Original Article

Spontaneous space closure in patients treated with early extraction of the first permanent molar: a retrospective cohort study using radiographs

Yasser Aldahool[a]; Mikael Sonesson[b]; Lillemor Dimberg[c]

ABSTRACT

Objectives: To assess the success rate of spontaneous space closure after extraction of the first permanent molar (FPM) in the maxilla and the mandible, and to identify the factors that make spontaneous space closure most favorable in each.

Materials and Methods: A retrospective records-based cohort study was conducted through a search of the database of the Public Dental Service, Stockholm County Council, Stockholm, for young adults born between 2000 and 2001, who underwent extraction of one or more FPM between 2006 and 2016. A total of 995 extracted teeth were identified, of which 203 teeth in 155 patients met the inclusion criteria.

Results: Of the 203 extracted teeth, 166 (81.8%) did not receive any orthodontic treatment. The success rate for space closure in orthodontically treated patients was 91.9%. The success rate for spontaneous space closure was 84.3%. All unsuccessful spontaneous space closure in the maxilla occurred in patients older than 12 years. The dental developmental stage of the second permanent molar (SPM) had a statistically significant association with spontaneous space closure in the mandible ($P < .001$).

Conclusions: The success rate of spontaneous space closure was high (84.3%) and was higher in the maxilla (94.1%) than the mandible (74.1%). Age at time of extraction and dental developmental stage of the SPM were significant factors for successful spontaneous space closure in the maxilla and mandible, respectively. (*Angle Orthod*. 2024;94:180–186.)

KEY WORDS: Dental caries; Dental enamel hypoplasia; Molar; Orthodontic space closure; Spontaneous space closure; Tooth extraction

INTRODUCTION

The first permanent molar (FPM) is one of the first permanent teeth to erupt in the oral cavity, around the age of 6 years.[1] FPMs are important for the establishment of the permanent occlusion.[2] The FPM has been the subject of different studies that discuss the management and consequences of its early loss, in addition to various factors that can lead to its extraction.[3–7]

The most common indication for extraction of the FPM is dental decay.[8,9] Another indication is severe molar-incisor hypomineralization (MIH), which might cause hypersensitivity, substantial tissue damage, and caries.[10] Early extraction of the FPM also can be due to failed restorative treatment, apical pathology after root-canal treatment, or orthodontic indications.[11]

Several treatment options are available for patients after early extraction of the FPM. One is a compensating extraction to avoid supraeruption of the antagonistic FPM.[12] Another is a balancing extraction of the contralateral FPM.[12] Spontaneous space closure is considered to be a treatment option[7] with good prognosis.[12–15]

It has been suggested that the most desirable time for extraction of the FPM in the maxilla is before the eruption of the second permanent molar (SPM) and before the crown of the SPM is superior to the cemento-enamel

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Accepted: November 2023. Submitted: June 2023.
Published Online: December 14, 2023

junction of the FPM.[5,12,16] Proposed time for extraction of the FPM in the mandible is when the SPM has complete formation of the crown and the furcation appears on the radiographs, commonly between 8 and 10 years of age.[3,5,12,14] However, clinically satisfactory results have been shown for both earlier and later extractions.[5,14]

Presence of a third molar is considered a favorable factor for spontaneous space closure, especially in the mandible.[3,5,14] Another advantageous factor is mesial angulation of the SPM.[13,14,17]

According to Teo et al.,[6] the highest success rate for spontaneous space closure after the extraction of the mandibular FPM is obtained with the combination of three factors: (1) engagement of the second premolar under the roots of the primary second molar, (2) mesial angulation of the SPM, and (3) presence of a third molar. It has been recommended that the extraction of the FPM should be postponed until all three conditions are met.[6]

However, available results and recommendations are not unanimous and have been questioned by other researchers.[14] Thus, there is lack of agreement on the most important factors for establishing spontaneous space closure after early extraction of the FPM. This study was designed to add knowledge about factors to take into consideration for successful spontaneous space closure.

The aim was to assess the success rate of spontaneous space closure in relation to (1) engagement of the second premolar under the roots of the primary second molar, (2) mesial angulation of the SPM, and (3) presence of a third molar in patients who were treated with early extraction of one or several FPMs. The variables with positive effect on spontaneous space closure were also to be identified.

MATERIALS AND METHODS

A retrospective records-based cohort study was conducted through a search on April 30, 2020 of the database of the Public Dental Service, Stockholm County Council, Stockholm, for specific extraction codes. The study was approved by the Swedish Ethical Review Authority (Dnr 2020-00180).

Inclusion Criteria

- Young adults between ages 19 and 20 (born in 2000 or 2001) who underwent extraction of one or more FPMs between 6 and 15 years of age.
- A panoramic or intraoral apical radiograph, maximum 6 months before extraction, that showed the first, second, and third permanent molars and second premolar.
- Presence of a panoramic or an intraoral apical, or bitewing radiograph, at the age of 19 or 20 for the assessment of space closure.

Exclusion Criteria

- None

Using the search criteria for the specified extraction treatment codes within the registrations, 742 eligible patient records of 995 extracted FPMs were retrieved. Records of 203 extracted FPMs in 155 patients met inclusion criteria and were further assessed. The main reasons for the exclusion of a record were poor radiologic documentation (572 FPMs) and the patient having a temporary record (194 FPMs) (Table 1).

Data Registration

The extracted data were: gender, age at extraction, site of extraction, dental developmental stages of the SPM, second premolar and the third molar, presence of the third molar, distalization of the second premolar before the extraction and at the follow-up, angulation and vertical relation of the SPM to the FPM before the extraction, spacing, and crowding, sagittal occlusion according to Angle classification, and whether or not the tooth was subject to orthodontic treatment and, if so, the treatment time and extent.

The teeth included in the study were divided into two groups: those that did and those that did not receive orthodontic treatment. The extracted data were registered at the time of the extraction. The outcome variable of spontaneous space closure was assessed using the radiographs taken when the patients were 19 to 20 years old.

Table 1. Reasons for Exclusion With Number of Records for Each Reason

Reason for Exclusion	No. of Records (Tooth Level)
Apical or panorama x-ray is missing/doesn't fulfill criteria	357
Temporary personal number	194
X-ray documentation is missing at follow-up	137
Apical x-ray is missing or doesn't fulfill criteria/OPG (>6 mo)	78
Tooth is not extracted. No data or x-ray.	16
Others	10
Total	792

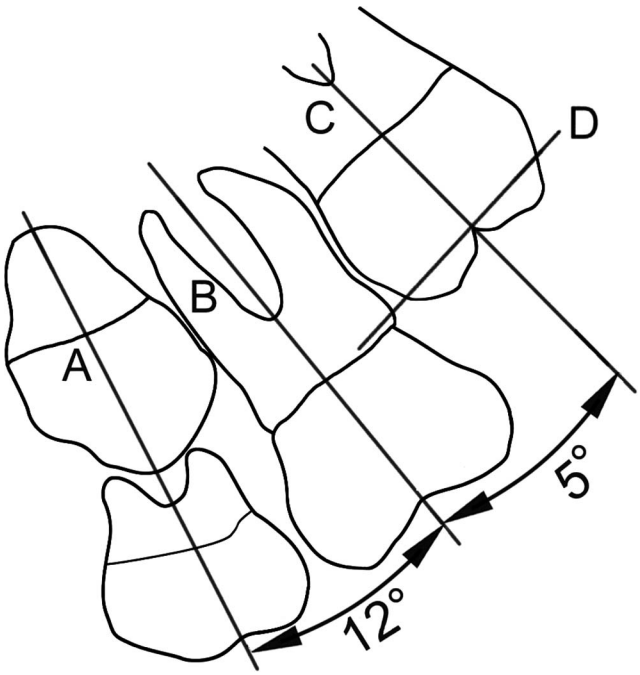


Figure 1. Example of the implemented measurement with AutoCad (Autodesk, San Francisco, CA; www.autodesk.com). (A) Line through the long axis of the second premolar and follows its angulation; (B) line through the long axis of the first permanent molar and follows its angulation; (C) line through the long axis of the second permanent molar and follows its angulation; (D) line through the occlusal surface of the second permanent molar to indicate its vertical relation with the first permanent molar according to Figure 3. 12° is the angle between A and B and shows the angulation of the second premolar when B is the reference. 5° is the angle between C and B, and shows the angulation of the second permanent molar when B is the reference.

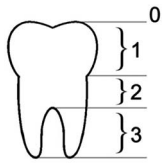
Data on the included teeth were carefully reviewed by one of the authors (YA). Information and radiographs were extracted from the record system (T4, Romexis) for registration and further examination and measurement. Data were collected for all included teeth. A note with the ethical approval number was written into the reviewed dental record to avoid double registration.

Measurements

The inclination of the SPM in relation to the FPM was analyzed by measuring the angle between two lines through the long axes of the teeth. The spontaneous distalization of the premolar was assessed by measuring the corresponding angle between the premolar and the FPM.

The vertical relation of the SPM to the FPM was measured by drawing a line through the occlusal plane of the SPM and comparing its level to that of the FPM (Figure 1). The vertical relation was divided into four different levels (Figure 2).

The rate of spontaneous space closure and distalization of the second premolar at follow-up was measured



0: Erupted
1: Crown level
2: Between CEJ and furcation
3: Between furcation and apex

Figure 2. Assessment of vertical relation between the first permanent molar (FPM) and second permanent molar (SPM).

by the length of a straight line between prominences of the teeth. The grading used for assessment of space closure at follow-up was according to the method used by Teo et al.[6] The space closure was graded from 1 to 4, with Grades 1 and 2 corresponding to successful closure and Grades 3 and 4 as unsuccessful (Table 2).

A tooth was considered mesially or distally inclined depending on its orientation and whether the angle between the tooth and the FPM was greater than 10° or not (Figure 3).

Dental developmental stages of the FPM, SPM, and the third molar were registered according to Demirjian et al.[18]

Intra- and interexaminer reliability tests for the radiographic assessments were made on 20 randomly chosen teeth using the site at https://www.randomizer.org/. The interval between the measurements for the intra-examiner test was around 3 months. The interexaminer test was conducted to validate the method. The second examiner was a specialist and senior consultant in oral radiology. All measurements were done by using a student version of AutoCAD 2021 and AutoCad 2022 (Autodesk Inc., San Francisco, CA; www.autodesk.com) within the period between November 2020 and April 2022.

Statistical Analysis

The statistical package SPSS 26.0 (SPSS Inc., Chicago, IL; www.ibm.com) was used. The General Estimation Equations (GEE) procedure was adopted for multilevel analyses with success rate as a binary outcome variable. Single values were used and the results were considered to be statistically significant at $P < .05$. The forward selection procedure was used to choose predictive variables.

GEE analyses were made at the tooth level for all patients that did not receive any orthodontic treatment

Table 2. Grading of Space Closure Using Radiographs[6]

Grade	Contact-Point Displacement
1	<1 mm
2	between 1 and 2 mm
3	between 2 and 4 mm
4	>4 mm

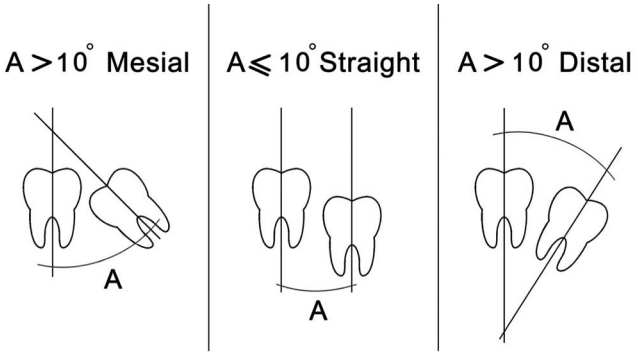


Figure 3. Assessment of angulation of different teeth in comparison to the first permanent molar (FPM) long axis.

after FPM extraction. No analyses were conducted on patients treated with orthodontic appliances due to the low number.

The intra- and interexaminer tests were conducted by calculating Coheńs kappa after re-evaluation of three variables: spontaneous distalization of the adjacent premolar before extraction, inclination of SPM in relation to FPM, and vertical relation between SPM and FPM.

The results of Coheńs kappa for intra-examiner tests were: spontaneous distalization of the adjacent premolar before extraction, kappa = 0.80; inclination of SPM in relation to FPM, kappa = 0.80; and vertical relation between SPM and FPM, kappa = 0.90. The results for the interexaminer tests were: spontaneous distalization of the adjacent premolar before extraction, kappa = 0.72; inclination of SPM in relation to FPM, kappa = 0.81; and vertical relation between SPM and FPM, kappa = 0.90. The results of both tests indicated high to very high reliability between the measurements.

RESULTS

In total, data from 155 patients and 203 associated teeth were analyzed. There was no great difference between teeth according to gender distribution (Table 3). Successful spontaneous space closure was seen in 84.3% (140 teeth). Unsuccessful space closure was seen in 15.7% (26 teeth). In the orthodontic group (treated with fixed appliance), successful space closure was seen in 91.9% (34 teeth), with unsuccessful space closure in only 8.1% (3 teeth) (Figure 4). The orthodontic treatment time varied between 3 months and 43 months.

The registered reasons for early loss of FPM were: caries (43.3%), MIH (25.6%), endodontic indication (17.2%), orthodontic indication (4.4%), remaining root (6.4%), and other indications such as tooth fracture 3%. The mean age for extraction of the FPM was 11.4 years with a difference in age between the successful and the unsuccessful teeth (Table 3).

In total, 572 teeth were excluded because of poor radiographic documentation, regardless of whether the documentation was done before or after the extraction. Poor documentation did not indicate the complete absence of radiographs, but the available radiographs did not fulfill the criteria needed to evaluate the studied factors.

Variables for Successful Spontaneous Space Closure

Presence of the third molar had no effect on spontaneous space closure. However, three variables were statistically significant with respect to successful spontaneous space closure and no need for further orthodontic treatment. The first was the extraction site ($P < .001$), with an odds ratio (OR) of 16.9:1 for successful spontaneous space closure in the maxilla compared to the mandible. The second was the age at extraction ($P = .032$), with an OR of 4.5:1 for more favorable extractions on patients younger than 12 compared to extractions at or after the age of 12. The third variable was the developmental stage of the SPM ($P = .015$). The most favorable developmental stages were E and F (root development at the level of the bifurcation) with an OR of 11.9:3.1, compared to developmental stages A to D (before start of root development) and an OR of 1, compared to unfavorable developmental stages G and H (root development at the level of the apical part or completed) (Table 4).

Maxillary Extractions

The success rate in the maxilla was 94.1%. Of 85 FPM extractions, only five (5.9%) showed unsuccessful spontaneous space closure. The small number of teeth with unsuccessful space closure made it impossible to

Table 3. Demographic Data of the Included Material[a]

	No Orthodontic Treatment			Orthodontic Treatment				
	Gender			Gender			Age (y)	
	Male	Female	Total	Male	Female	Total	Mean	SD
Successful space closure	67	73	140	16	18	34	11.2	1.7
Unsuccsessful space closure	11	15	26	0	3	3	13.0	2.1
Total	78	88	166	16	21	37		

[a] n = 203.

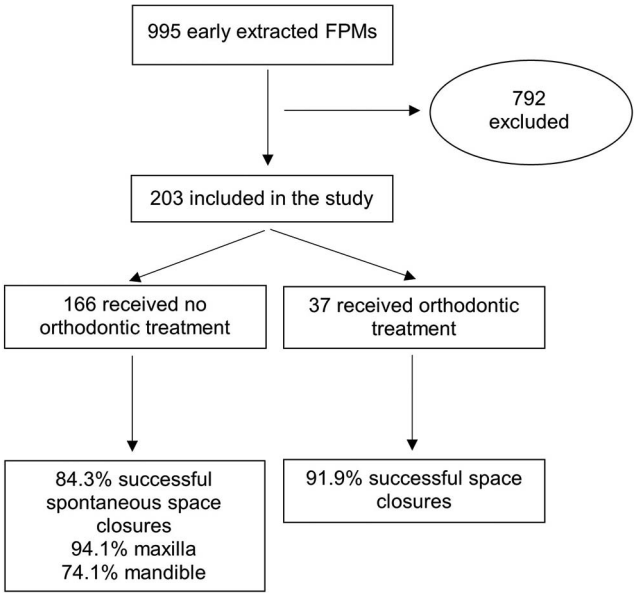


Figure 4. Flowchart showing treatment outcome after the extraction of the first permanent molar (FPM).

conduct any multilevel analysis on the material. However, a bivariate analysis was conducted, and the results showed that all teeth with unsuccessful spontaneous space closure were extracted when the patient was 12 or older.

Mandibular Extractions

The success rate in the mandible was 74.1%. Of 81 FPM extractions, 21 showed unsuccessful spontaneous space closure. Statistical analysis on the extracted teeth in the mandible yielded only one significant variable: the developmental stage of the SPM ($P < .001$). The most favorable stages were E and F with an OR of 42.9:10.1, compared with stages A to D and an OR of 1, compared to the unfavorable stages of G and H.

DISCUSSION

The main finding in this study was that the success rate for spontaneous space closure was high (84.3%) despite the high average age at the time of extraction (11.4 years). The success rate was higher in the maxilla (94.1%) compared to the mandible (74.1%). These results indicate a good chance of spontaneous space closure after extraction of an FPM. The results of the present study were similar to those of previous studies.[13,15] Nevertheless, the high success rate of spontaneous space closure in the maxilla of the same magnitude as in patients treated with fixed appliance, was an interesting, novel finding.

The only variable that was statistically significant for spontaneous space closure in the mandible was the dental developmental stage of the SPM ($P < .001$), with the most favorable outcome in dental stages E and F. Earlier dental stages A to D were also favorable, but less so. Dental stages G and H were unfavorable. These results were in agreement with prior findings.[5,6,15]

As in previous findings, FPM extractions in the maxilla had a greater number of successful spontaneous space closures than in the mandible, with high statistical significance ($P < .001$).[5,12,14–16,19] Maxillary extractions at a younger age (<12 years) also had statistically significant higher success rates than extractions at older ages (≥ 12 years) ($P = .032$), a result that was also consistent with a previous investigation involving younger children.[20]

According to the results of this study, the dental developmental stage of the SPM is more important when the FPM is extracted in the mandible, with stages E and F yielding the most favorable results. In contrast, for maxillary extractions, it was sufficient to evaluate using chronological age, with the most favorable results seen before the age of 12.

The mean age for extraction of the FPM in this study was 11.4 years, which was near to the mean age

Table 4. Factors Associated With Spontaneous Space Closure After Extraction of the First Permanent Molar at Tooth Level[a–d]

Independent Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	P
Jaw			$<.001$
Mandibular first molar	1		
Maxillary first molar	16.9	4.8–58.9	
Age at extraction			0.032
<12 y	4.5	1.1–17.9	
≥ 12 y	1		
Development stage; second pemanent molar (SPM)			0.015
A–D	3.1	0.38–24.9	
E–F	11.9	2.2–66.1	
G–H	1		

[a] Variables with $P < .05$ after using the general estimating equations statistical analyses with forward procedure are presented in the model.
[b] CI indicates confidence interval; OR, odds ratio.
[c] Development stages A–H represent the tooth development stages from bud formation until eruption.
[d] N = 166 teeth.

reported in an earlier study,[8] but older than the discussed ideal age of about 8–10 years.[3–5,13]

This study did not report any significant association between the presence of the third molar and spontaneous space closure. These findings differed from studies suggesting the presence of the third molar as being a favorable factor for spontaneous space closure.[3–5,14]

It was not possible to study the correlation between spontaneous space closure with the sagittal occlusion according to Angle classification and/or crowding because of a lack of information in the dental records. However, no risk due to distalization of the second premolar at the follow-up was found in this study. That finding agreed with the results of a previous study,[13] yet differed from the results of other studies.[5,12,15]

Strengths and Limitations

A retrospective cohort study has a risk of selection bias.[21–23] Nevertheless, the retrospective design has advantages such as efficiency, reduced time consumption, and lower cost.[21] The disadvantage of a records-based study due to lack of information in the dental records was noticed for the variables of spacing and crowding. However, the majority of the information was available, and the unique social security number system used in the Nordic countries allowed on registry search to identify dental records and extract important clinical data.[24] However, trichotomization for some of the variables could be considered as a limitation because it sometimes resulted in a lower kappa in the interexaminer test despite the fine differences in grades.

CONCLUSIONS

The following variables were significant for successful spontaneous space closure:

- Extraction site, with more favorable results for extractions in the maxilla compared to the mandible.
- Maxillary extractions before age 12 were more favorable than extractions done at or after 12.
- Dental development of the SPM in stages E and F at the time of the extraction had the most favorable results in the mandible.
- This study could not verify that engagement of the second premolar under the roots of the primary second molar, mesial angulation of the SPM, or the presence of the third molar were significant for successful spontaneous space closure.

ACKNOWLEDGMENT

The authors acknowledge Folktandvården Stockholm AB for providing generous economic support, docent periodontologist Leif Jansson for help with the statistical analysis, and senior oral radiologist, Klara Ragne, for collaboration in the interexaminer test.

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