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## Delayed eruption of permanent maxillary first molars among Saudi children: A cross-sectional study

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## ABSTRACT

**Aim:** This retrospective cross-sectional study aimed to determine the prevalence of delayed development and eruption of permanent maxillary first molars (U6) and associated dental anomalies in a sample of Saudi children. **Material and methods:** In total, 10,232 panoramic radiographs from 9,672 patients were screened for delayed U6 eruption. Radiographs showing delayed U6 eruption were further examined for associated dental anomalies. The dental age of participants was estimated using The London Atlas of Human Tooth Development and Eruption. **Result:** Twenty cases of delayed U6 eruption were found, with a prevalence of 0.2%. Of these patients, 3 and 17 were males and females, respectively; 9 and 11 cases were unilateral and bilateral, respectively. Congenital absence of the adjacent permanent second molar was observed in 8 cases, and the congenital absence of permanent teeth, except the adjacent second permanent molar and third molar, was observed in 6 cases. Peg-shaped lateral incisors were observed in 6 females. No significant associations were observed between delayed U6 eruption and dental anomalies. Overall, the average delayed U6 eruption was 2.3 years for males and 2.8 years for females.

**Conclusion:** Among a sample of Saudi children, the prevalence of delayed U6 eruption was 1 in 483 (0.2%) and five times higher in females. No significant associations were found between delayed U6 eruption and dental anomalies; however, congenital absence of the adjacent permanent second molar was observed in 40% of cases.

## 1. Introduction

The term “tooth eruption” refers to the process by which a tooth moves axially from the site of its development in the alveolar bone to the occlusal plane within the oral cavity (Ten Cate, 1998). Although tooth eruption is largely determined by genetics, a number of other factors—such as sex, socioeconomic level, craniofacial morphology, body weight, and height—can influence it (Almonaitiene et al., 2010). Generally, disturbances in tooth eruption can be attributed to either local causes, such as ectopic eruption, the presence of physical obstacles—such as odontomas—or systemic conditions (Suri et al., 2004). In clinical practice, delayed tooth eruption is the most frequently encountered variation (Suri et al., 2004). Suri et al. defined chronologic delayed tooth eruption as an eruption time that differs by over two standard deviations from the average expected chronologic eruption time for a specific tooth (Suri et al., 2004).

The eruption of the permanent maxillary first molar (U6) is crucial for occlusion development, establishing the vertical dimension of the face, and increasing masticatory force (Andrews, 1972; Proff et al., 2006). It also plays a significant role as an anchorage tooth in orthodontic treatment (Proff et al., 2006). In Saudi children, the mean U6 eruption time was 5.83 years in males (Khan et al., 2006), and 6.41 years in females (Chohan et al., 2007).

Delayed development and eruption of the U6 may result in unstable occlusion, which can negatively affect oral function (Proff et al., 2006). Several studies have reported the delayed U6 development and eruption in the absence of physical obstacles, while the development and eruption of permanent mandibular first molars occurred normally (Rasmussen, 1998; Nakano et al., 1999; Sano et al., 2010, 2015; Klein et al., 2016; Lee et al., 2017). Rasmussen (1998) was the first to describe 10 cases of delayed eruption of permanent first molars, which were delayed until around age nine. He named the delayed erupted U6 as “nine-year

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molars” based on the Scandinavian tradition of naming the first permanent molars as 6-year molars and the second permanent molars as 12-year molars (Rasmussen, 1998). In 1999, Nakano et al. investigated the prevalence of delayed U6 eruption in Japanese children, finding nine cases from 353 panoramic radiographs, a frequency of 2.6%. The authors posed the question of whether this was a delayed U6 eruption or an early eruption of the second molar associated with congenitally missing first molars (Nakano et al., 1999). Sano et al. (2010) evaluated 51 Japanese children with delayed U6 eruption and found that the average delayed eruption time was 2.09 years in males and 2.84 years in females (Sano et al., 2010). A study by the same author reported that the prevalence of delayed U6 eruption from 2001 panoramic radiographs obtained from 73 patients was 1.55%, with bilateral occurrence in 80% of cases and a male-to-female ratio of 1:2.65 (Sano et al., 2015). A study at the University of Colorado reported the prevalence of delayed U6 eruption in 13,140 children to be 0.4%, with an average delayed eruption time of 2.48 years in males and 2.93 years in females, and a male-to-female ratio of 1:2.1 (Klein et al., 2016). Another study analyzing the panoramic radiographs of 40 children with delayed U6 eruption found delayed development of adjacent second permanent molars in 39 quadrants, congenitally missing molars in 30 quadrants, and congenitally absent of permanent teeth in 23 (57.5%) children (Lee et al., 2017). The dilemma of delayed U6 development and eruption, its prevalence, associated dental anomalies, controversial issues related to the type of this anomaly (delayed eruption vs. congenitally missing), and the nomenclature of this anomaly require further investigation.

The aims of this retrospective cross-sectional study were to: 1) determine the prevalence of delayed eruption of U6 in a sample of Saudi children, 2) assess the relevant dental anomalies associated with it, and 3) suggest categorization and revision of the nomenclature of this anomaly.

## 2. Materials and methods

### 2.1. Ethical approval

The research methodology of this study was approved by Institutional Review Board (E-21-6409), followed by being approved and registered in the College of Dentistry Research Center (CDRC) (FR 0617) at King Saud University (KSU).

### 2.2. Sample selection

This retrospective study was conducted at the Dental University Hospital (DUH), KSU, Riyadh, Saudi Arabia. All digital panoramic radiographs of Saudi children aged (8–12 years) taken between September 2015 and January 2022 at the DUH were obtained from the information technology (IT) department of the dental clinics. Planmeca Romexis 3.6.0. R software was used to view all digital panoramic radiographs on a screen (HP ProDisplay P201) with the naked eye. A child was considered to have delayed U6 eruption if the following criteria were satisfied: 1) U6 not yet erupted, 2) all permanent maxillary and mandibular incisors erupted, 3) the mandibular first permanent molar erupted, 4) no history of extracted U6, and 5) no local causes of delayed tooth eruption (such as odontoma or ectopic eruption). The initial screening was conducted independently by two senior residents in pediatric dentistry (NWA and TAA) to obtain cases that satisfied the inclusion criteria. Both investigators reviewed the radiographs together to confirm the diagnosis and determine the prevalence of delayed U6 eruption. The radiographs were further examined to identify any coexisting dental anomalies. All anomalies were recorded and tabulated. Then, each identified child’s medical health history was reviewed and any associated medical conditions recorded.

The date of birth recorded in each patient’s file was subtracted from the date of the panoramic radiograph to calculate their chronological age. Dental age was estimated by direct comparison of the panoramic

radiographs with the diagram of The London Atlas of Human Tooth Development and Eruption, utilizing the permanent dentition of the left quadrant in the lower jaw (AlQahtani et al., 2010).

### 2.3. Statistical analysis

Data were coded, entered into a Microsoft Excel spreadsheet, and analyzed using SAS software (version 9.4; SAS Institute, Inc., Cary, NC, USA). For descriptive statistics, continuous variables are presented as means and standard deviations (SD), and categorical variables are presented as frequencies and percentages. The Fisher’s exact test was used to assess the association between the presence of delayed eruption permanent molars and categorical variables. The normality of continuous variables was assessed using the Shapiro–Wilk test. The chronological age in years was normally distributed; thus, the independent *t*-test was used to assess the association between chronological age and the presence of delayed eruption of permanent molars. The Mann–Whitney *U* test was used to assess the association between dental age and the presence of delayed eruption of permanent molars, as the data for dental age were non-normally distributed. The significance level for all tests was set at  $p \leq 0.05$ .

## 3. Results

A total of 10,232 panoramic radiographs from 9,672 patient records (47.1% males and 52.9% females) were reviewed, of which 20 cases presented with delayed U6 eruption. Thus, the prevalence of delayed U6 eruption was 1 in 483 (0.2%) (Table 1). Among the 20 cases, 3 were male (15%) and 17 were female (85%); thus, the male:female ratio is 1:5.6. Of these cases, 9 were unilateral (45%; 4 M on the right side and 5 on the left) and 11 were bilateral, for a total of 32 involved molars (Fig. 1).

In the 20 cases of delayed U6 eruption, congenital absence of the adjacent permanent second molar was observed in 8 cases, with a total of 12 teeth (7 females, 1 male) (Table 2). Congenital absence of permanent teeth, except the adjacent second molar or third molar, was noticed in 6 cases, with a total of 10 missing teeth. Peg-shaped lateral incisors were observed in 6 females with a total of 8 teeth. In one patient, 2 delayed erupted U6 showed taurodontism (Fig. 2). Two patients had a significant medical history (one had cleft lip and palate, and the other was diagnosed with delayed growth).

No significant differences were detected in terms of chronological and dental age between males and females, or between unilateral and bilateral cases. The average chronological age of males and females was 9.03 and 8.92 years, respectively; while the average dental age for males and females was 7.83 and 8.26 years, respectively. Overall, dental development was delayed by 14.4 months in males and 7.9 months in females. The average delayed U6 eruption were 2.3 years and 2.8 years for males and females, respectively.

**Table 1**  
Distribution of delayed eruption of U6.

Variable	N (%)	Chronological age in years, Mean±(SD)	Dental age in years, Mean±(SD)
Gender			
Male	3 (15.0)	9.03 (0.5)	7.83 (1.15)
Female	17 (85.0)	8.92 (0.85)	8.26 (0.9)
Lateral distribution			
Unilateral	9 (45.0)	8.67 (0.8)	8.06 (0.88)
Bilateral	11 (55.0)	9.15 (0.75)	8.32 (0.98)

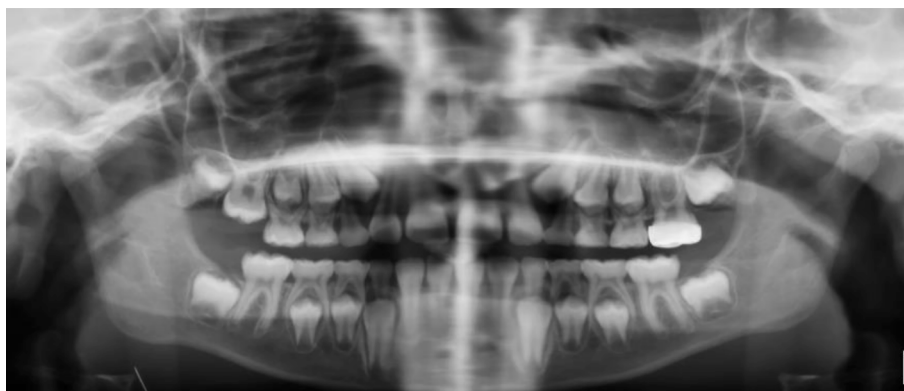


Fig. 1. Example of unilateral delayed eruption of U6 (Right side).

Table 2

Analytical statistics of associated anomalies, chronological and dental age with gender and lateral distribution.

Variable	CasesN (%)	Male 3 (15.0)	Female 17 (85.0)	P value	Unilatera 19 (45.0)	Bilateral 11 (55.0)	P value
Missing adjacent upper second molar Cases, N (%)	8 (40.0)	1 (12.5)	7 (87.5)	1*	4 (50.0)	4 (50.0)	1*
Congenitally missing teeth other than upper second molar or third molar Cases, N (%)	6 (30.0)	1 (16.7)	5 (83.3)	1*	3 (50.0)	3 (50.0)	1*
Peg shape lateral Cases, N (%)	6 (30.0)	0 (0.0)	6 (100.0)	0.52*	1 (16.7)	5 (83.3)	0.16*
Variable		Male	Female	P value	Unilateral	Bilateral	P value
Chronological age in years, Mean±(SD)		9.03 (0.5)	8.92 (0.85)	0.82**	8.67 (0.8)	9.15 (0.75)	0.17**
Dental age in years, Median (IQR)		8.50 (2.0)	8.50 (1.0)	0.58***	8.50 (1.0)	8.50 (2.0)	0.52***

\* Calculated using fisher exact test.

\*\* Calculated using independent t-test.

\*\*\* Calculated using Mann–Whitney U test.

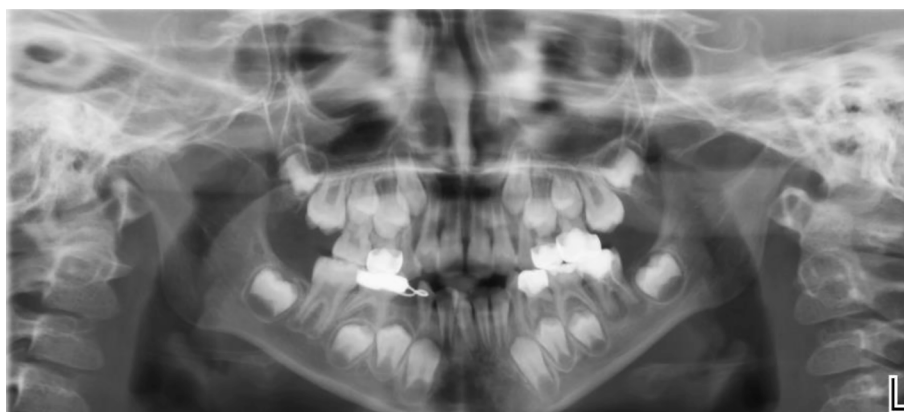


Fig. 2. Example of bilateral delayed eruption U6 that showed taurodontism.

#### 4. Discussion

In this study, the total number of panoramic radiographs examined was 10,232, which exceeded the total number of patient records (9,672) since several patients had more than one panoramic radiograph. The age range of 8–12 years was selected because all first permanent molars fully erupt by the age of 8 years, and the second permanent molar erupts at age 12 years, which may help in determining whether this tooth is the first or second molar.

The prevalence of delayed U6 eruption in Saudi children in this study was 0.2%, which is lower than that reported in previous studies (Nakano et al., 1999; Sano et al., 2015; Klein et al., 2016). Despite its low occurrence, it is imperative that dentists possess knowledge regarding this anomaly and be prepared to closely monitor the eruption of U6. The male-to-female ratio of 1:5.6 reported in this study, is in agreement with previous studies that showed that delayed U6 eruption in females was

two to three times higher than that in males (Rasmussen, 1998; Sano et al., 2010, 2015; Klein et al., 2016; Lee et al., 2017). Consistent with previous reports, this study observed a higher incidence of bilateral delayed U6 eruptions than in unilateral cases. (Rasmussen, 1998; Sano et al., 2010, 2015; Klein et al., 2016).

In 40% of our cases, we observed congenitally missing adjacent second molars, similar to the 43% reported by Lee et al. (2017) but higher than the 22% reported by Nakano et al. (1999) (Nakano et al., 1999; Lee et al., 2017). Nakano et al. interpreted delayed U6 eruption as congenitally missing U6 and subsequent early eruption of the second molar at age nine (Nakano et al., 1999). Lee et al. (2017) criticized Nakano et al.'s interpretation, arguing that missing teeth are often associated with other anomalies such as reduced tooth size and delayed tooth development (Lee et al., 2017). In this regard, the authors agree with Nakano et al.'s interpretation that delayed U6 eruption could be due to a congenitally missing U6 and early eruption of the second molar in cases in which

panoramic radiographs showed missing adjacent second molar. However, the cases showed the presence of an adjacent second molar, and the delayed U6 eruption was simply considered a delayed eruption regardless of changes in occlusion morphology (Lee et al., 2017).

In this study, congenitally missing teeth were observed in 30% of cases, which is comparable to that reported by Klein et al. (26%) but lower than that reported by Lee et al. (62%) and Rasmussen (90%) (Rasmussen, 1998; Klein et al., 2016; Lee et al., 2017). Similarly, an average count of peg-shaped laterals was observed in 30% of the cases, which is consistent with other reports (Klein et al., 2016). Several studies have documented an association between congenital tooth agenesis and generalized delay tooth development (Uslenghi et al., 2006; Tunç et al., 2011; Lee et al., 2017). Bilateral taurodontism of the delayed U6 eruption was detected in one patient who was diagnosed with delayed growth. Taurodontism has been documented in over 20 syndromes, and the literature has revealed a wide range of prevalence in the general population (Manjunatha and Kovvuru, 2010).

In this study, the mean time of delayed U6 eruption was 2.3 years for males and 2.8 years for females, which aligns with the results of other studies (Sano et al., 2015; Klein et al., 2016).

Delayed U6 eruption is an interesting and challenging topic in pediatric dentistry. The nomenclature of nine-year-old molars appears attractive but cannot be applied to all cases showing delayed U6 eruption. These cases need to be thoroughly examined and analyzed to collect the necessary information regarding the average time of delayed U6 eruption, the presence/absence of adjacent second molars, other tooth agenesis, and associated dental anomalies. This interpretation can be categorized as follows:

1. Cases that showed delayed U6 eruption with presence of adjacent second molar should be diagnosed as a simple deviation of eruption timing and labelled as “delayed eruption of U6.”
2. Cases that show delayed U6 eruption with missing adjacent second molar present a challenge, as some researchers consider this to be the first molar (Rasmussen, 1998; Lee et al., 2017), whereas others consider it a second molar (Nakano et al., 1999). In these cases, a term such as nine-year molar or new nomenclature such as 6+ or 6.5—which gives a clue of the presence of a single molar in the quadrant that has eruption time—located between the first and second molars, allowing more precise but flexible diagnoses.
3. Cases that show delayed U6 eruption with missing adjacent second molar, agenesis of other teeth, and/or other dental anomalies should be further investigated, as they could be part of a syndromic condition.

Due to recent advances in genetic analysis and its role in tooth development and dental anomalies, it is now known that mutations in certain genes can lead to malformations or the absence of teeth (De Coster et al., 2009). Mutations in MSX1 and PAX9 genes have been associated with tooth agenesis and craniofacial development (De Coster et al., 2009). The inclusion of genetic analysis in the investigation of the etiology of delayed U6 eruption and its related dental anomalies holds promise for future research.

## 5. Conclusion

In this study, 20 cases of delayed U6 eruption were found in a convenience sample of 9,672 Saudi children, a prevalence of 0.2% (1 in 483). The mean time of delayed U6 eruption was found to be 2.3 years for males and 2.8 years for females, and the male-to-female ratio was 1:5.6. No significant associations were found between delayed U6 eruption and dental anomalies; however, congenital absence of the

adjacent permanent second molar was observed in 40% of cases. The presence or absence of adjacent permanent second molar and other associated anomalies should be considered to provide a better diagnosis and description of cases with delayed U6 development.

## CRedit authorship contribution statement

**Omar A. Bawazir:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Project administration, Supervision. **Noor W. Abahussain:** Methodology, Software, Validation, Investigation. **Tuga A. Alduwayan:** Methodology, Software, Validation, Investigation. **Ayman M. Sulimany:** Methodology, Formal analysis, Writing – review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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