The relationship between bite depth and incisor angular change

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Bite depth is the measure of the vertical relationship between the maxillary and mandibular incisors. A vertical relationship which differs from the ideal is a contributing factor in many malocclusions; correcting the discrepancy is of major concern to clinicians. The causes of excessive overbite, including a deep curve of Spee and extrusion of incisors, have been well documented. Similarly, the causes of open bite, such as a tipped palatal plane or a steep mandibular plane, have been examined, This paper will examine the effect of the angulation of the incisors on the vertical relationship. Other factors being equal, flaring or proclining the incisors during orthodontic treatment decreases the bite depth, while uprighting the incisors increases the bite depth. This paper will present a two-dimensional geometric model to quantify the change in the overbite relationship of the incisors resulting from a change in their angulation.

Materials and methods

A geometric model was constructed to predict the increase or decrease in bite depth expected due to changes in incisor angulation. Tooth movement is described by defining the movement around a center of rotation.[1] By definition, for translatory tooth movement the center of rotation is infinity. Translation of the incisors does not change their respective angulations; consequently, their vertical relationship also remains unchanged.[1] Two other common orthodontic tooth movements are examined for their effect on bite depth in this model, namely controlled tipping, defined as tooth movement with the center of rotation at the apex, and uncontrolled tipping, defined as tooth movement with the center of rotation near the center of resistance. Both types of movement change the incisor's angulation and therefore change the overbite relationship. Figure 1 defines the variables and the symbols used in this model for the two types of tooth movement investigated.

Abstract

A geometric, two-dimensional model was developed, which estimates the effect of changing incisal angular position to the effective bite depth. Because of the constant lengths of incisors whose long axes can be viewed as the sides of a triangle, it is possible to calculate the amount of their overlap as a function of changing angle. Additionally, a distinction is made between controlled and uncontrolled tipping, defined in respect to their centers of rotation. It is suggested that an average of 0.1 to 0.2 millimeter change in overbite occurs for every degree of incisal angular change.

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Key Words

Overbite • Incisal angulation • Geometric model

Figure 1

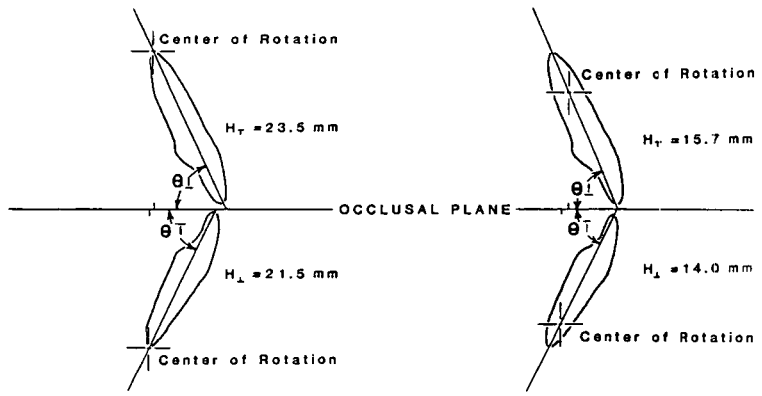

Figure 2

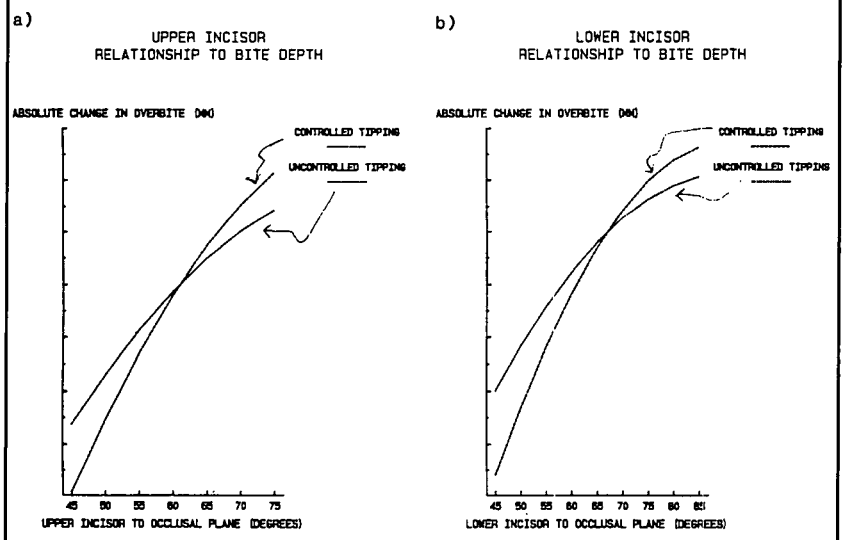

Figure 1
Definitions and symbols used in text. Note that the center of rotation in controlled tipping (A) is at the apex of the tooth, while in uncontrolled tipping (B) it is at or close to tooth's center of resistance.

Figure 2
Graphic presentation of relationship between the incisal angular change and the change in overbite for the maxillary (A) and mandibular incisors (B).

Table 1

	Standard
$\underline{1}$ to OP ($\theta\underline{1}$)	61° ± 7°
$\overline{1}$ to OP ($\theta\overline{1}$)	67° ± 7°

$\theta\underline{1}$ and $\theta\overline{1}$ denote the upper and lower incisal long axis angles to the occlusal plane, respectively. A one degree change in incisor angulation measured to a reference plane equates to a one degree change in the long axis to occlusal plane angle; therefore, the following discussion applies regardless to which reference plane the incisors are measured, e.g. the NA, NB, APg, IMPA, or any other standard reference plane (Figure 3). Average figures for maxillary and mandibular incisor crown and root lengths and their respective incisal angles are given in Tables 1 and 2.[2,3] These figures are used in part to derive ($H\underline{1}$) and ($H\overline{1}$). Crown length (H) is defined as the distance on the incisor long axis from the incisal edge to the center of rotation for the respective tooth movement planned.

Results

Based on geometric relationships of the involved structures, the formula derived to calculate the change in bite depth expected as a result of angular change in incisor position is as follows:
Bite Depth = (SIN $\theta\underline{1}$ final — SIN $\theta\underline{1}$ initial) · ($H\underline{1}$) + (SIN $\theta\overline{1}$ final — SIN $\theta\overline{1}$ initial) · ($H\overline{1}$)

Positive values resulting from the above formula indicate increasing overbite, and negative values indicate decreasing overbite. Figure 2 graphically represents the information from the above formula. The graphs plot the amount of overbite change attributable to the maxillary incisor in Figure 2A, and the mandibular incisor in Figure 2B. This is dependent on the change in the angle made by the incisal long axis to the occlusal plane and the type of tooth movement used. The horizontal axis on both graphs is the angle of the incisal long axis to the occlusal plane. Each increment on the vertical axis represents 0.5 millimeter of absolute change in the bite depth. To use Figures 2A and 2B to predict the treatment change in overbite, both the initial and the predicted final angles of the incisal long axis to occlusal plane are needed, as well as the type of tooth movement planned. When angular changes of both maxillary and mandibular incisors occur, then both graphs A and B

Table 2

		Crown Length (mm)	Root Length (mm)	Overall Length (mm)	(H) Controlled tipping (mm)	(H) Uncontrolled tipping (mm)
Max. Incisor	$\underline{1}$	10.5	13.0	23.5	23.5	15.7
Mand. Incisor	$\underline{\bar{1}}$	9.0	12.5	21.5	21.5	14.0

are used to calculate the cumulative effect of each incisor's respective contribution to the overall bite depth change. The net overbite change is thus calculated by adding the individual maxillary and mandibular arch changes. Table 3 summarizes information from the two graphs, giving the average figures for the change in overbite per degree change in the angle of the long axis to the occlusal plane. These average values may be used with reasonable accuracy as a rule of thumb for maxillary and mandibular incisor movements within the range of ±15 degrees from the average standard angulations in Table 1, i.e. between 46 degrees and 76 degrees for the maxillary and 52 degrees and 82 degrees for the mandibular incisors, respectively. By multiplying the appropriate value from Table 3 by the number of degrees of angular change in each arch, an estimate of the overall overbite change can be calculated within the limits of practical accuracy (confidence limit of 95 percent will have a "window" of less than 0.1 millimeter). For illustrative purposes, let us assume that the initial maxillary incisor angulation ($\theta\underline{1}$) is 60 degrees and the treatment plan calls for controlled tipping of five degrees (to 55 degrees); at the same time, no tipping is planned for the mandibular incisor, so its angulation should not change. The net overbite should increase or deepen approximately one millimeter (5 degrees x 0.204 millimeter).

Table 3
Change in Bite Depth
mm / deg.

Movement	Max. Incisor	Mand. Incisor
Controlled Tipping	0.204	0.146
Uncontrolled Tipping	0.132	0.095

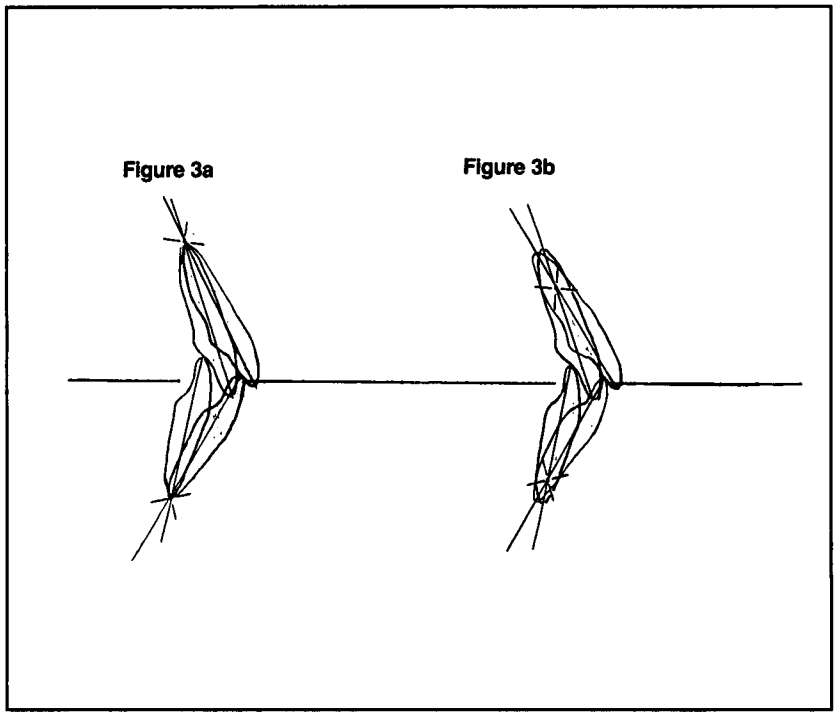

Figure 3
A is a two dimensional presentation of the controlled tipping and its resulting change in bite depth.
B is a presentation of the uncontrolled tipping and its resulting change in bite depth.

Discussion

This geometric model provides a method to estimate the amount of overbite change a clinician can expect from angular changes in the incisors by either controlled or uncontrolled tipping, all other factors being equal. The formula as described produces an accurate prediction of the overbite change. The graphs (Figures 2A and 2B and their extrapolated values in Table 3) provide the clinician with a useful rule of

thumb to estimate the change in overbite attributable to incisal angular changes. In clinical practice, the actual overbite change in a patient cannot be predicted by this method alone. Other notable factors which contribute to incisal vertical relationship are extrusion or intrusion of incisors or molars. The objective of this investigation is to quantify one important factor in the overall problem of the overbite relationship. Using the presented values (graphs in Figure 2 or the average values in Table 3) to predict how incisor angulation changes affect the bite depth quantifies the amount of vertical correction that must be built into a treatment plan to achieve the desired results.

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