Original Article

Extreme premolar rotations: a possible addition to the dental anomaly pattern?

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ABSTRACT

Objectives: To investigate the possible association between the presence of extreme premolar rotations (135° to 180° rotated premolars) and other dental anomalies within the dental anomaly pattern (DAP).

Materials and Methods: Thirty-two healthy subjects exhibiting at least one premolar rotated 135° to 180° were identified from the archives of a university orthodontic clinic. Inclusion criteria were: presence of a rotated premolar, availability of panoramic radiographs, dental study casts, and intraoral photographs. The concomitant occurrence of additional dental anomalies was evaluated based on the DAP, including tooth agenesis, infraocclusion of deciduous molars, peg-shaped lateral incisors, palatally-displaced canines and transpositions. Comparisons were made to a randomly selected control group (n = 96) without this anomaly, using chi-square statistics.

Results: The experimental group displayed a higher prevalence of dental anomalies compared to the control group. Forty-seven percent of patients in the experimental group exhibited dental agenesis, whereas only 8% of the control group had dental agenesis ($P < .001$). Infraocclusion of deciduous molars (22% vs 5%; $P = .005$) and canine impaction (16% vs 3%; $P = .035$) were also observed more frequently in patients in the experimental group.

Conclusions: These findings reveal significant associations between the presence of extreme premolar rotations and the occurrence of other dental anomalies, namely dental agenesis, infraocclusion of deciduous molars, and palatally-displaced canines. These observations suggest a shared genetic origin for these anomalies. (*Angle Orthod*. 2025;00:000–000.)

KEY WORDS: 180-degree rotated premolars; Dental anomaly pattern; Infraoccluded primary teeth; Palatally-displaced canines

INTRODUCTION

Extreme premolar rotations are a rare phenomenon, primarily documented through case reports.[1–4] Initially described by De Jonge, extreme premolar rotation involves a rotation of more than 135°, positioning the buccal cusps of premolars where their palatal or lingual cusps should be.[4] This condition has led to varied interpretations and explanations.

Several etiological factors have been proposed, including environmental and genetic influences. Environmental factors proposed include prolonged retention of deciduous teeth,[5] premature loss of primary teeth leading to mesial drift of the first permanent molar,[6] incomplete resorption of deciduous roots or pathological lesions in the apical area might exert pressure on the tooth bud, causing rotation.[7] Premature loss of first permanent molars have also been found to contribute to rotation and distal inclination of second premolars,[8] with the timing of tooth loss playing a significant role with these, rotations being more common in the mandibular arch.[9] Crowding has also been considered a concomitant factor,[8] although the space occupied by an extremely rotated premolar may not be different than that of a normally rotated premolar.[10]

A genetic origin hypothesis suggests a developmental rotation of the dental crypts during tooth formation. Moore's theory of axial gradients posits that differences

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in metabolic rates of cell poles could lead to abnormal tooth development and rotation.[11] Kjaer[12,13] investigated abnormal premolar eruption and concluded that deviations in the position of the crown follicle may cause delays or pauses in the eruption process.

Considering a genetic origin, a relationship with other genetic dental anomalies can be postulated. Peck described the so-called dental anomaly pattern (DAP) as an interrelationship among two or more dental abnormalities within the dentition, such as tooth agenesis, abnormal tooth size or shape, delayed formation or eruption, infraocclusion of deciduous molars, palatally-displaced canines, transpositions, and distal angulation of unerupted mandibular second premolars, which are observed together in patients at a higher frequency than could be explained by chance alone.[14] These anomalies are speculated to affect 10%–20% of orthodontic patients.[14]

Examples of these relationships include the association between tooth agenesis and delayed dental development,[15] agenesis of the maxillary lateral incisor and transposition of the maxillary canine and the first premolar,[16] and correlation between abnormalities in tooth size, such as generalized tooth-size reduction, and palatally displaced canines (often associated with microdontia).[17]

Infraocclusion of deciduous molars is characterized by insufficient tooth eruption resulting in a more gingival position of the occlusal surface relative to the occlusal plane.[18] Contributing factors may include abnormal eruption of permanent teeth,[19] ankylosis,[20] bone remodeling in the anterior mandible,[21] tongue posture,[22] neural crest malformations,[23] and Mendelian inheritance.[24–30] Infraocclusion is also often linked to other dental anomalies described in the DAP.[31–36]

Given the interrelated nature of noted dental anomalies and the lack of literature specifically linking extreme premolar rotations to the broader context of the DAP, further study is needed to clarify the etiology, prevalence, and impact of extreme premolar rotations on occlusal function and dental development. The aim of the present study was to investigate the possible association between extreme premolar rotations (135° to 180° rotations) and other dental anomalies included in the DAP. For clinicians, this can help raise awareness about a potential correlation between extreme premolar rotation and other dental anomalies, which could influence patient diagnosis and, consequently, treatment planning.

MATERIALS AND METHODS

Study Design and Ethical Approval

The present investigation was a retrospective, cross-sectional study including two groups of orthodontic patients derived from the archives of the orthodontic clinic of the University Clinics of Dental Medicine, University of Geneva. Data were anonymized and after a written request, clearance was given by the cantonal commission for research ethics in human beings (Req-2019-01103).

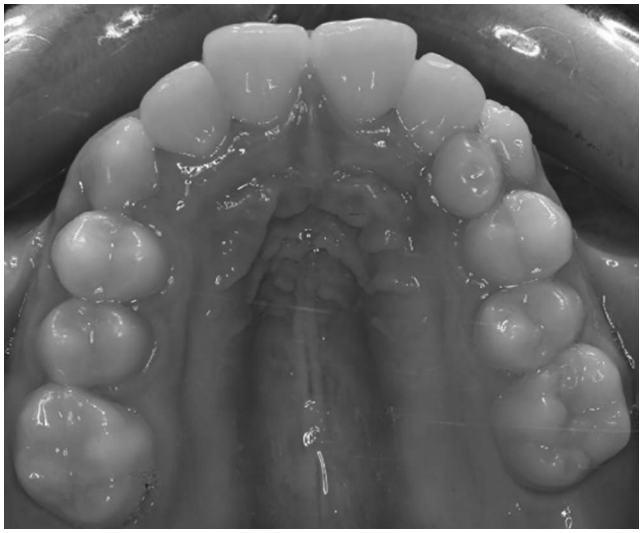

Figure 1. An example of a 180°-rotated premolar from the present sample, tooth 25.

Study Population

The study sample was divided into two groups: an experimental group with at least one premolar erupted with a rotation greater than 135° (Figure 1) as described by De Jonge,[4] and a control group (with a 3:1 ratio; more controls than cases) of randomly selected patients without any extreme premolar rotations. A three-to-one control-to-case ratio was employed as it has been suggested to increase statistical power and precision, reduce false negatives, and provide more robust, reliable conclusions with minimal additional resource cost.[37,38]

Inclusion criteria for the experimental group were: presence of at least one premolar exhibiting a 135° to 180° rotation (only fully erupted premolars were considered in the diagnosis); availability of a panoramic radiograph; availability of intraoral photographs; availability of dental study casts. Patients were excluded if they had cleft lip and/or palate or any craniofacial syndrome. The same eligibility criteria were used for the control patients, with the exception of having extreme premolar rotation.

Sample Selection

Patient records from all 4673 files from the archives of the division of orthodontics at the University Clinics of Dental Medicine, University of Geneva, were examined to identify cases of premolars with extreme rotation. Rotation was assessed based on the presence of

the palatal cusp toward the buccal side and the buccal cusp toward the palatal side. Determination of such cases was confirmed by assessing the intraoral photographs available.

After having identified all eligible cases, a control group was selected from the same clinic archives by randomly selecting three times the number of cases using the randomization tool available at www.randomizer.org.

Data Collection and Outcomes

Experimental cases were first identified by evaluating dental study casts for premolars rotated more than 135°, using the initial and any subsequent records, which were then verified using intraoral photographs. Each selected case, in the experimental and control groups, was evaluated by analyzing intraoral photographs, dental study casts, and panoramic radiographs to identify potential dental anomalies according to the DAP. Tooth annotation was carried out using the FDI tooth numbering system.

Panoramic radiographs were examined to identify the absence of permanent teeth (excluding third molars), infraocclusion of deciduous molars, distal angulation of unerupted lower second premolars,[39] transposition of the canine and first premolar, supernumerary teeth, impacted teeth, and morphologic anomalies such as root dilaceration. Subsequent radiographs confirmed dental agenesis, infraocclusion, and palatally-displaced canines.

Dental study casts were used to assess microdontia of lateral incisors (conical-shaped or reduced mesiodistal width), generalized tooth-size reduction, infraoccluded primary molars, maxillary canine-first premolar transpositions, supernumerary teeth, and severe space deficiencies or crowding.

Statistical Analysis

The experimental (135° to 180° rotated premolar) group was compared to the control group with regard to sex distribution (using a chi-square test) and age (using an independent sample *t*-test). The prevalence of each dental anomaly was calculated for each group, along with 95% confidence intervals (95% CI) using a binomial exact calculation (Clopper-Pearson method) due to small sample sizes. Chi-square statistics were also used to compare the presence of each of the individual dental anomalies in the experimental versus the control group. Yates' correction was used to prevent the overestimation of statistical significance for small data when at least one cell of the two-by-two contingency table had a count of less than five. A *P*-value threshold of .05 was used to signify statistical significance. Statistical analyses were carried out using IBM SPSS Statistics (version 26).

Error of the method was analyzed using repeated measures. Two evaluators examined the selected cases independently, and inter-rater agreement was calculated using kappa statistics. Panoramic radiographs were examined blindly without knowing whether they belonged to the test or control group, but blinding was not possible on dental study cast assessments since extreme premolar rotations were readily visible. One evaluator examined all of the cases twice, with at least a 2-week interval between the two examination sessions, and intra-rater agreement was calculated using kappa statistics.

RESULTS

Study Population and Baseline Characteristics

A total of 128 patients were included in the present study, divided into two groups: an experimental group of 32 patients (with at least one extreme premolar rotation), and a threefold-sized control group of 96 patients. The experimental group, characterized by the presence of at least one extremely-rotated premolar, consisted of 17 females and 15 males with a mean age of 15.4 $\pm$ 7.8 years. The control group comprised 63 females and 33 males with a mean age of 16.2 $\pm$ 9.2 years. Statistical analysis using chi-square tests revealed no significant differences in sex distribution between the two groups ($P = .21$), and an independent sample *t*-test revealed no significant age difference between groups ($P = .65$).

Due to the rarity of the condition of interest, all patients identified with extreme premolar rotations within the archives of the university orthodontic clinic were included, and an a priori sample size calculation was, therefore, not carried out. In lieu of this, a post-hoc power analysis was performed using G*Power (University of Dusseldorf, Germany), with the available sample and the data obtained in the two-by-two contingency table, for palatally-displaced canines as the outcome of interest, and an alpha error probability of 0.05. The resulting power was 98%.

Extreme Premolar Rotations in the Experimental Group

Within the experimental group, each case with at least one extreme premolar rotation was thoroughly documented. All subjects with a 135° to 180° premolar rotation displayed this anomaly in the maxillary second premolars, specifically teeth 25 or 15, with the exception of one patient who also exhibited rotation in the maxillary right first premolar (tooth 14). The maxillary left second premolar (tooth 25) was the most frequently rotated, occurring in 65.6% of the included cases, followed by the maxillary right second premolar

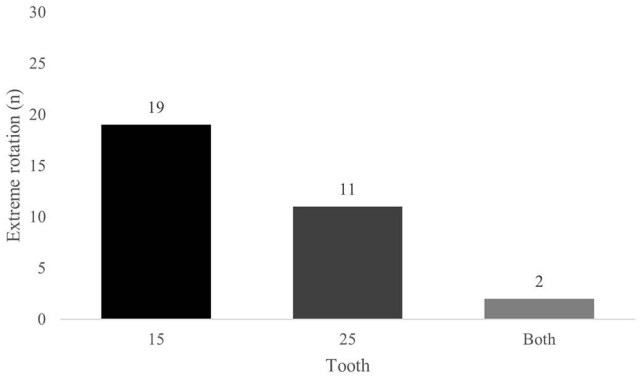

Figure 2. Number of patients with extreme rotations involving only the maxillary right or left second premolar, or both maxillary second premolars.

(tooth 15) with a prevalence of 40.6%. Bilateral premolar rotation was observed in two cases (Figure 2). No instances of extreme premolar rotation were noted in the mandibular arch.

Dental Anomaly Pattern (DAP)

Comparing the prevalence of the various anomalies included in the DAP between the experimental and control groups, chi-square tests identified statistically significant differences in the prevalence of dental agenesis (Pearson chi-square = 24.2; $P < .001$), infraocclusion of deciduous molars (Pearson chi-square = 7.8; $P = .005$), and palatally-displaced canines (Pearson chi-square = 4.4; $P = .035$) (Table 1). The prevalence of all other examined dental anomalies was not significantly different between the experimental and control groups (Table 1).

Reliability Assessment

Both inter-rater and intra-rater reliability assessment showed no inconsistency for the observations of all assessed dental anomalies, with kappa values of 1.00 (perfect agreement), except for distal angulation of the unerupted mandibular second premolars that showed a k value of 0.83 for inter-rater agreement and 0.87 for intra-rater agreement (excellent agreement).

DISCUSSION

The findings of the present study provided significant insight into the relationship between extreme premolar rotation and the spectrum of dental anomalies included in the DAP. Peck and Peck[40] theorized that some dental anomalies often occur together due to shared genetic influence. However, the relationship between extreme premolar rotation and those conditions was not specifically reported. The current study identified a statistically significant association between extreme premolar rotations and dental anomalies such as agenesis, infraocclusion of primary molars, and palatally displaced canines, suggesting a potential shared genetic etiology underlying these conditions, aligning with the theory proposed by Peck and Peck.

Several authors have discussed the associations between different dental anomalies. For instance, in 1996, Peck et al.[41] documented the relationship between tooth agenesis and peg-shaped maxillary lateral incisors with palatally-displaced canines as part of this phenomenon. Additionally, Baccetti[36] emphasized the prevalence of dental anomalies in orthodontic patients, highlighting the possibility of a genetic predisposition. Sidhu et al.[31] identified the infraocclusion of primary molars as part of a broader pattern of dental anomalies. The concurrence of infraocclusion and extreme premolar rotations in this study supports these findings, reinforcing the hypothesis of a shared genetic basis.

Additionally, the idea of morphogenetic fields in the etiology of various dental problems has been referenced in previous reports, suggesting that spatial and temporal development of premolars may be influenced by a premolar morphogenetic field.[42] This concept might explain why rotated and absent premolars may co-occur in the same individual.

Table 1. Prevalence of Dental Anomalies in Each Group, With 95% Confidence Intervals (CI) and Chi-Square Test Comparisons

	Premolar-Rotation Group		Control Group		Chi-Square	*P*
	n	Prevalence (95% CI)	n	Prevalence (95% CI)	Statistic	Value
Total no. of patients	**32**	**-**	**96**	-	-	-
Agenesis	15	46.9% (29.1–65.3)	8	8.3% (3.7–15.8)	24.19	**<.001**
Supernumerary teeth	0	0.0% (0.0–10.9)	1	1.0% (0.0–5.7)	0.33	.562
Peg-shaped lateral incisors	3	9.4%(2.0–25.0)	2	2.1% (0.3–7.3)	1.73	.188
Microdontia	0	0.0% (0.0–10.9)	0	0.0% (0.0–3.8)	0.00	1.000
Infraocclusion of deciduous molars	7	21.9% (9.3–40.0)	5	5.2% (1.7–11.7)	7.85	**.005**
Palatally-displaced canines	5	15.6% (5.3–32.8)	3	3.1% (0.6–8.9)	4.44	**.035**
Transpositions	1	3.1% (0.1–16.2)	0	0.0% (0.0–3.8)	0.33	.562
Distal angulation of unerupted second mandibular molars	1	3.1% (0.1–16.2)	4	4.2% (1.1–10.3)	0.07	.792
Other dental anomalies	3	9.4% (2.0–25.0)	2	2.1% (0.3–7.3)	1.73	.188

Conversely, some authors argue that environmental factors, rather than genetic influence, may explain the relationships between different types of dental anomalies. Seipel[8] examined variation in tooth position, asserting that developmental factors significantly influence the presence of dental anomalies. Cases documenting some tooth rotations[1–4,6,10,43] discuss potential etiologies and suggested that rotated premolars could result from genetic and environmental factors, including the premature loss of deciduous teeth. This notion was further supported by the work of Morgan[5] and Linder-Aronson.[44] Saimbi et al.[1] examined a case of a 180° rotation of mandibular first molars and varying degrees of rotation of mandibular premolars, suggesting that some rotations could result from space discrepancies, while extreme rotations might require alternative explanations, such as the theory of axial gradients proposed by Moore in 1953.[11]

Thilander et al.[9] also considered the role of environmental factors, such as the premature loss of deciduous teeth, in causing dental rotations. Kim et al.[7] explored pre-eruptive factors influencing tooth rotation and axial inclination, suggesting that these issues could potentially arise from developmental disruptions during tooth formation. Collectively, these studies indicate that environmental factors such as premature tooth loss and developmental disruptions can contribute to dental anomalies, including extreme rotations of premolars.

Harris and Dinh[45] provided theories on the mesial eruptive path of the upper first molars leading to inadequate space for premolars, causing them to erupt along pathways of resistance. This was supported by findings from other studies,[46–48] which discussed how early erupting first molars could occupy space designated for primary second molars, causing premature loss and impacting premolar eruption.

Considering both genetic and environmental factors, as well as epigenetics, may shed light toward explaining multiple dental anomalies co-occurring in the same individual. A comprehensive review[49] underscored the importance of considering both genetic and environmental factors in the etiology of dental anomalies. In the context of the anomaly presented in this study, extreme rotations of premolars and other dental anomalies such as agenesis, infraocclusion, and palatally-displaced canines may co-occur through a shared or common genetic origin, but the influence of environmental factors cannot be disregarded altogether. Extreme premolar rotations of 135° to 180° are a specific anomaly that is considered rare, and it is potentially indicative of genetic and environmental interactions affecting tooth development. Consequently, it is proposed that it should possibly be included within the DAP.

Limitations

This retrospective single-center study had limitations, including a small sample size and limited generalizability. Larger, possibly international, databases are needed to validate these associations and better understand the genetic and environmental factors in the expanded DAP. Additionally, whereas panoramic radiographs and dental casts are useful diagnostic tools, they may not fully capture these anomalies. Future studies should incorporate advanced imaging techniques and genetic testing for more detailed insights into the etiology of these conditions.

CONCLUSIONS

- Significant associations were found between the presence of extreme premolar rotations and other dental anomalies, including dental agenesis, infraocclusion of deciduous molars, and palatally-displaced canines.
- These associations suggest a shared genetic origin between the different dental anomalies.
- Practitioners should consider comprehensive diagnostic evaluation for patients with extreme premolar rotations, as they may be predisposed to other dental developmental anomalies.
- Further research is essential to unravel the underlying genetic mechanisms and improve diagnostic and treatment strategies for patients with co-occurring dental anomalies.

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