A Comparison of Lower Face Changes

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Is it worthwhile to prepare anchorage to enhance the resistance of the lower dental units to subsequent mesial displacement? Some clinicians contend that the extra effort will pay off in more forward growth of the mandible when the lower denture is subjected to Class II elastics. It is the purpose of this report to evaluate the changes in the dentofacial skeletal profile in two groups of female patients with relatively steep Frankfort mandibular plane angles and larger-than-normal apical base differences to determine if there is a relationship between anchorage preparation and protraction of the mandible.

Literature Review

The use of Class III mechanics to prepare anchorage was first advocated by Tweed[1] in 1940 and became the hallmark of the Tweed philosophy and technique. He said, "Anchorage preparation, in my opinion, is the most important step in clinical orthodontics." He went on to state that, "The clinical orthodontists who routinely create excellent facial changes for their patients are those who recognize the importance of and prepare anchorage routinely in their practice."

Tweed used anchorage preparation for two purposes: 1) to effect the placement of the lower incisors over the basal bone and 2) to establish resistance primarily in the mandibular posterior teeth for the purpose of utilizing this resistance for the distal *en masse* movement of the maxillary denture by means of Class II intermaxillary elastics. At first his attention was focused upon midface changes. Those changes could be quite evident in Class I and II facial patterns. It was not until Tweed utilized cephalometrics that he began to appreciate the changes that occurred in the lower facial skeletal profile. Dougherty[2] studied ninety-six Class II cases treated according to Tweed and concluded that anchorage preparation enhanced the ANB change. A study by Klontz[3] of 30 cases treated with anchorage preparation after the removal of four premolars showed that B point moved downward and forward relative to the anterior cranial base. Root[4] suggests that "depressing mechanics" (anchorage preparation would be an example) encourages closure of the Y-axis relative to the Frankfort plane. Could it be that the resistance of anchorage preparation, when coupled with Class II elastic mechanics, promotes the growth of the lower face?

Charlier et al.[5] concluded in a study on young rats that hyperpropulsion of the mandible produces additional growth of the condylar cartilage. Stockli and Willert,[6] using continuous cemented cast gold splints forcing the mandible to close about 5 mm anterior to centric in growing monkeys, histologically found that the posterior region of the condylar head showed a cartilage mass which had increased several times normal. There was a high resistance to relapse after removal of the splints. McNamara[7] produced Class III molar relationships with gold onlays in young monkeys; statistically significant increases in rate and amount of growth at the head of the condyle were observed. But in adult monkeys Meikle[8] found only minor remodeling changes in the condyle after subjecting the mandible to a Class II intermaxillary force. Hiniker and Ramfjord[9] also found in adult monkeys that anterior displacement of the mandible caused insignifi-

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cant adaptive changes in the TMJ. Adams et al.,[10] using ligated cast gold splints and Unitek Pace springs or elastics, corroborated previous findings, vis-à-vis monkey age and condylar change. Enlow et al.[11] in a state-of-the-art report on control of craniofacial morphogenesis writes, "The histologic and cephalometric evidence presently available from remodeling experiments in growing monkeys indicates that condylar growth can be directed more posteriorly by means of a protrusive mandibular force. However, similar force applied to adult monkeys produces changes in the articular eminence which vary from resorptive remodeling to early degenerative changes."

In humans, Ware and Taylor[12] in a study of twelve osteotomy patients whose facial growth had been consummated, found that following surgery the free condylar fragment was pulled downward and forward but generally re-established a position similar to the preoperative position within a year. They stated, "This study supports the conclusion that the mandibular condyle is capable of considerable remodeling as a result of altered function. Furthermore, it suggests that distraction of the condyle within the fossa may serve as a stimulus to compensatory condylar growth." Browne,[13] Meach,[14] and Marschner and Harris[15] have produced studies utilizing hyperpropulsion forces by means of activators in children showing protracted mandibular position. Boman[16] may well have been correct when he concluded in 1952 that, "While it is generally believed that orthodontic treatment does not stimulate growth beyond the alveolar process, perhaps it may provide conditions which will permit condylar growth to occur." Tweed would hold that anchorage preparation leads to maintenance of the occlusal plane during treatment thus enhancing the horizontal vector of mandibular displacement. Perhaps this is the condition which permits condylar growth to occur.

Materials and Methods

This study involved three subgroups of 25 patients each and one subgroup of 15 patients representing four different private orthodontic practices espousing the treatment goals of Tweed, viz., retraction of the lower incisors over basal bone to effect an FMIA of 65° or more. All patients were consecutively treated with a multibanded .022 edgewise appliance. The subjects were females with essentially permanent dentition. Pretreatment cephalometric requirements were: Frankfort mandibular plane of 30° or larger and ANB of 4.5° or more. The reason for utilizing this age and maturation level in females was to reduce the variable of nontreatment mandibular growth. Specifically, females at 12 years of age are close to terminating condylar growth; FMA values of 30° and more would require considerable condylar growth to produce a protraction of the mandible, and, lastly, SNA-SNB differences of 4.5° and more indicate a skeletal pattern with an inherent lack of mandibular growth compared with the maxilla. Thus, if this unlikely sample would show significant evidence of mandibular protraction (condylar growth), it might be reasonably concluded that it was due to the type of treatment.

Fifty patients were treated with anchorage preparation and 40 patients were not. In addition to the pretreatment cephalometric radiograph a posttreatment headfilm was taken. With the exception of one subgroup of 25 patients all radiographs were traced by the author. The excepted group was traced by the orthodontist who supplied the patient material. Pretreatment Frankfort plane was transferred

TABLE I

		Pre	*Post*	*Diff*
AGE	Anchorage Prepared	12:10.5	15:8.5	2:10
	No Anchorage Prepared	12:1	14:11	2:10
SN-MP	Anchorage Prepared	39	38.42	— .58
	No Anchorage Prepared	40.43	40.74	+ .31
FMA	Anchorage Prepared	32.86	32.23	— .63
	No Anchorage Prepared	33.98	34.28	+ .30
IMPA	Anchorage Prepared	92.52	86.68	—5.84
	No Anchorage Prepared	90.59	88.44	—2.15
FMIA	Anchorage Prepared	54.64	61.09	+6.45
	No Anchorage Prepared	55.44	57.29	+1.85
SNA	Anchorage Prepared	81.78	79.21	—2.57
	No Anchorage Prepared	81.38	79.64	—1.74
SNB	Anchorage Prepared	75.53	76.07	+ .54
	No Anchorage Prepared	74.93	74.66	— .27
ANB	Anchorage Prepared	6.25	3.11	—3.14
	No Anchorage Prepared	6.44	4.98	—1.46

to the posttreatment tracing in all cases for consistency. The following angular measurements were made: sella-nasion mandibular plane (SN-MP), Frankfort mandibular plane angle (FMA), lower incisor-mandibular plane angle (IMPA), Frankfort mandibular incisor angle (FMIA), sella-nasion-point A angle (SNA), sella-nasion-point B angle (SNB) and SNA-SNB difference (ANB) Table I. Superimposing the pre- and posttreatment tracings at S along SN, linear measurements were made of the difference between pre- and posttreatment nasion (N-N′). Using the same superimposition, measurements were made of the anteroposterior differences at right angles and parallel to Frankfort plane of pre- and posttreatment points A (A-A′), B (B-B′) and pogonion (P-P′).

Findings

Summarizing, the angular variables SN-MP, FMA and SNB showed opposite trends from pre- to posttreatment in the anchorage group as compared with the no-anchorage group. For IMPA, FMIA, SNB and ANB the trends were in the same direction from pre- to posttreatment. Using the "t" test of differences, the changes in the anchorage group were significantly greater than the changes in the no-anchorage group: p less than .01 for each variable (Table II).

Pre- to posttreatment changes in the linear measurements for A-A′, B-B′ and P-P′ were significantly greater at the .01 level for the anchorage cases than the no-anchorage cases. There was no significant difference between the two groups in the measurement of change at nasion, although the no-anchorage group had more growth (Table III).

TABLE II
Mean Differences Between Pre- and Post Treatment

Variable	*Anchorage*	*Non Anchorage*	*Significance*
SN-MP	—0.58	+0.31	$p < .01$
FMA	—0.63	+0.30	$p < .01$
IMPA	—5.84	—2.15	$p < 0.1$
FMIA	+6.45	+1.85	$p < .01$
SNA	—2.57	—1.74	$p < .01$
SNB	+0.54	—0.27	$p < .01$
ANB	—3.14	—1.46	$p < .01$

Significance determined from t-test of differences.

TABLE III

Mean Differences Between Pre- and Posttreatment

Variable	*Anchorage*	*Non Anchorage*	*Significance*
A-A′	—1.81 (0.20)	—0.76 (0.25)	$p < .01$
B-B′	1.19 (0.22)	0.25 (0.31)	$p < .01$
P-P′	2.08 (0.31)	0.88 (0.38)	$p < .01$
N-N′	1.15 (0.13)	1.43 (0.15)	N.S.

Numbers in parenthesis represent standard errors of the mean.
Significance determined from t-test of differences.
N.S. = not significant ($p > .05$).

Discussion

A class of patients was chosen for study whose condylar growth would be near termination, whose skeletal pattern would require mandibular protraction for esthetic improvement and whose direction of growth would be at variance with the horizontal expression of lower face characterized by so-called "good growers" or "low angle" cases. The patients were comparable in growth change at nasion.

The average age of the anchorage-prepared cases at treatment was nine months more than the average age of the cases in which no anchorage was prepared. The anchorage-prepared group demonstrated a posterior descent of the mandibular plane related both to anterior cranial base and to Frankfort plane. This was attributed to vertical condylar growth exceeding the sum of the vertical growth of the maxillary sutures and the maxillary and mandibular alveolar processes. The nonanchorage-prepared cases had a clockwise rotation of their mandibular planes when related to SN and Frankfort planes. This observation is explained by a failure of vertical condylar growth to equal the sum of the vertical growth of the maxillary sutures and the downward remodeling of the palate and bony maxillary arch. On average, the lower incisors were retracted more in the anchorage-prepared patients as would be expected from the use of the Class III mechanics. Resultantly, this group showed greater change in FMIA. It is to be noted that the FMIA, on average, failed to meet Tweed's treatment goal of 65° or better in both groups of patients. However, this is not unexpected, since in high-angle cases with large apical-base differences, retraction of lower incisors to satisfy Tweed's FMIA goal will often produce an esthetically unacceptable lingual inclination of the lower incisors. Usually, the operator will not retract the lower incisors to this extreme.

The anchorage-prepared cases also demonstrated significantly greater skeletal change at point A. This point was retracted by angular measurement to SN corroborated by linear measurement parallel to Frankfort horizontal plane. This result could be attributed to the increased anchorage having been prepared in the lower denture which, with Class II elastics, offered such resistance that greater retraction of the maxillary denture was accomplished.

Change at point B for the anchorage-prepared patients was a definite protraction. SNB increased in the anchorage groups suggesting a favorable condylar response to treatment. SNB changed negatively in the nonanchorage groups suggesting that condylar growth did not advance point B enough in relation to nasion to maintain its pretreatment angulation. B point, measured linearly parallel to Frankfort, showed significantly greater protraction in the anchorage-prepared cases.

A reduction in ANB *per se* does not, of course, reflect whether change occurred at nasion, point A, or point B. It simply is a measurement of the relationship of the anterior limits of the skeletal denture bases to each other. However, there was a significantly greater change toward a normal relationship in the anchorage-prepared patients. This was due to the greater retraction of A point and the greater protraction of B point in that group.

Pogonion also protracted more in the anchorage cases. The more significant protraction of lower face in the anchorage group can be explained on the basis of more vertical condylar growth than vertical growth of sutures and alveolar processes. This accounts for the flattening of the mandibular plane producing the greater anterior thrust of B point and pogonion. Isaacson et al.[18] have stated, "As the center of rotation moves toward the face, the possibility of converting vertical condylar growth to anteroposterior dental and facial changes progressively increases." It is interesting to note that the one subgroup showing the most counterclockwise change in mandibular plane also demonstrated the greatest point B and pogonion protraction.

Enlow[19] also points out that there is a concurrent remodeling of the ramus-corpus alignment in response to the amount and direction of condylar growth. This feature was not investigated.

Of prime concern to the orthodontist is the particular type of cartilage in the mandibular condyle. Enlow states, "The condylar cartilage is also regarded by many present-day investigators to be 'secondary' in type for another, special functional reason. That is, it appears to behave *secondarily* in its growth responses to the displacement movement of the mandible, which is believed by many to be primary. As the mandible is carried inferiorly and anteriorly, the condyle is correspondingly triggered to respond by growth in an opposite direction, thereby sustaining its proper anatomic position and articular relationship with the cranial floor." Perhaps anchorage preparation, restricting vertical alveolar growth in its resistance to Class II elastic mechanics, encourages the mandibular condyle to grow in a direction more compatible with normal growth vectors. Certainly the evidence herein suggests that hypothesis.

Summary

A comparison has been made of cases treated with deliberate anchorage preparation (Class III elastic mechanics) prior to Class II elastic mechanics and cases treated with Class II elastic mechanics only. Treatment goals were the same. Extraoral traction was used as necessary to achieve those goals. Appliance quantity and size were the same. Age, sex, and severity of malocclusion were comparable. It remained that the anchorage-prepared cases demonstrated a flattening of the mandibular plane, greater retraction of the lower incisors, more retraction of midface, and more protraction of lower face. These changes of lower face are consistent with the normal growth changes of the human face.

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References

1. Tweed, C. H.: The application of the principles of the edgewise arch in the treatment of malocclusions, *Angle Orthod.* 11:5-67, 1941.
2. Dougherty, H. L.: The effect of mechanical forces upon the mandibular buccal segments during orthodontic

treatment, *Am. J. Orthod.* 54:29-49, 83-103, 1968.
3. Klontz, H. A.: A study of individual tooth movements in overbite correction treated with Tweed philosophy and mechanics, *A.B.O. qualifying thesis.*
4. Root, T. L.: An easy way to understand the importance of the vertical dimension, paper presented at the *Ohio State University Orthodontic Alumni Foundation,* March 1974.
5. Charlier, J., Petrovic, A., and Herrmann-Stutzman, J.: Effect of mandibular hyperpropulsion on the prechondroblastic zone of young rat condyles, *Am. J. Orthod.* 55:71-74, 1969.
6. Stockli, P., and Willert, H.: Tissue reactions in the temporomandibular joint resulting from anterior displacement of the mandible in the monkey, *Am. J. Orthod.* 60:142-155, 1971.
7. McNamara, J. A.: Neuromuscular and skeletal adaptations to altered function in the orofacial region, *Am. J. Orthod.* 64:578-606, 1973.
8. Meikle, M. C.: The effect of a Class II intermaxillary force on the dentofacial complex in the adult Macaca mulatta monkey, *Amer. J. Orthod.* 58:323-340, 1970.
9. Hiniker, J. J. and Ramfjord, S. P.: Anterior displacement of the mandible in adult rhesus monkeys, *J. Prosthet. Dent.* 16:503-512, 1966.
10. Adams, C. D., Meikle, M. C., Norwich, K. W., and Turpin, D. L.: Dentofacial remodeling produced by intermaxillary forces in Macaca mulatta, *Arch. Oral Biol.* 17:1519-1535, 1972.
11. Enlow, D. H., Harvold, E. P., Latham, R. A., Moffett, B. C., Christiansen, R. L., and Jausch, H. G.: Research on control of craniofacial morphogenesis: An NIDR State-of-the-Art Workshop, *Am. J. Orthod.* 71:509-530, 1977.
12. Ware, W. H., and Taylor, R. C.: Condylar repositioning following osteotomies for correction of mandibular prognathism. *Am. J. Orthod.* 54:50-59, 1968.
13. Browne, R. W.: A cephalometric study of effective mandibular length changes seen on patients treated with functional jaw orthopedic appliances. M.S. thesis, *The Univ. of Michigan,* 1959.
14. Meach, C. L.: A cephalometric comparison of bony profile changes in Class II, Division 1 patients treated with extraoral force and functional jaw orthopedics, *Am. J. Orthod.* 52:353-370, 1966.
15. Marschner, J. F., and Harris, J. E.: Mandibular growth and Class II treatment, *Angle Orthod.* 36:89-93, 1966.
16. Boman, V. R.: Research studies on temporomandibular joint; their interpretation and application to clinical practice, *Angle Orthod.* 22:154-164, 1952.
17. Broadbent, B. H.: The face of the normal child, *Angle Orthod.* 7:183-208, 1937.
18. Isaacson, R. J., Zapfel, R. J., Worms, F. W., Erdman, A. G.: Effects of rotational jaw growth on the occlusion and profile, *Am. J. Orthod.* 72:276-286, 1977.
19. Enlow, D. H.: Rotations of the mandible during growth; determinants of mandibular form and growth, J. A. McNamara, Jr., editor, *Center for Human Growth and Development,* Ann Arbor, Michigan, 1975.

Discussion by George Kottemann, d.d.s.

As we all treat cases orthodontically we like to feel our appliance therapy is achieving the maximum results for a given patient, functionally and esthetically. Whether a given result was achieved according to the scientific principle we specifically engineered is sometimes open to conjecture.

Dr. Phelps speculated that perhaps the resistance of anchorage preparation when coupled with Class II elastic mechanics could promote the growth of the lower face and proceeded to give us proof, concluding that there was significant evidence of mandibular protraction (calling it condylar growth) that occurred as a result of therapy.

Perhaps this paper should have been discussed by a clinician schooled in the Tweed philosophy of treatment who was more familiar with such factors as the timing of anchorage preparation, when initiated, its duration, and the types of occipital or cervical anchorage generally utilized.

Many factors must be considered in evaluating this paper:

1. Did any patients possess deciduous second molars at the time of treatment —since "E" space can affect available arch length in either the upper or lower arch? Was there a common arch-length shortage in all cases? Point A and Point B could both be retracted more if additional space was available in a given case.

2. Were patients *full* Class II malocclusions as the severity of the malocclusion would dictate duration of elastic therapy required?

3. With four operators, four cephalometers, and two persons tracing headfilms many variables were added. Dr. McGonagle before this group in 1959 presented a paper in which five individuals tracing the same headfilm displayed a variation of 3.5° in the measurement of the FH to the mandibular plane angle.

4. When were head plates taken, shortly after elastic traction and band removal, or after a period of rest and retention?

5. Was the factor of enlargement considered, any linear measurements could be affected by cassette placement and inconsistent anode-target distance?

6. Were first premolars extracted in all cases? If second premolars were extracted, molar slippage could "close the bite" by a reverse scissors effect.

7. If a high-pull head gear was utilized depressing molars in a given case, this too could close a bite, affecting the FMA angle. The reverse could occur with careless use of cervical traction.

8. Can one assume that just because an occlusal plane was held level in treatment that the horizontal vector of growth would be enhanced?

9. Was there growth occurring in these patients (such as alveolar or condylar)? One group grew a greater amount at nasion which certainly would affect all measurements involving nasion.

In a similar study of corrected Class II, Division 1 malocclusions treated with Tweed mechanics, Robert Delaat of the Netherlands found that Point B moved back in Class II cases as well as Class I, but that the angle SNB did not change. There was also a general clockwise rotation of the mandibular and occlusal planes, but no significant advancement of Point B.

Ricketts reported on a study of completed cases and untreated controls before this group and found the following: (1) changes varying from a 4° increase to 5° decrease in the cranial base angle in the time period studied. If any changes occurred in the cranial base angle of Dr. Phelps' cases it might affect the anteroposterior position of the mandible. (2) Appositional growth occurred at pogonion. (3) Class III elastics did depress the mandibular molars allowing the bite to close when used in conjunction with high-pull head gear. (4) Dr. Ricketts speculated that growth at the condyles might occur *if* they were moved out of the fossae.

If the hypothesis that Dr. Phelps is attempting to prove is correct, that anchorage preparation creates a protraction of the mandible with Class II mechanics, could not the opposite be true depending upon time differentials, that the Class III elastics used during anchorage preparation could cause pressures on the articulating surfaces of the condyles and fossae great enough to create cellular change?

It is difficult to image that intermittent elastic use (with maybe a rare 24 hr./day wearer thrown in) could create the same environment in the condylar area that a splint might create as described by McNamara or Stockli and Willert in the review of the literature.

It would be interesting to see this study done on *full* Class II, Division 1 malocclusions with complete permanent dentitions, similar arch length discrepancies, and skeletally mature patients as determined by wrist films.

It is this discussor's opinion that even a single example of mandibular protraction demonstrated on a nongrowing individual as evidenced by wrist films and two consecutive, similar head plates prior to treatment would be more significant than many cases averaged together. I do not feel, using mean figures, that one can say that Point B was protracted four times farther in the anchorage group than the nonanchorage group when the figures are .25 mm and 1.19 mm, respectively.

In 1959, Dr. Brodie, discussing research stated, "The objective in all cases of research is to control every possible variable except the one with which we are concerned."

My concern is that Dr. Phelps had too many variables to make the assumptions he did.

I feel Dr. Phelps in presenting this paper has given us a great deal about which to think. Certainly as I wrote this discussion many principles involved in our every day clinical activities went through my mind. It is very easy to pick apart a piece of research, much easier than to create it in the first place. Maybe this is why I am basically a clinician and not research oriented.

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