Stability of the IMPA with Reference to the Begg Method

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The introduction of the Begg technique in the last decade has been a significant event in clinical orthodontics because it seemingly constituted a radical departure from basic biomechanical principles for tooth movement in the treatment of malocclusion as they were established at that time.

The use of light and differential force, absence of rigid arch contact in the bracket, as well as movement of teeth by tipping and subsequent uprighting, generated considerable debate amongst opponents and followers of the new venture. Nonetheless, adherents of the edgewise arch techniques were quick to adopt light and resilient round or rectangular wires and even the looped wires in acknowledgment of the revived and hitherto unrealized objective to move teeth with minimal tissue damage.

Yet the Begg technique was not denied severe criticism, focusing on flaring of mandibular incisors with inevitable relapse after retention, and unfavorable change in the facial profile.

The purpose of the present study was to evaluate changes, that is, increase as well as decrease, in the inclination of the mandibular incisors relative to the mandibular plane (the so-called *IMPA*) during orthodontic treatment with the Begg technique.

The *IMPA* is a part of Tweed's diagnostic triangle, formed by the lowermost tangent to the mandible and the long axis of the most anteriorly positioned mandibular incisor. The angle is not only influenced by orthodontic treatment but also may change during the normal course of growth and development. The mean value of this angle in excellent anatomical occlusions is generally reported as 90 degrees with a standard deviation of 5 degrees according to many authors.[1-6]

Considerable attention has been attached to the position of mandibular incisors in everyday orthodontic practice because optimum and stable results of treatment and facial esthetics are greatly dependent on their position and inclination. According to Lindquist's[7] extensive dissertation, lower incisors are the "single clue" for these objectives.

The effect of the Begg technique on the position of mandibular incisors has not been investigated to any extent, except for an early cephalometric appraisal by Williams[8] which has become a guideline for students of the Begg technique. Williams discussed the differences resulting from treatment with the Begg method as opposed to previously used techniques. He claimed that bodily lingual movement with simultaneous intrusion of the mandibular incisors within the alveolar bone was one of the most characteristic features of the Begg technique. This bodily movement occurred in spite of the fact that only one point contact was obtained between the wire and the bracket and without a torquing force.

Although such a system should result in tipping according to conventional concepts, Williams presented cephalometric evidence that bodily movement actually resulted without labial flaring, provided that theory and technique

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were used properly. Direct measurement of the *IMPA* was not included, but this angle could be calculated from other angular measurements recorded by Williams.

Clinical experience with the Begg technique at the Forsyth Dental Center did not offer clear-cut answers concerning changes in the *IMPA*. Moreover, when such changes were noted, satisfactory explanation could not be given. A study was therefore undertaken in which available clinical records were used to determine the magnitude and the direction of changes in the *IMPA*. A group of age- and sex-matched untreated subjects was also studied in an attempt to determine whether changes in the *IMPA* occur in growing children not subjected to orthodontic treatment.

Materials and Methods

The treatment group consisted of twenty-two male and twenty-eight female subjects, 11 to 14 years old, treated by the light wire Begg technique at the Forsyth Dental Center in Boston. Their malocclusions were classified as Class I (26) and Class II, Division I (24) with different amounts of crowding, overbite and overjet. All patients required four premolar extraction, prior to the routine three-stage Begg treatment which included inter- and intramaxillary elastics.

Standardized lateral head radiographs were obtained shortly before treatment, close to one year later after completion of Stage I, and after Stage III, approximately after another year, when the crowns and roots of all teeth had been placed in the desired position prior to retention.

For the comparison group, fifty untreated subjects were chosen from the longitudinal studies of twins and their age-matched siblings at the Forsyth Dental Center. They corresponded to the treated subjects with respect to age, sex and the intervals at which the lateral head radiographs had been obtained. Although the individuals in the comparison group did not have optimal occlusion, they did not reveal malocclusion demanding orthodontic intervention, having only minor amounts of irregularity with symptoms, such as slight crowding, overbite and overjet. All subjects in both groups were Caucasian.

The head radiographs were taken in the Broadbent-Bolton cephalometer. Tracing of radiographs was always done by the senior author. If the mandibular central incisors were not equally inclined, the most labially positioned incisor was traced. Two lines were drawn, one representing the long axis of the mandibular incisor and the other the mandibular plane from the lowermost point of the symphysis to the angular process of the mandible. If the left and right mandibular margins were shown as two lines, the midline was drawn, averaging the two outlines. The angle formed by the intersection of the two lines was measured to the nearest half degree.

Each radiograph was traced twice, on separate occasions, and each tracing was measured three times by the senior author on different days. The mean angle of the six resulting observations was calculated and recorded as the *IMPA* for that particular tracing. Moreover, the error of measurements has been determined as the standard deviation of differences* by comparing the average of three measurements obtained from the second tracing of these radiographs. The finding therefore represents a conservative estimate of both tracing and measurement errors because extreme differences in the measurements were smoothed by averaging the three measurements of the first and of the second tracing of fifty radiographs.

$$* \text{ error} = \left(\frac{\text{sum of differences}^2}{2n} \right) \frac{1}{2}$$

TABLE I

The IMPA of Males and Females at Three Successive Examinations in the Treatment and Comparison Groups

			Exam. I			Exam. II			Exam. III		
Group	Sex	Number	Mean	S.D.	F.Ratio	Mean	S.D.	F.Ratio	Mean	S.D.	F.Ratio
T	M	22	91.1	5.4	1.67	92.6	6.5	0.30	92.5	6.3	0.37
C	M	22	93.7	7.6		93.8	7.5		93.7	6.7	
T	F	28	93.7	8.0	3.78	93.8	8.2	4.99*	94.2	8.1	5.89*
C	F	28	89.8	6.6		89.5	7.5		89.5	5.8	

* $P < 0.05$ T = Treatment C = Comparison

Graphs were constructed by locating the initial value of the *IMPA* in each individual on the horizontal axis. An increase in the angle was subsequently plotted above the horizontal axis and a decrease below it, according to the scale on the vertical axis. Consequently, an unchanged angle was plotted directly on the horizontal axis. The line drawn at 45 degrees to the X and Y axes represents *IMPA* values of 90 degrees at the last examination. Thus, all changes in the angle toward this line, either by an increase or a decrease in the reading of the first examination, imply attainment of a perpendicular position of mandibular incisors to the mandibular plane.

The statistical analysis of the data involved comparison of the *IMPA* angles in the treatment and the nontreatment groups according to sex at the three age levels, together with a comparison of the mean increments in the *IMPA* angle and their standard deviations in the treated and untreated subjects.

Findings

The close comparability of age for the males and females in the treatment and nontreatment groups at the first examination was expected because age-matching of the subjects in the two groups had been a major criterion for sample selection.

The *IMPA* of untreated females was approximately 4 degrees smaller than that of treated females with differences bordering statistical significance at the first examination and attaining statistical significance at the second and third

TABLE II

Sex Differences in the IMPA of the Treatment and Comparison Groups at Three Successive Examinations

			Exam. I			Exam. II			Exam. III		
Group	Sex	Number	Mean	S.D.	F.Ratio	Mean	S.D.	F.Ratio	Mean	S.D.	F.Ratio
T	M	22	91.1	5.9	1.64	92.6	6.5	0.28	92.5	6.3	0.65
	F	28	93.7	8.0		93.8	8.2		94.2	8.1	
C	M	22	93.7	7.6	3.64	93.8	7.5	5.15*	93.7	6.7	5.30*
	F	28	89.8	6.6		89.5	5.7		89.5	5.8	

* $P < 0.05$ T = Treatment C = Comparison

TABLE III
Increment in the IMPA Between Examinations for Males and Females in the Treatment and Comparison Groups

			Exam. 1-2			Exam. 2-3			Exam. 1-3		
Group	Sex	Number	Mean	S.D.	F.Ratio	Mean	S.D.	F.Ratio	Mean	S.D.	F.Ratio
T	M	22	1.55	4.65		—0.18	5.06		1.36	5.29	
					1.04			0.06			0.51
C	M	22	0.09	2.83		—0.14	2.42		—0.05	3.08	
T	F	28	0.11	6.55		0.39	5.04		0.05	6.88	
					1.35			0.10			1.85
C	F	28	—0.32	2.18		0.04	1.99		—0.29	2.31	

T = Treatment C = Comparison

examinations (Table I). Males in the treatment and nontreatment groups showed only small differences in their angular values at each of the three examinations (Table I).

Because of the small *IMPA* of untreated females, the sex differences in the comparison group at the second and third examinations were likewise statistically significant (Table II). Yet within each sex and regardless of treatment, statistically significant differences were not observed between the *IMPA* at the three examinations (Table II). In fact, the mean findings suggest a lack of change in the angle in both groups regardless of treatment and growth.

Analysis of the increments in the *IMPA* during the three-year period showed, however, that individual male and female subjects exhibited considerable change in their angles between examinations as illustrated by the standard deviations of these increments (Table III) and also by the correlation coefficients at different examinations (Table IV). Moreover, both statistics point to greater individual variation in the increments of the *IMPA* in the treated subjects (Table IV) and particularly in the females (Table III), as compared with the untreated group.

Corrections for the tracing and measurement error (0.95 degrees) have not been made in the statistics presented in the tables.

The changes in the *IMPA* during treatment are also evident from inspection of the graphs. The readings varied in both directions during treatment, namely toward and away from 90 degrees (Fig. 1). In several individuals the angle changed markedly during the course of treatment but, after examining their clinical records, it was found that they cooperated poorly throughout the treatment. One patient, who changed from 102° to 113°, had a history of poor cooperation which included failure to wear elastics, broken appointments and negligence to maintain oral hygiene. Another patient started with an *IMPA* of 106 degrees but because of a large overjet, exceeding 10 mm, and a retrognathic mandible, no attempt was made to decrease the angle. The patient ended treatment with a reading of 107 degrees. If these two extreme variations were eliminated, the over-all

TABLE IV
Correlation Coefficients for IMPA's at Three Successive Examinations in the Treatment and Comparison Groups

Treatment Group		Examinations 1	2
Examination	2	0.69	—
	3	0.64	0.78
Comparison Group			
Examination	2	0.94	—
	3	0.93	0.95

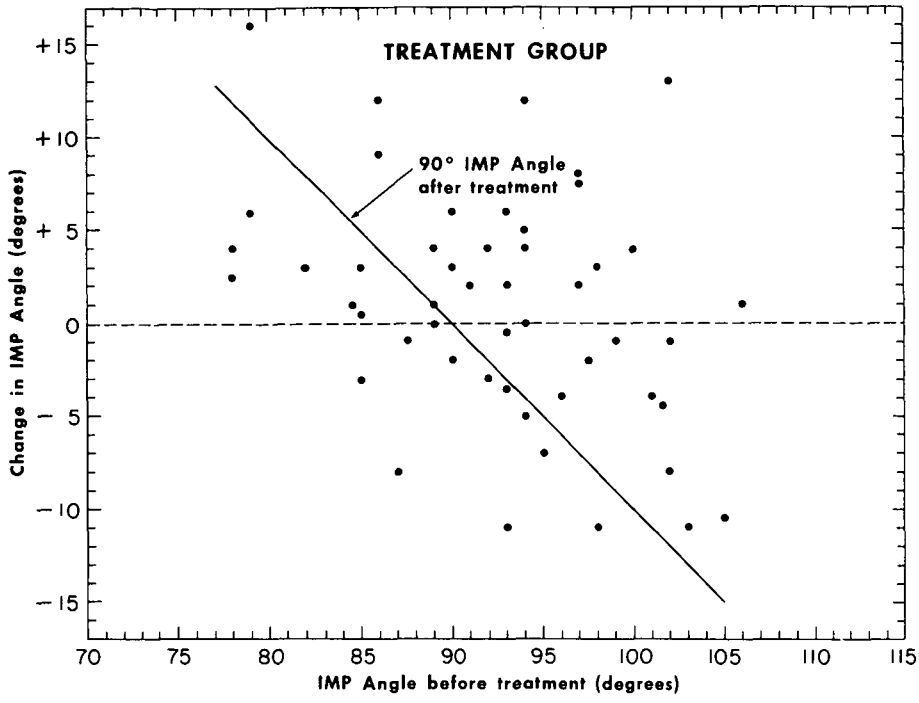

Fig. 1 The *IMPA* in individuals receiving orthodontic treatment with the Begg technique. Each dot indicates the angle before treatment (horizontal axis) and its change during treatment (vertical axis). An increase in the *IMPA* is plotted above the broken horizontal line and a decrease below it. An unchanged angle has been plotted directly on the broken horizontal line. The line drawn at 45 degrees to the *X* and *Y* axes of the graph represent *IMPA* values of 90 degrees at the last examination.

changes in the *IMPA* would not be altered significantly, that is, mandibular incisors did not have a tendency to be "upright" after treatment.

Likewise, individual treatment records were reviewed of patients with angles below 90 degrees that decreased further (*i.e.,* an *IMPA* of 87 degrees before treatment ended at 79 degrees). Intermaxillary elastics during Stage II of this patient's treatment were possibly too heavy, thereby causing lingual movement of the incisors. Another patient started with an *IMPA* of 93 degrees and ended with an angle of 82 degrees. The record did not contain information to explain this decrease, although considerable effort had been made to retract the maxillary anterior teeth and anchorage of posterior teeth was reportedly well preserved.

The data from the nontreatment group were also examined. The distribution of the comparison group (Figure 2) was similar to that in the treatment group (Figure 1), although slightly closer distributed around 90 degrees at the final examination and with somewhat less variability.

The greater individual differences in the *IMPA* of the treatment group were expected as a consequence of the malocclusions. The readings of the comparison group also changed either toward or away from 90 degrees, but to a lesser extent than in the treatment group.

Discussion

Results of this study do not offer a

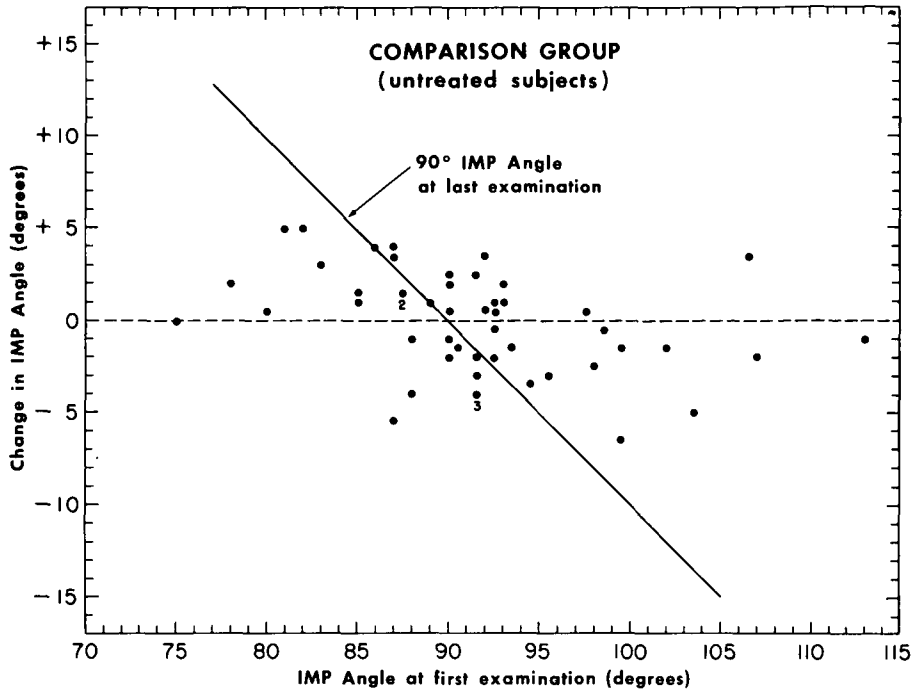

Fig. 2 The *IMPA* in untreated subjects (see legend of Figure 1 for additional explanation).

clear-cut answer to the question whether the Begg treatment brings about a marked change in the *IMPA*. The mean changes between any two examinations were not statistically significant for the group as a whole. On the other hand, the individual differences in increments of treated subjects, reflected in rather wide dispersion between examinations of points on the graphs, were not negligible. The comparison group likewise showed changes in the *IMPA* during the observation period, but to a lesser magnitude than the treated group.

The *IMPA* can by definition change by either one of its vectors, notably by a change in the inclination of the long axes of mandibular incisors or by a change in the inclination of the mandibular plane owing to growth.[9] Differentiation between these two theoretical possibilities was not made in this study, but one would expect that, of the two factors, the former would be more liable to undergo change, particularly in the treatment group.

Variability of the changes in the *IMPA* in the treated individuals may have several contributing factors which cannot be readily identified. The effect of multiple operators and cooperation of patients may have been associated with some of the observed differences.

Furthermore, the findings suggest that treatment procedures should have been monitored during and between stages of Begg treatment by studying intermittent treatment results carefully.

The direction of changes in the *IMPA* between various stages did not show a distinct trend. An approximately equal number of individuals exhibited an increase and a decrease in their initial reading, approximately of the same magnitude toward and away from a 90 degree angle. This finding pertains

to both the treatment and the comparison group but again, over-all variability was larger in the former.

The error of tracing and the error of measurement are included in all standard deviations shown in Tables I and III and probably resulted in a slight attenuating effect on the correlation coefficients (Table IV).

The changes in the *IMPA* observed in the untreated subjects await further confirmation in larger samples. Although there are indications that mandibular incisors upright during maturation, their labial inclination remains unexplained unless the change in the *IMPA* is conditioned by a change in the mandibular plane as a result of growth at the gonial angle or mandibular border.

One shortcoming of this study lies in the lack of comparable information on results with different treatment procedures, *e.g.*, of the edgewise technique, in respect to changes in the *IMPA*. Unfortunately, a comparable group of subjects treated by a uniform application of the edgewise arch technique was not available to the authors. Therefore, the reported study, which is retrospective in nature, can be considered only as a preliminary investigation.

How important is the right angle between the long axis of the incisor and the mandibular plane? From this study it would appear that an *IMPA* of 90 degrees is not essential to the successful result of treatment. It is obvious that an angle that deviates from 90 degrees can be compatible with esthetic and functional requirements of an individual patient and therefore should be left undisturbed.

The basic issue in the evaluation of the Begg lightwire technique is the extent to which the position of mandibular incisors can be maintained or changed, in accordance with the specific plan required to achieve optimal treatment results for an individual patient.

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