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ORIGINAL RESEARCH

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Timing for extraction of permanent first molars in school aged children: a pilot study

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Abstract

Extraction of permanent first molars (P1Ms) could create gaps, tipping and/or rotating of neighboring teeth, which depend on the extraction timing. This study evaluated the outcomes of P1Ms extraction in children who were classified based on their permanent second molar's (P2Ms) dental calcification at the time of extraction. In this retrospective study, the evaluations were made for 406 panoramic radiographs (PRs) of children aged 7–14 years who had single P1M extracted. Twenty-nine children having pre- and post-treatment PRs were selected based on the inclusion criteria. First, 2 groups were formed based on the extraction time by using the pre-treatment PRs; Early extraction group (EE) (n = 15) including Nolla Grades 5–6–7, and late extraction group (LE) (n = 14) including Nolla Grades 8–9–10 for P2Ms. Then, the inclination degrees of neighbouring teeth on extraction side and contralateral quadrant (non-extraction) side were measured by using the post-extraction PRs. Mann-Whitney U test was employed, and the statistical significance was set at $p < 0.05$. The mesial tipping tendency of P2M was significant towards the extraction side both at EE or LE calcification grades of P2Ms ($p > 0.05$). The mesial inclination degrees of maxillary P2Ms showed no statistically significant difference between the two sides of LE group. The ideal extraction time should be determined according to the dental age to plan an appropriate occlusal maintenance.

Keywords

Dental age; Calcification grades; Molar extraction; Permanent first molars; Nolla's method

1. Introduction

The permanent first molar (P1M) eruption starts around 6–7 years age and the root formation is completed by 9–10 years age. The early eruption of these teeth make them vulnerable to dental caries. P1Ms are the most frequently treated teeth for pit and fissure caries and hypoplasia. A restorative cycle may lead to extraction. The extraction of P1Ms in various clinical situations should be considered with the poor prognosis of P1M. Extraction is advised at a suitable time to minimize the negative effects on occlusion in severely compromised/carious P1Ms with endodontic treatment needs, failed endodontic treatment and hypoplasia [1].

The literature has conflicting views on P1Ms extraction. Some report that P1M extraction can dysfunction the masticatory system and maxillofacial tissues including skeletal, dental and periodontal tissues [1–3]. A missing tooth can have undesired outcomes such as gaps, tipping and/or rotation, and/or mesial-distal drifting, and/or lingual tilting of neighboring teeth, incisors retrusion and need for orthodontic treatment after the extraction [4].

The permanent teeth extraction should thus be the last option in dental treatments which ideally improve the oral health. Some studies report that P1M extraction at early childhood age can self-correct the space-discrepancies and prevent malocclusions development. Moreover, under the right conditions, P1M extraction can be followed by the successful permanent second molars (P2Ms) eruption to replace P1Ms, and the third molars eruption without impaction [5, 6].

The most effective extraction time is the childhood as suggested by previous studies, however with limited scientific evidence [2, 7, 8]. Eichenberger *et al.* [9] finds better clinical outcomes after P1Ms extraction in younger children (8–11.5 years) compared to older age [10]. Conversely, another study shows complete spontaneous space closure in maxilla and mandible after P1M extraction at an "early" or "late" timing [11]. In the College of Surgeons of England guideline, the ideal time for P1M extraction is at the chronological age of 8 to 10 years [12]. However, the chronological children age may not be in harmony with the dental age [9].

The present study was thus aimed to evaluate the P1Ms extraction time in children according to their P2M dental age.

The study hypothesis was that the P1M extraction affected neighbouring teeth inclinations differently based on the P2Ms dental age.

The null hypothesis was that the subsequent neighbour teeth

inclinations after P1M extraction at early and late P2M dental age were not different.

2. Materials and methods

In this retrospective study, 406 panoramic radiographs (PRs) were taken for the children having only one maxillary or mandibular P1M extracted in 12–24 months. The PRs were of the children who applied to Bezmialem Vakif University Pediatric Dentistry Clinic between the years 2013 and 2018.

Children had at least 7 years of age for the P1M extraction conducted 12 months ago. They were of maximum 14 years age when neighboring P2M and second premolar teeth calcification were completed.

2.1 Inclusion criteria

(1) Children with one maxillary or mandibular P1M extraction.

(2) Children having both pre- and post-extraction PRs (Planmeca, Helsinki, Finland; 62 kV, 5 mA, 14 s).

(3) Children with pre-extraction PRs taken between 0–3 months before the extraction.

(4) Children with post-extraction PRs taken between 12–24 months after the extraction.

2.2 Exclusion criteria

(1) Children with any other permanent teeth extraction.

(2) Presence of hypodontia, peg-shaped incisors and/or impacted teeth.

(3) Presence of craniofacial deformities like cleft palate.

(4) Children undergoing orthodontic treatment after the extraction.

2.3 Subjects selection

Twenty-nine children having both the pre- and post-treatment PRs including the other inclusion criteria were selected from 406 PRs. First, 2 groups were formed by using the pre-treatment PRs according to the Nolla's dental calcification grades [13] of P2Ms at the extraction time: Early extraction group (EE) (n = 15) including Grades 5–6–7, and Late extraction group (LE) (n = 14) including Grades 8–9–10. The Nolla's system had development score between 1 to 10 for each tooth, and divided the crowns and roots formation of teeth into ten grades. PRs assessments were performed separately for 10 cases to determine inter-rater reliability by pediatric dentist and oral radiologist.

2.4 Measurements

The inclination degrees of neighbouring teeth (second premolars (SPs) and P2Ms) were measured from the post-extraction PRs. Extraction side was employed as the study group while contralateral quadrant (non-extraction side) as control based on post-extraction PRs. Six angles were formed on PRs by using long axises (Fig. 1) for measuring the inclination degrees of neighboring teeth in extraction and contralateral (non-extraction side) sides. An orthodontist drew the long axes of molars on post-extraction PRs to form these angles *via* a line passing through mesial cusp tip and mesial root apex in the maxilla. The distal cusp tip and root apex were used in the mandible because the inclination of mesial root of mandibular molars showed greater form variety. For the maxillary or mandibular SP, the long axis was formed with the line passing through cusp tip and root apex of relevant tooth. A line through basis mandible and maxillary plane was drawn to form angles between the long axes of designated teeth with maxillary and mandibular planes. This assessed the mesial and/or distal inclinations of teeth.

2.5 The angles (Fig. 2 and Fig. 3)

(Angle 1) between the long axis of P2M and second premolar in the extraction side;

(Angle 2) between the long axis of P1M and SP in the contralateral side;

(Angle 3) the distal inclination of SP in extraction side;

(Angle 4) the distal inclination of SP in contralateral side;

(Angle 5) the mesial inclination of P2M in extraction side;

(Angle 6-P1M) the mesial angle between long axis of P1M and basis mandible in contralateral side, and

(Angle 6-P2M) the mesial angle between the long axis of P2M and basis mandible in contralateral side.

2.6 Statistical analyses

Statistical analyses were conducted using the Number Cruncher Statistical System (NCSS 2007 Statistical Software, East Kaysville, Utah, USA) and SPSS 20.0 for Windows (IBM Corporation, Chicago, IL, USA). Statistical significance was set at $p < 0.05$. Mann-Whitney U test compared the intragroup angular measurements. A pediatric dentist and oral radiologist evaluated the PRs to assess dental calcification grades of P2Ms. Interexaminer reliability was separately tested for the 10 cases using Kappa statistics. The same orthodontist reevaluated all PRs 1 week later to test the angular measurements repeatability. Intraclass correlation coefficient (ICC) evaluated the agreement between first and second measurements. The minimum sample size to detect significance difference was 4 by considering type I error (alpha) as 0.05, power (1−beta) as 0.8, effect size as 2.79, and two-sided alternative hypothesis (H1) [14].

3. Results

Interexaminer reliability between pediatric dentist and oral radiologist indicated the agreement in reliably assessing the P2Ms calcification grades. Intraclass correlation coefficient (ICC) for the angular measurements indicated a high-level reliability of 0.999 ((Confidence Interval) CI: 0.996–1).

Twenty-nine children's PRs were evaluated by fulfilling the inclusion criteria (Table 1). The mean age was 10 ± 1.73 years with median as 9 at the time of extraction. Two groups were composed based on the P2Ms calcification grades. Fifteen children were placed in the early extraction group (Group EE); "Grades 5–6–7" including 6 maxillary, and 9 mandibular extracted P1M, and 14 children in the late extraction group (Group LE); "Grades 8–9–10" including 7 maxillary, and 7 mandibular extracted P1Ms. The median and interquartile

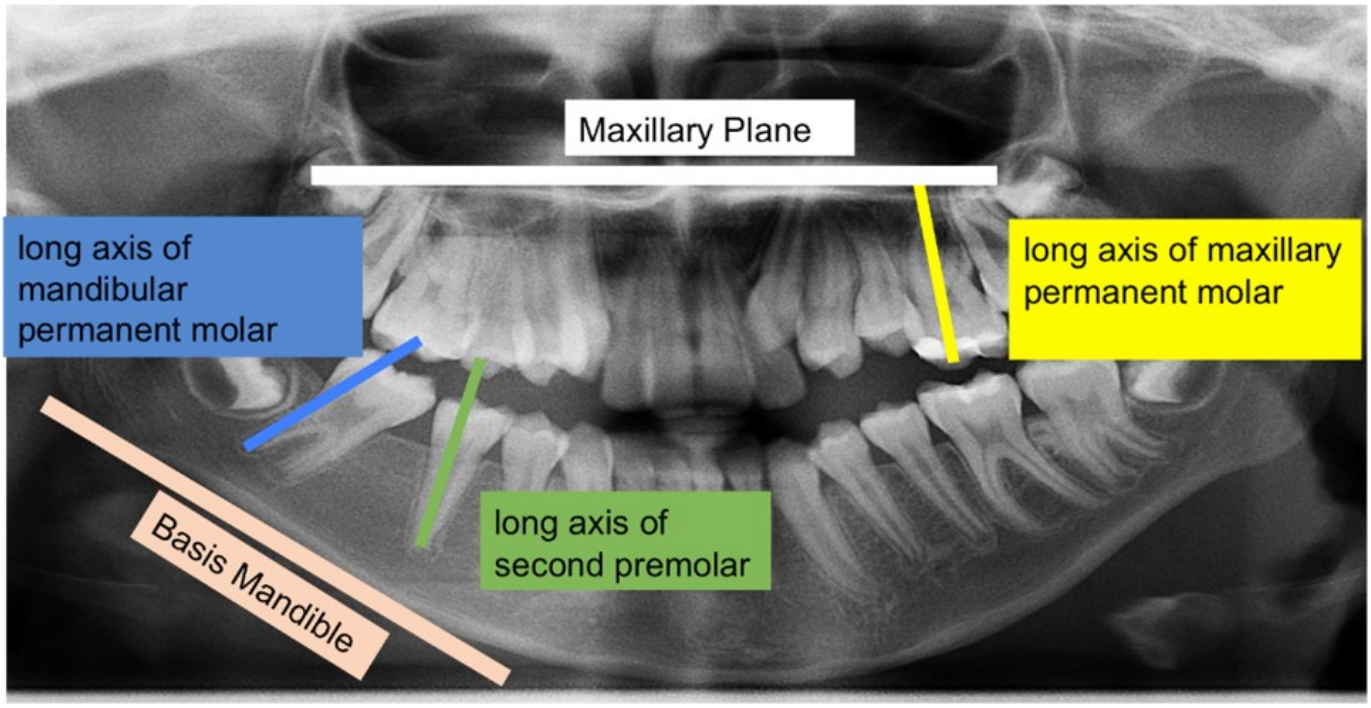

FIGURE 1. Drawn long axises. White line: maxillary plane; Orange line: basis mandible; Yellow line: long axis of maxillary permanent molar; Blue line: long axis of mandibular permanent molar; Green line: long axis of second premolar.

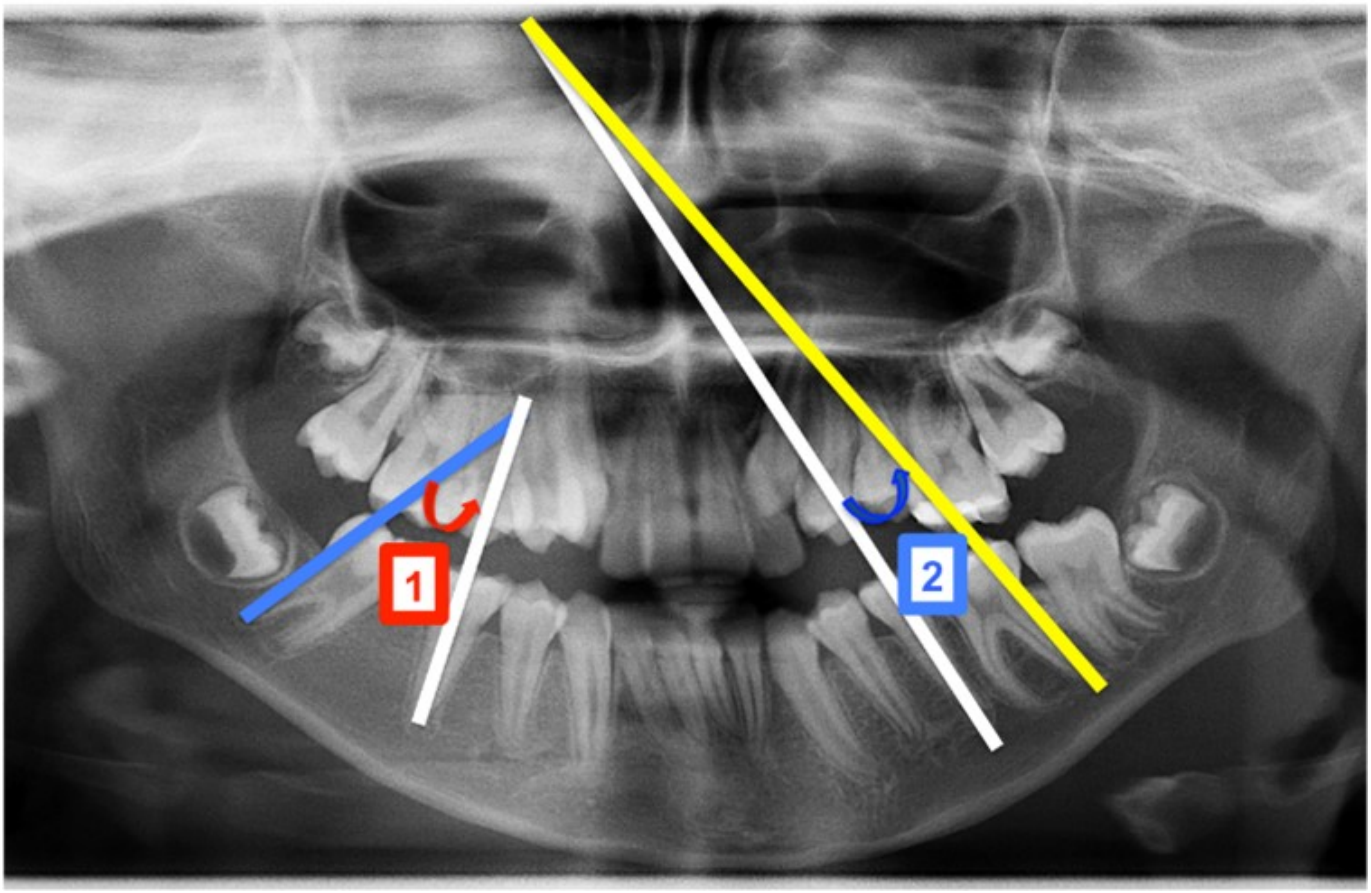

FIGURE 2. Forming the Angle 1 and Angle 2. (Angle 1) Red arrow: the angle formed between long axis of P2M and SP in the extraction side; (Angle 2) Blue arrow: the angle formed between long axis of P1M and SP in the contralateral side; White lines: long axis of SP; Yellow line: long axis of P1M; Blue line: long axis of P2M.

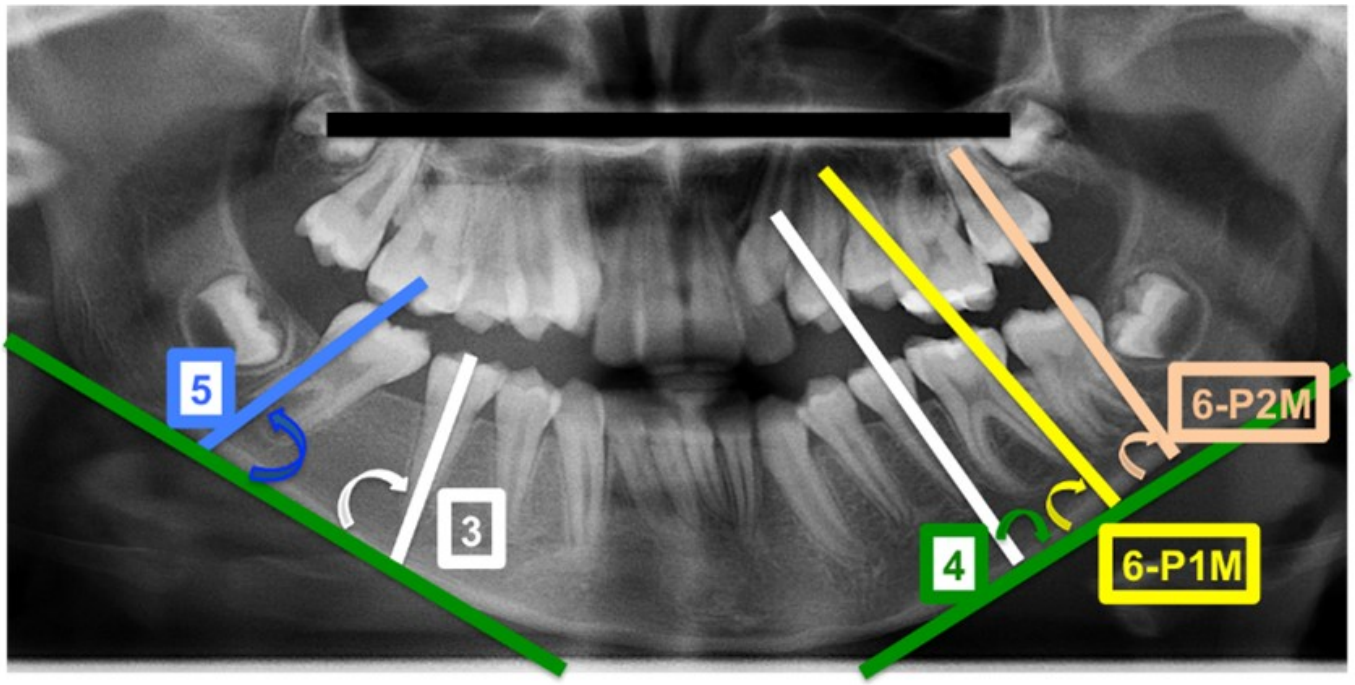

FIGURE 3. Forming the Angle 3, Angle 4, Angle 5, Angle 6-P1M and Angle 6-P2M. (Angle 3) White arrow: the distal angle formed between the long axis of SP and basis mandible in the extraction side; (Angle 4) Green arrow: the distal angle formed between the long axis of SP and basis mandible in the contralateral side; (Angle 5) Blue arrow: the mesial angle formed between the long axis of P2M and basis mandible in the extraction side; (Angle 6-P1M) Yellow arrow: the mesial angle formed between the long axis of P1M and basis mandible in the contralateral side; (Angle 6-P2M) Orange arrow: the mesial angle formed between the long axis of P2M and basis mandible in the contralateral side. Green line: basis mandible; Blue line: long axis of P2M in the extraction side; White lines: long axis of PS; Yellow line: long axis of P1M; Orange line: long axis of P2M in the contralateral side; Black line: maxillary plane.

ranges of angular measurements are given in Table 1.

Angles 1 and 2 were different for the extraction and contralateral sides in both maxilla and mandible ($p < 0.05$) (Table 2, Fig. 2). Angle 1 was the angle between long axes of P2M and SP in the extraction side, while Angle 2 was between the long axes of P1M and SP in contralateral side. This difference emphasized significant mesial tipping tendency of P2M in the extraction sides of both EE and LE calcification grades of P2Ms ($p > 0.05$).

Angles 3 and 4 were compared to evaluate the distal tipping tendency of SP (Table 3, Fig. 3). Smaller values were found in the extraction side compared to contralateral side. The difference was statistically significant only in the mandible for both EE and LE calcification grades of P2Ms.

Angles 5, 6-P1M and 6-P2M were compared to find the similarity in the inclinations of P2Ms on the extraction side to those of P1M and P2M on contralateral side (Table 4, Fig. 3). The smaller mesial inclination degrees were found in the extraction side (Angle 5) compared to contralateral sides, however, no significant difference was observed in the maxilla for late extraction group. The maxillary P2Ms had less tipping compared to EE group and mandibular counterparts in the late extraction group.

The mesial inclination degrees of P2Ms in the extraction side and P1Ms in contralateral side (Angles 5 and 6-P1M) were also evaluated to find if P2Ms in the extraction side could act like the extracted P1Ms (Table 4). Maxillary molars in the EE, and mandibular molars in LE group depicted statistically significant results indicating that maxillary P2Ms had less tipping after P1Ms extraction in Grades 8–9–10 than the Grades 5–6–7. Contrarily, the mandibular P2Ms had more tipping after the extraction in Grades 8–9–10 than in Grades 5–6–7. The ideal timings for P1M extractions of maxilla and mandible could thus be influenced by the calcification grades of P2Ms at the extraction time.

4. Discussion

Recent epidemiological studies exhibited that 60–90% carious lesions occurred in the pits and fissures of permanent first molars, despite the preventive ongoing programs [15]. More than 50% children over 11 years age had been reported for caries in the permanent first molars [7]. The preferred therapy in severely compromised permanent first molar with poor prognosis might be extraction, although being non-restorable. The first and the third mandibular molars were the frequently extracted posterior teeth, and the prevalence of mandibular P1M loss was reported as 10.9–22.2% [16, 17]. Some studies revealed that early P1Ms extraction might have favorable occlusion and spontaneous space closure outcomes [6].

There was little scientific evidence on the ideal extraction time to minimize the more negative side effects in mandible than in the maxilla [7]. In present study, similar results were found as the distal tipping degrees of SP teeth reflected higher

TABLE 1. The angular measurements including median and minimum–maximum values (showing in degrees).

Groups (number of children)	Extracted tooth	Angle 1 Median (IR)	Angle 2 Median (IR)	Angle 3 Median (IR)	Angle 4 Median (IR)	Angle 5 Median (IR)	Angle 6 Median (IR)	
							6-P1M	6-P2M
Early Extraction (n: 6)	maxillary P1M	12.5 (6–26)	3 (2–4)	83.5 (74–94)	86 (80–90)	89 (80–100)	94.5 (90–116)	111 (107–121)
Early Extraction (n: 9)	mandibular P1M	27 (10–43)	9 (1–14)	74 (63–81)	82 (75–91)	85 (69–98)	89 (78–96)	94 (84–107)
Late Extraction (n: 7)	maxillary P1M	13 (3–28)	3 (2–4)	79 (67–91)	85 (75–103)	107 (83–116)	96 (82–116)	110 (100–124)
Late Extraction (n: 7)	mandibular P1M	33 (24–48)	9 (4–20)	69 (58–85)	81 (66–86)	76 (73–85)	90 (86–95)	90 (84–95)

IR: interquartile range; P1M: permanent first molar; P2M: permanent second molar.
(Angle 1) the angle formed between long axises of P2M and second premolar in the extraction side;
(Angle 2) the angle formed between long axises of P1M and SP in the contralateral side;
(Angle 3) the distal inclination of SP in the extraction side;
(Angle 4) the distal inclination of SP in the contralateral side;
(Angle 5) the mesial inclination of P2M in the extraction side;
(Angle 6-P1M) the mesial angle formed between the long axis of P1M and basis mandible in the contralateral side;
(Angle 6-P2M) the mesial angle formed between the long axis of P2M and basis mandible in the contralateral side.

TABLE 2. Comparison of the Angle 1 and Angle 2 (showing in degrees).

Groups (number of children)	Extracted tooth	Angle 1 Median (interquartile range)	Angle 2 Median (interquartile range)	*p* value ($p < 0.05$)
Early Extraction (n: 6)	maxillary P1M	12.5 (6–26)	3 (2–4)	0.010*
Early Extraction (n: 9)	mandibular P1M	27 (10–43)	9 (1–14)	0.002*
Late Extraction (n: 7)	maxillary P1M	13 (3–28)	3 (2–4)	0.006*
Late Extraction (n: 7)	mandibular P1M	33 (24–48)	9 (4–20)	0.001*

*Mann Whitney U test was performed. *Significance was $p < 0.05$; P1M: permanent first molar.*
(Angle 1) the angle formed between long axises of P2M and second premolar in the extraction side; (Angle 2) the angle formed between long axises of P1M and SP in the contralateral side.

TABLE 3. Comparison of the Angle 3 and Angle 4 (showing in degrees).

Groups (number of children)	Extracted tooth	Angle 3 Median (interquartile range)	Angle 4 Median (interquartile range)	*p* value ($p < 0.05$)
Early Extraction (n: 6)	maxillary P1M	83.5 (74–94)	86 (80–90)	0.653
Early Extraction (n: 9)	mandibular P1M	74 (63–81)	82 (75–91)	0.001*
Late Extraction (n: 7)	maxillary P1M	79 (67–91)	85 (75–103)	0.170
Late Extraction (n: 7)	mandibular P1M	69 (58–85)	81 (66–86)	0.023*

*Mann Whitney U test was performed. *Significance was $p < 0.05$; P1M: permanent first molar.*
(Angle 3) the distal inclination of SP in the extraction side; (Angle 4) the distal inclination of SP in the contralateral side.

values in mandible for EE and LE groups.

After maxillary P1M extraction, the P2Ms tilted anteriorly into a camouflage position of the arch in the eruption process. Consequently, the P2M apex was comparatively more mesial in relation to the crown. Conversely, the apex of permanent second molar in the mandible was placed more distally.

TABLE 4. Comparison of the Angle 5 and Angle 6-P1M, 6-P2M (showing in degrees).

Groups (number of children)	Extracted tooth	Angle 5 Median (interquartile range)	Angle 6-P1M Median (interquartile range)	Angle 6-P2M Median (interquartile range)
Early Extraction (n: 6)	maxillary P1M	89 (80–100)	94.5 (90–116)*	111 (107–121)*
Early Extraction (n: 9)	mandibular P1M	85 (69–98)	89 (78–96)	94 (84–107)*
Late Extraction (n: 7)	maxillary P1M	107 (83–116)	96 (82–116)	110 (100–124)
Late Extraction (n: 7)	mandibular P1M	76 (73–85)	90 (86–95)*	90 (84–95)*

*Mann Whitney U test was performed. *Significance was $p < 0.05$; P1M: permanent first molar; P2M: permanent second molar. (Angle 5) the mesial inclination of P2M in the extraction side; (Angle 6-P1M) the mesial angle formed between the long axis of P1M and basis mandible in the contralateral side; (Angle 6-P2M) the mesial angle formed between the long axis of P2M and basis mandible in the contralateral side.*

The crown thus tended to incline mesially instead of bodily movement [16]. The findings herein also showed significant inclination in mandibular P2Ms after the P1Ms extraction. It could be concluded that mandibular P1M extraction had more negative side effects than observed in maxillary P1M extraction at early and late stages of P2M calcification.

It was claimed in a previous study that the spontaneous space closure between P2M and SP in the maxilla could be achieved with mesial tilting of P2M, even if P1Ms were extracted soon after P2Ms eruption [7]. This phenomenon was consistent with the results of present study which found no significant difference at the mesial inclination degrees of maxillary second molars (Angles 5 and 6-P2M) in the late extraction group. The maxillary P2Ms had less tipping than the counterparts after P1Ms extraction in late extraction group. It could thus be suggested to perform P1Ms extraction in maxilla at Nolla grades 8–9–10 of P2M calcification to minimize negative side effects. Similar with P2Ms, the findings of present study were supportive to the significant differences between distal inclination degrees of SPs in maxilla and mandible (Angles 3 and 4). Only the mandibular SP in extraction side had distal inclination tendency.

Previous studies reported that mandibular P1M extraction after the age of 8 years was likely to cause mesial tilting and lingual rolling of P2Ms [11, 18]. The results herein supported these studies. P1Ms extractions resulted in the inclinations of P2Ms and SPs despite the planned extractions in children aged 8–10 years [11, 18]. The ideal timing for space closure between P2Ms and SPs was expected until the age 8 for both maxilla and mandible. This was achieved by the distal drifting and/or tilting of SP, and mesial drifting and/or lingual tipping of P2M [7]. The groups of this study were composed according to the dental development stages of P2M instead of the chronological age of children at the time of extraction as the chronological age might not always be in harmony with dental development [9]. Moreover, the dental maturation of children at similar ages in various ethnic groups might also differ because of gene pools, living conditions, climate, socioeconomic status, nutrition and secular changes which affected the accuracy of dental age estimation. The dental development of each P2M in this study was thus assessed using Nolla's system which was more accurate than the Demirjian's system for estimating dental age in Turkish population [9].

The present study had some limitations. More cases would support strong evidence. The lack of clinical examination data could be considered as a limitation because of the retrospective study design. Hence, the bucco-lingual position of these teeth could not be identified. Furthermore, the 12–24 months follow-up period could create bias due to not having standard post-extraction time for all the subjects.

5. Conclusions

A developing dentition was affected by the permanent first molar extraction depending on the extraction timing, particularly in the mandible. The ideal extraction time must be considered keeping in view the dental age of children and planned according to the calcification grades of P2M teeth for the conducive outcomes.

ABBREVIATIONS

PR, panoramic radiographs; P1M, permanent first molar; P2M, permanent second molar; SP, second premolar; IR, interquartile range.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

MB, BY, MSK, TU, SO and PKT—designed the study, performed the research. MB and BY—performed the measurements. MSK—analyzed the data. MB, BY and MSK—wrote the manuscript. TU, SO and PKT—revised the manuscript. All authors designed and performed the research study. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was granted by Bezmialem Vakif University Local Ethics Committee (Protocol number: 12/129).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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