

Effect of Incisor Angulation on Overjet and Overbite in Class II Camouflage Treatment

A Typodont Study

Yasinee Sangcharearn^a; Christopher Ho^b

ABSTRACT

Objectives: To determine the amount of variation in overjet and overbite that may result from changes in upper and lower incisor angulations following upper first premolar extraction treatment in Class II malocclusions.

Materials and Methods: Typodonts were set up to simulate a skeletal Class II occlusion treated with upper first premolar extractions. The upper incisor angulation was altered through a range from 100° to 120° to the palatal plane by 2° increments. The overjet and overbite were measured with every 2° of upper incisor angulation change. A regression analysis was performed on the experimental data, and the regression coefficients, slope, and intercept were estimated.

Results: Excessive proclination of the lower incisors will result in an abnormal overjet and overbite relationship for any magnitude of upper incisor angulation. A normal lower incisor angulation facilitates the attainment of an optimal occlusion. Excessive palatal root torque of the upper incisors will result in an increase in overjet and a consequent decrease in overbite. If the upper incisors are excessively retroclined, an edge-to-edge incisor relationship will result.

Conclusion: Class II camouflage treatment with upper first premolar extractions requires correctly angulated incisors to achieve optimal buccal segment interdigitation and incisor relationship. Labial root torque and interproximal reduction of the lower anterior teeth should be considered when the lower incisors are excessively proclined.

KEY WORDS: Incisor angulations; Overjet; Overbite; Class II camouflage treatment

INTRODUCTION

Incisor angulations play an important role in achieving a normal occlusion during orthodontic treatment. A common feature associated with Class II upper arch extraction treatment is the proclination of the lower incisors and insufficient palatal root torque of the upper incisors (UIs). This may result in an insufficient overbite and overjet, incomplete closure of the extraction space, or poor buccal segment intercuspation. The final angulation of the upper and lower incisor teeth

must be considered if a satisfactory buccal segment relationship is to be achieved with normal overjet and overbite.

Planning for Class II camouflage treatment involving extraction of the upper first premolar teeth must consider the effect of upper and lower incisor compensations on the occlusion. The anterior and posterior occlusions are not mutually exclusive, and therefore, the overall occlusal scheme may be affected by changes in any part of the dental arch. In addition, changes to arch length and upper and lower arch coordination may be significantly affected by inadequate attention to detail in the second- and third-order angulation. Such changes may be due to inadequate axial angulation of the incisor teeth, labiolingual incisor edge thickness, rotation of teeth, mesiodistal crown tip, and tooth size discrepancies.

Sangcharearn and Ho¹ reported that a change of 20° in the UI angulation will alter the molar relationship by an average of 1.8 mm if the overjet and overbite remain unchanged. Although this amount is relatively small, it demonstrated that root torque does have the

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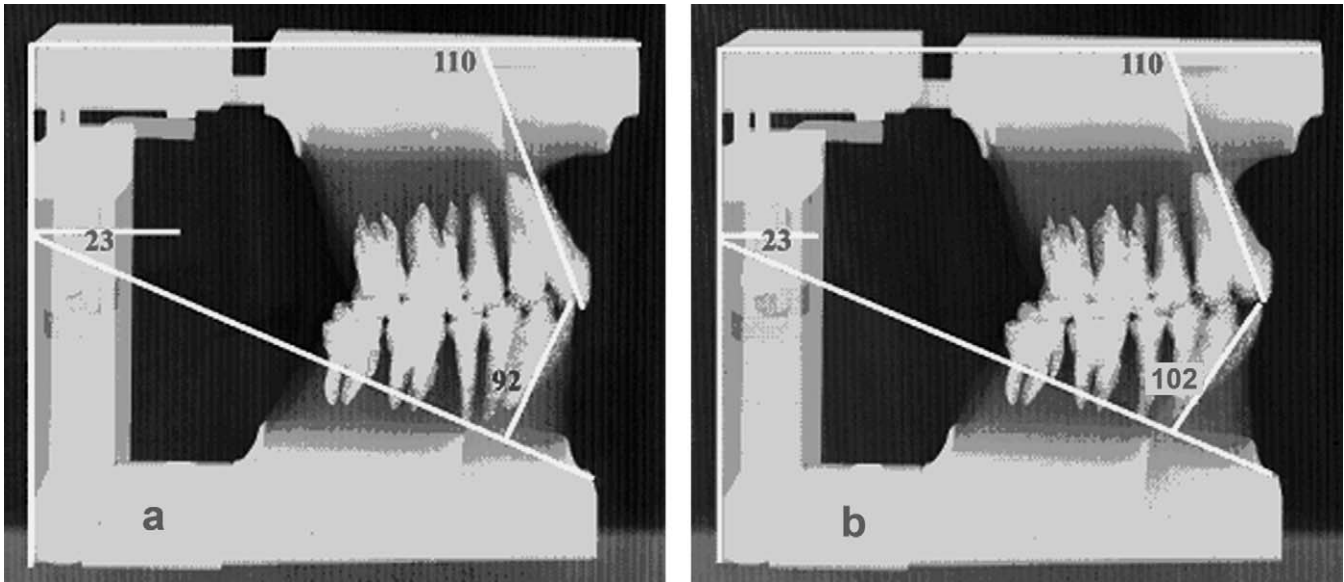


Figure 1. Radiograph of the typodonts in Class II occlusion with upper first premolars extracted. (a) Lower incisor–mandibular plane = 92° . (b) Lower incisor–mandibular plane = 102° .

potential to significantly affect the overall occlusal scheme through this change in arch length. For example, Class II cases finished with insufficient UI palatal root torque will result in a decrease in overall upper arch length. In such cases in which the overjet and overbite are finished within the normal range, the effect of improperly angulated UIs may be observed posteriorly as less than ideal intercuspation of the buccal segments.

The crown-root angulation of teeth should also be considered. Class II division 2 malocclusions exhibit significantly different crown-root upper central incisor angulations than other classes of malocclusion.² The axial inclination of the crown is a better measure of incisor position and the determination of incisor root torque requirements where bending of the incisor is observed.

It is common for clinicians to suggest that a tooth size discrepancy is responsible for the poor buccal segment intercuspation in cases in which the overjet and overbite are within normal limits.³ However, this may not always be the case. Although correct upper and lower incisor angulations are important for the attainment of ideal overjet, overbite, and buccal segment relationships, this is not always achievable. In Class II camouflage treatment, the underlying skeletal discrepancy is camouflaged by dental compensations. Although it is acknowledged that the severity of the anteroposterior discrepancy may preclude the ideal angulation of the anterior teeth, comprehension of these occlusal interrelationships and their effect on overjet and overbite may assist the clinician in diagnosis and treatment planning. This study aimed to determine the

amount of variation in overjet and overbite resulting from upper and lower incisor angulation changes in skeletal Class II upper first premolar extraction treatment.

MATERIAL AND METHODS

This study used typodonts with custom-made barium acrylic teeth set up to a Class II occlusion with extraction of the upper first premolars. A straight length of stainless steel wire was buried along the long axis of the tooth. The lower incisors (LIs) were positioned at 92° to the mandibular plane (MP) in the first part of the study and 102° to the MP in the second part of the study (Figure 1). The UI angulations were altered from 100° to 120° to the palatal plane (PP) in 2° increments.

An estimate of the sizes of the typodont teeth were predetermined from Ash and Nelson.⁴ The tooth widths were altered to match normal tooth-width ratios by using a tooth size discrepancy analysis.^{5,6} The typodont was set up to simulate a skeletal Class II pattern. The PP to MP angle was set at 23° compared to the normal value of $23.1^\circ \pm 1.7^\circ$.

Lateral cephalometric radiographs, using Mammographic Kodak Min~R films (Eastman Kodak Company, Rochester, NY), were used to radiograph the typodont to confirm the accuracy of each incremental 2° change of UI-PP angulation. The UI-PP angulation commenced at 110° and was increased incrementally by 2° from 110° to 120° and later decreased by 2° from 110° to 100° . The posterior occlusion was kept con-

stant. The overjet and overbite were measured with every 2° of UI-PP angulation change.

Standardization of Records

The radiographic images of the typodont were standardized by using a radiographic stand made to hold the typodont in the same position when it was mounted beside the radiographic film. Errors due to rotation and magnification were therefore reduced. The same cephalometric machine was used for the duration of the study, and each cephalogram was traced by the same researcher.

Tooth Morphology

The crown-root angulation (θ) of the UI teeth used in this study was 0°, which is within the normal range for Class I occlusions. The normal crown-root angulation (θ) for the upper central incisor is $-0.69^\circ \pm 4.88^\circ$.⁸ However, Delivanis and Kufinec² found that significantly more Class II division 2 malocclusions had a greater crown-root angulation than other classes of malocclusions. The greater crown-root angulation observed in Class II division 2 malocclusions was not reproduced in this study.

The amount of tooth thickness was controlled at not more than 2.75 mm, which could affect the anterior maxillary ratio, as suggested by Rudolph.⁹ The arch form used to set up the teeth is the OrthoForm III arch form (3M Unitek, Monrovia, Calif).

Measurement Error

To reduce measurement error, the experiment was replicated three times by using the same mold. The mold was used to set up all teeth into a Class II occlusion, with the UI-PP angulation set to 110° before changing the UI-PP angulation to a new value. Digital calipers (Mitutoyo Corporation, Kawasaki, Japan) were used to measure the change in overjet and overbite following every 2° of UI-PP angulation change. The overjet was measured as the horizontal distance between the upper and lower central incisors parallel to the occlusal plane. The overbite was measured as the vertical distance between the incisal edge of the upper central incisor and the incisal edge of the lower central incisor.

Statistical Methods

The regression analysis (Minitab Student Release 14; Minitab Inc, State College, Penn) was used to find the relationship between UI-PP angulations and the overjet and overbite. Significance was predetermined at $P < .05$. The regression equations were formulated

Table 1. Change in UI-PP Angulation, OJ, and OB Associated with LI Angulations of 92° and 102° to the Mandibular Plane^a

UI-PP, °	LI at 92°		LI at 102°	
	OJ, mm	OB, mm	OJ, mm	OB, mm
100	0.43	0	0.12	0
102	0.64	0	0.39	0
104	0.98	0.75	0.43	0
106	1.22	1.91	0.49	0
108	1.53	1.97	0.79	0
110	1.6	1.84	1	0
112	1.86	1.89	1.34	0.89
114	1.94	1.89	1.5	0.74
116	2.07	1.72	1.65	0.67
118	2.12	1.58	1.86	0.64
120	2.22	1.39	2.03	0.61

^a UI-PP indicates upper incisor-palatal plane; OJ, overjet; OB, overbite; and LI, lower incisor.

to predict the degree of change in overjet and overbite when the UI-PP angulation was altered.

RESULTS

The relationship between the change in UI-PP angulation and change in overjet and overbite was markedly different for LI angulated at 92° to the MP compared to LI angulated at 102° to the MP (Table 1).

Overjet and Overbite with the LI Positioned at 92° to the MP

The change in overjet for every 2° increase and decrease in UI-PP angulation from the base line angulation of 110° is shown in Figure 2. The overjet decreased from 2.22 mm to 0.43 mm when the UI-PP angulation changed from 120° to 100°. There was a significant relationship between UI-PP angulation and change in overjet ($R^2 = .992$, $P < .05$). The regression equation, $y = a + bx + cx^2$, is $y = -51.43 + 0.8747x - 0.003564x^2$ ($y =$ change in overjet; $x =$ degree of UI-PP angulation). The y intercept is $a = -51.43$ mm. The coefficient of the linear effect on y is $b = 0.8747$ mm/°. The coefficient of the quadratic effect on y is $c = 0.003564$ mm/°².

The overbite was observed to be zero when the UI-PP angulation ranged from 100° to 102°. However, once change in UI-PP angulations exceeded 104°, a positive change in relationship between UI-PP angulations and change in overbite was observed. The overbite increased from 0.75 mm to a maximum of 1.89 mm when the UI-PP angulation increased from 104° to 114°. Further increases in the UI-PP angulation from 114° to 120° resulted in a decrease in the overbite from 1.89 mm to 1.39 mm. The data fitted well with the growth curve, which approximated a cubic curve (Figure 3). There was a strong relationship between

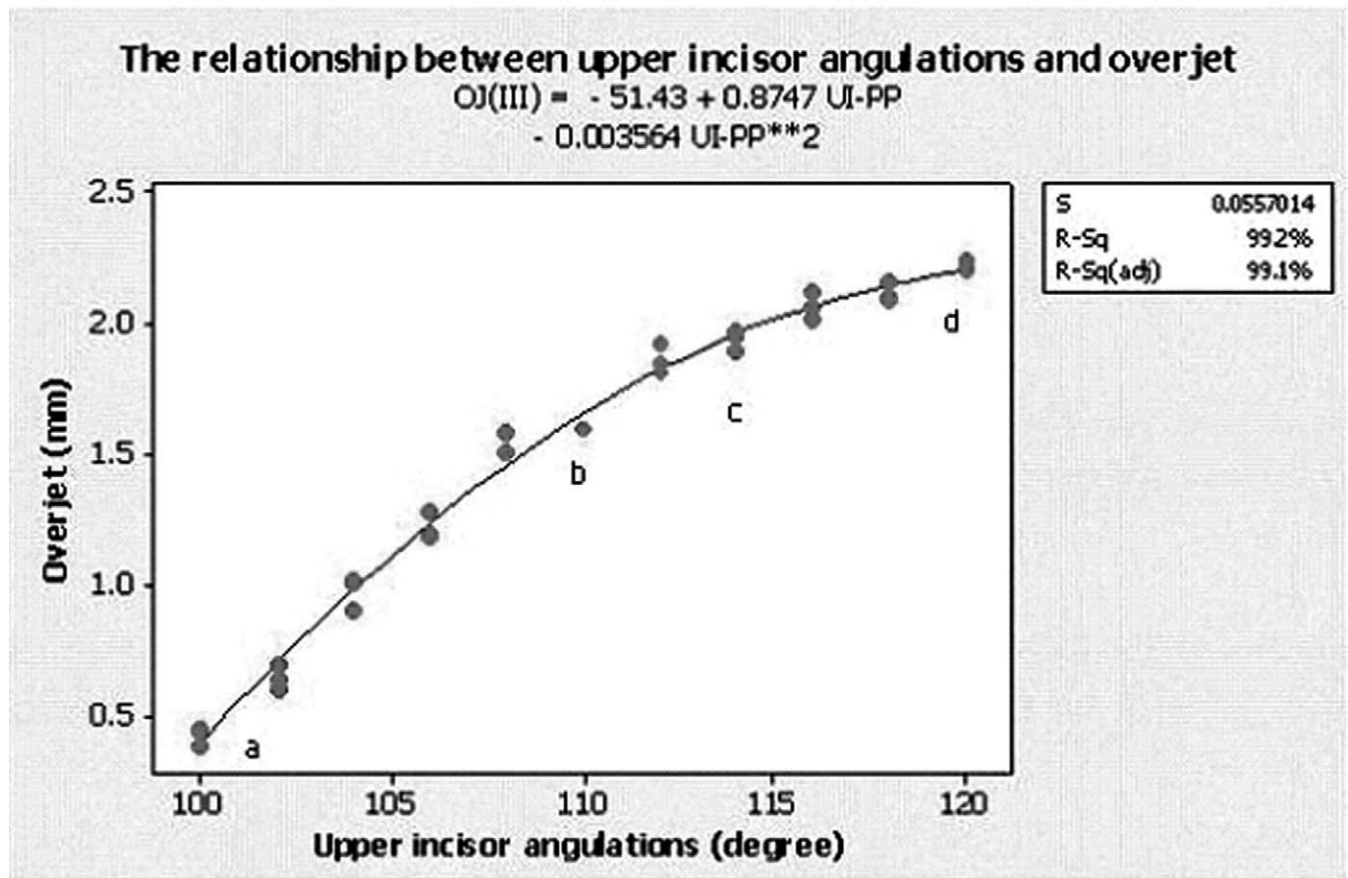
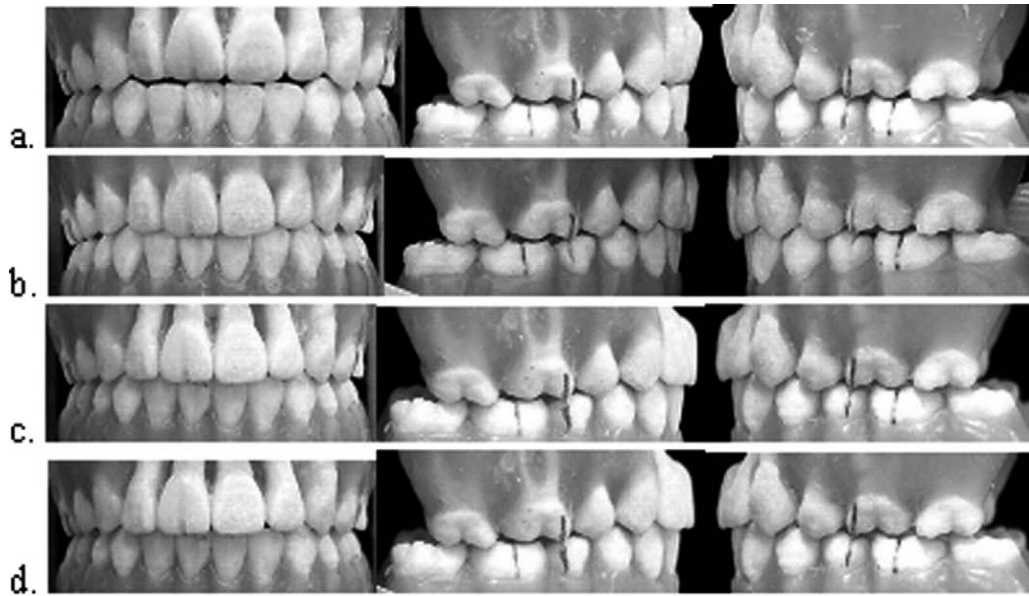


Figure 2. Scatterplot of upper incisor–palatal plane (UI-PP) angulations versus change in overjet. Lower incisor–mandibular plane = 92°. (a) UI-PP = 100°, (b) UI-PP = 110°, (c) UI-PP = 114°, (d) UI-PP = 120°.

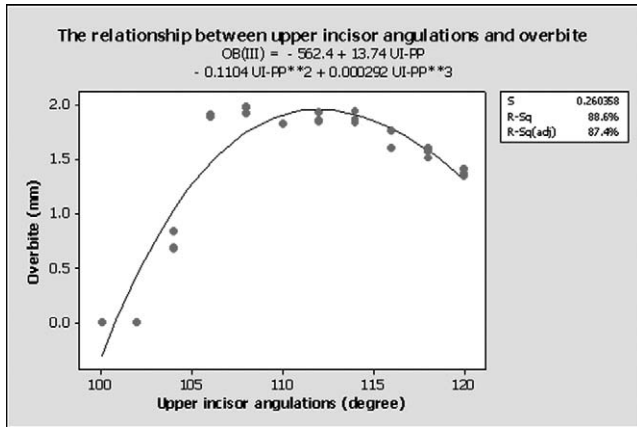


Figure 3. Scatterplot of upper incisor–palatal plane angulations versus change in overbite. Lower incisor–mandibular plane = 92°.

UI-PP angulation and the change in overbite ($R^2 = .886$, $P < .05$).

The reproducibility of the change in overjet and overbite with every 2° increase or decrease in UI-PP angulation showed a very high degree of accuracy. The estimated experimental error for change in overjet and overbite was 0.003 mm and 0.068 mm, respectively, with each observation being close to the corresponding mean.

Overjet and Overbite with the LI Positioned at 102° to the MP

There was a significant positive linear relationship between UI-PP angulation and change in overjet when the UI-PP angulation was changed from 100° to 120° ($R^2 = .98$, $P < .05$; Figure 4). The overjet decreased from 2.03 mm to 0.12 mm when the UI-PP angulation changed from 120° to 100°. The regression equation, $y = a + bx$, is $y = -9.77 + 0.0984x$ (y = change in overjet; x = degree of UI-PP angulation). The y intercept is $a = -9.77$ mm ($SE_a = 0.275$ mm, $df = 31$). The slope is $b = 0.0984$ mm/° ($SE_b = 0.00250$ mm/°, $df = 31$). Therefore, for every 1° increase of UI-PP angulation, the overjet will increase by 0.0984 mm. A change of 20° in UI-PP angulation will alter the overjet by an average of 1.968 mm.

When the UI-PP angulations ranged from 100° to 110°, the overjet was 1.0 mm or less and the overbite was observed to be 0 mm. However, once the UI-PP angulations increased past 110°, a negative relationship between UI-PP angulations and change in overbite was observed (Figure 5). The overbite decreased from 0.89 mm to 0.61 mm when the UI-PP angulation increased from 112° to 120°. The results showed that there is a significant negative quadratic relationship between UI-PP angulation and the change in overbite, with $R^2 = .823$ ($P < .05$). The regression equation, y

$= a + bx + cx^2$, is $y = 67.79 - 1.124x + 0.0047x^2$ (y = change in overbite; x = degree of UI-PP angulation) and applies only when the UI-PP angulations changed from 112° to 120°.

The reproducibility of the change in overjet and overbite with every 2° increase or decrease in UI-PP angulation showed a very high degree of accuracy. The estimated experimental error for change in overjet and overbite was 0.008 mm and 0.003 mm, respectively, with each observation being close to the corresponding mean.

Assumption of Regression

For all the regression analyses, the assumption of regression was checked by using the residual plot and residual analysis. The normal probability plot of the residuals revealed that the normality of data may be safely assumed. The residuals versus order and the residuals versus fitted data formed certain patterns, which may be explained by a lack of randomization in measurements. However, the experimental error is very small, and these patterns would not influence the estimates.

DISCUSSION

Dentoalveolar compensation for a sagittal jaw discrepancy is observed in mild to moderate skeletal Class II and III relationships. Skeletal Class II cases may have relatively upright UI and proclined LI. A near normal occlusion could therefore be observed despite an underlying mild skeletal base discrepancy. However, as the skeletal base discrepancy becomes more severe, natural dentoalveolar compensation is insufficient to overcome the greater discrepancy between the maxillary and mandibular skeletal bases.

Treatment planning for Class II malocclusions with a skeletal base discrepancy may involve growth modification procedures on growing patients, camouflage treatment on patients with little or no growth remaining, or surgical orthodontic treatment. The camouflage of Class II malocclusions with a mild to moderate Class II skeletal base discrepancy is, in essence, a compensation for the skeletal base discrepancy. However, significant dentoalveolar compensations could have a detrimental effect on anterior dental relations and/or buccal segment relationships. In particular, the final overjet and overbite may be less than ideal and is of interest in this study.

Bolton's⁵ tooth size analysis has been universally accepted to determine intermaxillary tooth size harmony. However, one cannot assume that a tooth size analysis that does not indicate the presence of any significant tooth size discrepancy will allow all cases to be completed to a normal occlusion. One must bear

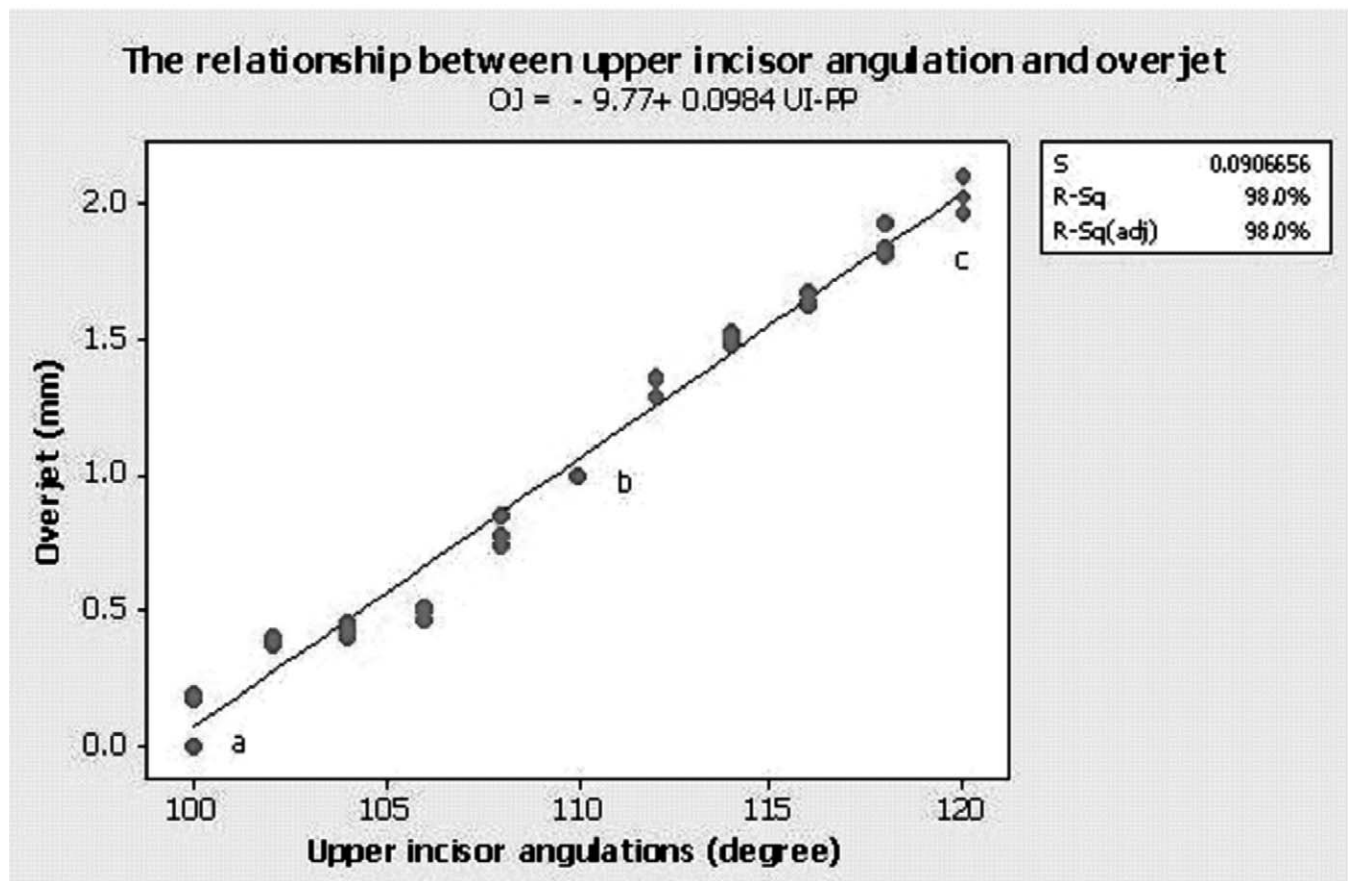


Figure 4. Scatterplot of upper incisor–palatal plane (UI-PP) angulations versus change in overjet. Lower incisor–mandibular plane = 102°. (a) UI-PP = 100°, (b) UI-PP = 110°, (c) UI-PP = 120°.

in mind that this assumption applies only when skeletal base relationships and incisor angulations are within normal limits. One could then ask, what are the limits and when does a tooth size analysis become not applicable?

This study showed that when the LI are normally angulated at 92° to the MP, the UI-PP angulations that allowed a normal overjet and overbite to occur ranged from 110° to 114°. UI angulations of less than 110°

resulted in a decreased overjet and overbite. UIs that were retroclined at 100° to 102° had an edge-to-edge incisor relationship unless extraction space is accepted somewhere along the upper arch. The smaller upper arch length compared to the lower arch length arising from the retroclination of the UI is a significant contributor to this effect. Positive overbite could be achieved if adequate palatal root torque of the UI could be obtained beyond the incisor thickness of the LI.

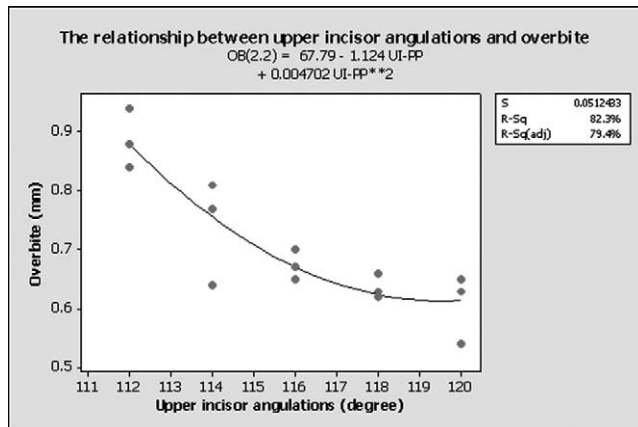


Figure 5. Scatterplot of upper incisor–palatal plane angulations versus change in overbite. Lower incisor–mandibular plane = 102°.

Changes to arch dimensions when UI angulations were altered were investigated by O'Higgins et al.¹⁰ They increased the angulation of the UI by 5° through an increase in palatal root torque, resulting in an increase in arch length by approximately 1 mm. They found that a decrease or increase of the UI angulations by 5° will affect the arch length by 0.92 mm.

Natural dentoalveolar compensation in Class II division 1 malocclusions may display normal to upright UI and proclined LI for the overjet to appear less severe. Further camouflage of this malocclusion could occur during orthodontic treatment. The injudicious use of Class II elastics could further lead to significant proclination of the LI. This study found that excessive proclination of the LI will result in an insufficient overjet and overbite relationship for any magnitude of UI angulation.

Proclination of the LI increases the mandibular arch length, which could create problems with coordination between the upper and lower arches. In addition, it could also result in an inability to achieve an adequate overjet and overbite, or it may restrict adequate retraction of the UI to close extraction spaces. No overbite was observed until the UI-PP angulation reached 112° to 120° when the LI were in a proclined position at 102° to the MP. Because of a lack of understanding, clinicians may blame this occurrence on a tooth size discrepancy. This problem is not uncommon in Class II upper arch extraction cases because Class II mechanics will procline the LI to some degree. To reinforce the lower arch anchorage, the use of a rectangular wire would be beneficial,¹¹ and the use of round wires should be used only with caution especially when elastics are used in a Class II configuration.

The UI-PP angulation is also an important determinant of normal anterior relationships. During overjet reduction, retraction of the UI could result in upright UI teeth. In his study of anterior interferences, Sondhi¹²

stated that palatal root torque of the maxillary anterior segment should be applied before continuing further with UI retraction. He advocated incorporating higher torque values into the maxillary incisor brackets to counter the overretroclination of the UI. This is an important clinical consideration when retraction of UI teeth is planned. A disadvantage of higher torque values is that concurrent loss of posterior anchorage is likely to occur if measures are not put into place to counteract the potential anchorage loss. At the other end of the spectrum, UI that were torqued greater than 114° to the PP resulted in an increased overjet with a decreased overbite.

Sarver and Sample¹³ described the importance of achieving correct upper and LI angulations during pre-surgical orthodontics. They postulated that improper UI angulations or excessive proclination of LI may impair adequate advancement of the mandible. A Class I buccal segment may also be difficult to achieve as the proclined LI edge will not permit good intercuspation of the buccal segments. From a clinical perspective, more emphasis should be placed on intra-arch mechanics in closing upper arch extraction spaces and less emphasis placed on the use of interarch elastics.

In reality, normal upper and LI angulations are impossible to attain in all cases. Besides accepting the problem, what can one do to overcome compensated LI that are excessively proclined in Class II treatment? As we appreciate that a tooth size analysis that shows no significant tooth size discrepancy does not mean much in such cases, arch coordination will still be a problem. However, if one were to consider creating a tooth size discrepancy by interproximal reduction of tooth width in the lower anterior segment, the lower arch length may be decreased sufficiently to achieve a greater overjet and overbite.

Tooth size analysis in cases that indicate the presence of a mandibular excess of tooth width will have a compound effect when the LI are proclined. The attainment of a positive overjet and overbite will be more difficult to achieve. Tooth size discrepancies and incisor angulation are therefore factors that should be considered in attaining interarch coordination. The clinician should not overlook the importance of interim cephalometric radiographs and the value of tooth size analyses.

It is important to appreciate that incisor angulation and tooth size discrepancies can affect not only the anterior incisor relationship but also the buccal segment relationships. Evaluation of incisor angulations and tooth size harmony should be performed on patients when the anterior and/or posterior occlusion does not intercusate satisfactorily. Ideally, these var-

ables should be assessed prior to the commencement of orthodontic treatment.

It should be noted that this study approximated the crown and root's long axis to a straight line, which represents the incisor angulation. As a separate issue that must be considered clinically, the crown angulation is variable, particularly in Class II division 2 malocclusions, which demonstrate a higher incidence of bending of the upper central incisor. This variation in crown angulation has the potential to affect the overjet and overbite, in which case the crown angulation rather than the crown-root angulation is a better measure of the final position of the upper central incisor.

Clinical Implications

Incorrect incisor angulations may be a significant, and perhaps more frequent, contributor to the presence of a poor buccal segment and/or anterior relationship. An important biomechanical consideration during treatment is the establishment of adequate UI palatal root torque prior to overjet reduction. Inadequate consideration of upper and LI angulations and/or tooth size discrepancies could compromise anterior occlusal and buccal segment relationships during the finishing stages of orthodontic treatment. Excessive proclination of the LI will result in poor overjet and overbite relationships. Incorporating LI labial root torque within the archwire, using negatively torqued LI brackets (eg, -6° of torque) and interproximal reduction of the lower anterior segment could be considered during the treatment planning stage.

Limitations of the Study

This experimental model has several limitations. It has not investigated the effects of tooth size, tooth size discrepancy, tooth shape, crown-root angulations, incisor edge thickness, and arch form on the inter-arch relationship. All of these occlusal variables were controlled in this typodont investigation. Although each of these variables individually and/or collectively has the potential to affect the overall occlusion, the extent of such effect(s) could not be examined in this study.

CONCLUSIONS

- Class II treatment with upper first premolar extractions require adequate UI palatal root torque to

achieve good buccal segment interdigitation and incisor relationships.

- Upright UI could result in an edge-to-edge incisor relationship, a normal overjet/overbite relationship with residual extraction spaces remaining, and/or a poor buccal segment relationship.
- Excessively proclined LI have the potential to contribute to an occlusion with minimal or no overjet and overbite.

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REFERENCES

1. Sangcharearn Y, Ho C. Upper incisor angulation and its effect on molar relationships. *Angle Orthod.* 2007;77:221–225.
2. Delivanis HP, Kuftinec MM. Variation in morphology of the maxillary central incisors found in class II, division 2 malocclusions. *Am J Orthod.* 1980;78:438–443.
3. Andrews LF. The six keys to normal occlusion. *Am J Orthod.* 1972;62:296–309.
4. Ash MM, Nelson SJ. *Wheeler's Dental Anatomy, Physiology, and Occlusion.* 8th ed. St Louis, Mo: Saunders; 2003.
5. Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. *Angle Orthod.* 1958;28:13–30.
6. Ho CT, Freer TJ. The graphical analysis of tooth width discrepancy. *Aust Orthod J.* 1994;13(2):64–70.
7. Anthanasiou AE. *Orthodontic Cephalometry.* London, UK: Mosby-Wolfe; 1995.
8. Williams A, Woodhouse C. The crown to root angle of maxillary central incisors in different incisal classes. *Br J Orthod.* 1983;10:159–161.
9. Rudolph DJ, Dominguez PD, Ahn K, Think T. The use of tooth thickness in predicting intermaxillary tooth-size discrepancies. *Angle Orthod.* 1998;68:133–138.
10. O'Higgins EA, Kirschen RH, Lee RT. The influence of maxillary incisor inclination on arch length. *Br J Orthod.* 1999; 26:97–102.
11. Bennett J, McLaughlin R. *Orthodontic Treatment Mechanics and the Preadjusted Appliance.* London, UK: Mosby-Wolfe; 1993.
12. Sondhi A. Anterior interferences: their impact on anterior inclination and orthodontic finishing procedures. *Semin Orthod.* 2003;9:204–215.
13. Sarver D, Sample L. How to avoid surgical failures. *Semin Orthod.* 1999;5:257–274.