

Background. Tooth eruption is a complex, multi-staged, and well-regulated biological and age specific process that can be affected and influenced by many systemic and local factors. The deviation more than ±2SD from the established norm of tooth eruption terms, while also taking account racial, ethnic, and gender factors, is important for the clinician.

Objective. To estimate the prevalence of delayed tooth eruption (DTE) of permanent maxillary anterior teeth among Ukrainian children sample and to investigate the epidemiology distribution of delayed eruption cases according to their causes based on CBCT data.

Materials and Methods. Cone Beam Computed Tomography (CBCT) data sets of 684 children (304 boys and 380 girls) aged 7–14 years old, who previously have sought for orthodontic diagnostics in Central Laboratory Diagnosis of the Head (CLDH), were collected and examined to detect any delayed eruption of the permanent maxillary anterior teeth. Signs of delayed eruption were identified considering tooth developmental stages, relationships between the chronologic age and dental developmental age, eruption sequence.

Results. The total prevalence of delayed tooth eruption of permanent maxillary anterior teeth among the 684 children was 42.84%. 293 children (155 boys and 138 girls) had at least one impacted or retained tooth. The maxillary canines the most frequently demonstrated signs of delayed eruption and compiled 30.7% of all examined cases and 71.67% of all delayed eruption cases, followed by the lateral incisors of the maxilla – 6.58% and 15.36% respectively, and the central incisors – 5.56% and 12.97% respectively. Loss of space in dental arch and the ectopic eruption pathway were the most causative factor of delayed eruption of permanent maxillary anterior teeth.

Conclusions. Delayed tooth eruption of permanent maxillary anterior teeth is frequently seen in everyday orthodontic practice and requires a multidisciplinary approach of diagnostics to avoid many treatment-related complications. CBCT data is essential for timely diagnostics of DTE and primary for the causative factors identification in order to provide optimal and effective management plan for each patient.

Introduction

Tooth development and eruption is very complex process of mutual histogenesis and morphodifferentiation that begins in the embryonic period, between the 5th and the 6th week of prenatal development, and ends with the axial movement of the mineralized tooth structures to its functional position in the oral cavity, between the ages of 6 and 14 years for permanent teeth. The exception are the third molars, or wisdom teeth, which begin to develop during the fifth year of a child's life and erupt between the ages of 17 and 21 [1].

Odontogenesis occurs through an interaction between the epithelial cells from ectoderm of the oral cavity, which gives rise to enamel-producing cells, and the neural crest ectomesenchyme which gives rise to all other tooth structures except enamel. The BMPs, FGFs, Shh, Wnt and other families of signaling molecules are involved in fine-tuning interaction epithelial cells and mesenchymal

cells during odontogenesis [2].

It is known that tooth eruption is a multifactorial, multilevel and multidimensional process, which involves all the structures of developing tooth: root follicle, periodontal membrane, and crown follicle. Mechanosensory interactions mediate molecular and enzymatic activity, which in turn controls the timing of the cellular events of eruption. Also important is the orientation of PDL fibroblasts, which determines the tooth directional movement and sufficient space in the pathway of eruption [3, 4].

Genetic, epigenetic and environmental factors can lead to various anomalies in tooth development from agenesis and primary failure of eruption (PFE) to anomalies in the number, shape, size, structure, and location of the teeth [5].

Missing or unerupted permanent upper anterior teeth have a major impact not only on phonetics and on chewing function, but also on smile and facial aesthetics. These factors may have an effect on self-esteem and general social interaction of children, that`s why knowing the eruption time of teeth is extremely important to orthodontic treatment planning as early as possible.

Fundamentally, delayed tooth eruption (DTE) is evaluated in two methods. One is an estimate of chronologic age as resulting from population studies, and for each population there is expected tooth eruption time [6]. This method is commonly used by clinicians due to its ease realization. In addition, the clinician should suspect delayed tooth eruption when the contralateral tooth has erupted more than six months ahead or when the sequence of eruption is disordered [7]. Second method is an estimate of progression of root formation as a biological sign of tooth eruption. Exactly dental age assessment method is one of the most accurate chronological age estimation methods used for criminal, forensic, and anthropological purposes [8].

There are many systemic and local factors that can cause to tooth agenesis, delayed tooth development (DTD), tooth retention or impaction of the permanent maxillary anterior teeth, which will clinically manifest as delayed tooth eruption. It is known that congenital malformations like the cleft lip and palate, consequences of primary teeth trauma, loss of space in dental arch, supernumerary teeth or odontomas are the most common causes of delayed eruption of the permanent maxillary anterior teeth [9, 10, 11].

CBCT scans should be used in cases of delayed tooth eruption as objective tool for diagnostics of tooth agenesis, visualization and interpretation for locating the position of tooth, and for verification of any other developmental anomalies or pathologies. CBCT images is also useful in determining a dental age and helps to assess the stage of dental growth of teeth from initial tooth mineralization and crown formation to the maturation of the root apex [12].

There are only a several studies that have assessed the prevalence of DTE in permanent maxillary teeth among Ukrainian children, and most of them concerned the canine tooth [13, 14].

Objective

To estimate the prevalence of delayed tooth eruption (DTE) of permanent maxillary anterior teeth among Ukrainian children sample and to investigate the epidemiology distribution of delayed eruption cases according to their causes based on CBCT data.

Materials and Methods

Study sample

In this retrospective cross-sectional study CBCT data sets of 684 of children (304 boys and 380 girls) aged 7–14 years old, who previously have sought for orthodontic diagnostics in Central Laboratory Diagnosis of the Head (CLDH) (Kyiv, Ukraine) in period between 2016 and 2022, were collected. A simple randomized sampling protocol was used to select the necessary sample size. The exclusion criteria were children who did not fit into the age range of the study. All 684 CBCT datasets of children were examined to detect delayed eruption of the permanent maxillary anterior teeth.

CBCT images were acquired using i-CAT Gendex CB-500 (Imaging Sciences International, Hatfield, PA) CBCT machine, FOV 16×13 mm with voxel size 300 μm and a low-dose protocol.

The decision-making of diagnosis of delayed tooth eruption and the determination of the radiographically recognizable cause contributing to DTE of the permanent maxillary anterior teeth was performed independently by two assessors (MN and DL). The minor disagreements between the two examinators were resolved through the review of respective CBCT images to formulate an agreement. Inter- and intrarater reliability was calculated using a set of 140 randomly selected CBCT data with the use of percent agreement and kappa values [15].

The CBCT assessment was based on the Atlas of Tooth Development and Eruption in regard to the alveolar tooth eruption timing [16].

Signs of delayed tooth eruption were identified taking into account tooth developmental stages, relationships between the chronologic age and dental developmental age, eruption sequence, and problem teeth were also compared to the corresponding teeth on the opposite side in each age and gender.

Radiographic evaluation

The DICOM (Digital Imaging and Communications in Medicine) data of all selected cases was collected and evaluated using the iCATVision software (v1.9.2.17 Imaging Sciences International, Hatfield, PA, USA). This CBCT program with 3D reconstruction allowed the realization of multiplanar reconstructions with coronal axially guided navigation for the evaluation of developmental stages and the absolute position of the each permanent maxillary anterior teeth with respect to other structures, for the identifying an eruption pathway, abnormal tooth eruption and local causes of DTE like a supernumerary teeth/mesiodens, odontomas, oral clefts, ectopic displacement, arch-length deficiency, odontogenic and nonodontogenic cysts and gemination, fusion, twinning, root dilaceration and ankylosis of permanent teeth.

The contrast, brightness, and sharpness adjustments were used for more accurate image interpretation.

Teeth with evidence of DTE were identified based on normal stages explained in the Atlas of Tooth Development [16].

Data collection with precise relevant information of each patient included in this study was carried out and recorded.

Statistical analysis

The electronic primary database was created using Microsoft Excel 2016 (16.0.6769.2017) spreadsheets. Statistical analysis was performed by using the STATISTICA 10 by StatSoft software.

The initial analysis was based on the methods of variation statistics. The frequency analysis for qualitative parameters (values) comprised determining the absolute number of observations (n) and the distribution expressed as a percentage (%).

While analyzing the quantitative parameters, the mean values were determined, the variability and statistical significance were assessed, the arithmetic mean (M), the mean square (standard) deviation, and the mean error of the mean value (m) were calculated.

$\bar{x}$, representing the sample mean, was calculated by the formula:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

The sample variance is the average of the squared differences from the mean found in a sample. It shows how much each number in the data set differs from the mean. It was calculated by using the following formula:

$$D = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

The standard deviation is the arithmetic square root of the sample variance:

$$\sigma = \sqrt{D}$$

The standard deviation is expressed in the same units as the data being measured and it demonstrates how far the data differ from the mean value (in absolute units). The standard deviation is an absolute measure of dispersion. The standard deviation values were used to

set the limits of the 95% confidence intervals.

When comparing frequencies (qualitative features), a statistically significant difference between the compared groups was evaluated, the analysis was performed using the Chi-square test (χ2 test).

First, the expected number of observations in each cell of the contingency table was computed. For this, the sums of rows and columns (marginal totals) were multiplied, and the resulting product was divided by the overall observation totals. Chi-square test statistic, χ^2, was then calculated using the formula:

$$\chi^2 = \sum_{i=1}^{n}\sum_{j=1}^{n}\frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

where i is the row index (from 1 to n), j is the column index (from 1 to n),
Oij is the actual number of observations in cell ij,
Eij is the expected number of observations in cell ij.

χ^2 values were compared with the critical values for the number of degrees of freedom (n − 1) × (n − 1). In the event that the obtained χ^2 value exceeded the critical value, it was concluded that there was a statistically significant difference between the groups.

Based on two-by-two tables, if at least one cell of the table had a count less than 10 but greater than 5, the χ^2 value was calculated adjusted for the Yates correction, which allows reducing the detection of differences where there are none. The following formula was used:

$$\chi^2 = \sum_{i=1}^{n}\sum_{j=1}^{n}\frac{(|O_{ij} - E_{ij}| - 0{,}5)^2}{E_{ij}}$$

To compare parameters that had a small number of observations in subgroups (5 or less), in order to assess the significance of the intergroup difference in frequency distribution, Fisher's exact test was used. The following formula was applied.

$$p = \frac{(A+B)!\cdot(C+D)!\cdot(A+C)!\cdot(B+D)!}{A!\cdot B!\cdot C!\cdot D!\cdot N!}$$

where
A, B, C, D are the actual number of observations in the cells of the contingency table,
N is the total number of those studied,
! – factorial (product of a sequence of all integers, each of which is one fewer than the given number).

The obtained p value greater than 0.05 demonstrated no statistically significant difference. A p value of less than 0.05 was indicative of statistically significant difference.

All statistical estimates were examined for statistical significance at a level not less than 95% ($p < 0.05$). The statistical methods of analysis and calculated values were examined (compared) at a given marginal level of type I error (α) not higher than 5% ($p < 0.05$).

Results

The total study sample included 684 CBCT datasets of children (n = 684) with the mean age of 10.73 ± 0.17 years old. Among study sample 304 subjects were boys (44.44%) with the mean age of 10.5 ± 0.25, while 380 subjects were girls (55.56%) with the mean age of 10.92 ± 0.22 years old (Table 1). The inter- and intra-rater reliability for the CBCT images assessment was 0.92 and 0.88 respectively that indicates excellent agreement between assessors.

Table 1. Prevalence of DTE of permanent maxillary anterior teeth cases according to age

	Boys, n	Mean age, ±	Girls, n	Mean age, ±	Total, n	Mean age, ±
Total cases	304	10.50 ± 0.25	380	10.92 ± 0,22	684	10.73 ± 0.17
Normal, incl. tooth agenesis	149	11.09 ± 0.39	242	11.31 ± 0.35	391	11.23 ± 0.22
Delayed Tooth Eruption, incl. oral cleft	155	9.94 ± 0.30	138	10.22 ± 0.33	293	10.07 ± 0.22

The cases of tooth agenesis (n = 10) were included in normal cases group and then were eliminated from the study. The cases of oral cleft (n = 11) were included in DTE cases group. DTE of the permanent maxillary anterior teeth was found in 293 children (42.84%), of whom 155 (22.66%) were boys and 138 (20.17%) were girls, out of the total number of analyzed cases (Table 2).

Table 2. Prevalence of DTE of permanent maxillary anterior teeth cases according to gender

	Boys, n (% of Total cases)	Girls, n (% of Total cases)	Total, n (% of Total cases)
Total cases	304 (44.44%)	380 (55.56%)	684 (100%)
Tooth agenesis	6 (0.88%)	4 (0.58%)	10 (1.46%)
Normal	143 (20.9%)	238 (34.80%)	381 (55.7%)
Delayed Tooth Eruption	148 (21.64%)	134 (19.59%)	282 (41.23%)
Oral cleft	7 (1.02%)	4 (0.58%)	11 (1.61%)
p-value		p < 0.05	

Among the total cases with DTE of permanent maxillary anterior teeth (n=293, incl. oral cleft), 78 (26.2%) were bilateral, and 215 (73.38%) presented a unilateral delayed eruption, of which 123 cases were left-sided, while 92 were right-sided DTE cases. The distribution of DTE by gender demonstrated that boys were more frequently affected by this condition (Table 3).

Table 3. Prevalence of DTE of permanent maxillary anterior teeth cases according to different variables

	Boys, n	% of DTE cases	% of Total cases	Girls, n	% of DTE cases	% of Total cases	Total, n	% of DTE cases	% of Total cases
DTE, incl. oral cleft	155	52.9%	22.66%	138	47.1%	20.18%	293	100%	42.84%
Bilateral	40	13.65%	5.85%	38	12.97%	5.56%	78	26.62%	11.41%
Unilateral	115	39.25%	16.81%	100	34.13%	4.62%	215	73.38%	31.43%
left-sided	61	20.82%	8.92%	62	21.16%	9.06%	123	41.98%	17.98%
right-sided	54	18.43%	7.89%	38	12.97%	5.56%	92	31.40%	13.45%

Based on formulated sample the most frequently delayed eruption teeth were the canines (n = 210) either unilaterally or bilaterally, which compiled 30.7% of total examined cases or 71.67% of total delayed cases, followed by lateral incisors with a total number of 45 cases and 6.58% and 15.36% respectively, while most rarely affected were the central incisors (n = 38), which formed 12.97% of the total cases or 5.56% of DTE cases (Table 4).

Table 4. Frequency distribution of DTE of permanent maxillary anterior teeth according to the individual tooth class, gender and age

	DTE, n	% of Total	% of DTE	Mean age, ±	Boys, n	% of Total	% of DTE	Mean age, ±	Girls, n	% of Total	% of DTE	Mean age, ±
DTE, incl. oral cleft	293	42.84%	100 %	10.07 ± 0.22	155	22.66%	52.90%	9.94 ± 0.30	138	20.18%	47.10%	10.22 ± 0.33
Central incisor	**38**	**5.56%**	**12.97%**	**8.97 ± 0.53**	**24**	**3.51%**	**8.19%**	**9.00 ± 0.58**	**14**	**2.05%**	**4.78%**	**8.93 ± 1.06**
right	13	1.90%	4.43%	9.46 ± 0.98	8	1.17%	2.73%	9.63 ± 1.11	5	0.73%	1.7%	9.20 ± 2.00
left	21	3.07%	7.17%	8.76 ± 0.69	13	1.90%	4.44%	8.69 ± 0.72	8	1.17%	2.73%	8.88 ± 1.46
Bilateral	4	0.58%	1.37%	8.50 ± 1.27	3	0.44%	1.03%	8.67 ± 1.73	1	0.15%	0.34%	8.00 ± 0.00
Lateral incisor	**45**	**6.58%**	**15.36%**	**8.60 ± 0.42**	**29**	**4.24%**	**9.9%**	**8.66 ± 0.52**	**16**	**2.34%**	**5.46%**	**8.63 ± 0.69**
right	14	2.05%	4.78%	8.86 ± 0.74	9	1.32%	3.08%	8.78 ± 0.91	5	0.73%	1.7%	9.00 ± 1.39
left	21	3.07%	7.17%	8.57 ± 0.55	13	1.90%	4.44%	8.62 ± 0.61	8	1.17%	2.73%	8.75 ± 1.03
Bilateral	10	1.46%	3.41%	8.30 ± 1.10	7	1.02%	2.39%	8.57 ± 1.53	3	0.44%	1.03%	7.67 ± 0.65
Canine	**210**	**30.70%**	**71.67%**	**10.91 ± 0.24**	**102**	**14.91%**	**34.82%**	**10.8 8 ± 0.33**	**108**	**15.79%**	**36.85%**	**10.73 ± 0.34**
right	65	9.50%	22.18%	11.40 ± 0.45	37	5.41%	12.63%	11.22 ± 0.55	28	4.09%	9.55%	11.21 ± 0.72
left	81	11.84%	27.65%	11.10 ± 0.43	35	5.12%	11.95%	11.09 ± 0.65	46	6.73%	15.7%	10.87 ± 0.56
Bilateral	64	9.36%	21.84%	10.19 ± 0.29	30	4.39%	10.24%	10.23 ± 0.38	34	4.97%	11.6%	10.15 ± 0.42

As far as the causative factors of DTE of permanent maxillary anterior teeth was concerned, 257 cases presented one CBCT sign responsible for DTE, while 36 cases presented combined CBCT signs with arch-length deficiency.

Table 5 shows that the most causative factor of DTE of permanent maxillary anterior teeth was arch-length deficiency that was reported in 187 cases, which amounted for 27.34% of total cases and 63.82% of DTE cases. The next most common CBCT-registered cause was the ectopic eruption pathway, observed in 33 cases, which stands for 4,82% of total cases and for 11.26% of DTE cases. In total, 1.6% of the sample (n=11) presented oral cleft (lip and palate), more often in association with arch-length deficiency.

Concerning the rest of the causative factors, supernumerary teeth (mesiodens) was presented in 28 cases that accounted for 4.09% of total cases and for 9.55% of DTE cases, while odontogenic cyst was identified in 20 cases (2.93% and 6.85% respectively).

The least common causative factors of DTE of permanent maxillary anterior teeth were: odontoma, which was found in 6 cases (0.88% of total cases and 2.05% of DTE cases); root dilaceration – in 5 cases (0.73% of total cases and 1.71% of DTE cases); and ankylosis – in 3 cases (0.44% and 1.02% respectively).

Table 5. Frequency distribution of DTE of permanent maxillary anterior teeth according to causes, gender and age

	n	% of Total	% of DTE	Mean age, ±	Boys, n	% of Total	% of DTE	Mean age, ±	Girls, n	% of Total	% of DTE	Mean age, ±
Oral Cleft (Lip and Palate)	11	1.60%	3.75%	10.30 ± 1.37	7	1.02%	2.39%	10.33± 2.24	4	0.58%	1.36%	10.25 ± 1.23
Arch-length Deficiency	187	27.34%	63.82%	10.12 ± 0.27	99	14.47%	33.79%	9.86 ± 0.35	88	12.87%	30.03%	10.41 ± 0.41
Odontoma	6	0.88%	2.05%	9.50 ± 1.41	1	0.15%	0.34%	9.0 ± 0.00	5	0.73%	1.71%	9.6 ± 1.71
Supernumerary Tooth	28	4.09%	9.55%	8.83 ± 0.93	18	2.63%	6.14%	8.33 ± 1.09	10	1.46%	3.41%	9.33 ± 1.49
Ectopic Eruption Path	33	4.82%	11.26%	10.62 ± 1.14	16	2.34%	5.46%	11.00 ± 1.39	17	2.48%	5.8%	9.75 ± 2.02
Odontogenic cyst	20	2.93%	6.85%	10.8 ± 1.04	9	1.32%	3.1%	11.00 ± 1.60	11	1.61%	3.75%	10.64 ± 1.43
Ankylosis	3	0.44%	1.02%	10.06 ± 0.72	2	0.29%	0.68%	10.6 ± 0.55	1	0.15%	0.34%	9.00 ± 0.00
Root Dilaceration	5	0.73%	1.71%	9.4 ± 2.53	3	0.44%	1.02%	9.00 ± 3.92	2	0.29%	0.68%	10.00 ± 3.92
One CBCT Sign	**257**	**37.57%**	**87.72%**	**9.96 ± 0.22**	**136**	**19.88%**	**46.42%**	**9.85 ± 0.30**	**121**	**17.69%**	**41.3%**	**10.19 ± 0.35**
Combined CBCT sign with Arch-length Deficiency	**36**	**5.26%**	**12.28%**	**9.64 ± 0.56**	**19**	**2.78%**	**6.48%**	**9.74 ± 0.72**	**17**	**2.48%**	**5.8%**	**9.53 ± 0.91**

CBCT images indicated for local etiological factors are presented in Figure 1 - 5.

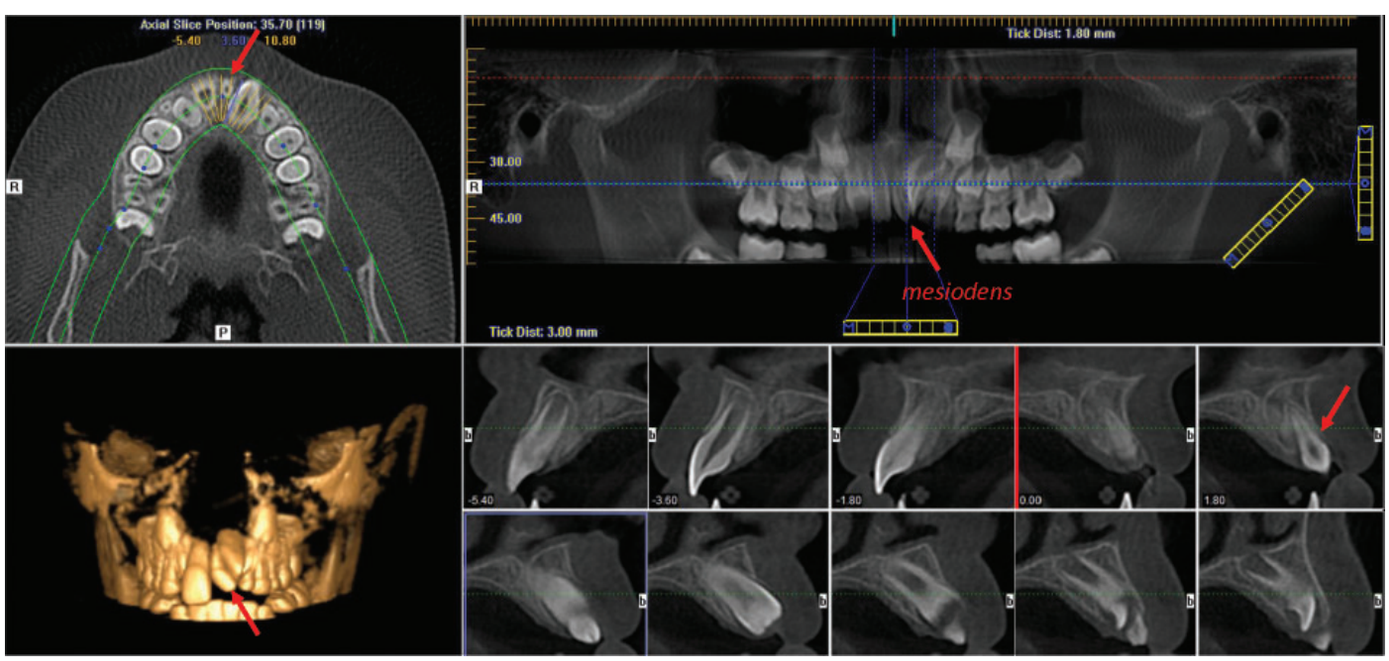

Figure 1. CBCT images showing delayed eruption of permanent left upper central incisor due to presence of supernumerary tooth (mesiodens)

Discussion

Teeth eruption disorders represent specific clinical conditions, caused by the influence of local factors provoking delay in chronological tooth eruption or even total eruption failure, while also number of genetic syndromes associated with the altered tooth emergence (regional odontodysplasia, Gardner syndrome, cleidocranial dysplasia, Albers-Schönberg osteopetrosis, mucopolysaccharidosis, Nance–Horan syndrome) [17, 18].

As previously was proposed clinical diagnosis of delayed tooth eruption could be establish only after considering mean age for eruption of specific teeth and stage of root formation registered radiologically [19]. Delay in chronological tooth eruption may be suspected if the contralateral tooth has erupted more than six months ahead, or in cases were normal sequency of tooth eruption was altered due to the different causes [20]. Considering observed difference in bilateral timing of permanent tooth emergence it was found that mean delay in chronological tooth eruption seems to be smaller for the teeth erupting in the earlier age compared to such erupting after 9-10 years old [19], nevertheless it remains of great clinical significance to distinguish situations with delayed tooth eruption and eruption failure in situations of present teeth

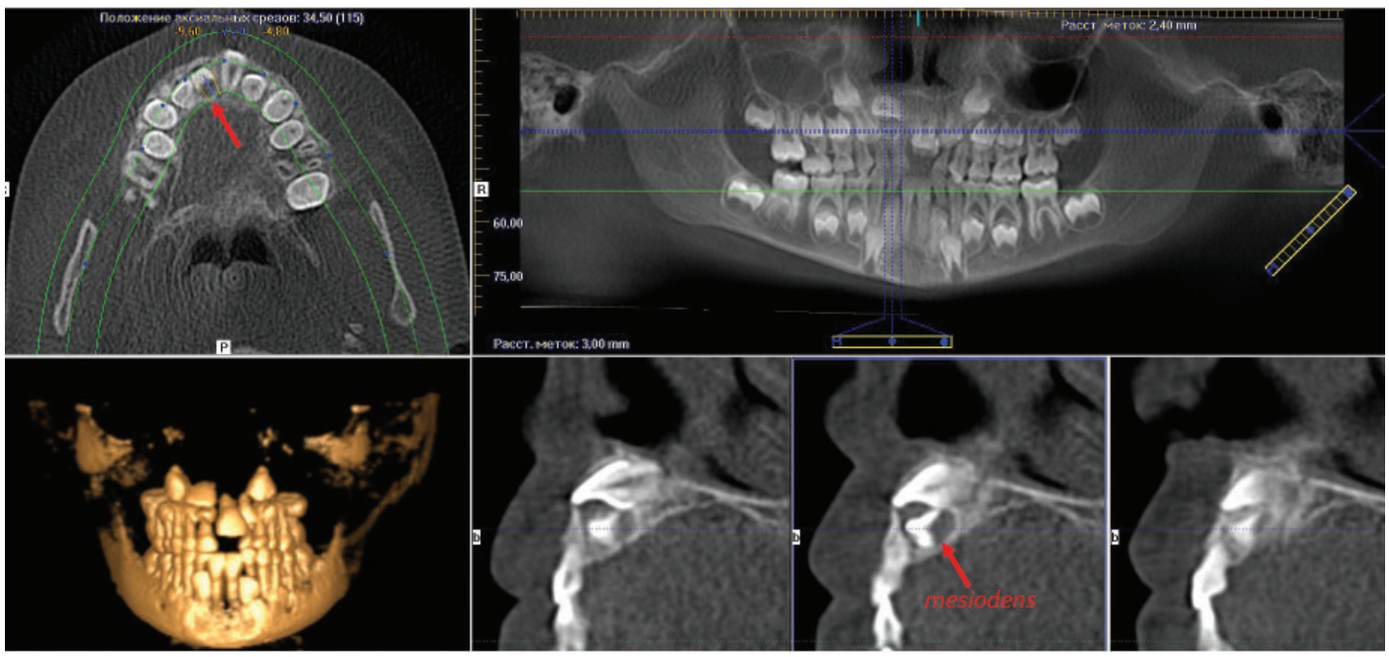

Figure 2. CBCT images demonstration delayed eruption and ectopic eruption path of permanent right upper central incisor due to presence of supernumerary tooth (mesiodens) and to retained right primary upper central incisor

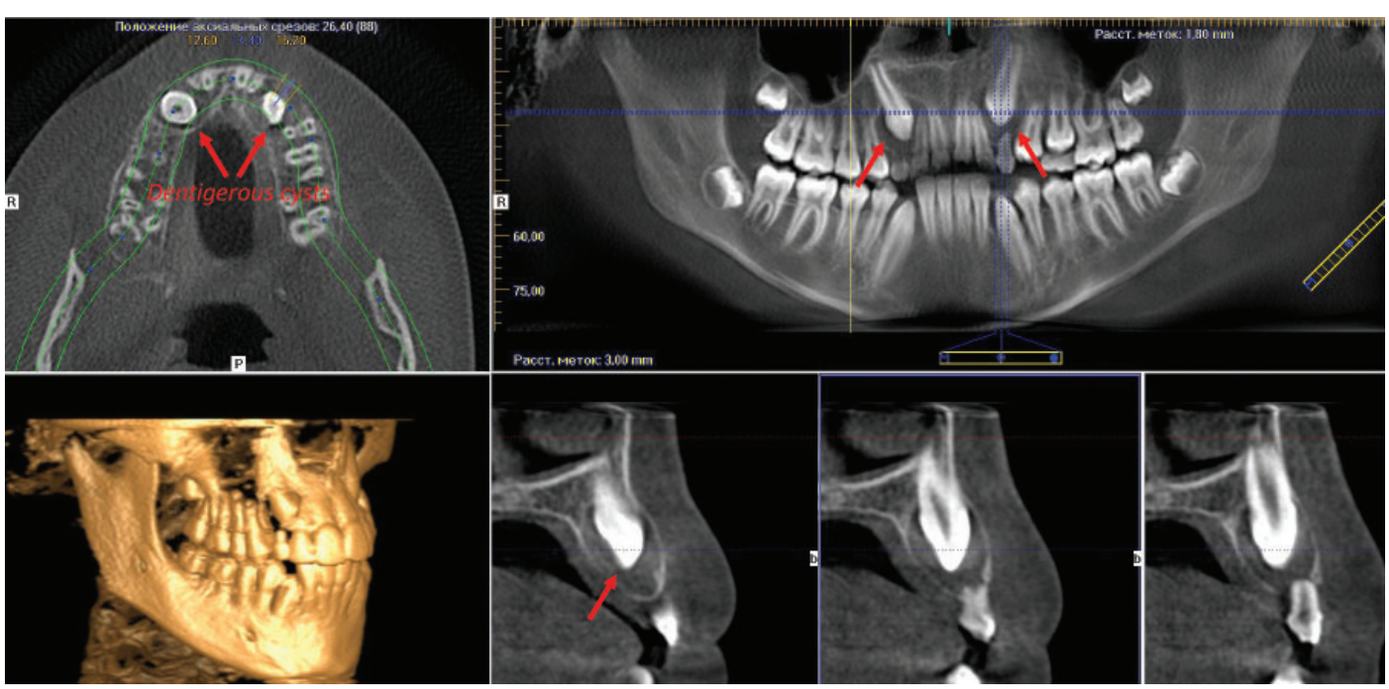

Figure 3. CBCT images showing bilateral delayed tooth eruption of permanent upper canines due to presence of Odontogenic cysts (Dentigerous) and to retained primary upper canines

germs. In persons with different somatic diseases delay in tooth eruption seems to increase with an age, reaching up to 54.2% prevalence among examined patient in the age older than 10 years [21].

Previous analysis of orthopantomograms' database revealed that the prevalence of delayed eruption of permanent central incisor was equaled to 3.09%, while also more cases were registered among boys compare to girls (69.5%:30.4%) [20]. Such outcomes of Aldowsari et al. research is in full correspondence with data that has been obtained in present study, since prevalence of delayed eruption of permanent central incisors was 3.51% for boys and 2.05% for girls. Tan et al. reported analogical level of prevalence for delayed tooth eruption of permanent incisors among children and adolescents equaled to 2% [22]. Even though the total prevalence of delayed eruption of permanent central incisors in present study is little higher compared to such presented in the previous retrospective cross-sectional study (5.56% vs. 3.09%), such diversity seems not to be clinically significant, while also it may be caused by the differences of using OPG and CBCT images, variations of analyzed study samples regarding their size and age range of study subjects (6-10 years vs. 7-17 years), and different origins of the subjects included into study sample. Pattern of greater prevalence for delayed tooth eruption

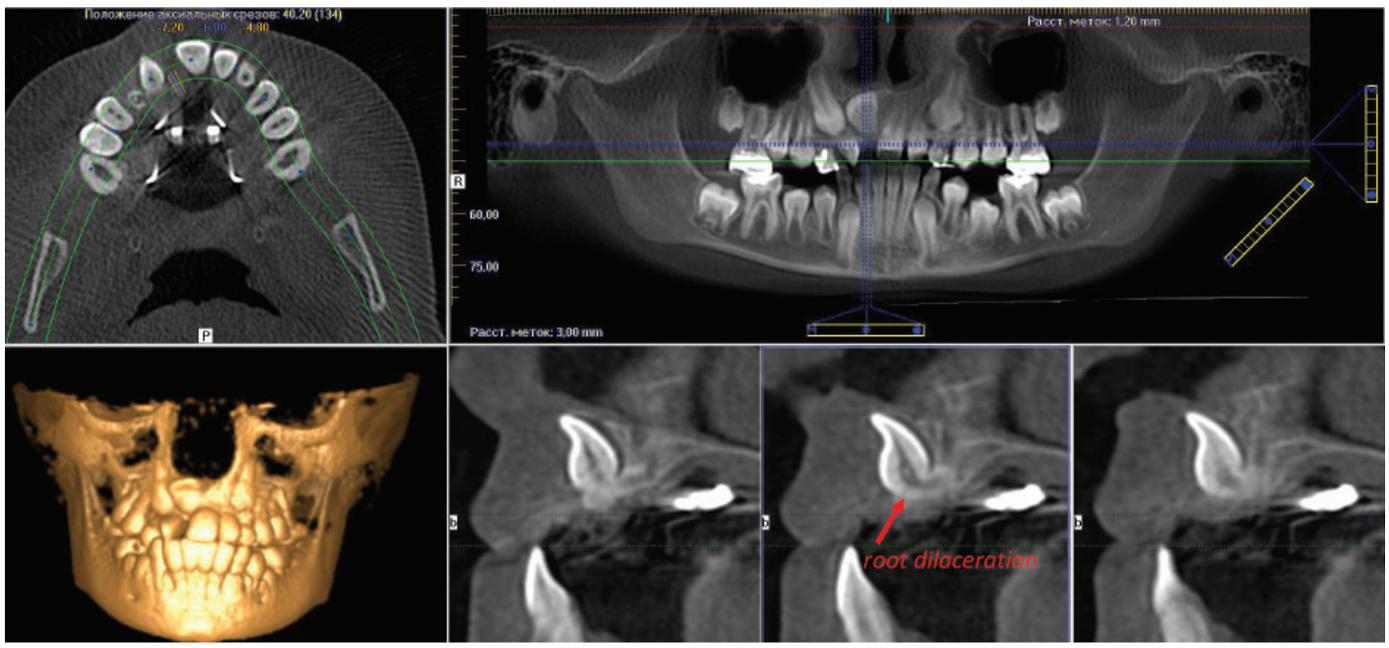

Figure 4. CBCT images demonstration delayed eruption of permanent right upper central incisor due to presence of its root dilaceration and ankylosis

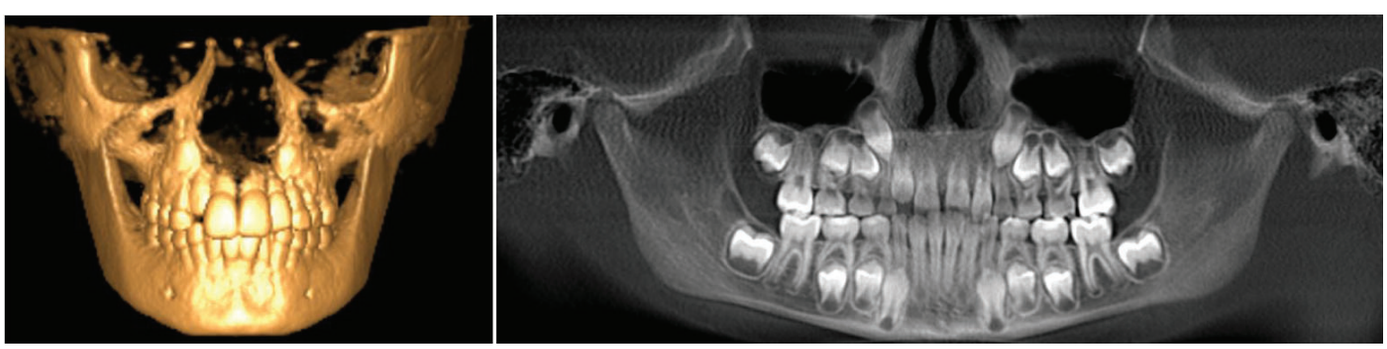

Figure 5. CBCT images showing delayed eruption of permanent right upper lateral incisor due to presence of the arch-length deficiency

among boys was noted in present research, while also in several previous studies of retrospective design [20, 22].

Recent clinical observation demonstrated that unilateral delayed eruption of anterior maxillary teeth may be registered three times more frequently than bilateral (78% vs. 22%) [20], while the same outcome was also obtained in present CBCT-based study representing 73.38% of delayed tooth eruption for unilateral cases and 26.62% for bilateral cases.

Several previous studies reported following factors as a main cause of delayed eruption of permanent maxillary teeth: retained and early loss of primary teeth, deficient arch space, supernumerary teeth, malformed teeth due to the previously obtained trauma, ectopic position [20, 22]. Traumatic displacement of the primary tooth may affect the development of the permanent tooth germ and further potentially may be associated with delayed eruption of permanent maxillary anterior teeth.

In present study it was found that arch-length deficiency was a major cause of delayed tooth eruption, which accounted for 63.82% cases, while the registration frequency of other causes was statistically lower. Examination of large OPGs sample found that only 17.39% of delayed tooth eruption were caused by the deficient arch space, while 43.47% of cases were associated with retained deciduous teeth [20]. Such maladjustments between present and previously provided research may be argumented by the differences of sample size, origin of study subjects, and age range of orthodontic patients that were analyzed during research.

Retrospective study of hospital records reviewed from 15987 children and adolescents found that three main causes of delayed tooth eruption for maxillary permanent anterior teeth were: dilacerations, supernumerary teeth and ectopic position of tooth bud [22]. Even though only some results obtained in the study of Tan et al. differs from those obtained in our research due to the differences of study sample size, but previously authors also have found that 20% and 2.2% of delayed tooth eruption cases were associated with not single, but two or even three underlying causes respectively [22]. Similarly in our research 12.28% of delayed tooth eruption cases were associated with combined CBCT signs of potential causes, rather than with single sign.

In previous research ectopic eruption and supernumerary tooth were responsible for 8.69% and 4.34% of delayed maxillary anterior tooth eruption cases [20]. Other studies reported that up to 26-52% of supernumerary teeth cases may be associated with delayed eruption of permanent teeth [23], on the other hand prevalence of supernumerary teeth seems to reach only up to 2% [24]. Due to the results obtained in present research ectopic eruption pathway, presence of supernumerary teeth and odontogenic cyst formed a triade of second the most prevalent causes of delayed tooth eruption, associated with 11.26%, 9.55% and 6.85% of affected cases respectively.

Oral cleft condition in present study was associated with 3.75% cases of delayed tooth eruption, which is in consistency of available data obtained during cross-sectional study [20]. Latter demonstrated that 4.34% cases of DTE may be related with cleft lip and palate [20]. Cleft palate seems to be associated with delay in tooth development,

which exceeds 6 months period [25, 26].

Animal model studies demonstrated that delayed tooth eruption may be also related to the genetic polymorphism, such as of rs17099443 in MMP8, which authors proposed to use as markers for delayed chronology of permanent teeth development and emergence [27]. Arid et al. reported that rs9594738 in RANKL may be related with delayed permanent tooth emergence with the odds ratio of 1.71 [28]. Also, osteoclast dysfunction mediated through osteoclast-specific lncRNA seems also to be a factor associated with delayed tooth eruption [29]. Systematic review has approved the role of genetic factors on delayed tooth eruption development based on results of longitudinal studies, while also highlighted the need in further genome-wide association studies to clarify cause-effect relationship [30]. Some authors single out so-called drug-induced form of delayed tooth eruption associated with the long-term consumption of nonsteroidal anti-inflammatory drugs and some bisphosphonates [18].

Recently vitamin D deficiency was categorized with greater odds ratio of delayed tooth eruption associated with persisted primary tooth [31], while approbation of nicotinamide demonstrated improvement of delayed tooth eruption condition in in vitro conditions [32].

Several approaches have been proposed for correct decision-making and further management of unerupted teeth and such within delayed eruption condition, due to which CBCT plays an important role in objectification of cause and peculiarities of each individual clinical situation, while also in planning sequence and timing of needed intervention to minimize risks of potential complications [33].

Limitations of present study associated with its retrospective design, due to which anamnesis of the patients could not be analyzed in full manner to detail all potential causes of the delayed anterior maxillary tooth eruption. Nevertheless, sufficient size of study sample, exact compliance with the criteria provided by Atlas of Tooth Development, and diagnostics of DTE based on complex assessment approach (evaluation of tooth developmental stages, comparison of the chronologic age and dental developmental age, specification of eruption sequence) supported high quality of evidences regarding prevalence and epidemiology distribution of tooth delayed eruption cases considering their causes. Also, it should be kept in mind that there is a deficiency of studies dedicated to the objectification of delayed tooth eruption prevalence among Ukrainian population, so provided research represents novel clinically significant information that should be considered by dental specialists in everyday practice.

Moreover, relatively high level of delayed tooth eruption prevalence noticed in present study should be considered not only in clinical dental practice, but also during the use of forensic odontology methods for the age estimation purposes. Delay in tooth development and tooth eruption may cause significant deviation of dental age in relation to chronological one thus limiting effectiveness and validity of standard dental age estimation techniques [8]. Nevertheless, such limitations may be overcome by implying correction coefficients into the standard regression formula, or by adjusting regression coefficients themselves after clinical and X-ray approvement of delayed tooth eruption condition. Considering above-mentioned factors, it seems to be reasonable to focus future forensic dental research on quantification of delayed tooth eruption effect on accuracy and preciseness of dental age estimation techniques taking into account variations of dental age in relation to chronological age.

Conclusions

The present study is the first to assess the prevalence of delayed tooth eruption of the permanent maxillary anterior teeth among Ukrainian children population considering parameters of gender, age, individual tooth class and the causes of DTE based on CBCT data. Delayed tooth eruption of permanent maxillary anterior teeth is frequently seen in everyday orthodontic practice and requires a multidisciplinary approach of diagnostics to avoid many treatment-related complications. CBCT data is essential for timely diagnose of DTE and primary for the causative factors identification in order to provide optimal and effective management plan for each patient.

Conflict of Interest

The authors hereby confirm absence of association with any organization or company that may have any financial or non-financial interest in the materials of research discussed in this article.

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Поширеність затримки прорізування постійних передніх зубів верхньої щелепи серед українських дітей: ретроспективне рентгенографічне дослідження з використанням даних КПКТ

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затримка прорізування зубів, КПКТ, постійні передні зуби, верхня щелепа, поширеність, етіологія затримки, українські діти

Анотація

Вступ. Прорізування зубів представляє собою складний, багатоетапний і специфічно врегульований біологічний процес, асоційований з віком, на який можуть впливати багато системних і місцевих факторів. Важливим для клініциста є відхилення від норми терміну прорізування більш ніж на ±2SD з урахуванням впливу расових, етнічних та гендерних параметрів.

Мета. Оцінити поширеність затримки прорізування (ЗПЗ) постійних передніх зубів верхньої щелепи серед вибірки українських дітей та встановити епідеміологічний розподіл випадків затримки прорізування з урахуванням причин їх виникнення на основі даних КПКТ.

Матеріали та методи. Було відібрано та досліджено набори даних даних конусно-променевої комп'ютерної томографії (КПКТ) 684 дітей (304 хлопчиків та 380 дівчаток) віком 7–14 років, які раніше зверталися з метою діагностики перед ортодонтичним лікуванням в Центральну лабораторію досліджень щелепно-лицевої ділянки та ЛОР органів (CLDH) з метою верифікації ознак затримки прорізування постійних передніх зубів верхньої щелепи. Виявлення ознак затримки прорізування проводили з урахуванням стадій розвитку зубів, співвідношення хронологічного віку та дентального віку, послідовності прорізування.

Результати. Загальна поширеність затримки прорізування постійних передніх зубів верхньої щелепи серед 684 дітей становила 42,84%. У 293 дітей (155 хлопчиків і 138 дівчаток) був ідентифікований принаймні один імпактний або ретенований зуб. Найчастіше затримкою прорізування характеризувалися ікла верхньої щелепи, які складали 30,7% серед усіх клінічних випадків та 71,67% серед усіх випадків затримки прорізування, бічні різці верхньої щелепи – 6,58% і 15,36% відповідно, і центральні різці – 5,56% і 12,97% відповідно. Дефіцит місця в зубній дузі та ектопічний шлях прорізування були найбільш поширеними причинами, що провокували затримку прорізування постійних передніх зубів верхньої щелепи.

Висновки. Затримка прорізування постійних передніх зубів верхньої щелепи часто зустрічається в повсякденній ортодонтичній практиці та вимагає мультидисциплінарного підходу до діагностики з метою уникнення багатьох ускладнень лікування в майбутньому. Дані КПКТ мають важливе значення для своєчасної діагностики ЗПЗ та є критично-необхідними для ідентифікації причинних факторів порушення, що в подальшому сприяє оптимальному та ефективному плануванню та реалізації лікувальних заходів у кожному індивідуальному випадку.

Заява про конфлікт інтересів
Цим автори підтверджують відсутність зв'язку з будь-якою організацією чи компанією, яка може мати будь-який фінансовий або нефінансовий інтерес до матеріалів дослідження, розглянутих в цій статті.

Заява про фінансування
Не було отримано жодного фінансування для допомоги в підготовці та проведенні цього дослідження, а також для написання цієї статті.

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