

A simple mathematical study of anterior dental relations

Part III: incisor and canine overbite

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Two previous articles described horizontal interarch relations with a simple model developed. This paper required further development of the horizontal relations to allow vertical overlap to be studied. An analysis of orthodontic and dental-prosthetic models provided values to refine horizontal description then guide vertical calculations. Tooth thickness and angles of the maxillary teeth were related to horizontal overlap to produce an estimate of potential overbite.

Principles were derived from the calculations and stated. Change can be predicted for overjet and overbite during and after orthodontic treatment. This series of articles expands the logical foundations by rationally considering a broad range of anterior occlusions.

There are limitations in observing one or two features of anterior occlusion without comprehending the influence of other significant measurements. Measuring change in anterior overbite is inadequate without concurrently accounting for changes of other variables such as:

spacing/enlarging/hypodontia; crowding; buccal relations and tooth thickness.

A better understanding of anterior dental relations is possible from use of this model and the principles derived from it.

Keywords: Occlusion, overbite, overjet, tooth width, tooth angles, tooth thickness.

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Introduction

This article uses the base of two previous articles (Part I¹ and Part II²) and further develops the mathematical description of anterior occlusion. Part I¹ describes an anterior arc of a dental arch and how two arcs, representing the maxillary and mandibular arches, may be related to each other. Adjustments of an arch to a reference plane are possible and an adjustment described as a canine adjustment was made, the concept of canine and other antero-posterior adjustments were further developed in Part II². Part II allows independent variation of angles and perimeters of each arc individually as well as adjusting for antero-posterior buccal relations; the results allowed the statement of a series of principles. At the completion of Part II the mathematical model is confined to horizontal relations (the plane of the arcs which approximates the clinical occlusal plane), the difference in the anterior region is described as incisor overjet and in the canine region as canine overjet.

The vertical dimension (dental overbite) in both the incisor and canine regions has not yet been addressed. This, the third article, relates overbite to overjet and includes calculations for the angle of the palatal surface of the maxillary teeth to the occlusal plane and thickness measurements. Features of occlusions, such as Angle³ classification and Dewey⁴ subclassification, pertaining to this model are now able to be examined. A better understanding of the relations of anterior dental occlusal features may lead to an improved understanding of anterior occlusion prior to treatment, as well as the changes which occur with and after treatment. Steadman⁵ described some of the issues and principles addressed in the current work and his stated principles can be examined by models such as this.

Figures for palatal surface angles of the maxillary teeth to the occlusal plane are needed to allow calculation of potential overbite. Edge-thickness measurements of maxillary and mandibular incisors and canines are required. Measurements of angles and edge thicknesses are used to indicate a possible range of angles and thicknesses which could be encountered in most patients. Normality was not defined by these measurements. The model has the ability to account for many anterior dental combinations.

Definitions

Some terms require further explanation as they vary in detail as the model develops to more closely approximate human occlusion.

Overjet: The horizontal overlap of the teeth in the occlusal plane.

In the previous articles overjet was calculated and inferred as the horizontal difference between both arches relative to a reference plane. The arches were considered lines of occlusion, with no thickness (passing through the contact points and along the edges of teeth as shown in Figure 1). This article accounts for tooth thickness and description of overjet must be modified in two ways. First, half the thickness of the mandibular teeth is added to the labial of the mandibular line of occlusion, and half the thickness of the maxillary teeth is added to the labial of the maxillary line of occlusion (this may be loosely approximated to the clinical mensuration method of Moorrees⁶). Second, the horizontal space between the arches is the distance between the labial of the mandibular teeth and the palatal of the maxillary teeth. Whereas overjet is calculated

from the labial of a maxillary tooth, the measurement used to calculate the potential overbite is from the palatal of the maxillary tooth. Figure 1 shows the overjet both as used in this paper and how it may differ from a clinical overjet.

Overbite: The vertical overlap of the teeth perpendicular to the occlusal plane as shown in Figure 1.

A numerical value for the potential maximum vertical overlap between the dental arches is derived mathematically. The overbite value calculated presumes simultaneous anterior and posterior contact of the dentition. The magnitude of an overbite, in clinical terms, would be less than the calculation if there is vertical space between the anterior teeth when the posterior teeth are occluding.

Objectives

The aim of this study is to enhance the model already developed^{1,2} by calculating potential overbites. Factors which may influence overbite magnitude include overjet, tooth thickness and tooth angulation. The goal of the study is to extend the logical and coherent integration of many factors to better understand and evaluate anterior occlusion.

Materials and Methods

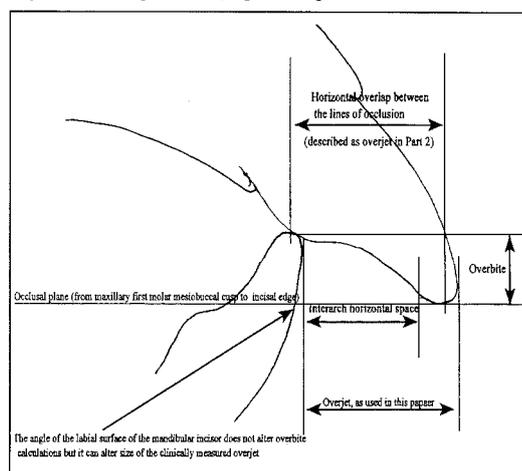
Measurements for incisor and canine thickness and angulation were required as a guide for use in overbite calculations. Methods were developed for measuring tooth angles and linear dimensions. With these measurements a vertical dimension is incorporated into the mathematical model^{1,2} described previously. The methods are outlined below.

Section 1: Measurement of angles of the palatal surfaces of maxillary incisors and canines.

Duplicates of study models from ten untreated patients were trimmed parallel to the occlusal plane (mesiobuccal cusp of the maxillary first molars to the maxillary incisal edge, used by Moorrees⁶). Twenty sets of dental casts were measured: ten pretreatment orthodontic study models and ten removable prosthodontic models from a local dental laboratory.

The models were then sectioned perpendicular to the arch and the angles of the incisors and canines were measured with a protractor. The incisors and canines have two measurements: the first is the angle from the palatal of the incisal to the concavity occlusal to the

Figure 1. A diagram clarifying the usage of various terms.



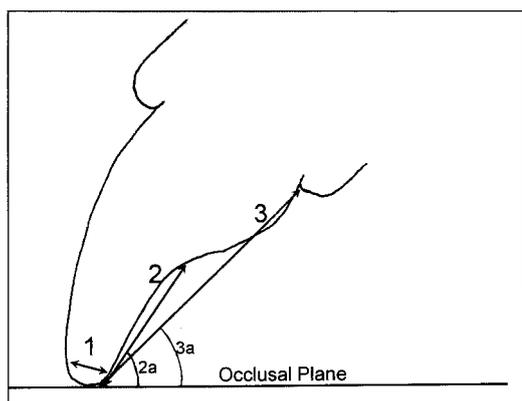


Figure 2. Tracing of a maxillary incisor with numbers 1, 2 and 3 linked to lines representing:
 1. thickness of the edge;
 2. length from the edge to palatal concavity and along the surface, just labial to the line. The angle of the edge portion of the palatal surface to the occlusal plane is measured; and
 3. length from edge to gingival margin and whole tooth angle to the occlusal plane.

cingulum, and the second from the edge, including the whole cingulum, to the gingival margin with both angles measured to the occlusal plane (Figure 2). The canines were measured in the same way as the incisors, again, to the occlusal plane.

Section 2: Linear measurement of some maxillary and mandibular incisor and canine features.

Helios(r) digital vernier calipers were used to measure features of incisors and canines. Edge thicknesses were measured on the models at the points where the form of the incisal edge becomes the buccal and lingual surface of the teeth (Figure 2, the line marked 1). In practice, there was no difficulty in recognising the edge thicknesses (consistently to 0.2mm). Tooth thicknesses were recorded for the central incisors and canines of both maxillary and mandibular teeth.

Two lengths were measured: the distance from the midpoint of the tooth edge to the depth of the concavity incisal to the cingulum (as used in the angular measure described above); and the distance from the incisal edge midpoint to the gingival margin (Figure 2, lines marked 2 and 3).

Section 3: Development of the mathematical model to include overbite.

The description of the use of a multi-dimensional spreadsheet for a mathematical model was outlined for the overjet model. Hardware used was an IBM(c) compatible personal computer with an Intel(r) 486 DX33 CPU and sixteen megabytes of RAM and Lotus Improv(c) 2.1 hardware.

The mathematical worksheet developed in two preceding papers^{1,2} provides a range of overjet values. Overbite is separated from the previous calculations to maintain an uncomplicated approach. The overjet range allows observation of change in overbite when compared with overjet and other factors.

The combinations and permutations of maintaining all variables multiply the size of the spreadsheet (in Part II the spreadsheet file is more than one megabyte in size; for example: six steps for maxillary tooth thickness, six for mandibular tooth thickness and eight for incisal angles means that the data grows 288 times — an unwieldy file for the personal computer being used). The spreadsheet is divided for overjet and overbite but this still allows modelling of results in a two-stage calculation (overjet then overbite) and the same as modelling on one spreadsheet.

The spreadsheet uses the following given values. Horizontal interarch distance values are arbitrarily nominated as encompassing most of the range of positive overjets likely to be found in humans. Other values start with the results presented in Table I and then the range examined is increased. Measurements requiring values for computation are:

- (1) figures for horizontal distance between the lines (planes) of occlusion;
- (2) tooth thicknesses of maxillary and mandibular incisors and canines;
- (3) linear measurements of the palatal surfaces of maxillary incisors and canines; and
- (4) angular measurements of the palatal surfaces of the maxillary incisors and canines.

Formulae are applied to the above values to calculate potential overbite.

The abbreviations used are:

- Overjet=OJ
- Horizontal distance between the lines of occlusion=HD
- Maxillary tooth thickness=MxTh
- Mandibular tooth thickness=MdTh
- Interarch Horizontal Space =IaS
- Angle= \angle
- $\pi = \pi$
- First preliminary potential overbite=ppOB1
- Second preliminary potential overbite=ppOB2
- Potential overbite=pOB
- Angle the palatal edge of the tooth makes to the occlusal plane= \angle_{edge}
- Angle of whole palatal surface to the occlusal plane= \angle_{whole}
- The mean angle of $\angle_{edge} - \angle_{whole}$ (from Table I)= -mean

Table I. Measurement of central incisors and canines of ten orthodontic (Orth) duplicate models and ten prosthodontic (Pros) models.

		MEAN	MAXIMUM	MINIMUM	STANDARD DEVIATION
Maxillary incisor tooth thickness	Orth	2.02	2.40	1.70	0.21
	Pros	2.40	2.83	1.68	0.39
Maxillary incisor concavity length	Orth	3.18	3.80	2.50	0.39
	Pros	4.46	5.04	3.91	0.37
Maxillary incisor edge to gingival margin length	Orth	8.49	10.50	7.60	0.75
	Pros	9.24	10.00	8.18	0.55
Maxillary incisor edge concavity angle (edge angle)	Orth	72	100	45	15
	Pros	65	80	55	10
Maxillary incisor edge to gingival margin angle	Orth	48	75	15	15
	Pros	48	65	40	8
Maxillary canine thickness	Orth	3.01	3.60	2.38	0.30
	Pros	2.53	3.08	2.20	0.26
Maxillary canine edge to concavity length	Orth	3.35	4.40	2.50	0.57
	Pros	3.90	5.91	2.82	0.90
Maxillary canine edge to gingival margin length	Orth	8.29	9.80	6.70	0.79
	Pros	8.86	11.30	7.07	1.27
Maxillary canine edge to concavity angle	Orth	64	77	50	8
	Pros	50	70	35	10
Maxillary canine edge to gingival margin angle (whole tooth angle)	Orth	43	55	35	6
	Pros	38	55	25	9
Mandibular incisor thickness	Orth	2.08	2.30	1.70	0.23
	Pros	2.27	3.00	1.37	0.53
Mandibular canine thickness	Orth	1.90	2.33	1.22	0.30
	Pros	2.42	3.41	1.80	0.48

The formulæ are:

- (1) Overjet is the horizontal distance between the lines of occlusion plus half the maxillary tooth edge thickness minus half the mandibular incisor thickness.

$$OJ = HD + \frac{MxTh - MdTh}{2}$$

- (2) Horizontal interarch space is the distance between the lines of occlusion minus half the tooth-edge thickness of both maxillary and mandibular teeth.

$$Ias = HD - \frac{MxTh - MdTh}{2}$$

- (3) Conversion formula for degrees into radians.

$$\angle(\text{radians}) = \frac{\angle(\text{degrees}) * \pi}{180}$$

- (4) The first calculation for potential overbite has the interarch space multiplied by the tangent of a tooth measurement angle.

For overjet > 0.

For overjet ≤ 0, overbite is given the value 0

$$ppOB1 = Ias * \tan(\angle \text{edge})$$

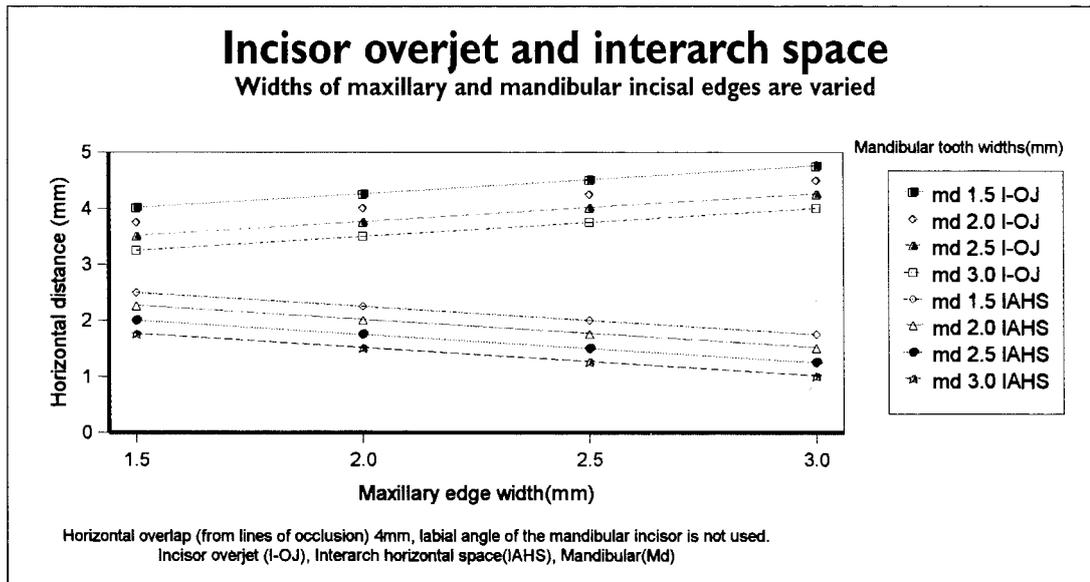


Figure 3

(5) The overbite value is modified to account for the variation in anatomy of the palatal of the maxillary teeth. If the overbite is greater than the distance from the tooth edge to the palatal concavity then a different angle may be required to calculate the overbite. Edge length and angular measurements are used in this formula. A conditional formula allows a second formula to be used if a specified condition is exceeded (as it was in this instance). This uses the “IF, THEN, ELSE” function of Lotus Improv

$$ppOB2=IF[ppOB1>EL],$$

THEN

$$[Ias=tan \frac{(\angle-\angle mean)*\pi}{180}]$$

ELSE

$$[ppOB1]$$

(6) Only one condition at a time was allowed by the spreadsheet formula. After the SE condition is activated in formula 5 some values result from formula 5 where ppOB2>SE, these are adjusted to the SE value, this formula was calculated manually.

$$pOB=IF[ppOB1>EL<ppOB2],$$

THEN

$$[EL]$$

Assumptions

- a) The calculations are for the potential maximum anterior overbite. This potential may be exercised in varying degrees ranging from anterior openbite to anterior dental contact on closure.
- b) Tooth thicknesses are greater than or equal to zero.
- c) The angle of the labial surface of the mandibular tooth is not lingually inclined any more than the palatal of the maxillary opposing tooth (otherwise the interarch contact could be such that the maxillary tooth contacts the mandibular tooth gingival to the incisal edge).
- d) At this stage, calculations for overjets are limited to zero and positive. The maxillary teeth are edge-to-edge or forward and lateral to the mandibular teeth.
- e) The overjet derived from the calculations of this paper will still differ from clinical overjet depending on the form and angle of the labial surface of the mandibular tooth (Figure 1).

Results

Sections 1 and 2 comprise angular and linear measurements of the palatal surface of the maxillary central incisors and canines, and edge-thickness measurements of maxillary and mandibular incisors and canines. Measurements are presented in Table I. The maximum and minimum values allow a range to be defined. The mean and standard deviations are provided to further describe the sample.

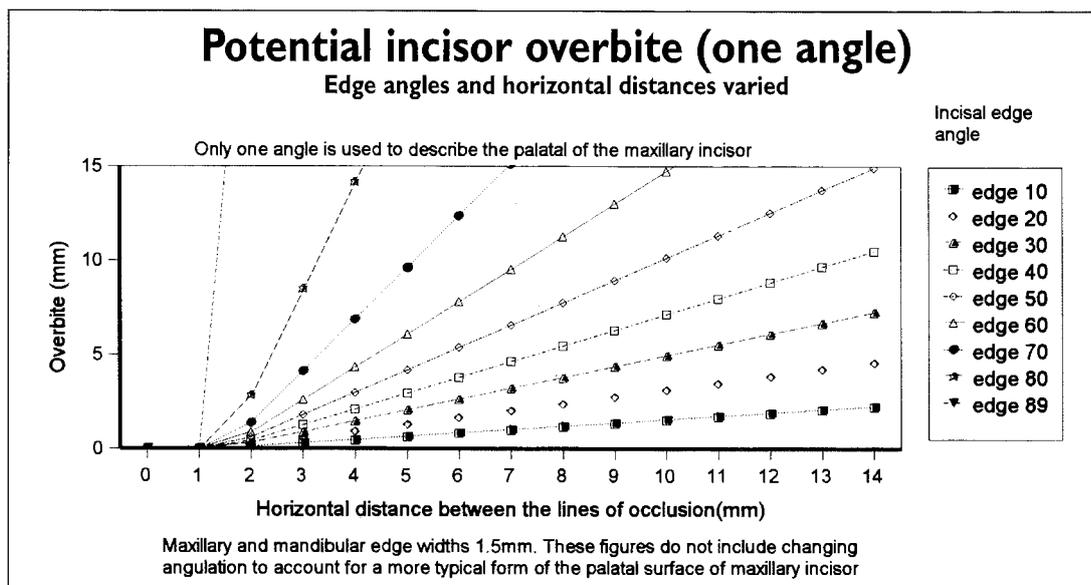


Figure 4

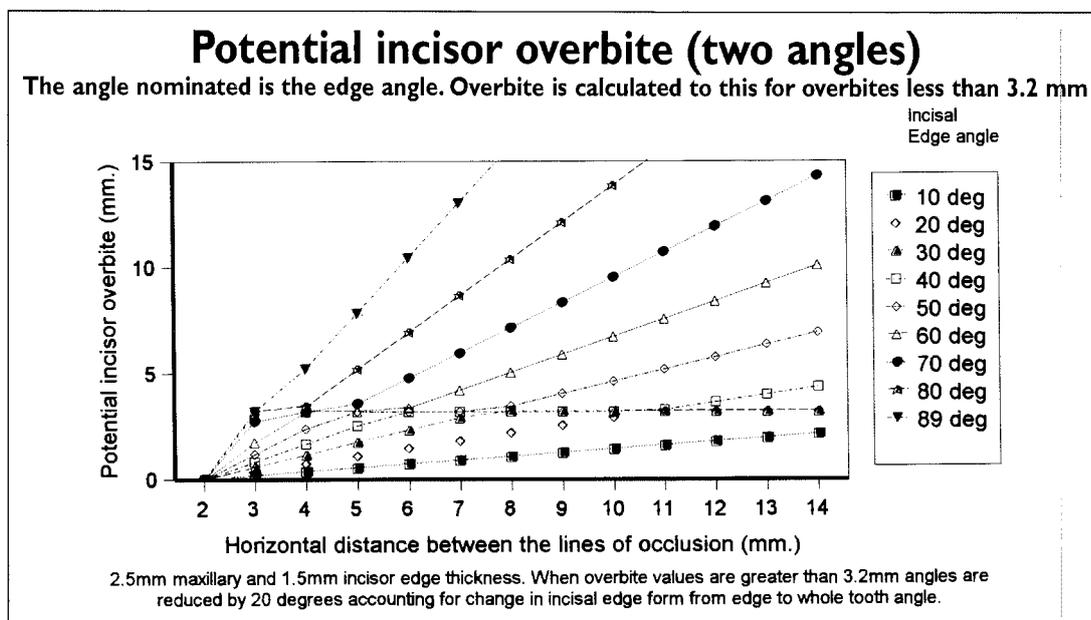


Figure 5

The values derived from the examination of models are used in the mathematical model in various ways, for example:

When a typical example of a tooth thickness or a particular length is required, a value close to the mean is used. The incisor and canine edge thicknesses and lengths are used in this manner.

The angular change from edge angle to whole-of-tooth angle uses the difference between the means of the edge angles and whole-of-tooth angles.

The ranges of measured values give an indication of values to use in later calculations, such as angles to examine or tooth thicknesses.

The results of Sections 1 and 2 were used for calculations in Section 3 and potential overjet values resulted. Overjet increases as maxillary tooth thickness increases and decreases as mandibular tooth thickness increases. Horizontal interarch space decreases with an increase in tooth thickness in either or both arches (Figure 3).

When the distance between the lines of occlusion increases both horizontal interarch space and overjet increases (Figure 3).

As the angle of the palatal surface of the tooth increases, the size of the potential overbite increases (Figures 4, 5 and 6).

The angle of the edge of a tooth is valid from the edge to the palatal concavity of the tooth.

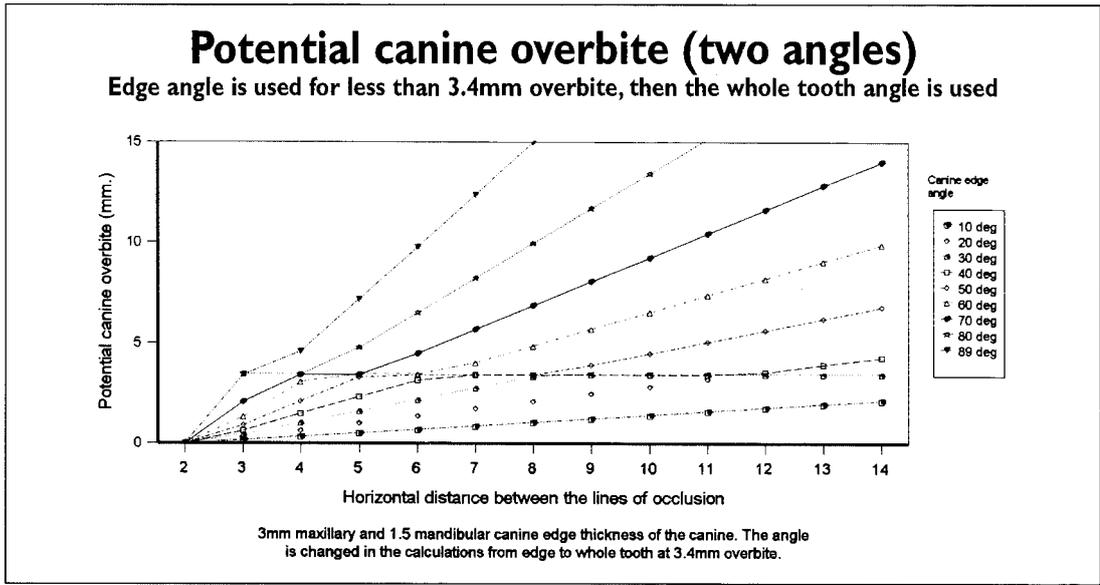


Figure 6

If overbite is greater than the distance from the edge to concavity, the angle of the whole palatal surface of the tooth becomes relevant in determining the calculation point of the interarch contact (Figures 5 and 6).

Discussion

The experiments and mathematical models are discussed first. Some principles can be stated from the mathematical model.

Sections 1 and 2

The experiments outlined in Sections 1 and 2 of this paper provide values which are applied to the mathematical model. Of the orthodontic plaster-models, two were chosen for their maxillary incisor proclination and two for their maxillary incisor retroclination. Their measurements provide a large range of tooth thicknesses and angles. This paper was not intended as a comprehensive examination of tooth measurements, but a need for some measurements was identified before further development of the mathematical model could progress.

The palatal form of the maxillary teeth was again measured for the difference in angular relations between the edge of the tooth and the full palatal surface (from edge to gingival margin). It would be possible to further and more accurately describe the palatal crown form and use this description with a model such as that being developed in this paper. A curvilinear or topographic description of tooth form would be an improvement for the future but is counter to the aim of maintaining simplicity within this model.

The form of the mandibular incisor was not further described as it was considered that only the labial of the incisal edge is usually relevant for determining overjet and potential overbite. As maxillary teeth overlap to the labial of the mandibular teeth, the angle of the palatal surface (if acute) will contact only the upper and outermost point on the mandibular tooth; unless the mandibular tooth is retroclined more than the palatal surface of the maxillary tooth. Even the most retroclined maxillary incisor of the models measured had a whole palatal-surface angle of seventy-five degrees to the occlusal plane; so, in a case in which overbite exceeds the edge length, the angle of the mandibular incisor labial surface to occlusal plane would need to be one hundred and five degrees or more.^a This does not imply that contact at a point other than the mandibular incisal tip could not occur; it was, however, considered less common and is not studied further here.^b The lack of measurements for the angle of the labial of the mandibular incisor also has implication for the overjet used in this model and may be a reason why it may differ from a clinical measure.^c

In most instances, the angle of the mandibular incisor does not directly influence overbite. This means maxillary tooth angle influences overbite more directly than interincisal angle; furthermore, it is the contribution of the maxillary tooth's to the interdental angle that most results in the overbite measure (attributable to dental angulation).

When the angle of the maxillary tooth edge (\angle_{edge}) is ninety degrees or more, the theoretical overbite is infinite.^d The greatest

a Taking the complimentary angle of the 180 degrees, this angle alters counter to change in the mandibular incisor to mandibular plane angle.
 b See assumption c.
 c See also Figure 1 and assumption e.
 d As $\tan 90$ degrees is infinity the angular measure of 89 degrees was used.

whole-tooth-angle (\angle whole) was seventy-five degrees for the maxillary incisor and fifty-five degrees for the maxillary canine; therefore, for this sample no tooth had a whole-tooth angle of less than fifteen degrees off perpendicular.

Section 3: Horizontal relations

The previous papers (Parts I^e and II^f) were concerned with archform and arch perimeters, and how these can be altered to vary horizontal overlap. It may be obvious, but there must be a horizontal space between the arches to allow overbite, otherwise the teeth occlude edge-to-edge with no overbite possible. The labio-lingual thickness of teeth alters both overjet and interarch horizontal space measurements. It was necessary to further describe the horizontal overlap before moving to the vertical overlap.

Negative overjets were not calculated at this stage, however, for a negative overjet, the edge of the maxillary tooth contacts the lingual of the mandibular tooth. The lingual form of the mandibular teeth would need description and a horizontal interarch space is needed to allow vertical overlap. Further measurements of the lingual surface of the mandibular teeth would then make calculation of the overbite in crossbite cases possible.^g

Discussion follows the formulæ as they act upon the given measurements. Principles are stated and presented when appropriate.

Principle 1: Overjet increases as interarch distance between the lines of occlusion increases.

The interarch horizontal measure in Parts I and II considered the tooth as a line of no thickness. The thickness of a tooth impacts on overjet and the space between the arches that is available for overbite. Formulæ (1) and (2) address how tooth thickness changes overjet and horizontal interarch space.

As the line of occlusion passes along the tooth edge, half of the edge thickness was deemed buccal to the line and half palatal to the line. Also, half the mandibular tooth edge is regarded as buccal to the mandibular line of occlusion. Figure 3 displays an increase in overjet, a decrease in horizontal interarch space as maxillary tooth thickness increases and a decrease in both as the mandibular tooth thickness increases. Four principles ensue^f from the calculations leading to Figure 3.

Principle 2: Overjet increases as maxillary tooth thickness increases.

Principle 3: Interarch horizontal space decreases as maxillary tooth thickness increases.

Principle 4: Overjet decreases as mandibular tooth thickness increases.

Principle 5: Interarch horizontal space decreases as mandibular tooth thickness increases.

Vertical relations

When an overjet is present, the opposing anteriors have the potential to overlap vertically and create an overbite. This potential may be accepted to varying degrees, from the posteriors and anteriors occluding simultaneously, to an anterior open bite. (Only the maximum potential overbite is described and discussed at this stage).

The amount of calculated overbite is dependant only on the angle of the palatal surface of the maxillary tooth to the occlusal plane. The maxillary tooth has two angles which are most significant in describing its palatal surface. A difficulty presents when the angle changes from one representing the edge angle to one representing the whole palatal surface. The conditional equations in this spreadsheet did not allow two concurrent conditions, so the overbite values between the two angles were changed manually to the conditional overbite value. The conditional overbite value represents the mean of the length of the edge of the tooth.^h

Steadman⁵ described the change in overbite with change in maxillary incisor angle; Figures 4, 5, and 6 supports this thesis.

Principle 6: For overbite to exist there must be a horizontal space between the dental arches for teeth to move vertically past each other.

Principle 7: Except when the palatal angle changes from edge to whole tooth, overbite increases as overjet increases.

Principle 8: Overbite increases as the angle of the palatal surface of the maxillary tooth to the occlusal plane increases.

Deductions made from combining the mathematical models of this series

Cognisance of the multiple factors that can impact on horizontal and vertical interarch relations allows some deductions to be stated. The combining of the models allows a means of forecasting how a horizontal factor would impact in both a horizontal and vertical dimension.

^e If absolute values are used, interarch horizontal space can be calculated from formulæ (i) and (ii) for negative overjet and then measures of the mandibular tooth used with formulæ (iv), (v) and (vi), therefore, formulæ (i) and (ii) are valid for horizontal description in both positive and negative directions.

^f It is possible to adapt the formulæ to calculate for negative overjets where the postulated principles would be:

1. Overjet decreases with increased maxillary tooth thickness;
2. Interarch horizontal space decreases with increased maxillary tooth thickness;
3. Overjet increases with increased mandibular tooth thickness;
4. Interarch horizontal space decreases with increased mandibular tooth thickness.

^g The edge length could be further adjusted by calculating the inverse sine of the edge length as the cutoff point, with this reducing the value when the depth of overbite triggers a change in the angle used for calculation (edge length was not further adjusted).

Principle 9: To reduce a deep overbite requires a decrease in the horizontal interarch space and/or angulation of the maxillary tooth, or both. If an increase in overbite occurs the interarch space is increased and/or the angulation of the maxillary incisor is increased, or both.

Principle 9 directly applies the concepts and theories and requires concurrent use of both horizontal and vertical components. Steadman⁵ described interactions between the horizontal and vertical and also strategies for altering overbite and overjet by changing arch perimeter or tooth angulation.

THE FOLLOWING ARE SOME CLINICAL EXAMPLES WHICH RELATE TO THE ABOVE MODEL

1. While Angle does not use the canine to define his buccal relations he described the position of the canines.

a. Angle Class II division 1

The buccal relation moves the mandibular arch posteriorly relative to the reference plane creating a large horizontal overlap. The more proclined the maxillary incisors, the less is the magnitude of the overbite. When the maxillary incisors are only mildly proclined an increase in both overjet and potential overbite occurs.

b. Angle Class II division 2

Again, the mandibular arch is moved posteriorly and, with larger maxillary incisor angles, the overbite increases rapidly. The typical maxillary anterior crowding associated with Class II division 2 shortens the maxillary perimeter due to the crowding, moving the maxillary incisors distally, reducing the horizontal overlap from the buccal relationship thus reducing overjet. The deep bite is from the incisor angles and anterior position of the maxillary buccal segments and reduced overjet is due to maxillary crowding.

c. Angle Class III

As the mandible moves anteriorly the overjet is reduced. Along the continuum from Class I to Class III the anteriors have their overjets and overbite values reduced until an edge-to-edge bite where both values equal zero. Moving to further Class III from edge-to-edge negative overjets are produced.

d. Angle Class I

While the buccal relations do not require antero-posterior adjustments there are still

many means of influencing overjet and overbite. Spacing, agenesis, crowding, archform, tooth angulation and thickness all influence interarch relations, with this study indicating the direction and size of change these factors would bring.

2. Some orthodontic concepts examined with the mathematical model

Haberle's associations of deep bite as it relates to this model

Deep overbite was associated with other features of occlusion by Haberle.⁷ Analysing Haberle's three features (Underdevelopment or collapse of the mandibular arch; Distal relationship of the mandibular arch relative to the maxillary arch; and Labioversion of the maxillary incisors) in the light of this series leads to increased distance and therefore increased potential overbite.

a. Underdevelopment or collapse of the mandibular arch.

Collapse of the mandibular arch is associated with mandibular crowding and underdevelopment could be caused by agenesis of mandibular teeth. Both factors would reduce the mandibular perimeter and thus increase the horizontal distance between the lines of occlusion, thereby allowing for more overjet and overbite of the anterior teeth.

b. Distal relationship of the mandibular arch relative to the maxillary arch.

This describes a change in the buccal relation towards Class II as described at the start of this section.

c. Labioversion of the maxillary incisors.

With the maxillary incisors positioned anterior to their mandibular counterparts, the potential for vertical overlap exists. The labioversion could be the result of spacing and protrusion of the maxillary incisors creating an increased maxillary perimeter length.

3. Post-treatment mandibular crowding attributed to either mandibular growth or eruption of mandibular third molars

If the buccal occlusion moves towards Class III, an increase in mandibular crowding and/or a decrease in overbite and overjet and/or an increase in maxillary spacing will result. An alternate explanation for the mandibular crowding could result from an increase in incisor overbite. Behrents⁸ (p97) describes the continued incisor eruption and notes that an increased

overbite could be expected but for tooth edge wear; as a result the horizontal interarch space is reduced (as if the increase in overbite had occurred without any tooth-edge wear) and the resultant occlusal interactions must also be accommodated by change in the occlusion.

If the dental occlusion is unchanged, post-treatment mandibular crowding would often be linked to increases in overbite.

QUESTIONS OF OCCLUSION WHICH COULD BE EXAMINED WITH THIS MODEL

How does the thickness of the marginal ridges of 'shovel-shaped incisors' alter final overbite, overjet and buccal relations?

Changes in the buccal relations of the dentition may occur over time. How can such changes be expressed in the anterior dentition?

If a finish with greater anterior and canine guidance is wanted then the buccal occlusion should be more Class II and the mandibular canines could be relatively narrower. What is the most desirable and for which patients?

How is severe attrition expressed in the anterior dentition and what strategies can be employed when treating such cases?

What implications do other models of anterior occlusion such as Begg and Slavicek^{9,10} raise for overbite, overjet, buccal relations and tooth widths and thicknesses? What changes are needed in the buccal occlusion or form of the anteriors?

Conclusion

Overbite, overjet, attrition, crossbites, crowding, archform, spacing, tooth angulation and arch dimensions cannot be considered in isolation or as small clusters of figures when anterior occlusion is being studied. The ramifications for Dentistry and Orthodontics are many and extensive when the relations between measurements noted in this series of articles are considered. The aim throughout has been to construct a mathematically-logical model that can be used as a tool to test hypotheses and better link the many features of anterior occlusion, thereby creating a more complete understanding than was previously possible.

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