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Assess Factors Related to Spontaneous Space Closure Following Early First Permanent Molar Extraction

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Abstract

Aim: This study aimed to identify prognostic factors influencing spontaneous space closure following the extraction of mandibular first permanent molars (FPMs), focusing on the developmental stage of the second permanent molar (SPM), its angulation, and the presence or absence of the associated third molar.

Material and Methods: In this cross-sectional study, we evaluated 177 mandibular SPMs. The factors considered for successful space closure included the developmental stage of the SPM, its angulation, and whether a third molar was present.

Results: The average age of patients at the time of SPM extraction was 9.4 years, with a follow-up assessment at an average age of 12.7 years. Among the 177 mandibular SPMs evaluated, 36 (20.3%) were classified at Demirjian stage D, 63 (35.6%) at stage E, 60 (34%) at stage F, and 18 (10.1%) at stage G. Angulation data revealed that 18 SPMs (10.1%) had distal angulation, 23 SPMs (13.0%) had mesial angulation, and 136 SPMs (76.9%) were upright. Notably, 79.1% of the mandibular quadrants showed signs of third molar formation during radiographic assessment. Overall, successful spontaneous space closure was observed in 93 (52.5%) of the mandibular SPMs.

Conclusions: No statistically significant relationship was found between chronological age and the developmental stage of the mandibular SPM concerning successful spontaneous space closure at the time of FPM extraction. The presence of the mandibular third molar may play a significant role in spontaneous space closure within the mandibular arch.

Keywords: *spontaneous, mandibular, SPM, angulation*

Introduction

First permanent molars (FPMs) typically erupt between the ages of 6 and 7, playing a crucial role in the development of dental occlusion [1][2]. These molars are particularly susceptible to dental caries compared to other permanent teeth [3][4][5], and they have the highest risk of caries in the permanent dentition [6]. The

unfavorable prognosis for FPMs often leading to extraction is primarily due to the high prevalence of dental caries, extensive multi-surface restorations, pulpal symptoms, and developmental issues such as molar-incisor hypomineralization (MIH) [7][8][9].

The early loss of FPMs can have detrimental effects. Nevertheless, some studies suggest that early extraction may yield positive outcomes from an orthodontic perspective, as it may promote spontaneous space closure [10][11][12]. Updated national guidelines in the United Kingdom recommend performing early extraction of FPMs between the ages of 8 and 10 years to facilitate spontaneous space closure [13]. A recent review argued that the timing of FPM extraction should take into account the Demirjian classification of the developmental stage of the second permanent molar (SPM) rather than relying solely on chronological age [10].

While studies indicate that spontaneous space closure can occur following the extraction of FPMs, there is ongoing debate regarding the favorable outcomes associated with this closure. For example, Teo et al. reported a high rate of spontaneous space closure (94%) in the maxillary arch [16], and Rahhal found that 84.6% of upper SPMs achieved complete spontaneous space closure after FPM extraction [17]. Conversely, other studies present conflicting evidence, showing less than 50% successful space closure in the mandibular arch [18][19]. It has been observed that spontaneous space closure is more challenging to achieve in the mandibular arch than in the maxillary arch [9][20].

Various factors influencing spontaneous space closure have been examined in multiple studies [14][15][18]. A positive correlation between spontaneous space closure and the chronological age of the subjects has been noted [13][18]. Teo et al. demonstrated that mesial angulation of SPMs was associated with the most favorable outcomes for spontaneous space closure following FPM extraction [14]. Furthermore, Eichenberger et al. reported that the presence of the third molar might have a beneficial effect on spontaneous space closure in the mandibular arch [21].

Although previous reports suggest that extracting FPMs while the bifurcation of the SPM is forming could serve as a predictor of successful space closure, there remains a lack of substantial evidence supporting the rationale for the timing of FPM extraction. The existing literature concerning factors affecting spontaneous space closure is insufficient. Therefore, this study aims to investigate the prognostic radiographic factors, including (a) the developmental stage of the bifurcation of the SPM, (b) the angulation of the SPM, and (c) the presence of the third permanent molar, in relation to spontaneous space closure after the early extraction of FPM.

Materials And Methods

The electronic dental records of 9,580 pediatric patients who underwent extraction of first permanent molars (FPM) , were reviewed by calibrated dental specialists (VC, AUG). Ethical approval for this cross-sectional study was obtained from the Medicine Ethics Committee

The inclusion criteria for participants were as follows: patients aged 6 to 10 years at the time of FPM extraction, patients with either unilateral or bilateral extraction of mandibular FPMs, and patients possessing high-quality pre- and post-extraction panoramic radiographs that displayed fully erupted second permanent molars (SPMs) and premolars in the post-extraction images (at ages 12 to 13). Exclusion criteria included patients with congenitally missing teeth, special healthcare needs, a history of unilateral or bilateral extraction of other permanent teeth, a history of oral pathologies (such as odontomas or cysts), previous surgical procedures, or those who had received orthodontic treatment during follow-up.

In total, 177 extracted mandibular FPMs meeting the inclusion criteria were selected for final analysis. All panoramic radiographs were obtained by a single radiology technician using a digital system (Enlil Digital System) and a Planmeca Promax 2D device, with a magnification factor of 1.2 × (Planmeca Inc., Helsinki, Finland), following the manufacturer's standard method (66 kV/10 mA/14 s). The gender and age of patients at the time of extraction were recorded. Each patient's panoramic radiograph, taken during FPM extraction, was evaluated for the developmental stage of the SPM using the Demirjian Development Stage classification [Figure 1] [22]. Specifically, Figure 1a shows mineralized cusp tips that are not yet coalesced, Figure 1b depicts mineralized cusps that have united, Figure 1c indicates a crown that is approximately half-formed, Figure 1d reflects crown calcification, Figure 1e represents bifurcation calcification, Figure 1f denotes early root calcification, Figure 1g shows late root calcification, and Figure 1h illustrates fully closed apices.

The angulation of the SPMs was categorized using a modified version of the Shiller method [23]. In this approach, an occlusal plane line (white line) was established through the occlusal plane of the FPM, and a second line was drawn along the midline of the SPM. The angle formed at the intersection of these two lines was defined as the angulation of the SPM [Figure 2]. A scale drawn on transparent acetate paper measuring 5 × 21 cm was utilized, accounting for the device's magnification, as described by Patel et al. [15], to measure the angle (x angle) from the panoramic radiographs. Based on these angle measurements, SPM angulations were classified into three groups: mesially angulated, upright angulated, and distally angulated (M, U, D) [Figure 3]. A smaller angle indicates a more mesial angulation. The presence of a developing third molar was confirmed if initial calcification or dental crypt formation was observable.

Assessment of Spontaneous Space Closure

A total of 133 patients were recalled for clinical and radiographic examinations. A calibrated orthodontist (AUG) evaluated spontaneous space closure among the 177 FPMs. Space closure assessment was based on the evaluation of the space between the mesial aspect of the SPM and the distal aspect of the second premolar, either clinically or radiographically. The outcomes of space closure were categorized into two groups: (a) successful space closure and (b) unsuccessful space closure. Successful space closure was identified by a visible contact point without interproximal space between the SPM and the second premolar, without tipping of the second premolar at the proximal contact area [Figures 4a, 5a]. In contrast, unsuccessful space closure was indicated by visible interproximal spaces between the SPM and premolars [Figures 4b, 5b].

Statistical Analyses

The primary researchers (VC, AUG) assessed the pre-extraction panoramic radiographs of the selected patients. The inter- and intra-examiner reliability was evaluated using the Intra-class Correlation Coefficient (ICC). Panoramic radiographs were re-evaluated after a two-week period to estimate intra-examiner reliability. The two examiners independently assessed various parameters (Demirjian development stage, SPM angulation, presence of the third molar), and cases with discrepancies were re-evaluated to reach a consensus score. The ICC results indicated good intra-observer agreement ($r = 0.811$).

Statistical analyses of the initial data were conducted using the SPSS software package (Version 23.0, Chicago, Illinois). Categorical measurements were summarized in terms of numbers, percentages, means, and standard deviations (continuous median and minimum–maximum when necessary). The Chi-square test or Fisher's exact test was employed to compare categorical variables. When comparing continuous measurements across groups, distributions were checked, and the Student's t-test was utilized. The distributions of chronological age, Demirjian development stage, SPM angulation, and the presence or absence of third molars were assessed for normality based on kurtosis and skewness. Independent factors affecting spontaneous space closure were identified using regression analysis. A regression model was constructed including all variables, with non-significant variables ($p \geq 0.05$) subsequently removed and the analysis repeated. A statistical significance level of 0.05 was set for all tests.

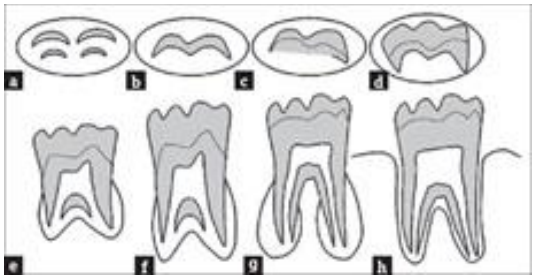

Figure 1:

Demirjian Development Stage (a-Mineralized cusp tips, not yet coalesced, b-Mineralized cusps united, c-The crown is approximately half formed, d-The calcification of crown, e- The calcification of bifurcation, f-The early root calcification, g-The late root calcification, h- The apices are completely closed) [22]

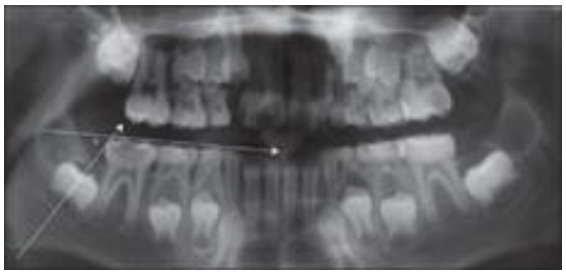

Figure 2:

Drawing panoramic film showing the lines and angle for angular measurements

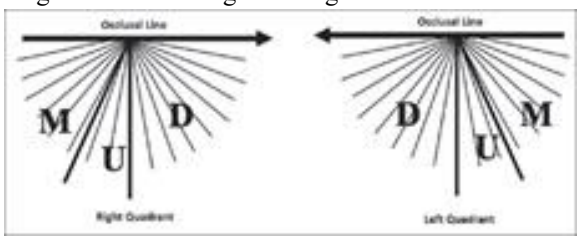

Figure 3:

The measurement scale described by Patel *et al*. [15] to determine the SPM angulation

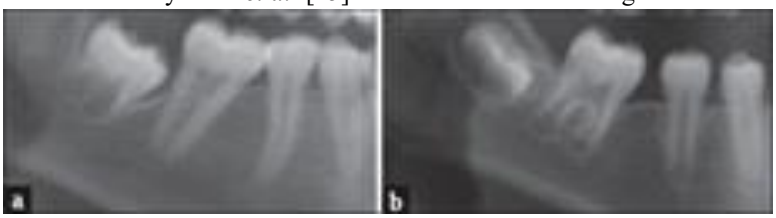

Figure 4:

(a) Visible radiologic contact-contact point between SPM and second premolar (b) Visible radiologic space (non-contact) between SPM and second premolar

Figure 5:

(a) Clinical contact-contact point between SPM and second premolar (b) Clinical non-contact between SPM and second premolar

Results

A total of 133 patients with 177 second primary molars (SPMs) were assessed to determine the prognostic radiographic factors influencing spontaneous space closure in the mandibular arch. Among these patients, 74 (55.6%) were male, while 59 (44.4%) were female. The average age at which the first permanent molars (FPMs) were extracted was 9.4 years, and the mean age at the time of post-extraction radiograph assessment was 12.7 years, with an average follow-up period of 3.5 ± 1.1 years. Successful space closure was observed in 93 out of the 177 SPMs, representing 52.5% of cases.

The analysis examined the relationship between spontaneous space closure and various prognostic radiographic factors, including the developmental stage of the SPMs, their angulation, and the presence or absence of third molars. Of the 177 mandibular SPMs, 36 (20.3%) were classified at Demirjian stage D, 63 (35.6%) at stage E, 60 (34%) at stage F, and 18 (10.1%) at stage G based on pre-extraction panoramic radiographs. However, no statistically significant correlation was found between the developmental stages of the SPMs and successful space closure ($p = 0.749$).

Regarding angulation, of the 177 mandibular SPMs, 18 (10.1%) exhibited distal angulation, 23 (13.0%) had mesial angulation, and the majority, 136 (76.8%), were upright. Statistical analysis revealed no significant association between successful spontaneous space closure and SPM angulation ($p = 0.220$). Notably, 79.1% of the quadrants displayed signs of third molar development during the pre-extraction panoramic assessment. The presence of third molars emerged as a significant predictor for successful space closure in the mandibular arch, with a p-value of 0.034

Further regression analysis evaluated the interactions between successful space closure and the prognostic factors, including chronological age, SPM developmental stage, SPM angulation, and the presence or absence of developing third molars. Among these variables, the presence of the third molar was determined to be a statistically significant predictor for successful space closure

Discussion

First permanent molars (FPMs) are highly susceptible to dental caries, as they are among the earliest permanent teeth to erupt and may exhibit developmental issues such as hypomineralization, particularly in cases of Molar-Incisor Hypomineralization (MIH). These factors often lead to both immediate and long-term clinical challenges. Olatosi et al. [24] found that the prevalence of early childhood caries was 21.2%, while other research indicates that the incidence of developmental defects like hypomineralization ranges from 10% to 30% [11]. Albadri et al. [25] identified extensive dental caries as a primary reason for FPM extraction in 70% of cases.

Previous studies have reported spontaneous space closure rates following FPM extraction ranging from 33.3% to 94% [14, 15, 20]. Additionally, differences in space closure between the maxillary and mandibular arches have been observed, with a higher likelihood of spontaneous closure in the maxilla compared to the mandible [9, 16]. Teo et al. [16] conducted a study on spontaneous space closure post-FPM extraction in patients aged 7 to 13 years, finding that 66% of the extraction sites in the mandible exhibited complete closure. In a related study, Patel et al. [15] found that 49% of 153 mandibular SPMs showed successful space closure, which aligns with earlier reports of closure rates of 38.5% to 50% in the mandibular arch [18, 19]. A more recent clinical investigation indicated that spontaneous space closure occurred at rates of 40% and 38.5% following the extraction of right and left mandibular FPMs, respectively [26]. In our study, FPMs were extracted at a mean age of 9.4 years, with 52.5% of the 177 quadrants achieving successful spontaneous space closure without distal movement of the second premolars.

Teo et al. [16] emphasized the significance of the developmental stage of the SPMs, suggesting that the early bifurcation stage (Demirjian stage E) may represent the optimal time for FPM extraction. Conversely, Gill et al. [27] argued that extracting the mandibular FPMs before or after the early bifurcation stage does not lead to complete space closure, resulting in distal drift, tilting, and rotation of the unerupted premolars. Patel et al. [15] found no correlation between SPM developmental stage and dental age regarding spontaneous space closure in the mandibular arch. Consistent with these findings, our study did not reveal a significant relationship between the developmental stage of SPMs and space closure ($p = 0.749$), supporting Patel et al.'s conclusions.

Furthermore, Patel et al. [15] suggested that the angulation of SPMs could predict spontaneous space closure. Teo et al. [14] assessed spontaneous space closure using panoramic radiographs in a cohort of children with a mean age of 9.2 years at the time of FPM extraction, concluding that mesially angulated SPMs resulted in the most favorable outcomes. However, our study found no significant relationship between SPM angulation and spontaneous space closure in the mandibular arch, with the majority of SPMs (76.8%) exhibiting upright angulation.

The initial crypt formation of mandibular third molars typically begins around 9 ± 2.35 years in girls and 9.79 ± 1.63 years in boys [28]. Eshghpour et al. [29] reported a 48.74% prevalence of impacted third molars among their studied mandibular third molars. Elsey and Rock noted that up to 73% of third molars were classified as impacted in young European adults [30]. Some studies have indicated that extracting mandibular FPMs increases space available for third molars to erupt and can enhance their positional adjustment [31]. Ay et al. [32] observed that the extraction of FPMs facilitates the eruption of third molars through the mesial movement of molars. Yavuz et al. [33] found that 17% of third molars erupted in quadrants where FPMs were extracted, compared to only 6.6% in non-extraction quadrants. In our study population, the eruption force of developing third molars on the FPM

extraction side appeared to accelerate the drift of SPMs into the extraction space. Regression analysis indicated that the presence of developing third molars was the most influential variable affecting the success of spontaneous space closure.

Conclusion

The analysis of data regarding FPM extraction revealed that the developmental stage of SPMs did not demonstrate statistical significance concerning spontaneous space closure. Additionally, there was no relationship between SPM angulation and spontaneous space closure in the mandibular arch. The development of third molars should be considered a critical factor for successful spontaneous space closure following FPM extraction. Interdisciplinary collaboration is recommended to address the implications of early FPM extraction effectively.

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