

Dealing with a compromised young first permanent molar, reflexion on the extraction option

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Dissertação conducente ao Grau de Mestre em
Medicina Dentária (Ciclo Integrado)

Gandra, 22 de Agosto de 2020

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Trabalho realizado sob a Orientação de Prof. Doutor Ana Paula
Lobo e Co-orientador Mestre José Pedro Carvalho

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Eu, acima identificada, declaro ter atuado com absoluta integridade na elaboração deste trabalho, confirmo que em todo o trabalho conducente à sua elaboração não recorri a qualquer forma de falsificação de resultados ou à prática de plágio (ato pelo qual um indivíduo, mesmo por omissão, assume a autoria do trabalho intelectual pertencente a outrem, na sua totalidade ou em partes dele). Mais declaro que todas as frases que retirei de trabalhos anteriores pertencentes a outros autores foram referenciadas ou redigidas com novas palavras, tendo neste caso colocado a citação da fonte bibliográfica.

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Eu, Ana Paula Lobo, com a categoria profissional de Professora Doutora do Instituto Universitário de Ciências da Saúde, tendo assumido o papel de Orientador da Dissertação intitulada « *Dealing with a compromised young first permanent molar, reflexion on the extraction option* », do Aluno do Mestrado Integrado em Medicina Dentária, Marie Laure Genevieve Tillay, declaro que sou de parecer favorável para que a Dissertação possa ser depositada para análise do Arguente do Júri nomeado para o efeito para Admissão a provas públicas conducentes à obtenção do Grau de Mestre.

Gandra, ___ de _____ de 2020

O Orientador

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Aos meus pais, por sua presença, seu amor e seu apoio nesses cinco anos.

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Resumo

Uma pesquisa bibliográfica foi realizada no PUBMED usando a combinação de termos de pesquisa « first permanent molar » and « tooth extraction » [MeSH Terms]. A pesquisa identificou 206 estudos, dos quais 11 foram considerados relevantes para este estudo.

Os resultados de uma extração precoce de PMP incluem mais ou menos fechamento espacial espontâneo, erupção acelerada e melhorada do TPM do mesmo quadrante, aumento de overjet, overbite e do ângulo interincisal pela verticalização dos incisivos, rotação em sentido anti-horário do plano oclusal juntamente com uma mandíbula encurtada após a perda de PMP mandibular e assimetria facial após uma extração unilateral na mandíbula.

As diretrizes atuais são baseadas em evidência científica baixa, no futuro serão necessárias mais recomendações relevantes baseadas em evidências. Ao enfrentar um FPM comprometido a uma idade jovem, o médico deve sempre consultar um ortodontista antes de tomar qualquer decisão, para não tornar um futuro tratamento ortodôntico mais complexo. Com as técnicas atuais de restauração e controle do comportamento e tendo em vista a atual incapacidade de controlar e prever todas as consequências de um ato tão invasivo como a extração de FPM em crianças, a opção de restauração sempre deve ser privilegiada, se possível. Restaurar o espaço na idade adulta com um implante e / ou próteses permite um melhor controle do espaço de extração com consequências muito menos prejudiciais.

O objetivo deste estudo foi determinar se a extração de um primeiro molar permanente (PMP) comprometido é uma opção de tratamento adequada, pesquisando suas consequências num indivíduo em crescimento.

PALAVRAS-CHAVE: Primeiro molar permanente ; comprometido ; extração

Abstract

A literature search was performed on the PUBMED using a combination of search terms « first permanent molar » and « tooth extraction » [MeSH Terms]. The research identified 206 studies, of which 11 were considered relevant for this study.

The outcomes of an early FPM extraction include a more or less spontaneous space closure, accelerated and improved eruption of the TPM of the same quadrant, increased overjet, overbite and interincisal angle by the uprighting of the incisors, counterclock wise rotation of the occlusal plane along with a shortened mandibule after a lower FPM loss and facial asymmetry after unilateral mandibular extraction.

The current guidelines are based on low scientific evidence, more relevant evidence-based recommendations will be needed in the future. When facing a compromised FPM at a young age, the practitioner should always refer to an orthodontist before taking any decision, as to not render a future orthodontic treatment more complex. With the actual restoration and behavior management techniques and in view of the current incapacity to control and predict all the consequences of an act as invasive as the extraction of FPM in children, the restoration option should always be privileged if feasible. Restoring the space in adulthood with an implant and/or prosthetics allows better control of the extraction space with much less harmful consequences.

The aim of this study was to determinate if the extraction of a compromised FPM is a proper treatment option, by searching its consequences on a growing individual.

KEYWORDS : First permanent molar ; compromised ; extraction

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LIST OF ABBREVIATIONS :

FPM : First Permanent Molar

SPM : Second Permanent Molar

TPM : Third Permanent Molar

MIH : Molar-Incisor Hypomineralisation

PR : Panoramic Radiograph

1 INTRODUCTION

The first permanent molar (FPM) is considered to be the cornerstone of the dentition, having a major role in the masticatory function, the integrity and the stability of the arches, as well as in the dentofacial harmony ^{1,2,3}. However, it is also the most frequently lost tooth ⁴.

First permanent teeth to erupt, it is often mistaken for a deciduous tooth by the parents, unnoticed until painfully carious ³. It has been quoted to be the most caries-prone tooth in the permanent dentition, with more than half of children over the age of 11 years experiencing some decay ⁵. The mandibular FPM is more often affected than the maxillary one ⁴.

The other main reason to early compromise of FPM is molar-incisor hypomineralisation (MIH), a condition of unknown aetiology of a 10 to 30% prevalence ⁶. Affected teeth present diverse degrees of hypomineralisation, alterations of enamel translucency, discoloration from white to yellow/brownish ^{6,7,8}. The enamel disintegration on the occlusal surface favors the subsequent development of caries ⁹. Managing severely hypomineralized teeth is challenging due to sensitivity, uncertainty in achieving anesthesia, difficulties in bonding, and limited cooperation due to dental anxiety, leading to a reportedly high retreatment rate ^{1,10,11,12}.

In addition to this, approximately 6% of children have one or more hypoplastic FPM, causing similar management difficulties as hypomineralisation ^{1,13,14}.

Compromised FPM in pediatric dentistry leads to clinical dilemmas, firstly whether to restore the tooth, which then enters into a costly restorative cycle at an early age, or to extract it and allow for spontaneous space closure by the second permanent molar ^{6,15}. Both options have possible implications such as different occlusal outcomes, maintenance requirements, and burden of care, which makes this decision difficult ¹⁶.

Secondly, if the extraction option is chosen, should it be extracted promptly or be temporized, and are other FPMs extractions required ¹⁷.

Elective FPM extractions should be considered when its overall long term prognosis is poor, in cases of extensive caries/restorations, severe hypoplasia / hypomineralisation, irreversible pulpitis, or periapical pathology ; indications being associated or not with an 1 orthodontic purpose ^{14,15,17,18}. Besides, when the loss of tooth units is required, it is not advisable to extract a sound premolar if the FPM in the same quadrant is heavily restored ^{15,17,19}. In addition to the existing clinical features, other factors may influence the decision-making, such as dental arch affected, dental age of the patient, presence and condition of the current and future surrounding teeth, presence of a malocclusion and which, degree of crowding, skeletal pattern, patient's and parent's potential cooperation with restorative/orthodontic treatment, expected future attention to oral hygiene and child's social background ^{5,6,13,17,20}.

The aim of this study is to determinate if the extraction of a compromised FPM is a proper treatment option, by researching its consequences on a growing individual.

2 METHODOLOGY

A literature search was performed on PUBMED (via National Library of Medicine) using the following combination of search terms: « first permanent molar », « tooth extraction [MeSH Terms]

The filters used in the searches were articles in english, on the human specie. Neither publication date limit was used, nor restriction of article type.

The criteria used for article inclusion also involved : children between 6 and 16 years old at the time of extraction of first permanent molar(s), extraction due to caries or MIH, metaanalysis, randomized controlled trials, cohort studies, case control studies. Cases relating extraction as part of an orthodontic treatment, case series and case reports were excluded.

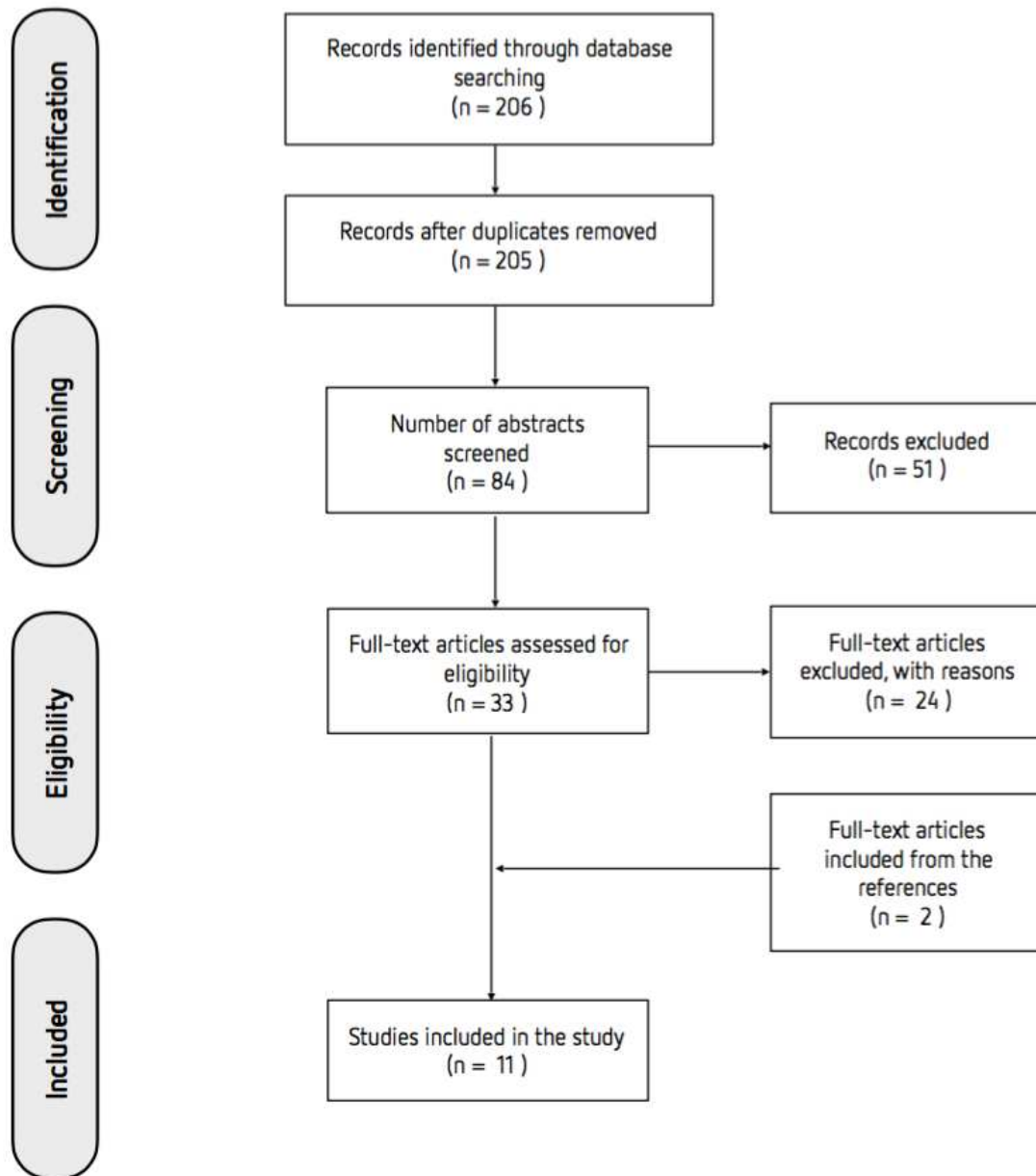


Figure 1. Flow diagram of the search strategy used in this study.^[P]_[SEP]

The duplicates were removed, a first selection by articles's titles was conducted, followed by the lecture of the abstracts to establish whether the articles met the purpose of the study. The reference lists of the selected full-text papers were scanned to find new relevant studies.

For each selected article, the following information was retrieved: the source, publication year, aim, study type, sample size, age at extraction and evaluation, methodology and findings (Table 1).

3 RESULTS

The literature search identified 206 articles in PubMed, as shown in Figure 1.

After reading the titles, 84 abstracts were screened, of which 33 potentially relevant studies were then read and their references screened. Of those studies, 24 were excluded because they did not meet the inclusion criteria. Two studies were included from the references. Hence, 11 studies were included in this review ^{4,21-30}.

Out of the 11 studies selected, four evaluated the SPM development and space closure ^{22,23,24,25}, one investigated the need for compensating and balancing extractions ³⁰, two articles observed the effect on the TPM ^{4,26}, one the effect on the incisor relationship ²⁷ and two others the effect on the skeletal development ^{21,28}. Lastly, one study studied the effect on the carious susceptibility ²⁹. The major findings were as follows :

- Comparing the space closure rate between the upper and lower arches, three authors ^{22,23,24} found that complete space closure for upper SPMs was more likely to be achieved than for lower SPMs, with T.K.Y. Teo ²² finding the difference to be statistically significant.

Table 1 : Data collected from the selected studies

Reference	Aim	Study design	Sample size	Age	Metodology	Findings
Space closure						
T.K.Y. Teo, P.F. Ashley, S. Parekh, J. Noar 22 2012	To assess the success of FPM extractions 5 years later.	Retrospective cohort study.	63 patients (236 FPM)	At extraction : Between 7 and 13 years (mean age 8.9 years) At evaluation : Mean time : 4.8 years later	Demirjian's dental developmental stage of the SPM were identified on a preextraction panoramic radiograph (PR) Angle classification was evaluated clinically. Space closure was evaluated with a ruler between the contact point of the second premolar and the SPM (see Table 2) Statistical tests were conducted using the MASS toolbox in R 1.53.	Category 1 space closure (see Table 2) was found in 74 % of patients in Class I occlusion, 87 % of Class II and 60 % of Class III. There was no significant relationship between the between Angle's classification and space closure. Out of all cases at the 'ideal' stage of development (Demirjian development stage E) at the time of FPM extraction, 94% of the upper SPMs and 66% of the lower SPMs had a category 1 space closure. SPMs at developmental stage F resulted in 100% of upper SPMs and 76% of lower SPMs grouped within category 1, an improvement in comparison to the "ideal" stage E. In the upper arch, category 1 was obtained in the majority of cases for all development stages (D,E,F,G). In the lower arch, only stages E and F resulted in category one in more than half the cases. (see Tables 2, 3 and 4) The results show that there was a significant difference in the outcomes of FPM extraction between arches, with an higher probability of category I space closure in the upper arch. However, no significative difference was found comparing the chances of development stages D to G for yielding category 1 of space closure.
G Serindere, B Bolgul, T Parlar, A Cosgun 23 2019	To evaluate space closure, the SPM's eruption, and changes in dental arch after the loss of the FPMs.	Cross sectional study	55 patients (83 FPM).	At extraction : Between 8 and 13 years (mean : 11.02 years old). At evaluation : Mean age 13.75 years, at least 2.5 years after the extraction	Demirjian's dental developmental stage of the SPM were identified on a preextraction PR. On the post-extraction radiograph, the space between the second premolar and the SPM was measured, and space closure was categorized with the classication given by Teo et al (see Table 2) WEKA data mining tools were used to analyze the data.	The highest rate of space closure was found in the patient who extracted all four FPM. Category 1 space closure was found in about half SPMs, category 2 in about a fifth and category 5 in little less than 30% of the cases. In total, 10.8% SPMs belonged to the "ideal" stage E of Demirjian's dental development. Out of those, 50% (one out of the two cases) of the upper SPMs and 57% of the lower SPMs had a category 1 space closure. The highest percentage of category 1 space closure in the upper arch was obtained after an extraction at stage F (71%).

Table 1 : Data collected from the selected studies

Reference	Aim	Study design	Sample size	Age	Methodology	Findings
Terry KuoYih Teo, Paul Francis Ashley and Donald Derrick 24 2015	To identify additional radiographic factors that could improve the prediction of spontaneous space closure of the lower SPM following FPM extraction.	Cross sectional study.	66 patients (127 lower FPM).	<u>At extraction :</u> Mean age 9.2 years old. <u>At evaluation :</u> Mean age 13,8 years old.	Demirjian's dental developmental stage of the SPM were identified on a preextraction PR, as well as the three radiographic factors : 1 = 2nd PM engaged in the bifurcation of its predecessor, 2 = SPM mesially angulated in relation to the FPM, 3 = presence of TPM. Space closure was evaluated intra-orally with a parodontal probe between the contact point of the second premolar and the SPM. (see Table 5)	FPM extraction at SPM stages D, E, and F was significantly associated with space closure only when compared to stage G. Out of the lower FPM extracted at the 'ideal time' stage E, 58% of the SPMs had grade 1 space closure, and 16% had a grade 4, and 57% of the SPMs at stage F had a grade 1 space closure. (see Tables 4 and 5) Grade 1 space closure was found in 83% of the cases with all three factors present. The presence of one or more of the three factors was associated with significantly better space closure, but after the presence of all three, the presence factors 2 and 3 together was associated with the most favourable outcomes. All cases with all three radiographic factors absent showed no grade 1 space closure but a significant association with grade 4 space closure. The most favourable outcomes overall came from a combination of SPM stage D, E or F with radiographic factors 2 and 3, or 1,2 and 3.
Sameer Patel, Paul Ashley, Joseph Noara 25 2016	To investigate if dental age, development stage of the SPM, angulation of the 2nd PM, angulation of the SPM and presence of the TPM at extraction had an impact on space closure.	Retrospective cohort study.	81 patients, including 148 maxillary FPM and 153 mandibular FPM.	<u>At extraction :</u> From 6 to 14,5 years old (mean age 9,6 years) <u>At evaluation :</u> From 0.9 to 7.5 years after the extraction (mean of 4 years.)	Demirjian's dental developmental stage of the SPM were identified on a preextraction PR, as well as the angulation of the second premolar and SPM (using a modification of the method of Shiller), the presence of TPM. Assessment of space closure was space closed or space present (radiograph or intra-orally). Paired t tests and Lin's concordance correlation coefficients were used For numeric variables, kappa and weighted kappa scores were used for categorical variables. SPSS and STATA statistical packages were used for data analysis.	In the upper arch, the only statistically significant variable was dental age. In the mandibular arch however, the second molar angulation and presence of the third molar were statistically significant in the prediction of successful space closure. The predicted probability of space closure in the lower arch were calculated to be, in presence of the TPM, 27.8% when the SPM had a distal inclination, 56.5% when upright, and 89.4% when mesially inclined. In absence of the TPM, 7.8% when the SPM was distally inclined, 21.3% when upright, and 63.7% with a mesial inclination.

Table 1 : Data collected from the selected studies

Reference	Aim	Study design	Sample size	Age	Metodology	Findings
Compensating / Balancing extractions						
Birgitta Jälevik, Marie Moller30 2007	To evaluate the development of the permanent dentition, and need for orthodontic treatment after extraction of FPM due to severe MIH.	Retrospective cohort study	27 patients	At extraction : From 5.6 to 12.7 years old (median age of 8.2 years). At evaluation : From 3.8 to 8.3 years after the extraction (mean of 5.7 years).	The eruption of the permanent dentition and space closure were analysed on orthopantomograms, casts, photographs, and/or bitewings.	(The results on space closure were not included in this study due to lack of specificity of a « good bite » development in comparison to the other studies included) In all cases of Class III relationship, a compensating extraction in the lower arch was made when an upper FPM was compromised; as well as in all cases of Class II, a compensating extraction in the upper arch was made. In four cases a lower FPM was extracted but not the upper opposite FPM. They all had a favourable development. In two of those cases, a compensating extraction was made on only one side, the bite development was not more favourable on either side. When extraction was made in the maxilla but not in the mandible, the bite development was still good. In no case a unfavourable centreline shift derived from a unilateral extraction.
Third molar development						
Yavuz I, Baydaş B, Ikbal A, Dağsuyu IM, Ceylan I4 2006	To evaluate if early loss of a PFM has an effect on the development of the third molar in the same quadrant.	Cross sectional study	165 subjects with unilateral FPM extraction (control group = non extraction side)	<u>At extraction :</u> Younger than 12 years old <u>At evaluation :</u> From 13 to 18 years (mean : 15.35 ± 2.53)	Third molar germs' formation on both sides was evaluated with Nolla's system on a PR. The Mann-Whitney U test was used to assess significative differences between genders, and the Kruskal-Wallis analysis of variance (ANOVA) between the extraction quadrants. The Wilcoxon signed rank test was used to compare the differences in the developmental stages. Data were analyzed with SPSS for Windows. Paired t tests were used	No significative difference between gender nor between the various extraction sides for the developmental stages of the third molars. The development of the third molars on the extraction side was significantly accelerated when compared with the contralateral teeth (P = 001) In 75.8% of the cases, the development of the third molars on the extraction side was more advanced than the contralateral teeth, in 22.4% they were at the same developmental stage. The paired t test indicated significant differences between the sides for the eruptive conditions of the third molars in subjects with unerupted third molars (P= 0.037) with reduced distances between the tips of the mesiobuccal cusps of the third molars and the occlusal plane.

Table 1 : Data collected from the selected studies

Reference	Aim	Study design	Sample size	Age	Methodology	Findings
					to compare the differences in the eruptive condition.	
Sinan Ay, Ugur Agar, A. Altug Bıçakçı, and H. Hüseyin Köşger 26 2006	To compare the spontaneous angular and positional changes of mandibular third molars in patients with asymmetric lower FPM extraction.	Cross sectional study	107 patients (52 have the mandibular right FPM missing, and 57 have the mandibular left FPM missing)	<u>At extraction :</u> Before the age of 16. <u>At evaluation :</u> From 18 to 40 years (mean = 25.69 years)	The locations and positions of the third molars were classified on the PR. The impactation depth was measured with the classifications of Pell and Gregory. Third-molar angulation was measured by the angle between the occlusal plane of the 1st and 2nd premolars and the occlusal surface of the third molar. The results were calculated with the software SPSS for Windows. The differences between 2 sites were evaluated with the chi-square test	The difference was statistically different (P < 0,01) for the three measurements between the extraction and non-extraction sides : <ul style="list-style-type: none"> - the percentage of TPM in class I ramus relationship : higher on the extraction side (79,4% compared to 20,6%). - the percentage of TPM with a class A impactation depths : higher on the extraction side (62,1% compared to 37,9%) - the percentage of TPM with a vertical inclination (<11°) : higher on the extraction side (67,8% compared to 32,2%). Only 1 third molar had an horizontal angulation (>70°) on the extraction side.
Incisor relationship						
Andrew Richardson 27 1979	To investigate the spontaneous changes in the incisor relationship in the first year after the extraction of both lower FPM.	Cross sectional study	43 patient with both lower FPM extracted	<u>At extraction :</u> A year earlier. <u>At evaluation :</u> From 8 to 14 years (mean = 11,4 years)	Every patient had a first 90° left lateral cephalometric radiograph taken before the extraction and a second approximately 12 months after. On each film the overbite, overjet and axial inclinations of the incisor teeth were measured using a ruler, setsquare, protractor and acetate sheets with fine lines. This tracing was transferred to the second film, the second positions of the teeth added to the tracing. The changes were then measured.	On average, the overbite was augmented by 0,7mm, the overjet by 0,3mm, the upper incisors proinclined by 0,3° and the lower incisors retroinclined by 0,1°. The overbite was increased in about half subjects and stable in a third ; the overjet was increased in a third and stable in half. Formerly normal overbite and overjet resulted in a stable overjet and an equal proportion of stable and deepened overbite. Moreover, the results showed that an overjet reduction in almost every case which has retroclination of both upper and lower incisors. An already increased overjet resulted in more cases of stabilized than more increased overjet. The article also studied the effects of extraction depending on the angle class : for a class I, the overjet was stable, and equivalent number of increased and stable overbite. For both class II division 1 and 2, approximately half of both overbite and

Table 1 : Data collected from the selected studies

Reference	Aim	Study design	Sample size	Age	Methodology	Findings
						overjet were increased, the other half being stable. In 5 out of 6 cases with an incomplete overbite, it was meliorated.
Skeletal development						
Murat Çaglarolu, Nihat Kilic, Abdulvahit Erdem 28 2006	To evaluate the repercussion of unilateral extraction of the first molars on skeletal asymmetry.	Retrospective cohort study	Group I : 25 subjects (one upper FPM extracted) Group II : 26 subjects (one lower FPM extracted) Group III : 30 subjects (control group)	<u>At extraction :</u> Before the age of 12. <u>At evaluation :</u> - I : mean age 18.25 years - II : mean age 17.75 years - III : mean age 18.50 years	Posteroanterior cephalometric radiographs were taken and the cephalometric traces were made with Quick Ceph 2000. Paired t tests were used to compare linear measurements between the extraction and non-extraction side in each group. Other measurements were analyzed with analysis of variance (ANOVA) and Scheffé tests to identify significant differences between the three groups. Statistical analyses were made using the SPSS software package for Windows.	Statistically significant differences were found comparing the extraction and non extraction side in groups I and II, as follows : the maxillomandibular width difference and antegonial notch distance were increased, jugular process distance was lower on the extraction side in the first group, and higher in the second group, and menton-antegonial notch distance was greater on the extraction side in group II. Comparing groups I and II with the control group, other statistically significant differences were encountered : the mandibular and maxillary widths were superior in the control group, with a difference in the mandibular width of higher significance. The mandibular deviation, as well as the dental midline deviation, were greater in the extraction groups. The dental midline shift was higher when a mandibular molar was extracted than a maxillary one. Halicioğlu
Halicioğlu K, Celikoglu M, Caglaroglu M, Buyuk SK, Akkas I, Sekerci AE21 2012	To investigate the effects of early loss of a both lower FPM on condylar and ramal heights and if it caused an asymmetry of the condyles.	Retrospective case control study	- study group : 30 individuals with bilateral loss of lower FPM - control group: 25 individuals	<u>At extraction :</u> Before 12 years old. At least 5 years (5 to 9) earlier. <u>At evaluation :</u> From 17 to 20 - study group : mean age 18.22 ± 1.30 - control group: mean age 18.24 ± 1.17	Comparison of the vertical heights of the mandibular right and left condyles and rami on PR, analyze of the values with parametric tests : student's t test to compare the asymmetry index values and a paired t test to uncover statistically significant differences for condylar, ramal, and condylar plus ramal height measurements. Statistical analyses were made using the SPSS software package on Windows.	The condylar, ramal, and condylar plus ramal height measurements were lower in the study group but no statistically significant difference was found. The condylar asymmetry index, ramal asymmetry index, and condylar plus ramal asymmetry index were higher in the study group but, likewise, no statistically significant difference was found.

Table 1 : Data collected from the selected studies

Reference	Aim	Study design	Sample size	Age	Methodology	Findings
Incidence on carious risk						
S. J. Oliver, P. M. H. Dummer, R. G. Oliver, R. Hicks, M. Addyt and A. Kingdon ²⁹ 1988	To determinate the caries status of second permanent molars and second premolars in 15/16 years old after loss of the FPM	Prospective case control study	793 children, divided in 2 groups : - group 1 : presence of FPM (control) - group 2 : absence of FPM.	<u>At extraction :</u> Before 11-12 years old. <u>At evaluation :</u> From 15 to 16 years	All subjects received an intra-oral examination and posterior bitewing radiographs were taken. In both arches, the numbers of sound, decayed or filled surfaces on the M and O faces of the second molar and the D and O faces of the second premolar were retrieved. Chi-squared tests using SPSS-X were used to find any significant differences between the two groups.	The loss of the FPMs resulted in a statistically significant reduction in the number of decayed and filled interproximal surfaces (except for the mesial surface of the maxillary second permanent molar), and, contrariwise, in a statistically significant increase in decayed and filled occlusal surfaces in both second permanent molar and second premolar of every quadrant.

Table 2 : Evaluation classification of space closure between second permanent molar (SPM) and second premolar based on the study of T.K.Y. Teo, P.F. Ashley, S. Parekh, J. Noar 22 (used in two articles 22 and 23)

1	Complete space closure between the contact point of the SPM and the second premolar. No angulation/rotation of either SPM or premolar. No distal movement of the premolar
2	1-5 mm space between contact points of second premolar and SPM
3	5-10 mm space between contact points of second premolar and SPM
4	Greater than 10 mm space between contact points of second premolar and SPM
5	Presence of angulation/rotation of SPM and/or second premolar. Distal movement of second premolar

Table 3 : Space closure after the extraction of a maxillary FPM (Demirjian's classification)

Source	Number of teeth	Age at extraction	Follow up period	Space closure (see table 2)			
				Stage D	Stage E	Stage F	Stage G
T.K.Y. Teo, P.F. Ashley, S. Parekh, J. Noar 22	117	From 7 to 13 years (mean age 8.9 years)	Mean time : 4.8 years	1 = 94 % 2 = 0 3 = 6 % 4 = 0 5 = 0	1 = 94 % 2 = 6 % 3 = 0 4 = 0 5 = 0	1 = 100 % 2 = 0 3 = 0 4 = 0 5 = 0	1 = 75 % 2 = 25 % 3 = 0 4 = 0 5 = 0
Serindere G, Bolgul B, Parlar T, Cosgun A. 23	27	From 8 to 13 years (mean age 11.02 years)	Min 2.5 years	1 = 0 2 = 0 3 = 0 4 = 0 5 = 0	1 = 50 % 2 = 50 % 3 = 0 4 = 0 5 = 0	1 = 71 % 2 = 29 % 3 = 0 4 = 0 5 = 0	1 = 50 % 2 = 27,8 % 3 = 5,6 % 4 = 0 5 = 16,7 %

Table 4 : Space closure after the extraction of a mandibular FPM (Demirjian's classification)							
Source	Number of teeth	Age at extraction	Follow up period	Space closure (see table 2)			
				Stage D	Stage E	Stage F	Stage G
T.K.Y. Teo, P.F. Ashley, S. Parekh, J. Noar 22	119	From 7 to 13 years (mean age 8.9 years)	Mean time : 4.8 years	1 = 44 % 2 = 28 % 3 = 6 % 4 = 0 5 = 22 %	1 = 66 % 2 = 19 % 3 = 9 % 4 = 2 % 5 = 5 %	1 = 76 % 2 = 10 % 3 = 5 % 4 = 5 % 5 = 5 %	1 = 44 % 2 = 12 % 3 = 25 % 4 = 12 % 5 = 0
Serindere G, Bolgul B, Parlar T, Cosgun A. 23	56	From 8 to 13 years (mean age 11.02 years)	Minimum 2.5 years	1 = 0 2 = 0 3 = 0 4 = 0 5 = 0	1 = 57 % 2 = 29 % 3 = 0 4 = 0 5 = 14 %	1 = 22 % 2 = 33 % 3 = 0 4 = 0 5 = 45 %	1 = 40 % 2 = 10 % 3 = 10 % 4 = 0 5 = 40 %
Source	Number of teeth	Age at extraction	Follow up period	Space closure (see table 5)			
				Stage D	Stage E	Stage F	Stage G
Terry Kuo-Yih Teo, Paul Francis Ashley, Donald Derrick 24	127	Mean age 9.2 years	Mean age at examination 13.8 years.	1 = 35 % 2 = 30 % 3 = 0 4 = 35 %	1 = 58 % 2 = 14 % 3 = 12 % 4 = 16 %	1 = 57 % 2 = 30 % 3 = 4 % 4 = 9 %	1 = 31 % 2 = 0 3 = 13 % 4 = 56 %

Table 5 : Evaluation classification of space closure between second permanent molar (SPM) and second premolar based on the study of Terry Kuo-Yih Teo, Paul Francis Ashley 24	
1	Extremely minor malocclusions including contact-point displacements less than 1 mm
2	Contact-point displacement of teeth greater than 1 mm but less than or equal to 2 mm
3	Contact-point displacement of teeth greater than 2 mm but less than or equal to 4 mm
4	Severe contact-point displacement of teeth greater than 4 mm

- T.K.Y. Teo ²² found no significant relationship comparing the patient's Angle class to the space closure grade.
- One author ²² found no statistically significant correlation between space closure and development stage, another ²⁴ found the difference in the space closure grade was only statistically significant between stages F and G in the lower arch. Extraction at Demirjian's stage E favored but did not guarantee complete space closure ^{22,23,24}. Extraction at Demirjian's stage F was linked to great outcomes, equal or even better than those observed with stage E ^{22,24}. Stage G resulted in the poorest outcomes in all studies (see Tables 2,3,4,5).
- Two authors ^{24,25} found the presence of radiographic factors had a more statistically significant impact on the variability of space closure than the SPM development stage. Terry Kuo-Yih Teo ²⁴ and Sameer Patel ²⁵ both concluded that a mesially angulated SPM combined with the presence of TPM gave the highest chances of successful space closure.
- One study ³⁰ displayed cases of uncompensated and unbalanced extractions. All showed a good spontaneous occlusal development, neither teeth elongation nor centreline shift was reported. Therefore, it can be deduced that compensating and/or balancing extraction is not always beneficial when extracting a permanent first molar.
- Early FPM extraction has an influence on the development of the TPM of the same arch. Two authors ^{4,26} found a statistically significant acceleration of its development, with a significant predisposition for a vertical angulation ²⁶.
- Richardson ²⁷ searched the consequences of bilateral extraction of lower FPM on the incisor relationship and found that in about half the subjects the overbite was increased and the overjet remained stable. The increase in overbite would be due to the retroclination of lower incisors and proclination of upper incisors. The overjet was however slightly increased on average. An increased overbite is expected when presenting a previous proclination of upper and lower incisors, an

increased overjet and, to a lesser extent, an already increased overbite. An incomplete overbite will tend to improve.

- Murat Çağlarolu ²⁸ analyzed the effect of unilateral extractions of both arches. He found asymmetry of the face, especially in the lower anterior region, with larger differences in the mandibular extraction group.
Halicioğlu K ²¹ observed cases of early bilateral lower FPM extractions. He found that the ramal and condylar height were lower in the extraction group, leading to a higher ramal and condylar asymmetry index in this group. However, all the differences were statistically insignificant.
- S.J. Oliver ²⁹ reported that the loss of the FPMs resulted in a statistically significant reduction in the number of decayed and filled interproximal surfaces, but a statistically significant increase in occlusal surfaces in both second permanent molar and second premolar of every quadrant.

4 DISCUSSION

When a FPM is affected by irreversible pulpitis, still restorable but the results would leave the teeth with a questionable prognosis, the clinician is faced with the dilemma of restoring or extracting the affected tooth ^{13,31}. The aim of this study was to determine if the extraction of a compromised FPM is a suitable treatment option.

I. Current guidelines

The following section is a presentation of the current guidelines to conduct the management of a compromised young FPM.

A few interrogations have to be answered to correctly plan an extraction of these teeth, as follows ^{2,20} :



• What is the prognosis of the compromised FPM? Is extraction indicated?

Extraction of a FPM during the mixed dentition stage should be considered when these teeth are affected by large cavities or restorations, irreversible pulpitis, periradicular infection, severe hypoplasia including MIH, in cases of frequently repeated treatments, when pulpal symptoms are hard to cure, or when the teeth is unrestorable ^{5,12,15}. Teeth affected by MIH exhibit post-eruptive breakdown under masticatory forces, facilitating plaque accumulation thus increasing the risk for developing caries ^{7,31,32}. The plaque accumulation is also favored by the hypersensitivity as the shooting pain can prevent from brushing the teeth ⁷. The treatment of these teeth is challenging both for the patient and the dentist due to difficulties in achieving a sufficient anesthesia, leading to an high retreatment rate ^{10,12}. Hence, for children with severe molar-incisor hypomineralisation the extraction of compromised FPM could probably be beneficial ¹². These molars should always be considered as candidates for extraction if space is required for the correction of a malocclusion ⁵.

If in doubt, get the patient out of pain, try to maintain the teeth and ask for an orthodontist's opinion ⁶.

• Is the third molar present?

The presence of the TPM is an advantage when extracting the FPM as the mastication capacity would not be lowered by its loss, using the SPM and the TPM. Although its presence in the arch is not always visible on radiographs when the FPM has to be extracted, its absence does not generally contraindicate the extraction of FPMs ^{7,14,15}.

• What is the general condition of the other teeth?

It is imperative to carry out a thorough clinical and radiographic examination to check the presence and condition of all the present and future teeth ^{5,33}. Any teeth missing or in a poor eruptive condition in the permanent dentition will affect the decision-making process ⁶. Particularly in the lower arch, the dentist should avoid a FPM extraction if there is a congenital absence of a permanent tooth in the same arch ¹³. Furthermore, any contra-lateral tooth of a poor prognosis would be a more appropriate option than a sound FPM to balance the extraction ⁵.

• How old is the patient? What is the current stage of dental development?

The ideal age for extraction, according to the literature, stands between 8-9/10 years, after the eruption of the lateral incisors (7-9 years old) but more importantly before the eruption of the SPM (11-13 years old) ^{5,6,17}. If at the extraction time the SPM is erupted, its drift movement will more like a tipping movement. However, if unerupted, the drift movement will be very close to the bodily movement, especially in the upper arch ³³. Hence, special attention is required in regard to the extraction timing, as it conditions the amount of spontaneous mesial movement of the SPM.

Nowadays, the extraction timing is also based on radiographic evidence, it is believed that extraction should be done when radiographically the crown of the SPM is formed and the calcification of its root bifurcation starts to form ^{6,10,17,32}. This corresponds to the Demirjian developmental Stage E ^{31,34}.

Earlier extraction in the lower arch would cause distal drifting, distal tilting and rotation of the second premolars, notably in a spaced dentition, as the tooth would use the FPM's socket as a path to eruption instead of the second deciduous molar ^{5,10,17,23}. In consequence, the mesial drift of the SPM is inhibited ^{5,32}. Additionally, the second premolar could become impacted against the SPM, leaving a space between the two premolars ^{5,17,23}. Extracting the second deciduous molar along with the FPM when still present could avoid this detrimental consequence ^{5,17,23,35}.

Earlier extraction in the upper arch is not as deleterious, the SPM could erupt in an acceptable position but most likely with an axial inclination ^{9,36}.

Late extraction will reduce the likelihood of spontaneous space closure, more intensely in the lower jaw, as the bodily movement of the SPM would be shortened ^{2,5,17,32,36}. It will result in both arches in mesial tilting and lingual rolling of the SPM, distal drifting and tilting of the second premolar, atrophy of the alveolar in the residual space, which may difficult later orthodontic space closure ^{5,14}. In addition, the lingual tilt could cause the development of a scissor bite ^{5,14}. The spacing left and/or poor occlusal contact created contributes to food entrapment and development of a periodontal pocket, worsened by the mesial tilt of the SPM ^{5,14,17}.

• Is the patient set to need an orthodontic treatment?



Orthodontists are frequently faced with a poor development of the occlusion due to uncontrolled extraction of first permanent molars in children, an issue that could be avoided if an orthodontics opinion was obtained as soon as a compromised FPM is detected ^{6,14,20}. It is important to consider whether future active appliance treatment will be necessary as it conditions the appropriate timing of extraction ².

If not needed, the best is to extract at the ideal developmental age to achieve spontaneous space closure ^{1,5,13}.

If future appliance treatment is likely to be necessary, affected FPMs should be maintained until the orthodontic treatment is provided ^{2,5}.

The FPM extraction is rarely voluntarily part of an orthodontic plan, space is provided away from the labial segments and its loss can extend and difficult the orthodontic treatment ^{5,14,17,31}. As an example, cases involving the extraction of FPM demand approximately 6 to 9 months more of fixed appliances treatment time in comparison to cases of premolar extractions ^{15,33}.

• Is there any arch crowding?

The presence of crowding in the buccal and lingual segments is one of the most important factors to obtain a decent occlusal result after the extraction of FPMs ⁵.

Spontaneous space closure is enhanced in cases with intra-arch crowding ^{5,14}. For example, if a late lower FPM extraction is conducted in an arch with mild crowding in the premolar region, the distal drift of the premolars will reduce the extent the second molar has to migrate mesially ⁵. Nonetheless, crowding relief can be expected only in the buccal segment, not in the labial segment, especially in the upper arch as space closure occurs take place so readily ^{5,15,17}.

In spaced dentitions, as only little space closure can be expected, the timing of compromised FPM removal is much more critical in order to obtain the maximum amount of mesial drift of the SPM ^{5,14}. The presumable remaining space will later require a fixed appliance treatment for closure ¹⁷.

• Is there a need for additional elective extraction?

Balancing and compensating extractions should be considered in the mixed-dentition

stage when no orthodontic treatment is to be undertaken ^{5,14}. Compensating extraction refers to the extraction of the FPM of the opposing quadrant. It aims to avoid the over-eruption of the antagonist molar occurring when left unopposed for a long period of time, which can potentially prevent the mesial migration of the adjacent teeth into the extraction space and cause occlusal interferences that might later predispose to temporomandibular joint dysfunction ^{5,6,14}. As the upper SPM tends to erupt and drift rapidly, antagonist contact with the lower FPM is so soon enough established that the risk of over-eruption of the latter is limited ^{14,17}. Therefore, when an upper FPM is compromised, compensating extraction of the opposing lower FPM is not indicated ^{5,6,9,17}. On the other hand, the compensating extraction of the upper FPM is advocated when the loss of the opposing lower FPM is projected ^{6,10,14}.

Balancing extractions stands for the extraction of a tooth from the contralateral quadrant, not necessarily a FPM. It aims to preserve arch symmetry, prevent centreline shift and crossbite ^{5,6,14,17,18}. Balancing in both arches is required when there is a symmetrical crowding. Balancing in absence of crowding is required in the lower arch, but not in the upper arch ^{5,6,14,17}. When timing of lower FPM removal is not ideal, balancing the extraction with a premolar instead of a sound FPM might be more profitable ^{14,17}. There is only little data in the literature supporting the justification of elective extractions when a FPM loss is enforced ^{5,6}. The risk of over-eruption seems to be relatively small, and dental midline shift is believed to be unlikely in an uncrowded arch ^{5,6}. Results from Jalevik ³⁰ showed that additional extractions are not necessary to obtain a good spontaneous occlusal development, as out of all cases presenting unbalanced and/or uncompensated extractions not a single case presented teeth elongation or centreline shift. These results are in concordance with other studies, as Merjare ³⁷ found little risk of midline deviation, no case of over-eruption, although one opposing upper molar showed rotation. These articles however did not specify if any of the related cases had any sort of prior malocclusion and which.

Hence, balancing extractions of a sound FPM only to preserve a midline would seem irrational. However, as seen in the study by Murat Çaglarolu ²⁸, unilateral extractions in both arches could cause facial asymmetry.

Compensating extractions do not seem to be justified, as an appliance to prevent its overeruption would be a better, less invasive option ^{5,17}.

• Is there any malocclusion, if yes, which one?

The occlusal relationship prior to the loss of a FPM has an impact on its planning and consequences:

- Class I

When the patient has a class I occlusion, little to no crowding, the approach is to wait for the optimal age for extraction ^{6,31}.

When there is significant crowding in the buccal segment, spontaneous alleviation of crowding and correct space closure are expected when extraction is done at the optimal time ^{5,6}. When there is crowding in the labial segment, it may be better, if possible, to postpone the FPM extraction until the SPM erupts and inhibit its mesial movement with a lingual arch to use the space for correction ^{5,6,15}.

- Class II

The primary complicating factor in Class II cases is the timing of the upper FPM extraction because of the space required to correct the incisor relationship ⁶.

A class II division 1 malocclusion pattern is not a complicating factor when a lower FPM is compromised, the dentist should aim for the right timing and opt for a removable appliance or a transpalatal arch rather than a compensating extraction when the overeruption of opposed upper FPM is feared (although it will have to be worn for an extended period of time) ^{6,14,17}. Plus, the upper FPM may be in occlusion with the lower second primary molar second premolar tooth, a contact eliminating the risk of overeruption ^{14,17}. On the other hand, in a class II division 2 malocclusion pattern, the overbite control may be a considerable difficulty, as controlling the position of the mandibular labial segment is difficult after an extraction in the lower arch ⁵. Hence, if possible, lower FPM extractions should always be avoided in deep anterior bite cases ^{5,14}.

Both malocclusion class II division 1 and 2 alter the treatment planning in case of an impending loss of an upper FPM, specifically in presence of labial crowding ^{6,17}. When there is a significant space requirement in the upper arch, if the upper FPM can be temporized it should be retained as a natural space maintainer until the second permanent molars have erupted, then mesial migration of the upper SPM can be restrained using a palatal arch with Nance button or a headgear for the extraction space to be latter used to correct

the malocclusion, dental alignment and reduction of the overjet with fixed appliances^{5,6,9,14,15,20}. Using the extraction space of a condemned upper FPM to correct the malocclusion prevents from later adding the extracting of two upper premolars, which can be necessary if the extraction space is closed by the SPM^{6,17}.

If the upper FPM requires immediate extraction, orthodontic treatment has to be instituted as soon as the SPM have erupted to correct the incisor relationship⁶.

- Class III

Class III malocclusion cases are always complex to approach, an orthodontist's opinion is necessary as the patient will need an orthodontic treatment to correct the anterior crossbite whichever management option is chosen for the compromised FPM^{6,14,17}. First and foremost, the practitioner should always abstain from extracting in the upper arch, as it can hamper the correction of the reverse overjet^{6,14}. Improper extraction of mandibular FPM may also complicate future orthodontic treatment¹⁷.

Cobourne⁶ affirms compensating and balancing in cases of a reverse overjet are not recommended, whereas Gill⁵ states a specialist's opinion should always be obtained in such cases.

• Thus, when is the appropriate timing for extraction?

To summarize the above, a FPM is indicated for impending extraction between the ages of 8 to 10 (a larger window is acceptable in the upper arch), in absence of an underlying malocclusion except a Class II division 1 malocclusion (for a lower arch extraction), little to no crowding or crowding in the buccal segment only^{5,6,9,14,15,17}.

It should be maintained until the correct age if the patient is too young. To facilitate a future orthodontic treatment and adequate use of the extraction space, it should be postponed until the eruption of the SPM if the patient is older than the age gap (for a lower arch extraction), or presenting labial crowding, or presenting a Class II division 1 or 2 malocclusion (for an upper arch extraction) especially if combined with significant crowding^{5,6,14,15,17,20}.

FPM extraction should be avoided if possible in dental class III in the lower jaw, in spaced dentitions, and in arches where a permanent tooth is missing^{5,6,14}.

It is contra-indicated in the lower jaw in cases of deep bite, and in the upper jaw in cases of anterior crossbite^{5,6,14}.

II. Outcomes

The outcomes of early extraction of a FPM include both dentoalveolar and skeletal consequences²:

- Space closure

Space closure is conceivably the most challenging aspect of first molar extraction cases¹⁵. After a tooth is extracted, the neighboring teeth tend to drift towards the extraction space²⁰. In the case of FPM extraction, the space is closed to a greater extent by the SPM than by the second premolar²⁰.

In our study, three authors^{22,23,24}, related space closure based on which Demirjian's stage the SPM was at the time of the extraction. Outcomes showed best results for stages E and F, good results for stage D, with a statistically significant decrease only for the stage G. (see Tables 2, 3, 4 and 5). According to Demirjian's classification, by stage D the crown is completed to the cemento-enamel junction, at stage F the root length is superior or equal to the crown height and stage G shows a complete root length with an open apex³⁴. Therefore, extraction at the « ideal » stage E enhanced chances of but did not guarantee space closure. Another study reported similar results, indicating that extraction of FPMs at stages E and F gave the best outcome³¹.

Two articles included in our review observed the effect of additional radiographic factors on the prediction of the space closure outcome, and both authors agreed on the fact it bettered the results^{24,25}. SPM level D, E or F, along with mesial angulation of the SPM in relation to the FPM and the presence of TPM, gave the most favorable outcomes.

The space closure rate is different depending on the dental arch, all studies included in our review presented a higher rate of complete space closure in the upper arch than in the lower arch^{22,23,25}. In accordance, a systematic review found an overall success rate of spontaneous space closure of 72% in the upper arch, yet only 48% in the lower arch⁹.

Timing is therefore more critical in the lower arch^{6,14,15}. The difference in the eruption pathway between the maxilla and mandible could be the reason that the maxilla showed better space closure².

The apex of the upper FPM is usually placed mesially in relation to the crown which gives it a distal angulation ; as it erupts, the SPM will move mesially, with a slight mesial tip and

mesio-palatal rotation into a satisfactory position that favours spontaneous space closure^{2,5,9,20}. However, the palatal tip and rotation can lead to a cross bite³³.

The lower FPM have a much more vertical path of eruption¹⁵. The apex of the second molar is placed more distally, causing the crown to tip further mesially as the tooth bodily drifts, as well as rolling lingually^{9,15}. Two authors concluded that even if a lower FPMs was extracted at the optimum stage of root development, rotation and/or tipping of the SPM and/or the second premolar as well as a remaining gap cannot always be prevented, and later orthodontic correction will certainly be needed^{9,30}.

• Third permanent molar

Space gained from the FPM extraction is believed to highly improve the probability of the lower third molar to erupt, both earlier and in a more desirable position^{5,6,9,14}. The results in our review were similar, neither gender nor extraction arch had an impact, a statistically a significant acceleration of the 3rd molar development was observed on the extraction side, and a better angulation was noticed⁴. Thus, alike the SPM, the TPM's development is accelerated after the loss of a FPM². Furthermore, the presence of third molars might have a positive influence on spontaneous space closure, as observed in the mandible in the review by Eichenberger⁹.

• Incisors

The early loss of a FPM may affect the occlusion considerably. Changes in the anterior teeth's inclination, overbite and overjet have to be expected the 1st year after the extraction¹³. Loss of upper FPM allegedly does not disturb the incisor relationship¹³.

However, loss of lower FPM leads to an attenuation of the mandibular incisor crowding, an increased overjet, as well as an uprighting of the lower incisors causing an increase of the overbite and the interincisal angle^{5,6,13,38}. Richardson²⁹ found similar results, with on average a slight increase of the overjet despite half of the subjects presenting a stable overjet and only a third showing an increase.

These consequences were found to a greater extent on patients who initially presented proinclined lower incisors and augmented overjets, explaining why a lower FPM extraction

contra-indicated in cases of Class II division 2 ^{17,18,29,47}. Richardson ²⁷ reported that cases of Class II division 1 or 2 had an increased overjet and overbite after the FPM loss.

- Skeletal development

If a tooth loss leads to an imbalanced occlusion, premature contacts and asymmetrical chewing habits, it may induce asymmetric adaptive muscular development of the mandible, which could cause modeling of the condyle and skeletal asymmetries, affecting the soft tissues negatively ^{6,21,28}.

Çaglarolu ²⁸ showed that unilateral extraction in both arches cause asymmetry of the face with an increased maxillomandibular width difference on the extraction side, dental midline and chin deviation towards the extraction side, observing more significant differences after an extraction in the mandible than in the maxilla. Halicioglu ²¹ found that early loss of FPM caused the ramal and condylar height after bilateral lower extraction to shorten but to an insignificant level. His observations are in concordance with Normando ³⁸ who stated that bilateral loss of lower FPM leads to a loss of vertical dimension, resulting from a moderate decrease of the lower anterior face height, counterclock wise rotation of the occlusal plane (increased interincisal angle).

Thus, both bilateral and unilateral extraction of the lower FPM are harmful on the skeletal development, with unilateral extraction adding facial asymmetries ^{21,38}. The mandible was found to be more affected than the maxilla ^{21,38}. Unilateral extractions have to be avoided since midline discrepancies correction is particularly challenging when the cause of the asymmetry is skeletal ³⁹.

- Carious susceptibility

The attitudes on the matter are very differing, from very enthusiastic opinions claiming that patients subsequently remained caries/fillings free, to very pessimistic claims that it may even jeopardize the dentition as a whole by increasing the incidence in caries, causing occlusal disturbances, changes in facial appearance and even speech problems ¹⁵. The results of the study ²⁹ included in our review revealed that extraction of the FPM itself does not overall lower the carious risk of the adjacent teeth, with results of a significant

reduction in decayed and filled interproximal surfaces but an increase on occlusal surfaces in the SPM and second premolar following the loss of a FPM.

- Further need for an orthodontic treatment?

An appropriate timing of FPM extractions will simplify the following fixed appliance orthodontic treatment ¹⁴. A small residual space between the SPM and second premolar can be easily and quickly closed, whereas the more spacing, the more treatment time needed, and the more complicated the treatment mechanics get (such as the use of temporary anchorage devices like mini-implants and miniplates for example) ^{9,14}.

The idea that early loss of the FPM will avoid a financial burden is incorrect, as a subsequent orthodontic treatment will most likely be needed despite correct planning of the extraction ⁹. As reported earlier, it does not always guarantee absence of a remaining gap, tipping and rotation of neighboring teeth, so children will always need to be monitored post-extraction ⁹.

III. Other clinical options

- Restoration

Rather than extracting the compromised FPM, the practitioner might prefer to choose to try to restore it. Pulp preservation is a primary goal when treating a young permanent tooth, as its long term retention requires a favorable crown/root ratio and thick dentinal walls ⁴⁰. Treating children with compromised FPMs is a challenge to the clinicians due to the child's dental anxiety and limited compliance, the difficulties in anesthesia and optimal bonding of the restoration, and the clinical difficulty of an open apex ^{31,41}. In addition, in a tooth affected by MIH the border between demineralized and unaffected isn't net ³⁷. Two approaches are possible, either removing all defective enamel, invasive but effective, or only the porous enamel, risking margins breakdown due to a defective bonding ^{32,37}.

In a systematic review, Taylor ⁴¹ studied the success of endodontic therapies on a first permanent molar tooth in a child under the age of 16 and found that pulpotomies had an overall success rate of 91.1% and pulpectomies of 36%. Only one case report of the use of



regenerative techniques was found, which reported success in one tooth. No studies included reported on apexification. Tooth extraction is therefore not to be considered when a pulpotomy can be performed. However, there is currently no retrospective evidence presenting a reliable, secure and effective conservative treatment option when the pulpal involvement is more serious.

The success rate and longevity of a restoration depends on the material its made of. Merjare ³⁷ found the order of success rate from the lowest to the highest was glass ionomer cements, compomer, amalgam, composite, stainless steel crown and gold/porcelain casting restoration. There was no difference between upper and lower molars. Another restoration option is indirect posterior composite restorations ^{37,42}. Merjare ³⁷ also noted that 18% of the patients showed over-eruption of a molar opposite a restored molar, owing to abrasion and inadequate anatomic form of the restoration of the disto-buccal cusp of the opposite lower first molar.

- Space maintenance

When a young patient presents a compromised FPM after the eruption of the SPM, the practitioner can decide to maintain the space rather than to orthodontically close it, to later fill this space with an implant, fixed or removable prosthesis, or even autotransplantation of the TPM. Holding the space is generally the treatment of choice when the favorable development of the third molar is uncertain ³⁶.

Space maintenance can be achieved in different ways, using a cast overlay band and loop, a band and loop maintainer with occlusal bar and rest, a conventional fixed bridge, a resin-bonded bridge, or stainless steel crown bridge ^{36,43}.

Rajashekhara ⁴³ presented a case report of the use of a stainless crown bridge as a space maintainer after the loss of a lower FPM at 13yo, intended to remain in place until the patient could receive a more permanent prosthetic replacement or an implant. This treatment was proven to be conservative, functional, cost-effective, with an excellent patient compliance. This option has all the advantages of an ideal space maintainer: easy to construct, it preserves the mesiodistal dimensions of the lost tooth, prevents the supra eruption opposing teeth (unlike a cast overlay band and loop, for example) and does not restrain normal growth and development ⁴³.

Nowadays, the evidence base for the management of first permanent molar extraction is weak, with currently no high scientific evidence level trials relating the planning and outcomes of a FPM loss ⁶. A randomized controlled trial called the SIXES dental trial is carried out, with the purpose of providing reliable evidence for clinicians as to whether compensating extraction of upper FPMs should be carried out following loss of lower FPMs ⁴⁴. At present, no study available relates the effect of all the modifying variables (dental age, development stage of the SPM and IInd premolar, malocclusion, arch discrepancy, presence of the TPM, compensating and balancing extraction) on every outcome of the early loss (development of the SPM, TPM and second premolar, space closure, incisor relationship, midline deviation, crowding relief, effect on a malocclusion, skeletal asymmetry, skeletal development in general), on a large enough scale to draw rational conclusions. In addition, presently, there is also a lack of scientific evidence on the outcomes of the conservation treatment techniques specifically when realized on a young first permanent molar.

5 CONCLUSION

The outcomes of a FPM extraction on a growing individual include a more or less spontaneous space closure, accelerated and improved eruption of the TPM of the same quadrant, uprighting of the incisors, counterclock wise rotation of the occlusal plane along with a shortened mandible after bilateral lower FPM loss and facial asymmetry after unilateral mandibular extraction.

Considering extraction as a treatment option at the same level as conservative treatment when it can be performed should be avoided. In view of the current incapacity to control and predict all the consequences of an act as invasive as the extraction of FPM in children, the restoration option should always be privileged if feasible. The aim should be to preserve it as long as possible, and maintain the space. Restoring the space in adulthood with an implant and/or prosthetics allows better control of the extraction space with much less harmful consequences.

This clinical dilemma highlights the importance of prevention in pediatric dentistry, as well as the education of both the child and the parents on the importance of dental hygiene, even at such a young age.

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