The Mandibular Dental Arch: Part I, Lower Incisor Position

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The decision as to whether or not extraction of teeth is required is perhaps the fundamental problem of orthodontic diagnosis. Contemporary practice has directed the attention to the mandibular arch as the most limiting and, therefore, of first consideration for diagnosis, as suggested by Tweed. Many systems and theories of diagnosis have been utilized by the clinician as an aid in diagnosis. Quantitative evaluation of the dental arch itself[23] and various systems of cephalometric measurements have been proposed.[6,17,19,20] Some writers[9,10] have proposed that the dental arch should be altered as little as possible. At the time of writing, however, many of the most basic questions remain unanswered. These include:

1) Can a normal relationship be defined between the lower incisor and the bony skeleton?

2) Is there a guide for lower incisor placement which would enhance stability?

3) What is the effect of movement of the lower incisor upon its stability?

4) What is the effect on the soft tissue profile of incisor movement?

5) Can the positions of the cuspids, premolars, and molars be altered and remain stable?

6) Are there useful norms for cuspid, premolar, and molar widths which can be used as guides to enhance stability of results?

7) What is the effect of incisor, cuspid, premolar, and molar expansion on arch perimeter and how may this best be calculated for treatment planning?

As a beginning in the search to answer these questions, two samples were collected, one treated and one untreated.

Stable occlusions as provided by nature are useful points of departure for determining what might be normal. With this objective in mind, the *Foundation for Orthodontic Research* has compiled a sample of 82 Caucasian adults, age 18 and over.[4] There were 23 males and 59 females who, in the opinions of the practicing orthodontists contributing the cases, possessed a "normal" or ideal occlusion. The records included frontal and lateral headfilms and plaster models.

To study the effect of treatment in the short term and long term, a sample has been gathered by Ricketts. Four hundred of his first-retained patients were asked to return for complete records for the purpose of research; approximately 150 responded. The sample includes cephalometric frontal and lateral headfilms and plaster models before treatment, at end of treatment, and postretention. The duration of time between end of treatment and postretention varies from 1 to 15 years.

The above two samples have been utilized by several investigators to shed light upon the previously cited problems. Included in this group are orthodontic students from Loma Linda University and independent researchers. The following papers will serve to present a summary of their work in a form

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that might be more useful to the practicing orthodontist than if the individual papers were published in their entirety.

For the purposes of recording data, all records were processed by Rocky Mountain Data Systems. Cephalometric tracings were prepared of the frontal and lateral headplates by a trained technician and checked against the X-ray by a senior technician. For serial X-rays the landmarks were corroborated longitudinally to minimize the variance of independent selection. Fifty cephalometric points were then digitized using an Oscar-F Analog Digital Converter with resolution of 1/6 millimeter. Using an IBM 360/65 digital computer, all relevant measurements were calculated from these digitized points. The resulting computer output was then checked against the tracing for accuracy; this insured a variance of less than one degree or one millimeter.

Lower Incisor Position

The position of the lower incisor has been recognized as the key to orthodontic diagnosis and treatment planning due to its effect on esthetics, stability, and space available in the mandibular arch. The purpose of this section is to discuss the various alternative methods of determining lower incisor position, its strength and weakness in terms of function and stability. Esthetics will be treated in a later paper. The following questions are raised:

1) Can the lower incisors be moved labially and lingually and maintain stability?

2) Which is the most suitable reference line to use in positioning the lower incisors for the purpose of optimum *function?*

3) Which is the most suitable line for positioning the lower incisors to insure *stability?*

Literature Review

Movement

One point of view regarding movement of the lower incisors has been that anterior movement of the lower incisors should be avoided, and that they should remain in their original positions. Hixon[9,10] concluded that the majority of cases in which the mandibular arches have been expanded anteriorly will relapse to the original position or farther lingually. He suggested that, if crowding is present in the lower arch, extraction is the only treatment from which a stable result can be expected.

Weinstein[20] believed that the teeth are in a state of equilibrium as a direct result of muscular balance and that the lower incisor should be finished near its original position. Miller[12] expressed the same opinion: that, if the results of the treatment are to remain stable, the teeth should be placed within the form of the dental arch as presented.

On the other hand, Ricketts[15] has proposed methods of diagnosis using the APo plane as a guide for positioning the lower incisor anteroposteriorly after constructing the jaw-to-jaw relationship of the patient at the end of treatment. If the lower incisor were still behind the APo plane, his method would require a labial inclination or movement of the lower incisor.

Posen[13] measured perioral musculature and found that indeed the strength of the musculature was correlated with the position of the incisors. Class II, Division 2's had the strongest perioral musculature; Class I bimaxillary protrusions, the weakest. However, he also observed that in treatment a change in the oral environment due to a more normal denture position was accompanied by a change in perioral musculature toward more normal readings. He advocated inclining the incisors labially toward the norm in Class II, Di-

vision 2 cases rather than extraction, and retraction of incisors in bimaxillary protrusions for the purpose of obtaining a more normal lip function.

No adequate experiment which would demonstrate the long-range stability of lower incisor movement has yet been published. The purpose of this paper is to present quantitative data based upon the analysis of normal occlusions and long-range posttreatment cases.

Reference line

In theory, the lower incisor would tend to adapt to the relative denture base relation, particularly to the convexity. In other words, the denture can be seen as reciprocally balanced between the denture bases and the natural drape of the muscle, and the natural function of the mouth seems to direct the lower incisor to a harmonious position with respect to the jaw relationship.

Since the lower and upper incisors function interdependently, as do the jaws, it is reasonable to conclude that the position of the maxilla should not be ignored when positioning the lower incisors. However, "reasonableness" should not be the sole criterion. Therefore, an examination must be made of the scientific data for substantiation of this theory.

Solow[18] found that the upper central incisor inclination was positively correlated with the length and the prognathism of the mandible. He also found the lower central incisor inclination to be positively correlated with the length and prognathism of the maxilla. Therefore, an increase in mandibular length and prognathism was compensated for by increased palatal root torque in the upper central incisor. An increase in maxillary length and prognathism was compensated for by a forward tipping of the lower incisors.

A study of incisor inclination by Linder-Aronson on 60 patients[5] indicated a significant correlation between the angle ANB and the inclination of the lower incisors, regardless of the measurement being made to either the NB or the ML line. He concluded further that "A correlation between lower incisor inclination and the basal jaw relationship (ANB) has also been established. The correlation ($r = 0.52$) between the angles LI-ML and ANB is of particular interest, as it cannot be explained as being due to a topographical relationship between these variables, and is instead seen as expressing a biological interdependence."

Thus, the preceding work would indicate that important functional aspects would be ignored if point A (position of the maxilla) were omitted from consideration in placing the lower incisor.

Tweed[20] proposed the importance of the measurement of the lower incisor to the mandibular plane (Fig. 1). He hypothesized that the NB plane can be used as a guide. Downs[6] first suggested using the APo plane. Raleigh Williams[22] stated that "To place the tip of the lower incisor on or in front or the APo line (is) a necessary goal if the clinician is to achieve the optimum in facial esthetics and denture stability."

As a result of the teachings of these successful clinicians, many orthodontists today use these cephalometric lines for the purpose of insuring stability.

To study the effect of incisor repositioning on stability, 78 sets of records (Dr. Ricketts) were selected on the basis of completeness and of having a postretention period of at least 4 years.*

To determine the amount of lower incisor movement during treatment, the beginning tracings were superimposed

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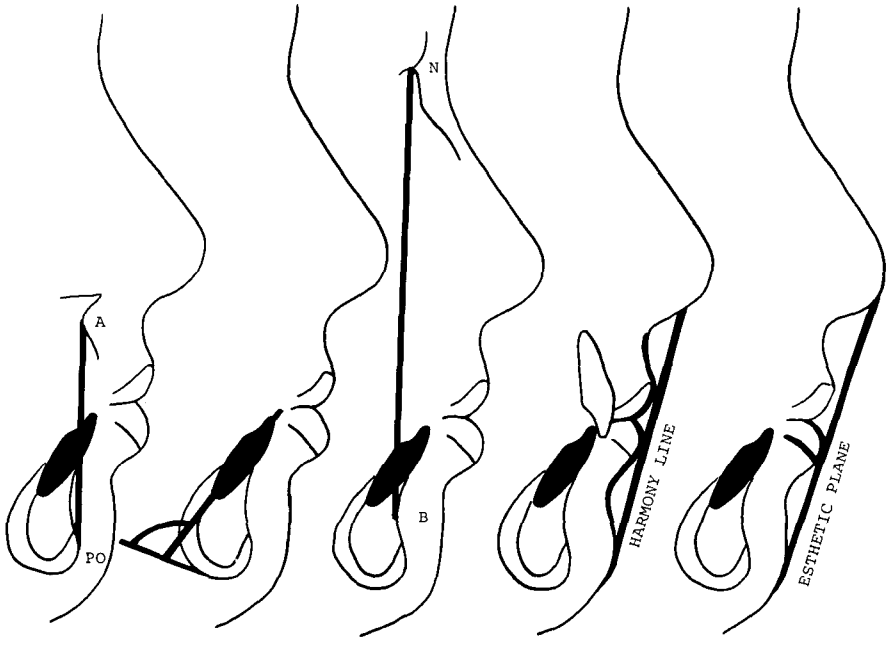

Fig. 1 Five different methods of determining the position of the lower incisor are shown above. (a) Relating the lower incisor to the APo plane. (b) Relating the inclination of the lower incisor to the mandibular plane. (c) Relating the lower incisor to the NB plane. (d) Determining the position of the lower incisor which gives optimum lip harmony (Holdaway). (e) Positioning the lower incisor such that the resulting lower lip will relate ideally to the esthetic plane.

on the corpus axis at suprapogonion (Fig. 2). The amount of change in the incisal edge was measured in relation to a perpendicular to the Frankfort horizontal.[16]

The sample was divided into three groups. The first included 23 patients with lower incisors moved forward one millimeter or more during treatment. The second group contained 26 patients with lower incisors finished between 2 mm lingual and 1 mm labial of their original positions. There were 29 patients in the third group with lower incisors retracted 2 mm or more. The Loma Linda University Scientific Computer Center was used for the statistical analysis.

To establish whether there was any connection between the lower incisor position and posttreatment crowding, a quantity had to be defined to represent

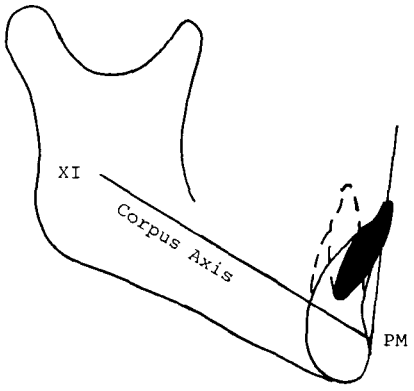

Fig. 2 Shown here is the method of measuring the amount of lower incisor movement by superimposing the beginning and final tracings on the corpus axis at suprapogonion (PM).

Fig. 3 There are two possible modes of relapse: Crowding (left), and spacing (right). If we calculate the mean posttreatment crowding of the two cases presented, we would have 3 mm crowding (left), and 3 mm spacing (right), and thus an average of zero. This shows that the mode of relapse favors neither crowding nor spacing. Another measure is mean absolute discrepancy which would consider both cases 3 mm relapse and therefore mean posttreatment discrepancy would be 3. Both might be considered important in an analysis.

"stability." If one case has 2 mm crowding and a second has 2 mm spacing, this should not average out to zero. This could be called an average of 2 mm absolute discrepancy, meaning that spacing and crowding are just two forms of instability. Hence, in this study absolute discrepancy is used where spacing and crowding are considered the same (Fig. 3). Table I presents mean absolute discrepancy for the three groups. The group in which the lower incisor was moved forward 1 mm or more had a mean absolute discrepancy of 1.26 mm, the second group mean was .81 mm, and the third, .69 mm.

The mean "crowding" (where spaces and overlap can "average each other out") for this group was .04 showing that spacing was as often the mode of relapse as crowding. The mean "crowding" for the other two groups was .81 and .34, respectively. The coefficient of linear correlation between the variables incisor movement and crowding was calculated as .03 showing essential independence.

Table I does show a slight difference between mean absolute discrepancies of the three groups. However, when the one patient with 8 mm spacing is removed, the three groups agree to within .22 mm of discrepancy. The analysis of variance gave an F-ratio of 1.422, not statistically significant at the 10% level. The fact that no statistically significant difference was observed does not prove that there is no relationship. The sample size was limited and, in addition, since it was a random sample of treated cases from the practice of a successful clinician, there was little postretention crowding. Had a larger sample, including more crowded cases, been used, different results might have been observed.

TABLE I

Movement of Lower Incisor During Treatment of Postretention Crowding

	Group	Mean Absolute Discrepancy
I	$\underline{1}$ moved forward 1 mm or more	1.26 mm *(.91 mm)
II	$\underline{1}$ 1 mm forward to 2 mm retraction	.81 mm
III	$\underline{1}$ retracted 2 mm or more	.69 mm

*Much of the reason for slightly greater discrepancy in the first group was due to one patient in the sample with 8 mm spacing. When this patient was removed from the sample, the value becomes .91 mm.

The fact that there was less mean crowding in the group where the lower incisor was moved forward than in the group where it was held the same certainly refutes the concept that advancement of the incisor should never be attempted. A statistical comparison was

made between the group in which the lower incisor was advanced and the group in which the lower incisor was held. The only area of significant difference was in the pretreatment relationship between the lower incisor and the APo plane. Those cases in which the incisor was advanced began with the tooth behind the APo plane.

Ricketts has repeatedly emphasized a clinical evaluation of musculature and therefore the lower incisor was not being advanced indiscriminately. The results do agree with the hypothesis that the position of the lower incisor can be altered during treatment and can be expected to remain stable, given careful pretreatment diagnosis. We may now reject the theory that the lower incisor must be maintained in its original position. We can ask: "Where should it be placed for the individual patient?"

The Foundation for Orthodontic Research conducted a study of 82 individuals with normal occlusion. Among the variables measured the following correlations were calculated with regard to convexity (point A to the facial plane): lower incisor to APo (mm), .16; lower incisor to inclination-APo (deg.), —.12; lower incisor to NB (mm), .60; and lower incisor to NB (deg.), .51.

We see a significant correlation between the relationship of the lower incisor to the NB line (which excludes the maxilla) and the convexity. Hence, if the NB line were used as the sole criterion for the placement of the lower incisor, the resulting position would not be the same as the position selected by nature, since in the natural occlusion the amount of convexity was a significant factor.

This is perhaps one reason why many experienced clinicians have rejected cephalometrics as not being sufficiently distinctive. If the cephalometric analysis and determination of the lower incisor position were based on one of two popular analyses (Steiner or Tweed), the results would not be individualized to the jaw-to-jaw relationship of that particular patient. However, as the above data show, the correlation between the placement of the lower incisor with respect to the APo plane and convexity is minimal demonstrating that this plane as a guide does indeed adequately account for the convexity of the profile.

The results of these studies would tend to support the hypothesis that it is necessary to include the position of point A in planning for the position of the lower incisor, and that the lower incisor to APo plane does take this into account.

In a similar manner to the study of incisor movement, Allen investigated the relationship between posttreatment stability and various reference lines including: lower incisor to APo (mm), lower incisor to NB and IMPA.

The sample was again divided into three groups, each containing an approximately equal number: Group I, lower incisor finished 3 mm or more compared to the APo plane; Group II, final lower incisor position between +1 and +3; Group III, final incisor position +1 or less.

The results are shown in Table II. Correlation and analysis of variance methods again showed no significant relationships between final lower incisor positions to the three planes and postretention absolute discrepancy. They also show no significant differences, as evidenced by the analysis of variance and correlation coefficients. The results support the assertion that cephalometric reference lines are not the key to stability of the lower incisor.

Again, it should be emphasized that different results might be obtained in a sample with greater amounts of crowding and/or with larger sample sizes. The fact that there was a 30 degree

TABLE II

Posttreatment Position of Lower Incisor Relative to APo, NB, and IMPA Planes and Postretention Crowding

		Mean Absolute Discrepancy
I	$\underline{1}$ — APo + 3 mm or more	1.0 mm
II	$\underline{1}$ — APo + 2 mm	1.2 mm
III	$\underline{1}$ — APo + 1 mm or less	.72 mm
I	$\underline{1}$ — NB + 3 mm or more	.73 mm
II	$\underline{1}$ — NB + 5 mm to + 7 mm	1.05 mm
III	$\underline{1}$ — NB + 4 mm or less	.72 mm
I	IMPA + 100 degrees or more	.68 mm
II	IMPA + 94 deg. to 100 deg.	1.08 mm
III	IMPA + 93 degrees or less	.64 mm

range in stable cases with regard to inclination to mandibular plane suggests that there is a considerable variation that can be accepted with stability in the individual patient.

Summary

The position of the lower incisor with respect to hard tissue references has been evaluated. Two samples were used for this purpose: one containing 78 patients with posttreatment records having a postretention period of at least 4 years, and the other composed of 82 normal occlusions. The results indicated:

1) There was no significant difference in relapse of lower incisor crowding between cases where the lower incisor had been moved lingually, labially, or held in the same relative position during treatment.

2) The position of the maxilla should be considered when placing the lower incisor. The APo plane adequately serves as a guide to this purpose, whereas other reference lines such as mandibular plane or facial plane do not.

3) The positions of the incisors with respect to popular cephalometric reference lines such as APo, NB, or mandibular plane were not correlated with the relapse of mandibular crowding. Therefore, other clinical guides might be more successful for determining stability.

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