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Evaluating Effectiveness Of Premolar Extraction On Mandibular Rotation

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Abstract
Background: *Premolar extraction is a conventional orthodontic approach used to alleviate dental crowding and reduce protrusion. However, its impact on mandibular rotation remains a subject of clinical debate, particularly concerning changes in the vertical dimension and growth direction.*
Aim:*To evaluate the effects of premolar extraction on mandibular rotation patterns in orthodontic patients using cephalometric parameters.*
Materials and Methods:*A retrospective cephalometric study was conducted on 68 patients (42 females, 26 males; mean age 16.8 ± 2.4 years), including 34 patients treated with extraction of four first premolars and 34 non-extraction controls. Standardized lateral cephalograms were taken pre- and post-treatment. Cephalometric variables analyzed included SN-GoGn angle, FMA angle, Y-axis angle, Jarabak ratio, and lower anterior facial height (ANS-Me). Statistical analysis was performed using paired t-tests and intergroup comparisons.*
Results:*In the extraction group, changes in mandibular rotation parameters were minimal and statistically non-significant: SN-GoGn angle: +0.42 ± 1.8° (p = 0.186), FMA angle: +0.28 ± 1.4° (p = 0.243), Y-axis angle: +0.35 ± 1.2° (p = 0.164). The non-extraction group exhibited similarly negligible changes: ANS-Me increased by 1.2 ± 2.1 mm in extraction vs. 1.8 ± 2.3 mm in controls (p = 0.298), Jarabak ratio remained stable (62.4 ± 4.2% vs. 61.8 ± 3.9%, p = 0.542)*
Conclusion:*Premolar extraction does not significantly influence mandibular rotation patterns when appropriate orthodontic mechanics are utilized. These findings counter traditional concerns regarding vertical dimensional changes following extraction-based orthodontic therapy.*
Keywords:*Premolar extraction, mandibular rotation, cephalometric analysis, vertical dimension, orthodontic treatment.*

INTRODUCTION

Premolar extraction has been a cornerstone of orthodontic treatment for decades, primarily utilized to address dental crowding, protrusion, and arch length discrepancies [1]. Despite its widespread clinical application, the effects of premolar extraction on mandibular rotation and vertical facial dimensions remain a subject of considerable debate within the orthodontic community [2]. The concern stems from the theoretical "wedge effect," which suggests that premolar extraction and subsequent space closure may lead to unfavorable mandibular rotation and increased facial height [3].The mandible's rotational pattern during orthodontic treatment is a critical determinant of facial aesthetics and treatment stability [4]. Bjork's landmark studies established that mandibular rotation can occur in either a forward (counterclockwise) or backward (clockwise) direction, significantly influencing facial profile and vertical proportions [5]. Forward rotation is generally associated with improved facial aesthetics in Class II patients, while backward rotation may result in increased facial convexity and vertical dimension [6]. Recent investigations have yielded conflicting results regarding the impact of premolar extraction on mandibular rotation. Some studies report minimal changes in mandibular plane angles following extraction treatment [7], while others suggest that extraction therapy may induce backward mandibular rotation and increase lower anterior facial height [8]. The discrepancy in findings may be attributed to variations in extraction protocols, treatment mechanics, and patient selection criteria [9].

Contemporary research has focused on the relationship between premolar extraction and mandibular kinematics, with studies demonstrating that extraction treatment may alter mandibular movement patterns in approximately 25% of cases [10]. Furthermore, investigations examining the effects of different extraction patterns have shown that the choice between first and second premolar extraction does not significantly influence vertical dimension changes [11].The biomechanical considerations during space closure are paramount in determining treatment outcomes. En masse retraction techniques and segmented arch mechanics have been developed to optimize anchorage control and minimize unwanted side effects [12]. The use of temporary skeletal anchorage devices has further refined extraction treatment protocols, potentially reducing the adverse effects on mandibular rotation [13].Despite extensive research, there remains a significant gap in understanding the precise effects of premolar extraction on mandibular rotation, particularly when controlling for variables such as growth pattern, treatment mechanics, and patient age. Most existing studies have focused on Class II division 1 malocclusions, with limited investigation of extraction effects across different malocclusion types [14].
The aim of this study was to evaluate the effectiveness of premolar extraction on mandibular rotation by comparing cephalometric changes in extraction versus non-extraction orthodontic patients, with particular emphasis on mandibular plane angles, facial height ratios, and vertical dimension parameters.

MATERIALS AND METHODS

Study Design: This retrospective cephalometric study employed a comparative design to evaluate mandibular rotation changes following orthodontic treatment with and without premolar extraction. The study protocol was approved by the institutional review board, and all patient records were anonymized prior to analysis.
Sample Size and Selection: The study sample comprised 68 orthodontic patients selected from treatment records spanning a five-year period (2018-2023). Sample size calculation was performed using G*Power software with an effect size of 0.5, alpha level of 0.05, and power of 0.80, indicating a minimum required sample of 64 subjects.
Inclusion criteria: Age between 14-25 years at treatment initiation Complete orthodontic treatment records with pre- and post-treatment lateral cephalograms Treatment duration between 18-36 months
Angle Class I or Class II malocclusion Good quality cephalometric radiographs with clear anatomical landmarks
Exclusion criteria: Previous orthodontic treatment Craniofacial syndromes or developmental anomalies Orthognathic surgery during or after orthodontic treatment Incomplete treatment records
Poor quality radiographs with obscured landmarks Patients were divided into two groups: extraction group (n=34) consisting of patients treated with extraction of four first premolars, and non-extraction group (n=34) serving as controls. Groups were matched for age, gender, and initial malocclusion severity.
Equipment and Materials
Lateral cephalograms were obtained using standardized protocols with consistent magnification factors. All radiographs were taken using the same cephalometric unit (Planmeca ProMax 3D, Helsinki, Finland) with standardized positioning techniques. Cephalometric analysis was performed using digital tracing software (Dolphin Imaging 11.95, Chatsworth, CA, USA).
Experimental Procedures
Pre-treatment (T1) and post-treatment (T2) lateral cephalograms were traced by a single calibrated examiner to eliminate inter-examiner variability. Intra-examiner reliability was assessed by re-tracing 20 randomly selected radiographs with a two-week interval, yielding correlation coefficients >0.95 for all measurements.
Cephalometric measurements included:
SN-GoGn angle: angle between sella-nasion line and gonion-gnathion line
FMA angle: angle between Frankfort horizontal plane and mandibular plane
Y-axis angle: angle between sella-gnathion line and Frankfort horizontal plane
Lower anterior facial height (ANS-Me): linear distance from anterior nasal spine to menton
Total anterior facial height (N-Me): linear distance from nasion to menton
Posterior facial height (S-Go): linear distance from sella to gonion

Jarabak ratio: ratio of posterior facial height to anterior facial height

Statistical Methods

Statistical analysis was performed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated for all variables. Normality of data distribution was assessed using the Shapiro-Wilk test. Paired t-tests were used to evaluate pre- and post-treatment changes within groups, while independent t-tests compared changes between groups. Statistical significance was set at $p < 0.05$. Effect sizes were calculated using Cohen's d, with values of 0.2, 0.5, and 0.8 representing small, medium, and large effects, respectively.

RESULTS

Demographic Characteristics

The study sample comprised 68 patients with mean age 16.8 ± 2.4 years (range 14-25 years). The extraction group included 22 females and 12 males, while the non-extraction group consisted of 20 females and 14 males. No significant difference in age or gender distribution was observed between groups ($p > 0.05$). Mean treatment duration was 24.6 ± 4.2 months for the extraction group and 22.8 ± 3.8 months for the non-extraction group ($p = 0.084$).

Mandibular Rotation Parameters

Analysis of mandibular rotation parameters revealed minimal changes in both groups. In the extraction group, the SN-GoGn angle increased from 31.2 ± 4.8° to 31.6 ± 4.6° (mean change 0.42 ± 1.8°, $p = 0.186$). The non-extraction group showed a similar increase from 30.8 ± 5.2° to 31.2 ± 5.0° (mean change 0.38 ± 1.6°, $p = 0.203$). The difference between groups was not statistically significant ($p = 0.891$).The FMA angle demonstrated comparable patterns, with the extraction group showing an increase from 25.8 ± 3.9° to 26.1 ± 3.8° (mean change 0.28 ± 1.4°, $p = 0.243$). The non-extraction group increased from 25.4 ± 4.1° to 25.8 ± 4.0° (mean change 0.35 ± 1.3°, $p = 0.157$). No significant difference was observed between groups ($p = 0.754$).

Y-axis angle changes were similarly minimal, with the extraction group showing an increase of 0.35 ± 1.2° (from 58.6 ± 3.2° to 59.0 ± 3.1°, $p = 0.164$) and the non-extraction group demonstrating an increase of 0.42 ± 1.4° (from 58.2 ± 3.6° to 58.6 ± 3.5°, $p = 0.136$). The between-group comparison revealed no significant difference ($p = 0.698$).

Facial Height Measurements

Lower anterior facial height (ANS-Me) increased in both groups, with the extraction group showing a mean increase of 1.2 ± 2.1 mm (from 66.8 ± 5.4 mm to 68.0 ± 5.6 mm, $p = 0.003$) and the non-extraction group demonstrating an increase of 1.8 ± 2.3 mm (from 65.9 ± 5.8 mm to 67.7 ± 5.9 mm, $p = 0.001$). The difference between groups was not statistically significant ($p = 0.298$).

Total anterior facial height (N-Me) showed similar patterns, with increases of 1.6 ± 2.4 mm in the extraction group and 2.1 ± 2.6 mm in the non-extraction group ($p = 0.421$). Posterior facial height (S-Go) increased by 1.4 ± 1.8 mm in the extraction group and 1.7 ± 2.1 mm in the non-extraction group ($p = 0.536$).

Facial Height Ratios

The Jarabak ratio remained stable in both groups, with the extraction group showing a minimal decrease from 62.6 ± 4.3% to 62.4 ± 4.2% (change -0.2 ± 1.8%, $p = 0.542$) and the non-extraction group demonstrating a slight decrease from 62.1 ± 4.0% to 61.8 ± 3.9% (change -0.3 ± 1.6%, $p = 0.387$). No significant difference was observed between groups ($p = 0.891$).

Subgroup Analysis

Subgroup analysis based on initial growth pattern revealed interesting patterns. In hyperdivergent patients (SN-GoGn > 35°), both groups showed slightly greater increases in mandibular plane angles, but the differences remained non-significant. Hypodivergent patients (SN-GoGn < 27°) demonstrated minimal changes in both groups, with slight decreases in some mandibular rotation parameters.

Effect Sizes

Effect size calculations revealed small effect sizes for all measured parameters, with Cohen's d values ranging from 0.12 to 0.28 for between-group comparisons. This indicates that while some differences existed between groups, they were not clinically meaningful. (Table 1-5)

Table 1: Demographic Characteristics of Study Participants

Parameter	Extraction Group (n = 34)	Non-Extraction Group (n = 34)	p-value
Mean Age (years)	16.9 ± 2.2	16.7 ± 2.6	0.734
Gender (F/M)	22 / 12	20 / 14	0.613
Treatment Duration (months)	24.6 ± 4.2	22.8 ± 3.8	0.084

Table 2: Changes in Mandibular Rotation Parameters

Cephalometric Variable	Extraction Group (T2 – T1)	p-value (within group)	Non-Extraction Group (T2 – T1)	p-value (within group)	p-value (between groups)
SN-GoGn angle (°)	+0.42 ± 1.8	0.186	+0.38 ± 1.6	0.203	0.891
FMA angle (°)	+0.28 ± 1.4	0.243	+0.35 ± 1.3	0.157	0.754
Y-axis angle (°)	+0.35 ± 1.2	0.164	+0.42 ± 1.4	0.136	0.698

Table 3: Changes in Facial Height Measurements

Measurement	Extraction Group (T2 – T1)	p-value (within group)	Non-Extraction Group (T2 – T1)	p-value (within group)	p-value (between groups)
ANS-Me (mm)	+1.2 ± 2.1	0.003	+1.8 ± 2.3	0.001	0.298
N-Me (mm)	+1.6 ± 2.4	0.004	+2.1 ± 2.6	0.002	0.421
S-Go (mm)	+1.4 ± 1.8	0.009	+1.7 ± 2.1	0.006	0.536

Table 4: Changes in Facial Height Ratios (Jarabak Ratio)

Group	Pre-Treatment (%)	Post-Treatment (%)	Mean Change (%) ± SD	p-value (within group)
Extraction Group	62.6 ± 4.3	62.4 ± 4.2	−0.2 ± 1.8	0.542
Non-Extraction Group	62.1 ± 4.0	61.8 ± 3.9	−0.3 ± 1.6	0.387
p-value (between groups)				**0.891**

Table 5: Effect Sizes (Cohen's d) for Between-Group Comparisons

Variable	Cohen's d	Effect Size Interpretation
SN-GoGn angle	0.12	Small
FMA angle	0.18	Small
Y-axis angle	0.14	Small
ANS-Me	0.27	Small
Jarabak ratio	0.15	Small

DISCUSSION

The findings of this study demonstrate that premolar extraction does not significantly affect mandibular rotation when appropriate orthodontic mechanics are employed [15]. These results align with contemporary research suggesting that concerns about adverse vertical dimension changes following extraction therapy may be overstated [16]. The minimal changes observed in mandibular plane angles and facial height ratios in both groups support the notion that treatment mechanics, rather than extraction per se, are the primary determinants of mandibular rotation [17].

The stability of the SN-GoGn angle in both groups contradicts earlier studies that reported significant increases in mandibular plane angles following premolar extraction [18]. This discrepancy may be attributed to improved treatment protocols and the use of more sophisticated biomechanical approaches in contemporary orthodontic practice [19]. The application of segmented arch techniques and optimized force systems has likely contributed to better control of vertical dimension during space closure [20]. Our findings regarding lower anterior facial height are consistent with recent systematic reviews that concluded premolar extraction does not significantly reduce facial height [21]. The similar increases in ANS-Me distance in both groups suggest that the observed changes are primarily growth-related rather than treatment-induced [22]. This is particularly relevant considering that the majority of patients in our study were still in their growth phase, where natural increases in facial height are expected [23]. The stability of the Jarabak ratio in both groups provides additional evidence that facial proportions are maintained during orthodontic treatment regardless of extraction status [24]. This finding is clinically significant as it suggests that the traditional concern about the "wedge effect" may be less relevant in modern orthodontic practice [25]. The maintenance of facial height ratios indicates that the proportional relationship between anterior and posterior facial heights remains stable during treatment [26].
The subgroup analysis based on initial growth pattern reveals that hyperdivergent patients may be more susceptible to minor increases in mandibular plane angles, although these changes were not statistically significant [27]. This observation suggests that extra caution may be warranted when treating patients with pre-existing vertical growth patterns, though extraction therapy should not be automatically contraindicated [28].The biomechanical principles underlying space closure play a crucial role in determining treatment outcomes [29]. The use of en masse retraction techniques with appropriate moment-to-force ratios has been shown to minimize unwanted side effects during space closure [30]. Additionally, the implementation of temporary skeletal anchorage devices has revolutionized extraction treatment by providing absolute anchorage and reducing the risk of adverse mandibular rotation [31].
The stability of mandibular rotation parameters observed in this study may also be attributed to the careful selection of extraction cases and the application of appropriate treatment mechanics [32]. The use of loop mechanics and controlled force systems during space closure has been shown to minimize extrusion of posterior teeth, thereby preventing backward mandibular rotation [33]. Furthermore, the emphasis on incisor intrusion rather than posterior extrusion has become a standard approach in modern extraction treatment protocols.
Study Limitations: Several limitations should be acknowledged in interpreting these results. First, the retrospective nature of the study limits the ability to control for all variables that may influence mandibular rotation. Second, the study sample was limited to a single treatment center, which may affect the generalizability of findings. Third, the relatively short follow-up period does not allow for assessment of long-term stability of the observed changes. Fourth, the study did not evaluate the effects of different space closure mechanics, which may have varying impacts on mandibular rotation.
Clinical Implications: The findings of this study have important clinical implications for orthodontic treatment planning. The results suggest that premolar extraction can be safely performed without significant concerns about adverse mandibular rotation when appropriate treatment mechanics are employed. This may influence treatment decisions in borderline cases where extraction therapy might provide optimal dental alignment and facial aesthetics. However, careful consideration of individual patient factors, including growth pattern and facial proportions, remains essential for optimal treatment outcomes.

CONCLUSION

This study demonstrates that premolar extraction does not significantly affect mandibular rotation when modern orthodontic techniques and appropriate biomechanical principles are applied. The minimal changes observed in mandibular plane angles, facial height measurements, and facial proportions were similar between extraction and non-extraction groups, indicating that extraction therapy does not inherently cause adverse mandibular rotation. The stability of the Jarabak ratio and the maintenance of facial height proportions provide reassurance that premolar extraction can be safely performed without compromising facial aesthetics. These findings challenge traditional concerns about the "wedge effect" and support the continued use of extraction therapy as a viable treatment option for appropriate cases. The results emphasize the importance of proper treatment mechanics and biomechanical considerations in achieving optimal outcomes, regardless of extraction status. Clinicians can proceed with confidence in extraction treatment when indicated, focusing on appropriate force systems and space closure techniques to maintain mandibular rotation stability.

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