The Mandibular Dental Arch, Part IV: Prediction and Prevention of Lower Anterior Relapse

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Disproportionate relationships between skeletal and dental structures are basic to the etiology of malocclusions, and the prediction of such relationships is thus critical to the attainment of success in orthodontics.[10,14,15,18] More particularly, the lower incisal segment is notoriously tenacious in its ability to quickly relapse to crowding after years of orthodontic treatment.[20,21] While traditional approaches to this problem have stressed the relationship of overall tooth mass to bone mass and interarch relationships, there remains a relative paucity of information regarding actual tooth size and its role in the development of lower anterior crowding.[2,3,13,18] However, the rapid development of sophisticated cephalometric methods provides much unexplored potential for the discovery of malrelationships prior to orthodontic treatment and, thus, the prevention of ultimate postretention relapse.

Literature Review

Positive correlations between tooth size and skull size have been documented by Ballard and others.[1,5,10,25] Ballard concluded that stability was attainable only by stripping the teeth which have overly large mesiodistal dimensions to achieve the optimal tooth to bone relationship. More recently, two studies have dealt more directly with the mandibular incisors, craniofacial morphology, and the prediction of posttreatment relapse by analyzing discrepancies between these parameters.

Peck and Peck[20,21] have noted the somewhat autonomous behavior of the lower incisors in that they are often seen to relapse, even in lower premolar extraction cases. Postulating that aberrancies in anterior tooth morphology are critical to the etiology of this relapse, they formulated a morphological index of incisor size and shape:

$$\frac{\text{Mesiodistal Width}}{\text{Faciolingual Width}} \times 100$$

The applicability of this index was tested to crowded and well-aligned anterior cases. Cases that relapsed in the lower anterior segment were shown to possess larger ratios on the average than uncrowded subjects. This difference seemed to be due not only to a large mesiodistal size, but also to a small faciolingual measure indicating a general morphological deviation. Peck and Peck concluded that, while posterior extraction may create a favorable overall tooth mass/arch length ratio, anterior morphological deviations can nevertheless lead to anterior relapse. Using their data, Peck and Peck developed normal ranges in lateral and central incisors from which they could predict probable relapse in particular patients. They then surmised that with the instigation of interproximal stripping prior to the commencement of orthodontic treatment, patients could be placed within the normal range thereby preventing subsequent relapse.

A study by Nordeval[19] involving the mesiodistal dimensions of the lower incisors and their alignment yielded similar results. However, Nordeval also demonstrated a strong relationship between lower incisal alignment and craniofacial morphology. He found crowded cases to have a larger ANaB angle and a more severe mandibular inclination relative to the maxillary base as measured against the ANS-PNS axis. Ideally aligned cases

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generally demonstrated a larger gonial angle.

Thus, it is clear that excessively large lower incisors can be a primary agent in the etiology of lower anterior crowding. Furthermore, Nordeval's evidence reveals the possibility that lower incisal dimensions may be well-correlated with skull dimensions. While the Peck and Peck results provide a useful method for analyzing incisal dimensions, a more accurate method to determine potential for crowding might involve the calculation of a patient's optimal incisal size according to his specific skeletal dimensions. The advantages of such a tool are threefold: Skeletal/tooth relationship can be diagnosed early, thus predicting the likelihood of lower anterior relapse if corrective measures are not undertaken during treatment. The degree of discrepancy having been assessed, stripping or, in severe cases, extraction can be instituted to alleviate the potential problem. Finally, a cephalometric method is practical for office use or inclusion within a computerized cephalometric analysis.

Thus, the present study sought to develop a cephalometric method by which cases with a great potential for postretention relapse can be identified prior to orthodontic treatment, so that special treatment considerations can be made.

Methods and Materials

Initially, 50 untreated cases were analyzed to find correlations between mesiodistal incisor size and specific craniofacial measurements taken from lateral and frontal headfilms. All 50 cases were randomly selected from a group of 82 adults (>18 years), 59 males and 23 females, judged by members of the *Foundation* for *Orthodontic Research* as having ideal occlusions including perfect lower incisor alignment.

It was reasoned that a consistent relationship between skeletal and dental parameters in the "ideal" situation would reveal an optimal range into which all orthodontically treated cases should ultimately fall in order to expect an acceptable postretention incisor alignment.

Mesiodistal and faciolingual measurements were taken from plaster models using sharply pointed dividers and a Boley gauge containing a sliding vernier scale, accurate to 0.1 mm. Mesiodistal tooth sizes were measured at the level of greatest width of the teeth generally within the incisal one third and most often at the incisal edge. Faciolingual measurements were recorded at the level of the gingiva. All operations were performed by the same experimenter.

The lateral and frontal tracings for each case were analyzed by the Rocky Mountain Data Systems (RMDS) computerized cephalometric system which calculated values for over 50 craniofacial measurements. Additional computer programs were designed to examine all correlative phenomena between total mesiodistal incisor size and eight of the RMDS cephalometric indices which were empirically judged as most likely to be strongly related to acceptable incisor size. The eight parameters recorded are explained below and illustrated in Figures 1 and 2.

Mandibular Arc: The angle between the corpus and condylar axes.

Corpus Length: The distance between the mandibular Xi point and pogonion.

Facial Depth: The angle between the facial plane and Frankfort plane (Downs' facial angle).

Mandibular Plane Angle: The angle between mandibular plane and the Frankfort horizontal.

Facial Axis: Angle formed by the intersection of line Ba-Na with line Pt-Gn where Pt is the intersection of the inferior border of foramen rotundum with the posterior wall of the pterygomaxillary fossa. Gn is the intersection of the facial and mandibular planes.

Molar-to-Jaws: Average of left and right distances between buccal surfaces of the lower molars and the frontal jaw planes

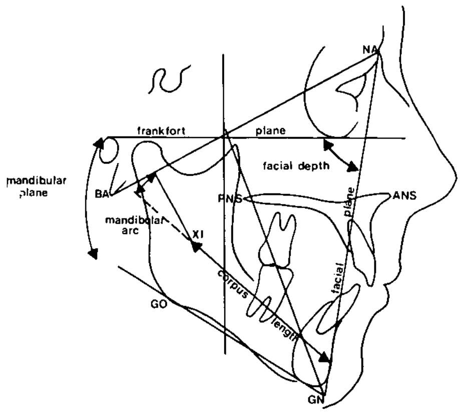

Fig. 1

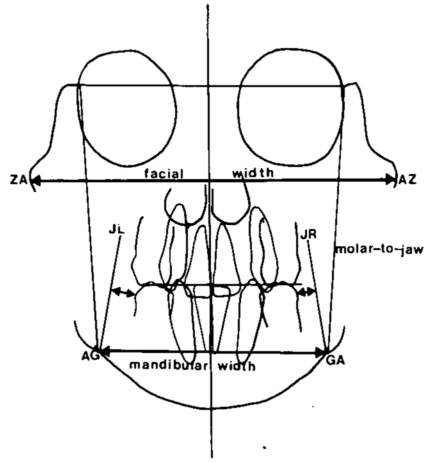

Fig. 2

(JL-AG and JR-GA).

Facial Width: The width of the zygomatic arches as measured by the distance ZA and AZ.

Mandibular Width: The distance AG-GA where AG and GA are the left and right lateral inferior margins of the antegonial protuberances.

Mesiodistal incisor size was tested for correlation with each variable alone, as well as with all possible combinations of the 8 variables. In addition, stepwise multiple linear regression analysis was used to determine a linear equation which related the sum of the widths of the four lower incisors to a subset of the eight variables defined above, and was most highly correlated with this width.

Having established this relationship in ideal samples, an attempt was made to prove the equation's ability to predict postretention relapse of lower incisors in treated cases. Pretreatment records for two groups of treated cases, one showing posttreatment relapse (greater than 2 mm) and one showing no relapse (0 mm), were measured and evaluated by the equation developed for normal occlusions described above. No interproximal stripping or lower incisor extraction took place during treatment of these cases. Actual incisor sizes were compared with those computed by the equation. It was then seen whether patients with actual incisor widths significantly greater than those predicted by the equation tended to result in postretention relapse more often than those cases in which the equation indicated that the incisors were not excessively large.

The principal source of subjects for the relapse and nonrelapse groups of the experiment was a population of postretention cases compiled by Ricketts for the study of long and short-term changes with orthodontic treatment. Additional cases were provided by Dr. Kleve Johnson.

Selection of cases for either the relapse or nonrelapse group was determined by the objective measurement of plaster models. Twenty-five cases, judged to have 0.0 mm overlap of the lower incisors and canines, were selected for the "retained" group. Eleven of these were male and fourteen female.

Subjects were assigned to the relapse population on the basis of having greater than 2 mm overlap of the mandibular incisors and canines. This group consisted of ten cases, seven male and three female. Within the ideally aligned sample four subjects had two premolars extracted. Three cases within the relapse group had premo-

Variable	Multiple Regression Coefficient	S.E.	F to Remove
Mandibular Arc	0.11	0.035	9.50
Corpus Length	0.09	0.023	13.08
Mandibular Plane	0.07	0.035	4.14
Constant	11.66		

Multiple R = 0.59
Std. Error of Estimate = 0.87
F Ratio = 7.30

TABLE I. Statistical results for the three variables found to be significantly correlated with incisor size.

lar extractions and one patient had a congenitally absent lower left first premolar.

Finally, an effort was made to duplicate the results of Peck and Peck using these 35 treated cases. Appropriate mesiodistal to faciolingual lower incisor ratios were calculated to determine whether these ratios were higher for the relapse cases than for the stable cases.

Results

Optimal correlation between the sum of the mesiodistal lower incisor widths and craniofacial morphology for the adult normal occlusion sample was obtained when the following *three* variables were taken in combination: mandibular arc, corpus length, and mandibular plane angle. The results of a stepwise multiple linear regression analysis are given in Table I and show that, while each of these variables alone yields only a slight positive correlation, together they yield a fairly strong multiple correlation coefficient of R=0.59. Furthermore, evaluation of "F to remove" scores indicates that each variable above bears a critical relationship to the multiple regression as a whole. Using this regression analysis, the following equation was generated for *adult* cases:

Sum of lower incisor widths (mm) =.11x(mandibular arc in degrees) +.09x(corpus length in mm) +.070x (mandibular plane in degrees) +11.66 (constant).

Predicted incisor size in the ideal sample differed from actual measured size by a mean deviation of only 0.87 mm.

The above equation, while apparently quite useful, is appropriate only for adult cases. Modifications were necessary to expand the applicability to cases involving children. The function was corrected for children according to age and sex using the following equations for growth rates and sex differences as established by RMDS: ($\overline{X}_1$, $\overline{X}_2$, and $\overline{X}_3$ are norms for the three pertinent measurements corrected for age and sex.)

$\overline{X}_1$= mandibular arc=34.09−(X−Y)/2

$\overline{X}_2$= corpus length=75.5−(X−Y) x (1.6)

$\overline{X}_3$= mandibular plane=19.97+(X−Y)/3

Where X=18 years for males, 15 years for females and Y=actual patient age in years. Integration of these norms into the initial formula yielded the following relationship, applicable to children of any age or sex:

Incisor Width=
.11 x (mand. arc.−$\overline{X}_1$)+
.09 x (corpus length−$\overline{X}_2$)+
.07 x (mand. plane−$\overline{X}_3$)+
11.66 (constant).

Pretreatment predicted and actual incisor values were compared for each subject within the relapse and nonrelapse groups, and the average discrepancies were calculated for each group. Nonrelapse cases showed a mean discrepancy of +1.14 mm with a standard deviation of 1.53 mm. Relapse cases yielded a mean discrepancy of +1.70 mm and S.D.=.98mm. A positive

NORMALIZED REGRESSION

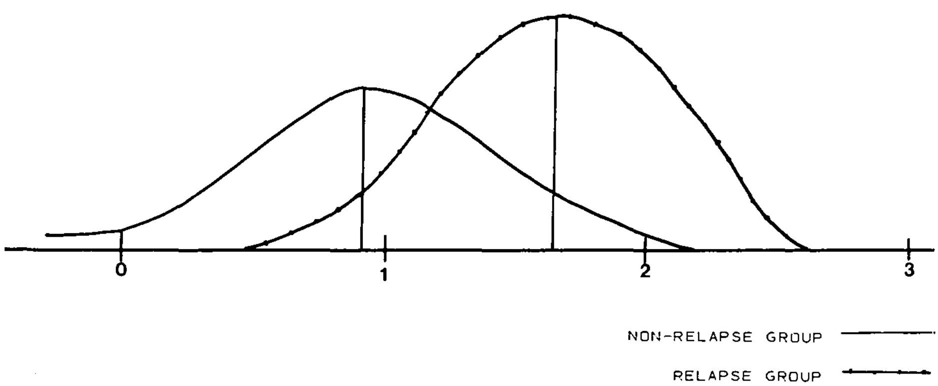

Fig. 3

PECK AND PECK

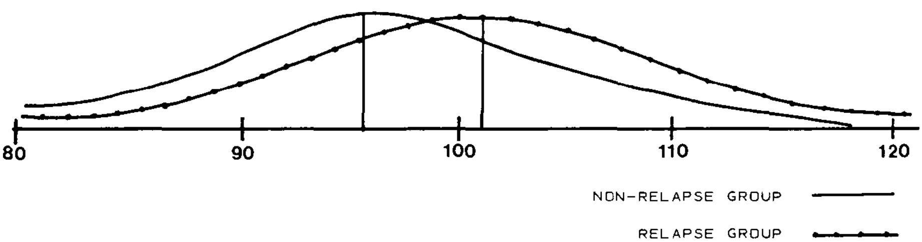

Fig. 4

sign indicates that observed values for incisor widths were larger than those predicted by the equation. Relapse group incisors were larger than their predicted sizes by a significantly larger margin than were those of the retained cases. The average discrepancies for the two groups were found by statistical t-tests to be statistically significantly different at the p=.005 level with t=2.85 and 33 degrees of freedom.

Next, it was decided to test the effectiveness of the regression equation as a discriminator between the postretention relapse and nonrelapse cases. The following discriminatory criterion was established.

All patients with a difference between actual and predicted sum of the incisor widths greater than +1.2 mm would be classified as potential relapse cases. All other cases would not be expected to relapse. These results are graphically represented in Figure 3.

Using the sample of 35 treated cases described above, it was found that nine of the ten actual relapse cases could have been identified prior to treatment. Unfortunately, only 13 of the 25 nonrelapse cases were properly identified, the remainder being improperly categorized as potential relapse cases.

Finally, Peck and Peck ratios were found for each of the treated cases. It was determined using a statistical t-test that there was no significant difference between the ratios of the relapse and nonrelapse group at p=.10 (90% level of significance). This result is illustrated in Figure 4.

Thus, for this sample the Peck and Peck incisor ratio technique was not an adequate discriminator between the two populations. For these data the newly derived linear regression estimator, while far from perfect, was definitely superior to the ratio technique.

Discussion

The results of this investigation demonstrate a multiple regression relationship between the mandibular arc, mandibular plane and corpus length, and lower mandibular incisor size in well-aligned dental arches. Furthermore, this relationship can be used to frequently identify, prior to the onset of orthodontic treatment, those cases which will ultimately relapse in the lower anterior segment if interproximal stripping or extraction is not employed.

The accuracy of the derived function may be described as unidirectional in that, while nine of ten cases were accurately identified as potential relapse cases, 12 of 25 cases with acceptable incisor-to-skeleton relationships were not correctly diagnosed (Fig. 3). In clinical terms, these 12 cases would be stripped *unnecessarily* to obtain an ideal relationship. However, there is no real penalty for a limited amount of needless stripping, and the advantages to be gained by the adjustment of truly unfavorable cases are enough to outweigh this limitation.

The results of the mesiodistal/faciolingual analysis (Peck and Peck) were equivocal. As shown in Figure 4, there was much overlap between the two groups and the populations were not significantly different. Two notable differences between their study and the present one may account, at least in part, for this inconsistency. While orthodontically-treated subjects of the present study ranged from 7-15 years of age, Peck and Peck's subjects ranged in age from 17-27 years. If an appreciably greater amount of interproximal attrition exists in the 17-27 age group, mesiodistal measurements would certainly have been affected, perhaps accounting for their definitive results. Secondly, Peck and Peck's measurements were taken directly in the mouth, while in the present study they were taken from models. The height of faciolingual contour may often be found subgingivally, and thus would not have been gauged properly on plaster casts. Again, this would skew mesiodistal/faciolingual scores in the present study toward higher values preventing the attainment of accurate results.

Conclusions

The posttreatment stability of the lower incisor has been shown to be a function of the relationship of the lower incisor size to the size of the face and jaws. Examination of the three pertinent variables used in this study indicates that the general facial pattern is important to the prognosis for the anterior segment. It is apparent that those cases which can accommodate wider incisors possess greater values for corpus length and mandibular arc and lower mandibular plane angles, demonstrating shorter, wider, brachycephalic characteristics. Those patients who cannot accommodate wide incisors show smaller measurements and a long, narrow (or dolichocephalic) facial pattern. Thus, the facial pattern is of prime importance in identifying potential relapse case. These findings are consistent with those of Lavelle.[10]

A method has been outlined by which discrepancies between the teeth, face, and jaws, and ultimately the available bony support can, in many cases, be clinically diagnosed before orthodontic treatment is initiated. This diagnosis is necessary in that it appears the anterior segment will relapse if this tooth excess is not corrected, regardless of posterior treatment rendered.

As an initial guideline for clinical use, it is suggested that the +1.2 mm classification criterion be applied in defining acceptable limits of incisor size. Interproximal stripping should be applied when lower incisor width exceeds the predicted value by more than 1.2 mm in borderline extraction cases. This, in fact, may suffice to alleviate the problem without the need for posterior tooth sacrifice. The use of this regression equation may also be applied to severely crowded cases which require extraction. If anterior crowding appears to be solely due to the impingement of posterior teeth, it is likely that posterior extraction will correct this problem. However, an incisor width greater than +2.0 mm above the mean is highly suspect and should still be stripped in anticipation of future relapse.

Pretreatment prediction of posttreatment relapse is an attractive prospect, because it eliminates retreatment of cases whose relapse could have been prevented at the outset. This ability also minimizes needless extractions by singling out cases whose malalignment may be treated by stripping alone. Additional application is useful when determining the arch form for a particular patient. If it can be shown that the incisors are too large for the facial pattern, an arch form can be designed to the proper incisor size rather than the disproportionate one.

The relationship revealed in this investigation can prove an invaluable aid to orthodontic treatment planning. If used in conjunction with sound clinical judgment regarding the particular patient, it can vastly improve the long and short term success of orthodontic results.

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