Occlusal Plane and Overbite

WILLIAM J. THOMPSON, D.D.S.

Orthodontics is progressing in the direction of a more dynamic concept of occlusion, of functional harmony, and of biological and mechanics interdependence. Fortunately, the progression from the older concept of a static Class I occlusion to the current functionally generated occlusion has not been completely new to orthodontics. In a great part this is due to the very early work in occlusion and occlusal physiology by Thompson,[5] Brodie,[5] Wylie,[23] Ricketts,[13] Moyers[9] and others who have discussed various neuromuscular and functional aspects in orthodontics. In recent years this concern for functional occlusal harmony has brought forth considerable controversy over the relationship of the occlusal plane and overbite during the orthodontic treatment program.

LITERATURE REVIEW

Schudy,[15,16] Simons,[14] Barton[1] and others have discussed overbite and occlusal plane changes at great lengths.[6,10,19,20,21] Schudy has contributed considerable research and theory related to overbite and occlusal plane. His studies indicate that the correction of overbite is difficult in low angle cases and difficult to hold, but in steep angle cases overbite corrects readily and is easy to hold. Schudy recommends specific procedures in treatment to control the overbite in low or high angle cases. His research, as well as that of Williams,[21,22] Simons,[14] and Phillips[11] indicates that the occlusal plane can be changed in treatment, that it may return in the direction of its original position, and that physiologically the changes are usually favorable and not injurious to the dentition or its environment.

Schudy[16] seems convinced that posterior dental height is the most important change that influences the overbite. He feels that this change plus the effects of incisor depression and interincisal angulation are the principal determining factors in both the change and relapse of overbite. For overbite to be maintained he recommends that the appliance be designed to extrude molars in low angle cases, to prevent intrusion of lower incisors, and to provide an interincisal angle of 135°. He is equally strong in his opinion that lower molars not be extruded in high angle cases; this will tend to increase the vertical dimension of the face by opening the Y axis.

Wylie,[23] in discussing vertical dimension of the face, said that vertical dimension at rest position is directly related to occlusal vertical dimension. He also stated that rest position is of equal importance to orthodontics as is the classical relationship of full occlusion. He discussed the apparent correlation of muscle morphogenetic patterns as they influence rest position and described those cases in which muscle length or tonus are not rigid entities as the patients most likely to respond orthodontically. In those individuals he felt the total amount of vertical dimension usually expressed or permitted by the musculature is not attained by the normal growth. These cases, thereby, respond well to orthodontics which produces or stimulates vertical growth increases. He cited Strang's[17] idea of closed bites being infraeruption of buccal teeth, a supraeruption of anterior teeth, or a combination of both.

Most of the literature and research is contradictory about the effects of treatment on vertical dimensions, overbite or occlusal plane. One author, McDowell,[7,8] presented a unique description of the correction of overbite in his discussion of the various force phenomena with anchorage control in Begg, Bull and Tweed mechanics. In his description of dynamic and static anchorage, he described the use of changes in occlusal plane and posterior dental height to produce a positive interlock of posterior occlusion during treatment. He felt that the elevation of molar teeth through the freeway space produced a muscle pull which caused a cuspal interlock that acted as a dynamic anchor unit. McDowell measured the freeway space during treatment and found it to change in various phases of treatment in the Bull, Tweed and Begg techniques. In Begg treatment the retraction forces were measured at 4.5 oz. while the vertical type muscular anchorage forces were 15 oz. In Begg light wire treatment McDowell concluded that the main anchorage was produced by molar elevation through the freeway space causing a forceful muscular interlock of the occlusion. The interlocked anchorage was held as incisors were retracted and depressed in bite opening. Since an unusually large freeway space could, according to McDowell, permit a significantly great increase in posterior dental height to gain anchorage intercuspation, then perhaps freeway space is an important consideration in determining the probable success or failure of bite opening.

The purpose of the present study was to evaluate the tooth movements related to occlusal plane and overbite which were produced by light, differential forces of the Begg system. The appliance forces in this system are influenced in great magnitude by muscle force, dental physiology, and masticatory function. The forces used were believed to be mostly simple and physiologic in nature, namely, tipping, extrusion, drifting, and rotation. The concept of static type anchorage was not used. Rather, a system of occlusal interlock, muscle tonus, and tooth morphology was relied upon to facilitate directional tooth movement. No skeletal or orthopedic type of force was utilized; only light differential forces of 1-3 oz. were maintained to initiate the movement physiology. In this report only those variables related to functional occlusal plane and incisal guidance are evaluated. The investigation determined the degree of change which occurred during treatment and the change which occurred after all retaining appliances had been removed. The hypothesis was that the cases should show a very high degree of stability if, in fact, they were treated within their morphogenetic limits with a physiologic theory of treatment that enabled the child to accommodate naturally to the skeletal, dental and muscular changes produced by treatment.

In the treatment of the cases to be reviewed in this investigation, the use of molar elevation for anchorage and the changing of occlusal plane and incisor position were utilized in each case. It was felt that, by working within the flexible muscular environment with light forces, it would be possible to get functional adaptation by the neuromuscular environment which would lead to good stability. For example, in deep bite cases with large freeway spaces, such as Class II, Division 2, considerable molar elevation occurs in obtaining functional anchorage. The elevation changes the occlusal plane and aids in bite opening. By using light forces, forces less than that generated by the closing musculature, the molar is elevated in a physiologic environment within the individual's capability of natural adaptation. If only a small freeway space exists, then the degree of physiologic molar elevation is limited and correction of overbite also limited, e.g., deep bite Class II bimaxillary problems or steep angle problems. In these cases, by using too much force for too long, it may be possible to carry the molar through the freeway space in excess. The excessive elevation of the molar would produce bite opening both by physiologic change (within the freeway) and by skeletal change (hinging open of the mandible and opening of the Y axis). Both types of bite opening are stable, but one is more physiologic and desirable; one changes the mandibular occlusal plane, but not the skeletal axis of the mandible; the other changes both. To minimize the nonphysiologic type skeletal rotation, special care must be exercised in mechanics to use light force for a minimum amount of time to reduce excessive elevation of the anchor teeth.

Determining the stability of the changes in occlusal plane that were produced during treatment by molar elevation and incisor depression was the prime purpose of this investigation.

Material

The material for the investigation was taken from 50 cases selected at random from the author's practice. The only requirements of the selection were that the patients had to be free of retention for at least 6 months and that all pre- and posttreatment records were available. The study included 21 males and 29 females, but no sex differential was evaluated. The range of time after retention was from 7 to 77 months, the mean being 33 months. No distinction was made as to extraction or nonextraction since we were concerned with posttreatment stability in all cases. All patients were treated by one operator with the Begg technique using differential force and light Class II elastic mechanics. Measurements were made from lateral cephalograms produced in a Wehmer cephalostat at a fixed target and film distance. Measurements were made by two investigators. If differences were evident, the determinations were remade and averages were used.

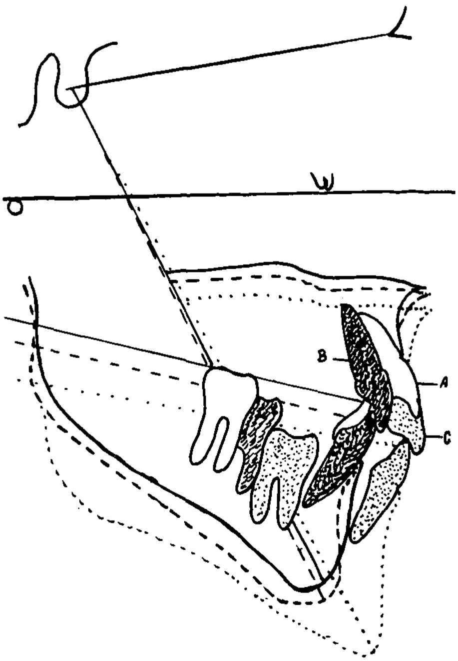

Fig. 1 All variables were measured before treatment (A), after treatment (B), and after all retention (C). Range of measurements after treatment was 7 months to 77 months. Average treatment period 21 months. Superimposition on sella-nasion.

The following variables were studied before treatment, after treatment, and free of all retention: $\overline{6}$ to mandibular plane (gonion, menton), $\overline{1}$ to mandibular plane, $\overline{1}$ incisal tip to D, $\underline{1}$ to SN in mm, occlusomandibular plane angle and overbite (Fig. 1).

Overbite was expressed as the vertical overlap of the upper to lower incisor and measured on a line perpendicular to the occlusomandibular plane. Occlusal plane was determined by extending a line which bisected the incisor overbite and intersected the cusps of the lower molars. The angle established by this line and the mandibular plane was concluded to be the occlusomandibular plane angle. Lower molar height was measured from the mandibular plane on a perpendicular line through the lower molar cusp tips. Lower incisor

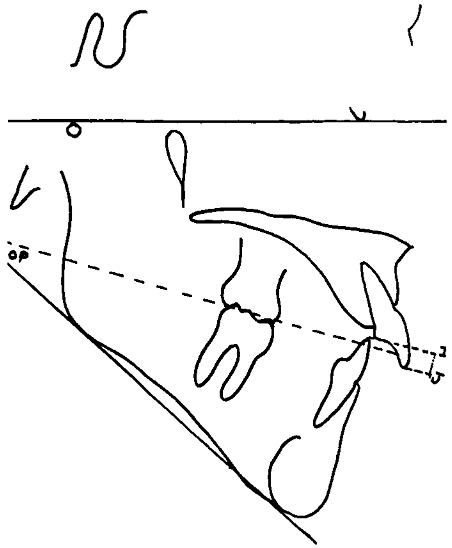

Fig. 2 Overbite was measured from a line parallel to the occlusal plane from mandibular to maxillary incisal edges (I to J). The occlusal plane was established by a line bisecting the incisor overbite, and passing through the lower molar cusps.

height was measured to mandibular plane on a line perpendicular to the mandibular plane. The lower incisor was also measured directly to a projected point "D" on this same line in an effort to minimize mandibular plane changes at menton due to morphological sex changes, especially with maturity at the age level of boys after retention. Upper incisor height was measured on a perpendicular line from the incisal tip to the sella nasion plane. The growth of the midface was measured on a perpendicular line from A point to sella nasion (Figs. 2, 3).

For ease of statistical comparison, pretreatment measurements were denoted group A, after treatment Group B, and out of retention Group C. Descriptive statistics were generated by the University of Michigan, School of Dentistry, Statistical Laboratory and consisted of means, standard deviations, and maximum and minimum values. Paired t-tests were used to test the significant differences between the means for each variable between each group. A multivariate approach in the form of the discriminate analysis was applied to all three groups incorporating all variables to ascertain whether there was a statistical difference between the patient before treatment, after treatment, and out of treatment.

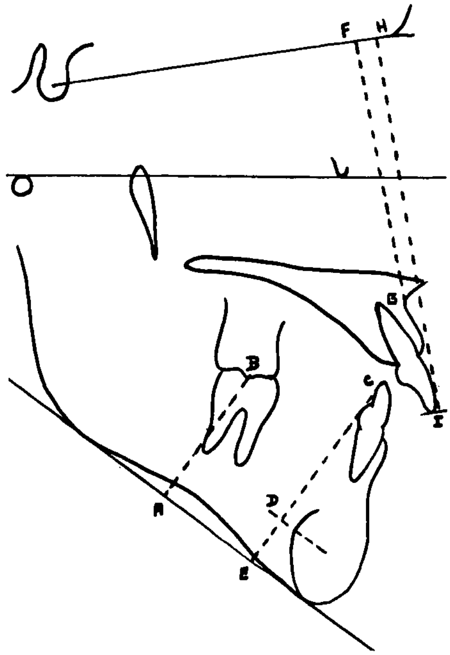

Fig. 3 Lower molars were measured to mandibular plane (A to B), lower incisors from incisal edge to mandibular plane (C to E), and incisal edge to "D" point (C to D). Maxillary incisor change was measured from SN to incisal edge of upper centrals (H to I) and compared with general growth of upper face from SN to point "A" (F to G).

The multivariate analysis was performed interselecting and relating each of the measurements for all three periods. The analysis was performed as a second test of reliability of the changes. The multivariate analysis was programmed to select individual measurements or groups of measurements to determine if the changes measured be-

TABLE I
OVERBITE

Group	Mean	S.D.	S.E.
A	4.8	1.9	.3
B	2.4	.9	.1
C	2.9	.5	.2
A-B	2.5*	1.8	
B-C	—0.5*	1.1	

* Significance P = .001

TABLE II
OCCLUSOMANDIBULAR ANGLE

Group	Mean	S.D.	S.E.
A	19.6	4.4	.6
B	17.2	4.8	.7
C	17.4	5.1	.7
A-B	2.4*	3.2	
B-C	—.2	2.7	

* Significance P = .001

tween A, B and C were apt to be due to chance or if they were measurements of change or stability.

It should be noted that any posttreatment change has been assumed to be relapse for purposes of this study. Some or all of the changes could be just natural growth and development.

Findings

Overbite, measured as the vertical overlap of the incisors, shows a distinct reduction during the treatment period, group A to group B. The amount of reduction in overbite during the treatment was highly significant. A mean reduction in overbite of 2.5 mm occurred during treatment. The pretreatment range in overbite was 0-9 mm while the after treatment range was 0-4 mm indicating that significant overbite changes occurred in some cases (Table I).

The mean change in overbite between groups B and C was a measure of the relapse which occurred after retention during the settling of occlusion. The change was —.5 mm with a standard deviation of 1.1 (Table I). The statistical significance of the change was .0018 indicating that a definite increase in overbite did occur during the settling period. The small degree of the change was an important finding from the clinical standpoint since it suggests that a very satisfactory amount of correction in overbite held up in these cases.

Alterations in the occlusal plane during treatment were similar to those recorded by other investigators, namely, that the occlusomandibular plane angle was reduced or became flatter during treatment. The mean change was 2.4°, determined to be highly significant. The actual angular change between groups A and B was 19.6° to 17.2° with a standard deviation of 3.2° (Table II). The evidence from these cases supports the hypothesis that light wire Begg type mechanics does change the occlusomandibular plane significantly during treatment. Whether this change is neuromuscular or skeletodental, a stable change was observed in the comparison of occlusal plane variations which occurred during the settling phase.

The mean change in occlusomandibular plane during the settling period was —.2° indicating a slight tendency for the occlusal plane to return to its original level. The amount, however, was statistically insignificant and certainly clinically insignificant. It could be that the changes in occlusal plane were, in fact, as McDowell described, done within the freeway mechanism and were substantially tolerated by the patient.

To evaluate where the changes in overbite and occlusal plane occurred, anteriorly or posteriorly, an examination was made of the changes in lower molar position and in the positions of the upper and lower incisors. Lower molar changes were measured from mandibular plane. The mean change in the lower molar during treatment was an elevation of 3.5 mm with a standard deviation of 2.0 (Table III). The stability of this change was found to be very good. The mean change in the

TABLE III
LOWER MOLAR TO MANDIBULAR PLANE

Group	Mean	S.D.	S.E.
A	31.7	2.6	.4
B	35.2	3.0	.4
C	36.1	3.3	.5
A-B	—3.5*	2.0	
B-C	—0.9*	1.6	

* Significance P = .001

molar elevation during the settling process was —0.9 mm denoting a continued elevation or eruption during the postsettling period. Since active treatment lasted 21 months, retention 24 months and postretention 33 months, the total mean period for observation was 78 months. During this time a net change of 4.4 mm elevation occurred in the molar height. In percentages, 80% of the change (3.5 mm) occurred during 21 months of treatment and 20% during 57 months of retention and nonretention. The stability of molar elevation in these cases was highly significant, statistically and clinically, and its change during settling has little to do with changes in occlusal plane or overbite during this period.

Lower incisors were evaluated from two positions: from incisal edge to mandibular plane and from incisal edge to Steiner's point "D". It was hoped that by using two reference areas the alterations in incisor height due to growth alterations at menton could be accounted for in the total change. The mean change of lower incisor to mandibular plane showed a depression of 0.5 mm with a standard deviation of 2.2 mm (Table IV). Similarly, the depression as measured to point "D" was 1.4 mm with a standard deviation of 1.7. The mean of 0.5 mm recorded to mandibular plane was probably influenced considerably by alterations in bone at menton. It was considered insignificant statistically while the larger 1.4 mm depression measured at D was significant at the p = .001 level.

TABLE IV
LOWER INCISOR TO MANDIBULAR PLANE

Group	Mean	S.D.	S.E.
A	44.5	3.4	.5
B	44.0	3.2	.5
C	45.3	3.3	.5
A-B	.5	2.2	
B-C	—1.3*	1.6	
LOWER INCISOR TO "D" POINT			
A	31.8	2.7	.4
B	30.4	2.6	.4
C	31.2	2.9	.4
A-B	1.4*	1.7	
B-C	—0.7*	1.1	

* Significance P = .001

Clinically, it appears that Begg treatment does depress lower incisors and this is a significant factor with molar elevation in changing overbite. How stable the change is was evaluated in the observations taken after settling of the occlusion. The mean change during settling indicated a relapse or return of the incisor of 1.3 mm, measured to mandibular plane and 0.7 mm measured to point D. Both changes were shown to be highly significant statistically (p = .001) indicating a definite settling relapse of the clinical depression of lower incisors. In percentages, when comparing mean values of incisor depression during treatment with relapse during settling, it can be expected that at least 53% of the total depression will return contributing to a relapse of overbite.

The final consideration of changes in occlusal plane and overbite concerned the upper incisor (Table V). Measurements after treatment indicate a mean elongation of the upper incisor of 2.4 mm. The increase must be considered to include changes produced by midface growth, SN to A point, alveolar growth, and effects of treatment. Since Begg treatment is designed to produce upper incisor depression, the 2.4 mm must be the resultant of incisor extension due to growth and clinical depres-

TABLE V
UPPER INCISOR TO SN

Group	Mean	S.D.	S.E.
A	81.0	4.6	.6
B	83.4	4.6	.6
C	84.9	2.9	.4
A-B	2.4*	2.7	
B-C	1.5*	1.8	
SN TO POINT "A"			
A	58.1	4.6	.6
B	61.9	4.6	.6
C	63.00	6.3	.9
A-B	3.8*	2.4	
B-C	1.2*	2.4	

* Significance P = .001

sion. The growth of the midface was measured from SN to A point with the mean change of 3.8 mm. It would appear that the total effect of treatment was to depress or hold back total vertical development of the upper incisor by 1.4 mm. In the settling phase of treatment the upper incisor showed a mean elongation of 1.5 mm. During this same period midfacial vertical dimension, SN to point A, increased 1.2 mm. A net elongation of 0.3 mm of the upper incisor occurred in the settling period. Since both changes at midface (p = .05) and at the incisor tip (p = .001) were highly significant, it can be expected that some clinical depression of the upper incisor will relapse contributing to a change in occlusal plane and overbite during the settling process. Since the lower incisor relapse is approximately 0.7 mm and the upper incisor relapse 0.3 mm, and considering all changes were at high levels of statistical significance, it appears that depression of the upper incisor was more stable than was lower incisor depression in maintaining the occlusal plane and overbite. Although these mean values show relatively insignificant amounts from a clinical viewpoint, it must be remembered that standard deviations indicate in certain cases this relapse could be clinically significant (Table VI).

TABLE VI

Variable	B-C	Mean Change
1/1	133.3-133.8	+ .5
U1SN	96.5-96.9	+ .4
U1AP	2.8-3.0	+ .2
L1AP	.4- —.2	— .6
L1MP	93.2-93.3	+ .1
OVERBITE	2.4-2.9	+ .5*
OCC PL	17.2-17.4	+ .2
MAND PL	37.2-36.6	— .6
SNA	79-78.8	— .2
SNB	75.3-75.3	.0
SNA MM	61.8-63.0	+1.1*
SNB MM	99.2-100.6	+1.4*
L6MP MM	35.2-36.1	+ .9*
L1MP MM	43.9-45.2	+1.3*
L1D MM	30.4-31.9	+ .7*
U1SN MM	83.4-84.9	+1.5*

* sig P = .05

The Multivariate Approach

Until now the discussion of the data has been limited to the univariate approach, or examining the variables one at a time. The application of the discriminate analysis provides the opportunity to observe to what extent each grouping is distinct and separate from the other groupings. In this study the question may be asked, "Is there a measurable difference in the teeth and jaws of patients before, during, and after treatment?" The answer to this question is provided by the number of correctly identified observations as may be observed on the diagonal of Table VII. Since most patients (92 out of 100) are correctly classified in the before treatment category (A), it is clear that for the variables studied that there is little similarity between the patient before treatment compared with after treatment and out of retention. However, the large error of misclassification between groups B and C (after treatment and out of treatment) is readily observed in the diagonal elements of Table VII (62 of 100). Hence the discriminate analysis strongly supports the

TABLE VII
DISCRIMINATE ANALYSIS

Group			
A	92	4	4
B	2	62	36
C	0	38	62

univariate approach that there is *maximum difference* between the patient *before* treatment and *after* treatment, but there is *little difference* between the patient *after* treatment and *out of retention.*

Summary

It appears from the findings in this study that significant changes occur in the mandibular occlusal plane and overbite during light-wire Begg treatment. The treatment mechanics tend to elevate the lower molar 3.5 mm, depress the lower incisor 1.4 mm, and depress the upper incisor 1.4 mm. The net result of these changes was a flattening of the mandibular occlusal plane angle from 19.6 to 17.1 degrees. The changing anterior and posterior dental units produced a net decrease in overbite of 2.5 mm during treatment.

Lower molar changes during settling indicated no relapse of these teeth, but rather continued vertical growth of approximately 0.9 mm. The lower incisors tend to return to the pretreatment level, but about one half of the clinical depression of 1.4 mm of the lower incisors held. Maxillary incisors tend to be more stable than lower incisors, but elongate about 0.3 mm during settling indicating a net retention of 1.1 mm of clinical depression. The over-all change of these units during the settling period produced a net mean change in the occlusal plane of 0.2°, or no clinically significant change, and a mean relapse in overbite of 0.5 mm, also clinically insignificant.

In determining the relative stability of these changes after retention it was found that the various measurements did show some change in the settling period, 7 months to 77 months with no retention. The changes were found to be unusually small and statistical evaluation showed excellent stability. The clinical insignificance of the small differences which were found also suggests that the cases were quite stable from a practical treatment goal. The orthodontic changes in occlusal plane and overbite brought about by light differential forces are very stable. Mechanics based upon neuromuscular and occlusal anchorage, freeway and functional pathways, within a specific morphogenetic skeleton, seem to provide a dento-occlusal complex that is within the patient's natural adaptability. The changes induced by the treatment may be stable because they are simply produced and coordinated within the natural adaptable limits of the patient's own facial programming.

4008 9th Ave. West
Bradenton, Florida 33505

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