

# A method of measuring the apical base

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**SUMMARY** The maxillary and mandibular apical base areas were measured, using a gnathograph, on the study casts of 156 adults and children representing Class II division 1, Class II division 2 and Class III malocclusions. There were significant differences between the groups at each age. The maxillary apical base areas tended to be smaller for the adults than for the children in all three occlusal classes. By contrast, the mandibular apical base areas tended to be larger for the adults than for the children, except in Class II division 1 malocclusion.

Following a logarithmic transformation to stabilize the variance, regression lines were fitted to relate the size of the maxillary and mandibular apical bases to one another, for the malocclusion groups within each age group. The method gives additional information regarding the degree of apical base discrepancy in a given case, but more work is required before it can be used as a diagnostic tool.

## Introduction

The term 'apical base' was first defined by Lundström (1923) and refers to the junction of the alveolar and basal bones of the maxilla and mandible in the region of the apices of the teeth. In contrast to Angle, Lundström believed that orthodontic therapy was unable to produce any significant growth of the apical base.

Traditionally, it has been the custom to assess the apical or dental base relationship either by means of palpation or on cephalograms. Cephalometric methodology traditionally measures the relationship of the points A and B, denoting the apical base in the region of the central incisors, to the anterior cranial base. Both of these methods have their disadvantages, the one being subjective and the other being limited to one isolated relationship. In addition their primary aim is the relationship of the apical bases at their anterior limit without making any assessment of their size.

Since the days of Lundström there has been much interest in the German literature concerning measurement of the apical base (e.g. Schwarz, 1938) and various instruments, using the principle of surveying orthodontic models described by Stanton (1918), have been developed to transfer tracings of the apical base to paper. The first was described by Simon, reported by Korkhaus (1939), and more

recently by Klueglein (1985) and Denden (1989). The purpose of these studies was to record the contour of the apical base and to relate this information to treatment decisions such as extraction. Tweed (1945) also recognized the diagnostic potential of study casts in relation to the incisors. He described a method of sectioning the casts in the midline to determine the relationship of the incisors to the alveolar and basal bone.

The objective of the present study was to measure the area encompassed by the apical base, using the gnathograph designed by Klueglein, on a series of study casts representing the classes of malocclusion associated with skeletal discrepancy to establish whether significant differences exist and to assess the utility of such an approach.

## Materials and methods

The pre-treatment dental study casts of 156 subjects were the material for the study. They were selected from the University of Mainz, Germany, model archives. Only casts where impressions had been taken to record the full sulcal depth and which were free of air blows and defects were included. All subjects possessed a full complement of teeth anterior to the first permanent molars commensurate with their age.

Two age groups were studied: (i) a child group with an age range of 8–14 years; and (ii) an adult group consisting of patients of 18 years or over. Each group was sub-divided with respect to sex and malocclusion (Class II division 1, Class II division 2 and Class III according to British Standards definitions). The details are shown in Table 1.

These groups were chosen to permit comparison of the apical bases in growing and adult dentitions. The apparatus used to measure the apical bases was that of Klueglein (1985) as shown in Figure 1. It consists of two articulated arms; one, spring-loaded, which allows free movement of a ball-ended probe to survey the outline to be described and the second, with a pen attachment, which moves reciprocally in response to movement of the first and permits the outline described by the first to be traced.

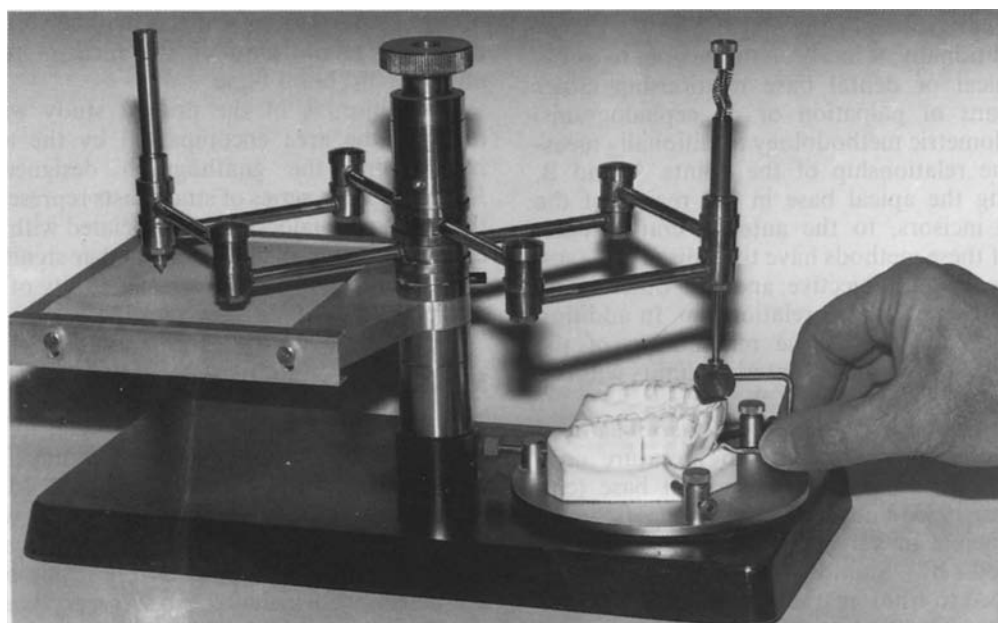
(This apparatus is called a pantograph in standard English.)

All study models were trimmed parallel to the occlusal plane and secured to the table beneath the probe with three screws.

To facilitate surveying the apical casts, the most concave contour of the sulci in relation to the apices of the teeth was drawn in pencil. A perpendicular was dropped from the contact point between the first permanent molar and the second premolar (second deciduous molar in younger subjects) to the apical base line to denote the posterior limit for the purpose of the study. Using a Videoplan (Kontron Instruments GmbH, D-85375 Neufahrn, Germany) image processing system at the Institute of Anatomy, University of Mainz, it was possible to digitize the outlines of the upper and lower apical bases for each set of models

**Table 1** Sex distribution and mean age (years) by malocclusion class for child and adult groups.

Group	Class II/1			Class II/2			Class III			Total
	M	F	Age	M	F	Age	M	F	Age	
Child	18	17	10.5	19	15	11.0	8	13	10.5	90
Adult	9	12	25.5	9	11	25.5	13	12	21.0	66



**Figure 1** Gnathograph of Kleuglein used in the study.

and to calculate the area bounded by the line denoting the mesial of the first permanent molars. This system was originally designed for computerized measurement of the area of cells.

### Statistical analysis

For the children and adults separately, a one-way analysis of variance (ANOVA) was carried out to compare the average areas of each apical base across the three occlusal classes. A significant result was followed up with an appropriate technique to compare all pairs of occlusal classes simultaneously, namely Tukey's confidence intervals, with overall confidence of 95 per cent.

A standard analysis of covariance (ANCOVA) of log (mandibular apical base area) was carried out for the children and adults separately with the covariate being the log (maxillary apical base area) and the grouping variable being occlusal class. Logarithms were taken to stabilize the variance.

The hypothesis that the slopes of the regression lines for all three groups were the same (no interaction) was tested first. When a model with a common slope was found to fit the data adequately, further tests were carried out to establish whether the intercepts for different groups were significantly different. Where they

were not, a final model was fitted where coincident lines represented some groups.

### Results

Three outliers were identified in both child and adult groups. On further investigation these were found to be subjects with gross skeletal abnormalities and they were eliminated from the statistical analysis.

The mean areas for maxillary and mandibular apical bases are given in Tables 2 and 3 and the significant differences between the malocclusion groups are shown.

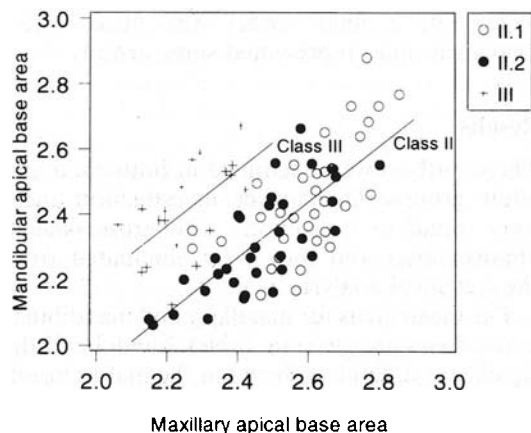
In order to relate the maxillary and mandibular areas to one another, the logs were plotted for both child and adult samples in Figures 2 and 3. For the child group there was no evidence to reject the hypothesis of equal slopes for regression lines in the three groups. There was no significant difference between the intercepts for the parallel regression lines representing the two divisions of Class II, so they were modelled with the same (the lower) regression line (Figure 2). For the adult sample (Figure 3), the hypothesis of equal slopes again could not be rejected. The Class II division 2 regression line is closer to the (lower) Class II division 1 line but further from the (higher) Class III line.

**Table 2** Area (cm<sup>2</sup>) of maxillary dental base: mean (SD).

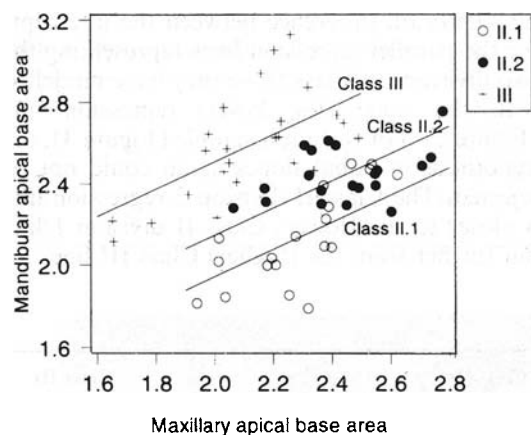
Group	<i>n</i>	Class II/1	<i>n</i>	Class II/2	<i>n</i>	Class III
Child	34	13.6 (1.8)	34	11.9 (1.8)	19	9.6 (1.0)
Adult	19	10.0 (1.9)	20	11.7 (2.2)	24	8.5 (1.8)
	F-Test F		<i>P</i>		Tukey's multiple comparisons (overall 5% significance level)	
Child	37.5		<0.001		III < II/2 < II/1	
Adult	13.7		<0.001		III < II/1, III < II/2	

**Table 3** Area (cm<sup>2</sup>) of mandibular dental base: mean (SD).

Group	<i>n</i>	Class II/1	<i>n</i>	Class II/2	<i>n</i>	Class III
Child	34	11.8 (2.2)	34	10.2 (1.7)	19	11.2 (1.6)
Adult	19	8.7(2.1)	20	11.6(1.6)	24	13.7(3.7)
	F-Test F		<i>P</i>		Tukey's multiple comparisons (overall 5% significance level)	
Child	6.4		0.003		II/2 < II/1	
Adult	22.2		<0.001		II/1 < II/2, II/1 < III	



**Figure 2** Plot of the log of the mandibular apical base area against the log of maxillary apical base area in the child sample. The upper regression line represents the Class III subjects and the lower the Class II subjects.



**Figure 3** Plot of the log of the mandibular apical base area against the log of the maxillary apical base area in the adult sample. The uppermost regression line represents the Class III subjects, the middle the Class II division 2 subjects and the lowest the Class II division 1 subjects.

Both child and adult samples show that the Class III subjects have, on average, a relatively larger mandibular apical base area and the Class II division 1 subjects, on average, a relatively larger maxillary apical base area. The Class II division 2 group falls in between.

Regression equations, arising from the analysis of covariance discussed above, are presented below to describe the relationship between the mandibular and maxillary dental base areas in Class II and Class III malocclusions:

### Children

E (log mandibular base)

$$= 0.489 + 0.852 \log \text{max base (III)}$$

$$= 0.221 + 0.852 \log \text{max base (II.1, II.2)}$$

Test of the null hypothesis of equal slopes:  $P = 0.960$  (NS). Test of the null hypothesis of equal intercepts for II.1 and II.2:  $P = 0.340$  (NS).

### Adults

E (log mandibular base)

$$= 1.166 + 0.670 \log \text{max base (III)}$$

$$= 0.805 + 0.670 \log \text{max base (II.2)}$$

$$= 0.601 + 0.670 \log \text{max base (II.1)}$$

Test of the null hypothesis of equal slopes:  $P = 0.071$  (NS).

### Discussion

This study represents the first step in describing the areas of the upper and lower apical bases and their mathematical relationship to one another in child and adult malocclusion groups.

It was interesting to note that the mean maxillary area in the child sample was consistently larger than that in the adult sample in all classes of malocclusion as was the mandibular area in Class II division 1. This may be explained by the fact that the sulcus is less deep in the child, while in the younger, mixed dentition, subjects it may be enlarged due to unerupted premolars and canines. Otherwise it may have been a sampling effect due to the cross-sectional nature of the material and the tendency for adult Class III groups to contain more surgical cases with large mandibles.

It is clear from the results, however, that the areas described by the apical bases are proportionally larger in the maxilla in Class II malocclusion as compared with the mandible and the reverse in Class III malocclusion. It is also clear that the amount of maxillary/mandibular discrepancy appears to be less in the adult Class II groups as compared with the child groups and greater in the Class III group. This is particularly noticeable in the Class II division 2 group and may indicate a tendency for normalization with growth. Although there are significant differences between the means for each group there are areas of overlap indicating the adaptability of the dento-alveolar process both favourably and unfavourably.

No attempt has been made, at this stage, to relate the apical base outlines to one another in space. Naturally the antero-posterior and vertical relationships of the bases to one another can profoundly influence the occlusal classification. Consequently apical base size is only one element which determines the malocclusion type, so that overlap between the Classes is not surprising.

It is generally agreed (Mills, 1982) that dental arch circumference anterior to the first permanent molars does not alter significantly from childhood to adulthood, nevertheless, on the basis of the cross-sectional material described here, there is evidence to show potential for change in the region of the apical base. The method described, therefore, has potential for use in orthodontic diagnosis, treatment planning and prognosis prediction, once the limits of possible expansion/contraction have been ascertained.

When carrying out orthodontic appliance therapy it is generally the objective to adapt the upper arch to the existing contour of the lower, as the scope for expansion or contraction of the lower arch is minimal in most cases. Consequently contraction of the upper arch in Class II and expansion in Class III are usually the most successful methods of dealing with apical base discrepancy. Even this has its limitations and whilst there have been suggestions concerning the limits of the 'orthodontic envelope' (Proffit and Ackerman, 1985) and also in relation to the limits of orthodontic correction of Class III malocclusion (Kerr *et al.*, 1992), such studies have been confined to purely two-dimensional cephalometric measures of prognathism. It is now necessary to calculate the apical base areas of normal or Class I cases and relate them to one another to establish baselines and to ascertain how much apical base modification is possible with different forms of

treatment. Once this has been done it would then be possible to predict, in an individual case where apical base discrepancy is a feature, whether or not it is possible to compensate for this by orthodontic means alone.

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