

## Influence of unilateral maxillary first molar extraction treatment on second and third molar inclination in Class II subdivision patients

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### ABSTRACT

**Objective:** To assess the maxillary second molar (M2) and third molar (M3) inclination following orthodontic treatment of Class II subdivision malocclusion with unilateral maxillary first molar (M1) extraction.

**Materials and Methods:** Panoramic radiographs of 21 Class II subdivision adolescents (eight boys, 13 girls; mean age, 12.8 years; standard deviation, 1.7 years) before treatment, after treatment with extraction of one maxillary first molar and Begg appliances and after at least 1.8 years in retention were retrospectively collected from a private practice. M2 and M3 inclination angles (M2/ITP, M2/IOP, M3/ITP, M3/IOP), constructed by intertuberosity (ITP) and interorbital planes (IOP), were calculated for the extracted and nonextracted segments. Random effects regression analysis was performed to evaluate the effect on the molar angulation of extraction, time, and gender after adjusting for baseline measurements.

**Results:** Time and extraction status were significant predictors for M2 angulation. M2/ITP and M2/IOP decreased by 4.04 (95% confidence interval [CI]: -6.93, 1.16;  $P = .001$ ) and 3.67 (95% CI: -6.76, -0.58;  $P = .020$ ) in the extraction group compared to the nonextraction group after adjusting for time and gender. The adjusted analysis showed that extraction was the only predictor for M3 angulation that reached statistical significance. M3 mesial inclination increased by 7.38° (95% CI: -11.2, -3.54;  $P < .001$ ) and 7.33° (95% CI: -11.48, -3.19;  $P = .001$ ).

**Conclusions:** M2 and M3 uprighting significantly improved in the extraction side after orthodontic treatment with unilateral maxillary M1 extraction. There was a significant increase in mesial tipping of maxillary second molar crowns over time. (*Angle Orthod.* 2016;86:94-100.)

**KEY WORDS:** Class II subdivision; Maxillary first molar extraction; Molar inclination

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### INTRODUCTION

The prognosis of the third molar (M3) eruption is one of the clinical issues encountered by orthodontists while treating adolescents. M3 impaction represents the most common tooth impaction in contemporary populations.<sup>1</sup> Controversies have been reported with regard to the incidence of M3 impaction related to gender, ethnicity, and location.<sup>2</sup> There is evidence that factors such as vertical growth pattern, reduced mandibular length, molar axial inclination, and delayed maturation may influence the likelihood of M3 eruption.<sup>3,4</sup> Overall, impacted maxillary third molars do not remain static; however, their position over time may be

Accepted: December 2014. Submitted: October 2014.

Published Online: March 12, 2015

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considered unpredictable, as indicated by the limited longitudinal data.<sup>5</sup>

In theory, extraction of posterior teeth followed by orthodontic mesialization of the buccal segments may enhance the mesioangular inclination, and therefore the eruption status, of M3s. Orthodontic treatment involving extraction of two maxillary first premolars,<sup>6</sup> four first premolars,<sup>7</sup> or four first molars<sup>8</sup> resulted in significant improvement in the developing M3 position compared to nonextraction therapy. Other researchers observed no significant differences on the final M3 angulation between subjects orthodontically treated with either first premolar extraction and nonextraction<sup>1,9</sup> or first premolar and second molar (M2) extractions.<sup>10</sup>

To date, M3 mesiodistal angulation after asymmetric extraction has been scarcely subjected to investigation.<sup>11,12</sup> A retrospective study<sup>12</sup> of spontaneous positional changes in mandibular M3s after unilateral mandibular first molar (M1) extraction for nonorthodontic purposes demonstrated improved positions of the M3s. Furthermore, in an asymmetric extraction subgroup of orthodontic patients undergoing maxillary M2 extractions, the eruption rate of third molars was accelerated on the extraction side.<sup>11</sup>

The objective of this study was to determine the posttreatment angulation changes of maxillary second and third molars in a sample of Class II subdivision adolescents treated with unilateral maxillary M1 extraction and fixed orthodontic appliances.

## MATERIALS AND METHODS

A sample of 21 Class II subdivision adolescents (eight boys, 13 girls; mean age, 12.8 years; standard deviation [SD], 1.7 years) consecutively treated with unilateral extraction of a maxillary M1 and Begg technique was retrospectively collected from the archives of a private practice in Gorinchem, The Netherlands.<sup>13</sup> The rest of the inclusion criteria were as follows: white; Class II  $\geq$  1/2 premolar width molar occlusion on one buccal segment and Class I on the contralateral segment; up to mild crowding in the mandibular arch; full complement of permanent teeth; and panoramic radiographs of good quality obtained pretreatment (T1), posttreatment (T2), and at a minimum follow-up period (T3) of 1.8 years (mean follow-up, 2.6 years; SD, 1.0 years) (Table 1). The right maxillary M1 was extracted in 14 subjects, whereas the left M1 was extracted in seven of the cases. The nonextraction side served as the control.

According to the technique,<sup>14,15</sup> prior to molar extraction, bands with 6-mm single 0.018-inch round buccal tubes and palatal sheaths were placed on the maxillary second molar of the extraction side and the contralateral maxillary first molar. Premolars were not

**Table 1.** Age of Subjects and Time Intervals in Years (Means, Standard Deviations [SDs] in Parentheses)<sup>a</sup>

	Males (n = 8)	Females (n = 13)
Age T1	13.2 (0.8)	12.6 (2.0)
Age T2	15.5 (1.0)	14.8 (2.1)
Age T3	17.5 (1.0)	17.8 (2.4)
T2–T1		2.2 (0.4)
T3–T2		2.6 (1.0)

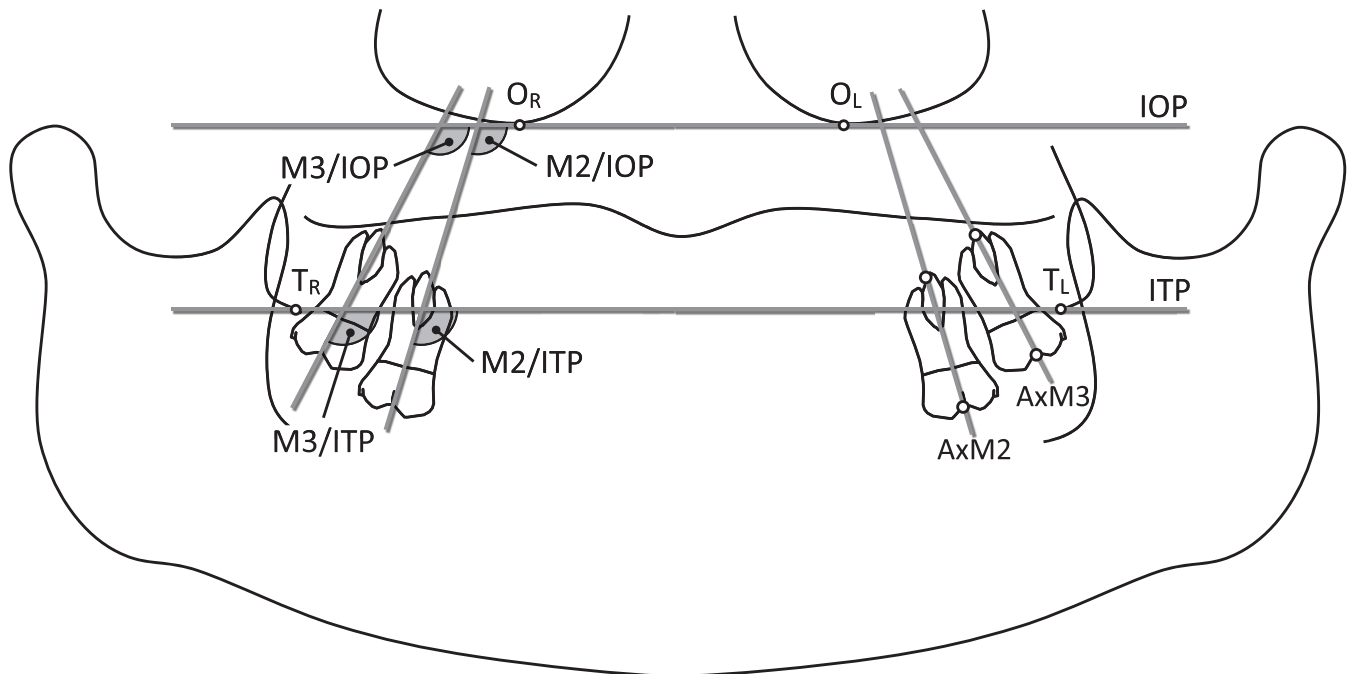
<sup>a</sup> T1 indicates pretreatment; T2, posttreatment; and T3, minimum follow-up period.

directly bonded with Begg brackets to facilitate sliding mechanics. Anchor bends on an individually made archwire constructed of 0.016-inch premium plus pull-straightened Australian wire (Wilcock, Whittlesea, Australia) mesial of the molar tubes prevented mesial tipping of the molars. Light horizontal elastics (5/16 inch) were worn for 24 hours on the Class II buccal segment and replaced once per week. Anchor and v-bends between mandibular canines and molars were added to achieve bite opening. Anchorage required for canine retraction was reinforced by means of a transpalatal arch. When a Class I canine and premolar interocclusal relationship had been established, the premolars were bonded and Class II elastics are used instead. After alignment of the maxillary premolars, the 0.016-inch starting wire was replaced by a 0.018-inch premium plus archwire (Wilcock). During space closure and when indicated, torque auxiliaries were inserted. In the final treatment stage, adjustments were made in the archwires for detailed finishing.

Scanning of the panoramic radiographs (Epson Expression 1680 Pro, Suwa, Nagano, Japan; resolution of 600 dpi) and digitization of landmarks by means of specialized software (Viewbox 3.0; dHAL Software, Kifissia, Greece) were performed by the first author. The landmarks, reference planes, and angular measurements<sup>6</sup> used for the study are displayed in Figure 1. Molar inclination was estimated using the following angles: M2/IOP, the angle between the M2 long axis and the interorbital plane (IOP); M3/IOP, the angle between the M3 long axis and the IOP; M2/ITP, the angle between the M2 long axis and the intertuberosity plane (ITP); M3/ITP, the angle between the M3 long axis and the ITP (Figure 1). Given the stage of the root development, the most apical point visible on the panoramic radiograph was selected as the midpoint of the root apex. To determine intraobserver agreement, 14 randomly selected sets of variables were remeasured 2 weeks after the initial assessment.

## Statistical Analysis

Means and SDs were estimated for all four molar angular measurements. The intraclass correlation coefficient (ICC) was calculated to assess intraobserver



**Figure 1.** Landmarks: Right orbital ( $O_R$ ) indicates most inferior point of the right orbital cavity; left orbital ( $O_L$ ), most inferior point of the left orbital cavity; right tuberosity ( $T_R$ ), most inferior point of the right maxillary tuberosity; and left tuberosity ( $T_L$ ), most inferior point of the left maxillary tuberosity. Reference planes: interorbital plane (IOP), plane defined by  $O_R$  and  $O_L$ ; intertuberosity plane (ITP), plane defined by  $T_R$  and  $T_L$ ; AxM2, AxM3: M2 and M3 long axes constructed by the midpoints of the occlusal surfaces and root apices of the molars. M2 and M3 inclination angles: M2/IOP, M3/IOP, M2/ITP, and M3/ITP.

reliability. The Pearson's correlation coefficient ( $r$ ) was calculated between the two different plane-defined measurements. Random effects regression analysis was implemented in order to assess the effect on the molar angulation of extraction, time, and gender after adjusting for baseline measurements. A .05 level of significance was used to determine statistically significant effects. Statistical analysis was carried out with the STATA statistical software package (STATA<sup>®</sup> 13, Stata Corporation, College Station, Tex).

## RESULTS

The ICC values ranged from 0.95 to 0.97 for all angular variables, reflecting excellent intraobserver reliability. All measurements conducted using both planes were highly correlated ( $r = 0.99-1.00$ ).

Descriptive statistics (means, SDs) are summarized in Table 1. Means and SDs of the measured angular variables are presented for the extraction and non-extraction sides in Table 2.

All molar measurements exhibited increasingly improved mesial inclination (ie, smaller angular values between T1-T2) regardless of whether teeth had been extracted or not. This tendency for an increase in the mesial tipping of the molar crowns was more evident in the segments in which the M1 had been extracted (Figure 2).

The statistical analysis (Table 3) indicated that for M2 angulations both extraction and time were significant predictors of the final outcome, whereas gender was not. In more detail, for M2/ITP and M2/IOP there was a decrease of  $-4.04^\circ$  in the extraction group (95% CI:  $-6.93, 1.16$ ;  $P = .001$ ) and of  $-3.67^\circ$  (95% CI:  $-6.76, -0.58$ ;  $P = .020$ ), respectively, compared to the nonextraction group, after adjusting for time and gender.

The adjusted analysis also showed that extraction was the only predictor for the angulation of maxillary third molars related to the intertuberosity and interorbital planes that reached statistical significance. M3 mesial inclination increased by  $7.38^\circ$  (95% CI:  $-11.2, -3.54$ ;  $P < .001$ ) and  $7.33^\circ$  (95% CI:  $-11.48, -3.19$ ;  $P = .001$ ). There was evidence that gender was associated with third molar angulations; however, this difference did not reach statistical significance at the 5% level. Age appeared similar among treatment groups and was not found to be a significant predictor, and, therefore, it was not included in the final analysis.

## DISCUSSION

Our study shows that maxillary second and third molars moved to more favorable positions after treatment regardless of the M1 extraction. These M3 angulation findings are in line with comparative

**Table 2.** Means and Standard Deviations (SDs) of the Angular Measurements for the Extraction (n = 21) and Nonextraction (n = 21) Sides<sup>a</sup>

Variable	T1		T2		T3	
	Extraction	Nonextraction	Extraction	Nonextraction	Extraction	Nonextraction
M2/IOP, °	113.3 (7.3)	114.3 (7.3)	105.2 (8.4)	108.5 (8.0)	101.1 (7.9)	105.9 (10.0)
M3/IOP, °	126.5 (13.7)	123.2 (11.1)	107.7 (11.3)	117.2 (11.9)	107.3 (8.6)	112.7 (13.5)
M2/ITP, °	113.6 (7.4)	114.0 (7.1)	105.2 (8.3)	108.7 (7.7)	101.0 (7.6)	105.9 (9.6)
M3/ITP, °	126.8 (13.8)	122.9 (10.9)	107.6 (10.5)	117.3 (11.5)	107.2 (8.8)	112.7 (12.9)
	T2–T1		T3–T2		T3–T1	
M2/IOP, °	–8.1 (12.0)	–5.7 (7.4)	–4.1 (8.5)	–2.7 (6.4)	–12.3 (9.9)	–8.4 (8.0)
M3/IOP, °	–18.8 (17.3)	–6.0 (16.5)	–0.4 (11.3)	–4.5 (10.2)	–19.3 (16.0)	–10.5 (15.0)
M2/ITP, °	–8.4 (11.5)	–5.4 (7.7)	–4.1 (8.2)	–2.7 (6.8)	–12.6 (9.4)	–8.1 (7.8)
M3/ITP, °	–19.2 (16.9)	–5.6 (16.3)	–0.4 (10.6)	–4.6 (10.2)	–19.6 (16.6)	–10.2 (14.6)

<sup>a</sup> T1 indicates pretreatment; T2, posttreatment; T3, minimum follow-up period; M2, second molar; M3, third molar; ITP, intertuberosity; and IOP, interorbital planes.

studies<sup>1,9</sup> of samples treated with first premolar extraction and nonextraction approaches. However, maxillary second molars in the extraction side became 1.4–1.6 times more upright than the contralateral teeth at T2, whereas the mesial inclination of maxillary third molars increased by 3.1–3.4 times. Likewise, bilateral M1 extraction and fixed orthodontic treatment with Begg appliances in Class II division 1 patients led to a fourfold uprighting of maxillary third molars in comparison to nonextraction controls.<sup>16</sup> On the other hand, Class II individuals treated with two maxillary first premolar extractions demonstrated a double increase in the mesial inclination of maxillary third molars compared with those treated with via the nonextraction route.<sup>6</sup> In extraction treatment planning (premolars or molars), differences in the intra-arch location of the extraction site and in the amount of tooth mass removed should be considered.<sup>6</sup> The closer the position of the extracted tooth to the maxillary third molar, the more influential will be the extraction on the M3 development.<sup>17</sup> In this context, molar extraction protocols may produce more favorable conditions for M3 uprighting than do premolar extractions. Nevertheless, the available eruption space may be drastically reduced during orthodontic management of severe Class II malocclusion and crowded cases.

Based on the regression analysis results, improved inclinations of maxillary second and third molars may be expected after Class II subdivision treatment with a single M1 extraction. In addition to this, time was a significant predictor for second molar angulation. Thus, maxillary second molars involved in fixed orthodontic treatment of asymmetric Class II malocclusion are likely to present smaller inclination angles over time, notwithstanding whether or not the maxillary first molars are extracted in one segment.

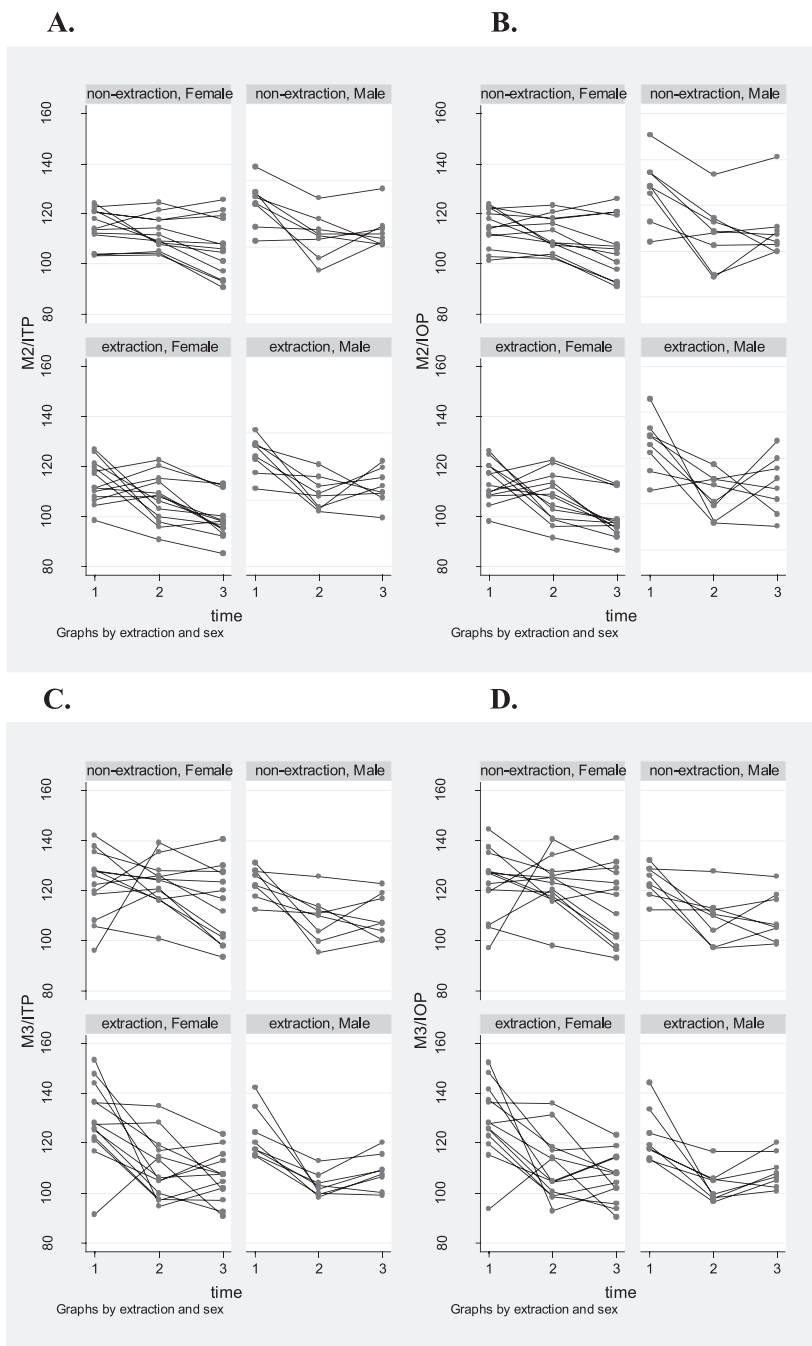
Direct comparison of published studies on the effect orthodontic extractions on M3 eruption may not be feasible as a result of methodological issues such as lack of control groups,<sup>11,18–21</sup> unclear definition of

malocclusion, discrepancies in anchorage requirements, mixed extraction protocols,<sup>11,21,22</sup> examination of radiographic records other than panoramic radiographs,<sup>11,15,21</sup> or inclusion of linear rather than angular measurements.<sup>8,11,21</sup>

Use of consistently identifiable reference landmarks is a matter of concern in consecutive measurements. Jain and Valiathan<sup>7</sup> defined angulation of mandibular second and third molars in relation to a horizontal palatal plane constructed from the anterior nasal spine and the nasal spectrum. However, these authors omitted assessment of the reproducibility in terms of locating the definition landmarks. Others<sup>1,8–10,12,20</sup> used the occlusal plane to measure tooth inclination changes, in spite of its reliance on treatment mechanics. In our study, we selected instead two horizontal reference planes based on skeletal structures, of which the repeatability had been validated by previous research.<sup>6</sup> Despite the high correlation between the measurements defined by the two planes, we decided to use both types to increase measurement validity.

We aimed to measure on orthopantomograms molar angular changes in the sagittal plane following extraction of a maxillary M1 and orthodontics. However, variations of the molar position in the buccolingual direction or rotations around the tooth long axis could not be considered because of the inherent panoramic image distortions.<sup>23–26</sup> Increased buccal root may resemble distal tipping, while increased lingual root torque may appear as more mesial tipping on panoramic radiographs.<sup>26</sup> Therefore, the use of panoramic images to assess root angulation should be approached with extreme caution and understanding of the technical limitations. In this sense, rotated, buccally or lingually displaced molars may need to undergo a second short fixed appliance treatment to obtain proper occlusal contacts.

Another point of discussion may be related to the length of the observation period. Our follow-up did not extend beyond the expected eruption time of maxillary



**Figure 2.** Angulation changes of second and third molars by extraction-nonextraction group, sex, and time point per patient (A: M2/ITP; B: M2/IOP; C: M3/ITP; and D: M3/IOP).

third molars, and, thus, the actual improvement in M3 position might have been underestimated. A second follow-up study may yield more useful conclusions on the treatment effect on the eruption success of maxillary third molars.

To our knowledge, this is the first study of split-mouth design to examine the influence of asymmetric maxillary M1 extraction on the axial inclination of adjacent molars. The split-mouth design reduces

interindividual variability from estimates of the treatment effect and therefore may be considered advantageous.<sup>27</sup>

**CONCLUSIONS**

- Orthodontic treatment with unilateral maxillary M1 extraction resulted in a significant increase in the mesial inclination of maxillary second and third molars.

**Table 3.** Coefficients, Associated Confidence Intervals (95% CIs), and P-Values from the Random Effects Analysis for Second and Third Molars; M2/ITP (T1), M2/IOP (T1), M3/ITP (T1), M3/IOP (T1), Baseline Values of M2 and M3 Inclination<sup>a</sup>

M2/ITP	Coefficient	P-Value	95% CI
Time	-3.42	.020	-6.30, -0.54
M2/ITP (T1)	0.42	.002	0.15, 0.69
<b>Gender</b>			
Female	Reference		
Male	-2.20	.330	-6.63, 2.23
<b>Extraction</b>			
No	Reference		
Yes	-4.04	.006	-6.93, -1.16
<b>M2/IOP</b>			
Time	Coefficient	P-Value	95% CI
Time	-3.42	.029	-6.50, -0.35
<u>M2/IOP (T1)</u>	<u>0.40</u>	<u>.004</u>	<u>0.13, 0.68</u>
<b>Gender</b>			
Female	Reference		
Male	-2.20	.328	-6.61, 2.21
<b>Extraction</b>			
No	Reference		
Yes	-3.67	.020	-6.76, -0.58
<b>M3/ITP</b>			
Time	Coefficient	P-Value	95% CI
Time	-2.48	.197	-6.25, 1.28
<u>M3/ITP (T1)</u>	<u>-0.06</u>	<u>.535</u>	<u>-0.26, 0.13</u>
<b>Gender</b>			
Female	Reference		
Male	-6.03	.063	-12.39, 0.34
<b>Extraction</b>			
No	Reference		
Yes	-7.38	<.001	-11.22, -3.54
<b>M3/IOP</b>			
Time	Coefficient	P-Value	95% CI
Time	-2.47	.237	-6.55, 1.62
M3/IOP (T1)	-0.04	.733	-0.24, 0.17
<b>Gender</b>			
Female	Reference		
Male	-5.96	.063	-12.24, 0.32
<b>Extraction</b>			
No	Reference		
Yes	-7.33	.001	-11.48, -3.19

<sup>a</sup> T1 indicates pretreatment; M2, second molar; M3, third molar; ITP, intertuberosity; and IOP, interorbital planes.

- Maxillary second molar crowns significantly tipped over time on both extraction and nonextraction sides.

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