Original Article

Anteroposterior skeletofacial classification and its relationship to maxillary second molar buccopalatal angulation

Timothy P. Levine[a]; Gregory J. Matthews[b]; Lydia A. Salama[c]; Alan Yee[d]

ABSTRACT

Objective: To compare second molar angulation to the occlusal plane with cephalometric measurements corresponding to AP skeletal discrepancy.

Materials and Methods: 72 patients' pre-orthodontic records were analyzed. A plane was constructed along the cusps of the upper second molar and measured to a proxy for the occlusal plane. The angle between the planes was measured. ANB, Wits appraisal, U1-SN, IMPA, A-B perpendicular to Frankfort, and overjet were measured on the patients' cephalograms. Generalized additive mixed model analysis was performed to analyze the relationship between the second molar angulation and the cephalometric measurements.

Results: All six cephalometric measurements showed a significant relationship with the second molar angulation, with Class III patients having a larger angle than Class II and I patients.

Conclusions: Class III patients have upper second molars that are significantly tipped from the occlusal plane. The second molars require special attention for correction prior to orthognathic surgery for Class III patients in order to avoid deleterious effects from the malpositioned teeth. (*Angle Orthod.* 2020;90:851–856.)

KEY WORDS: Orthognathic; Surgery; Class III; Occlusion

INTRODUCTION

Orthodontics in preparation for orthognathic surgery requires consideration of intra-arch mechanics and planned surgical movements. The goal of presurgical orthodontics is to facilitate the jaw movements, which may not require idealized tooth positions.[1] Failure to achieve this presurgical goal may potentially present unwanted and deleterious post-operative sequelae for the patient. One observed example is under-corrected maxillary second molars.

[a] Director of Orthodontics, Department of Dentistry/Oral and Maxillofacial Surgery, Jacobi Medical Center, Bronx, NY, USA.
[b] Assistant Professor, Department of Mathematics and Statistics, Loyola University Chicago, Chicago, IL, USA.
[c] Attending Orthodontist, Department of Dentistry/Oral and Maxillofacial Surgery, Jacobi Medical Center, Bronx, NY, USA.
[d] Resident, Orthodontics, Roseman University of Health Sciences, Henderson, NV, USA.
Corresponding author: Dr Timothy P. Levine, Jacobi Medical Center, Department of Dentistry/Oral and Maxillofacial Surgery, 1400 Pelham Pkwy S, Bldg. 1, 3NE1, Bronx, NY 10461, USA (e-mail: timothy.levine@nychhc.org)

Accepted: May 2020. Submitted: December 2019.
Published Online: September 8, 2020

For decades, orthodontists have debated the routine engagement of second molars due to the technical difficulty of bonding or banding the teeth.[2,3] However, as surgical patients have third molars that are often impacted, extracted, or absent,[4,5] second molars usually serve as the terminal teeth in the orthognathic setup. It was observed that Class III surgical patients have second molars lacking in adequate buccal root torque,[6] while Class I and II surgical patients did not share this feature. As the maxillary second molars do not have full occlusal opposition in Class III, but do in Class I and II bites, that should not be unexpected. Just as teeth compensate in the anterior for AP skeletal issues, they likewise will compensate in the posterior.[7]

It is probable that the mechanism is similar to what occurs when a tooth is left unopposed, either naturally or following extraction. The exact process of unopposed tooth movement is not well understood.[8] Compagnon et al. demonstrated that primary eruption occurred with growth of the periodontal complex, and that eruption continued well past 10 years without an opposing tooth.[9] It also has been demonstrated that teeth with as much as 30% partial occlusal contact displayed a similar amount of supraeruption as those with an absent opposing tooth. Importantly, unopposed teeth do not simply supraerupt in a purely vertical direction after tooth extraction, as they also will tip and rotate.[10] These misaligned teeth can become problematic if an opposing contact is later established. This would lead to a hypothesis that skeletal Class III malocclusions would have second molars that are supra-erupted and likely tipped.

Misaligned second molars can lead to occlusal interferences in the post-surgical bite. These interferences can destabilize the distal mandibular segment, jeopardizing the healing phase, negatively affect the surgical outcome,[11] and potentially cause temporomandibular joint dysfunction.[12] Often, during surgical planning, these potential interferences will be identified and intraoperative enameloplasty can be performed.[13] This is suboptimal; healthy tooth structure is removed, and there are significant risks of causing sensitivity, pulpal irritation, or pulpal damage.[14] Especially large interferences should only be treated via orthodontic correction, ideally prior to the orthognathic surgery.[15] If the interferences are caught during presurgical planning, this will necessitate a delay of the operation. Additionally, intrusion performed too quickly or with excessive force will create risks that include alveolar bone loss and/or periodontal defects adjacent to the intruded teeth.[16]

While the general phenomena of supraeruption have been studied, specific research examining the relative position of second molars based on skeletal malocclusion has not. The aim of this study was to investigate the relationship between the position of the maxillary second molars and the presence of an anteroposterior skeletal intermaxillary discrepancy.

MATERIALS AND METHODS

The study was approved by the Albert Einstein College of Medicine Institutional Review Board. Subjects were drawn from the existing database of orthodontic records in a private orthodontic office in New York City. All records included photographs, digital panoramic and cephalometric radiographs (Planmeca, Roselle, IL), and digital models from an intraoral scanner (iTero, Align Technology, San Jose, CA), all uploaded into Dolphin Imaging (Patterson, St. Paul, MN). Only pretreatment records were evaluated for inclusion.

Records were sorted chronologically, starting at the oldest. Overjet, as measured on digital models, was used as a proxy for skeletal classification. Less than 0 mm of overjet was designated Class III, more than 3 mm of overjet designated Class II, and between 0 and 3 mm designated Class I. To narrow the focus to anteroposterior issues, individuals with anterior open bite were excluded. Those without fully erupted upper or lower second molars were also excluded, as were any intraoral scans that did not fully capture the second molars. The first 25 consecutive records that fit each classification were selected for the study.

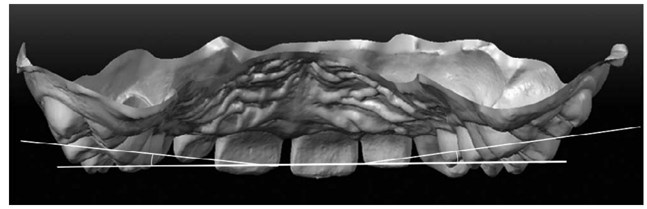

Figure 1. Sample digital upper model with planes used for measuring the second molar angle to constructed palatal plane.

Digital models were downloaded into OrthoCAD (Cadent, Carlstadt, NJ). Each model was oriented such that the occlusal plane was horizontal and perpendicular to the screen, with the second molars oriented toward the viewer and incisors away from the viewer. Lower models and bites were not included, blinding investigators to the classification of each cast. An image of the digital model in this orientation was imported into PowerPoint (Microsoft, Redmond, WA). A one-pixel line was drawn between the mesiolingual cusps of the upper first molars, serving as a proxy to the occlusal plane. One pixel lines were drawn from the mesiobuccal to mesiopalatal/palatal cusp of each of the right and left second molars to establish a right and left molar plane. Figure 1 shows an example of the constructed lines. The images were printed and a protractor was used to record the angle between the occlusal plane and each molar plane by a single orthodontist. Ten images were randomly selected to repeat the angle construction and measurement to assess intra-operator reliability and a second orthodontist repeated the angle construction to assess interoperator reliability.

Each subject's lateral cephalometric x-ray was traced by a single orthodontist. To validate the tracings, 10 radiographs were randomly selected for repeated tracing by the same orthodontist, as well as by a second orthodontist. A custom analysis with a series of common cephalometric measurements used in orthognathic surgery diagnosis and planning, specifically Wits appraisal, A-B perpendicular to Frankfort horizontal (A-B || F), ANB, cephalometric overjet (facial of L1 to facial of U1), lower incisor-mandibular plane angle (IMPA), and upper central to SN angle (U1 to SN), was exported into a comma separated values (CSV) file for analysis in R stats package (R Foundation, Vienna, Austria).

Generalized additive mixed models (GAMM) were used to examine the relationship between the angular second molar measurements and each cephalometric measurement individually with a random effect used to account for the correlation between teeth that were

Table 1. Averages and Standard Deviations for U7 Angle and Cephalometric Measurements by Skeletal Malocclusion Group

	Class I		Class II		Class III	
	Average	SD	Average	SD	Average	SD
U7 angle	11.8	4.6	10.9	4.7	21.0	8.4
OJ	2.4	1.4	5.2	2.7	-0.9	3.3
Wits	-1.3	2.1	4.3	3.2	-7.9	3.5
A-B ∥ FH	3.4	2.9	9.8	5.8	-3.5	3.5
ANB	3.9	2.5	7.0	2.8	-0.8	2.6
U1-SN	107.7	7.1	102.3	10.7	113.7	8.4
IMPA	90.1	6.7	100.2	8.4	87.6	8.0

located in the same jaw (ie, left and right second molar angulations). *P*-values were calculated for testing the significance of the smoothed term using a variation of the test described in Wood[17] and computed using the "gamm" function in the R stats package. Significance level was set at 0.05 and the Holm-Bonferroni correction[18] was applied to control the family-wise error rate (FWER) when performing multiple tests. Scatter plots were generated for each of the cephalometric measurements against each molar angle and then overlaid with a locally weighted scatterplot smoothing (LOESS) curve. Intra-observer and interobserver reliability for second molar angle and cephalometric tracing were estimated using intraclass correlation (ICC).[19]

RESULTS

Seventy-five patient records were selected, based on the study criteria, from the pre-existing records database. During the full analysis of the records, three patients were excluded due to incomplete cephalometric images preventing tracing: two individuals from the Class III group and one from the Class I group. A total of 72 patient records were analyzed: 23 skeletal Class III (OJ $<$ 0 mm), 24 skeletal Class I (OJ between 0 mm and 3 mm), and 25 skeletal Class II (OJ $>$ 3 mm). Each set of records provided observations of both right and left maxillary second molars, producing 144 second molar angle measurements. Table 1 shows the mean angulation of the second molars and cephalometric measurements by skeletal malocclusion group.

Overjet, Wits, A-B ∥ F, ANB, U1-SN, and IMPA were all found to be significantly related to molar angular measurements at the 0.05 level. Table 2 shows the results of the GAMM analysis.

Figure 2 shows scatter plots of each of the cephalometric measurement (Wits appraisal, A-B ∥ F, ANB, overjet, IMPA, and U1 to SN) against the angular measurements of the second molar. The LOESS trend lines are plotted on the graphs. The plots of the six cephalometric measurements showed that, as the skeletal measurement was more Class III, the second molar angulation increased.

Table 2. *P* Values for Generalized Additive Mixed Model Analysis

Cephalometric Measurement	*P* Value (* indicates significance at $P < .05$)
Overjet	$P < .0001$*
Wits appraisal	$P < .0001$*
A-B perpendicular to Frankfort horizontal	$P < .0001$*
ANB	$P < .0001$*
U1-SN	$P = .01$*
IMPA	$P < .001$*

For the 10 repeated angular measurements, the ICC was 0.955 for intra-observer reliability and 0.844 for interobserver reliability. The ICC was 0.930 for the intra-observer reliability and 0.848 for interobserver reliability. All four of these results indicated excellent agreement between the repeated measurements.

DISCUSSION

The hypothesis of the study was that angular position of the maxillary second molars would have a significant relationship with skeletal malocclusion. The results of this study supported that hypothesis, as all six cephalometric measurements showed a significant relationship with upper second molar angulation. Furthermore, based on clinical observation, patients with a skeletal Class III malocclusion would have uncontrolled eruption due to the light or absent opposing tooth; the data showed that skeletal Class III patients did, in fact, have maxillary second molars that appeared to be further out of alignment than Class I or Class II individuals. The graphed plots from Figure 2 illustrate a clear relationship of the measurements that were associated with Class III patients (more negative OJ, Wits, A-B ∥ F, ANB, smaller IMPA and larger U1-SN) with the measured U7 angulation.

As described in previous studies,[8,10] teeth without opposition do not simply supraerupt but have a buccolingual component as well, which was borne out by the data. Class III patients showed a significantly greater angulation of the maxillary second molars compared to Class I and Class II patients. The molars were tipped buccally, which caused relative extrusion of the palatal cusps. While this study did not examine the degree of vertical malpositioning, the same factors that lead to the buccoversion of the molars also appear to have led to supraeruption of the teeth, which ought to be studied in the future.

From a practical standpoint, a simple calculation can be performed to illustrate how the angulation of a single tooth can be problematic. Based on published second molar anatomical measurements,[20] the overall length of the tooth is 21.4 mm. Using an arc-length calculation,

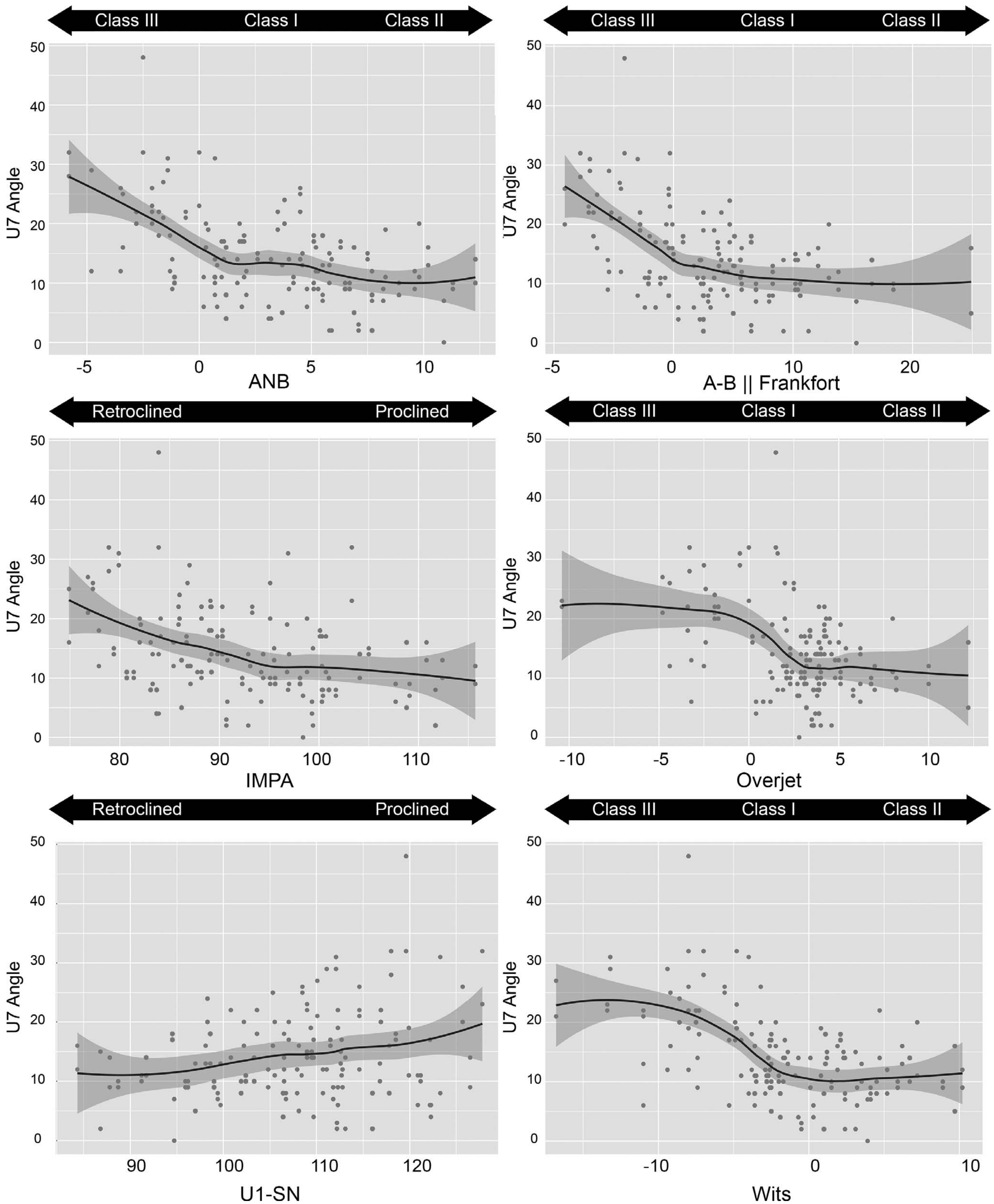

Figure 2. Scatterplots of cephalometric measurements vs second molar angles, with a locally weighted scatterplot smoothing (LOESS) trendline fit.

each degree of tipping would move the palatal cusp arc 0.37 mm. The present study, as shown in Table 1, showed that the second molars had approximately 10° more buccal tipping in Class III's (21.0°) compared to Class I's (11.8°) or Class II's (10.9°), which results in excess palatal cusp tip of 3.7 mm toward the buccal, placing the palatal cusp of the second molar further in line with the central groove of the first molar.

The general goal of presurgical orthodontics is to facilitate the movement of the jaws during surgery. The decision of whether interdigitation is idealized before or after surgery should be made between the orthodontist and the oral surgeon.[21] There are, indeed, some orthodontic movements that are easier to achieve after correction of the skeletal problems. Ultimately, an adequate presurgical occlusion is required for predictable results[7] and to limit complications from healing.[11]

Orthodontists who are preparing Class III surgical patients should be aware of the potential issues that can arise from malpositioned maxillary second molars. As second molars so often serve as the terminal teeth in the arch, the leverage to align these teeth is naturally decreased, and they are necessarily treated via cantilever mechanics. As such, it is especially critical for the orthodontist to incorporate the maxillary second molars into the treatment as early as possible, and to evaluate their position continuously during treatment. The ideal evaluation would include progress models with articulation approximating the postsurgical bite. Surgeons, likewise, should be mindful of the maxillary second molars and refer back to the orthodontist if the patient is not yet ready for surgical correction.

While the results of the present study were strong, there were several areas in which future work could strengthen the findings. First, patients with skeletal discrepancies can also have significant transverse discrepancies, which this study did not account for; a comprehensive study that accounted for bone width with molar angulation may be helpful, though this may not alter clinical implications. Additionally, a non-dental reference plane may prove useful. As the present study used digital models, the line drawn from first molar cusps served as a proxy for the occlusal plane but a more precise measurement of molar angulation is possible. Using cone beam computed tomography imaging, it could be possible to compare the angle formed between the long axis of the second molars and those of the first molars and premolars. And the vertical discrepancy, which can be somewhat inferred from the angular position, was not specifically measured and analyzed; doing so would further illustrate the extent to which this issue presents itself.

CONCLUSIONS

- Second molar angulation has a significant relationship with skeletal malocclusion. Class III discrepancies and increased buccal tip of the second molars are closely related. Orthodontists preparing patients for orthognathic correction must be conscious of the position of the second molars, correcting the angulation early in the presurgical phase to prevent interferences.
- Surgeons should be aware of the possibility that second molar interferences may affect the intercuspation.

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