Analysis - Concepts and Values
Part I

Thomas R. Gebeck, D.D.S., M.S.

Introduction

Our orthodontic heritage is rich in individuals, techniques, research and responsibility. There has also been no shortage of professionals and dental supply houses proposing *new* treatment modalities nor those willing to try them. With any new treatment approach or modification, responsibility dictates that basic clinical research be conducted to justify continued use and interest.

Dr. Angle introduced the edgewise technique and presented numerous cases that supported the efficacy of his appliance. This appliance afforded orthodontics its initial step in its quest for excellence. His primary concern in the development of the appliance was to offer a method of maintaining a full complement of teeth that were properly aligned. He strongly felt that if even one tooth were missing, the resulting dentition could not function properly.

In the late thirties and early forties, Dr. Tweed identified his orthodontic treatment objectives and provided modifications in the edgewise appliance and its use. His treatment objectives demanded that esthetics, function, health of tissues, and limits of the denture be assessed before concluding success or failure of orthodontic treatment. His research provided the profession a method of treatment planning based on the diagnostic facial triangle. The use of the triangle gave us an esthetic guideline (FMIA), and defined the anterior limit of the denture (IMPA). The benefits, to the profession and the public, were improvements in facial esthetics and better stability of the treated case. The Tweed technique became accepted; excellence was redefined.

As the Tweed technique grew in acceptance, it became apparent that for it to survive, it had to address problems of consistency of treatment and duplication of results.

Dr. Levern Merrifield began working closely with Dr. Tweed in the 1950's. Several years ago, Dr. Merrifield represented a modification to Tweed's basic edgewise technique and labeled it *the directional force technique.* He and his colleagues studied the effects of all orthodontic force systems and their effect on the dento-facial complex. Directional forces were defined: *A group of force systems utilizing directional control to precisely position the teeth in both arches so they are in optimum harmony with their*

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environment. The widespread use of this technique within the Charles H. Tweed International Foundation began to demonstrate shorter treatment times and more importantly, treatment reproducibility by those orthodontists using it.

As the consistency of treatment improved, continued research allowed Dr. Merrifield to present sound clinical data which provided an assessment of facial esthetics, (Z-angle), and a definition of the posterior limit of the denture. Once again, the Tweed philosophy and orthodontics had been raised to new levels of excellence.

Control of the dentition and consistency of treatment have always been concerns of the conscientious orthodontist. Predictability had been suggested but never formally tested until the late 1970's. Dr. Merrifield's performance testing of patients at various stages in treatment revealed shocking data and lead the way for many of the changes and improvements in the technique as it is used today.

He found that better control resulted with initial use of edgewise archwires, that active torque should be accurately measured prior to placing archwires, and that treatment could be strategically staged to maximize leveling, cuspid retraction, incisor retraction, torque control, Class II correction and finalizing mechanics. Treatment was becoming controlled and consistent; results were more predictable.

Excellence, or the pursuit of it, has been the buzzword of orthodontic programs and papers during the 1980's, giving the practitioner the impression that this latest piece of information must be accepted if he is to continue to provide the best for his patients. Excellence seems to be relative to the technique one uses. Each of the techniques purports to be the best and, therefore, the dilemma. What is best?

Excellence, by definition, means outstanding—it does not mean perfection. It is doubtful that there will ever be the *perfect orthodontic technique*. It is hopeful that efforts in striving for excellence will permit the evolvement of a technique that works in harmony with normal skeletal-dental development, and not against it: one that takes advantage of growth rather than adversely affects it.

Purpose

This study began one and one-half years ago when Dr. Merrifield and I were discussing treatment and its effect on growth. For the last year, we have collected data, traced headfilms, discussed statistics, and cooperatively written this paper. We wanted to determine if there is any clinically differences between dental and craniofacial skeletal relationships during treatment in samples of patients with good results and patients with poor results when treated with Tweed directional force mechanics.

In today's orthodontic practice, the majority of problems involve Class II Division I malocclusions and Class I bimaxillary protrusions. The Tweed philosophy of treatment has provided an excellent diagnostic and mechanical approach for the treatment of such cases, and has continuously sought to improve the technique so that today there is a controlled, consistent and predictable biomechanical treatment system.

It should follow then, that all Tweed treated cases finish with stable dentures, improved facial esthetics, healthy mouth tissues and functional occlusions. They don't! This paper will examine some of the differences between the successful and unsuccessfully treated malocclusions where directional force mechanics were used.

Method

Three sample groups of this study consisted of a control or growth sample; a successfully treated sample; and an unsuccessfully treated sample. Both treated samples consisted of Class II Division I and Class I bimaxillary protrusion malocclusions. The cases included in the two treatment samples were received from Tweed Foundation members utilizing directional force treatment mechanics. The cases were selected for their respective samples depending on how well the results satisfied original treatment objectives.

The before and after cephalometric films of 44 cases, 23 females and 21 males, were selected from the University of Michigan's University School Growth Study. The majority of the films were taken at ages 12 and

14 years. However, a few of the cases selected were 13 and 15 years of age. The before and after cephalometric films of 40 well treated cases, 26 females and 14 males, closely matched the control with respect to age. All cases satisfied the requirements of Tweed's four treatment objectives. The before and after cephalometric films of 16 cases, 9 females and 7 males, demonstrating unsuccessful treatment were obtained from the same clinicians. These cases did not satisfy Tweed's treatment objectives.

The before and after cephalograms in each of the three samples were traced; the following skeletal and dental values were recorded:

Skeletal Values

Nine familiar values are FMA, FMIA, IMPA, SNA, SNB, ANB, palatal plane, occlusal plane, and Z-angle. The three unfamiliar values are posterior face height (PFH), anterior face height (AFH), and mandibular response (MR).

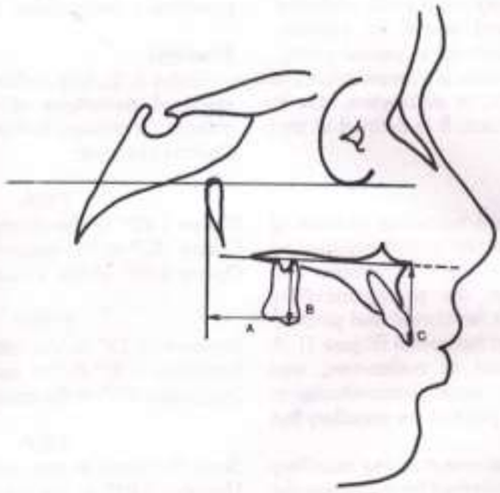

Figure 1. Maxillary Dental Variables

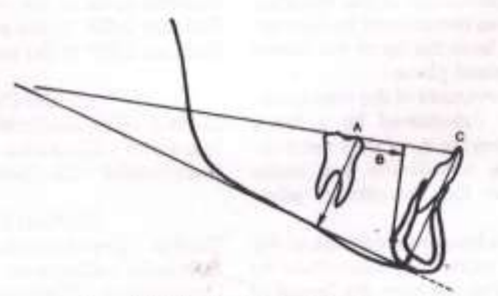

Figure 2. Mandibular Dental Variables

Posterior face height is a linear measurement from articulare, along a line tangent to the posterior border of the mandible, to the intersection of the mandibular plane.

Anterior face height is a linear measurement from palatal plane to menton, measured perpendicular to palatal plane.

Mandibular response is a measurement of mandibular change, in millimeters, due to growth and treatment. It is defined in part II of this paper.

Dental Values

The change in the horizontal position of the maxillary first molar was determined by dropping a line from the most posterior and superior point on the pterygomaxillary fissure to Frankfort horizontal and perpendicular to Frankfort horizontal (Figure 1). A linear measurement in millimeters, was made from the pterygoid perpendicular to the mesial contact point of the maxillary first molar.

The vertical movement of the maxillary first molar was determined by measuring the distance from the tip of the mesiobuccal cusp of the maxillary first molar to the palatal plane.

The vertical movement of the maxillary central incisor was determined by measuring the distance from the tip of the central incisor to the palatal plane.

The vertical movement of the mandibular first molar was determined by a linear measurement from the tip of the mesiobuccal cusp of the mandibular first molar perpendicular to the mandibular plane (Figure 2).

The change in horizontal position of the mandibular first molar was determined by measuring the distance from the mesial of the first molar along the occlusal plane to the point of intersection of a perpendicular drawn from X point on the lingual symphysis.

The vertical change in the mandibular central incisor was determined by measuring the distance from the tip of the incisor to the mandibular plane.

Statistical Method

The statistical model chosen for comparing the data was the analysis of variance, i.e., the student "T" test. Means and standard deviations were generated for each sample. Means of the differences were also found for each sample, and differences of the means provided a comparision between samples.

Findings

Tables 1, 2, and 3 show the means and standard deviations of all three sample groups. Of primary interest are some of the skeletal changes:

FMA:

Closes 1.42° in the control.
Closes .47° in the successful sample.
Opens 2.96° in the unsuccessful sample.

FMIA:

Increases 1.12° in the control.
Increases 8.78° in the successful sample.
Decreases .90° in the unsuccessful sample.

IMPA:

Stays the same in the control.
Uprights 8.81° in the successful sample.
Uprights 2.09° in the unsuccessful sample.

ANB:

Remains same in the control.
Reduces 2.86° in the successful sample.
Reduces 1.62° in the unsuccessful sample.

Palatal Plane:

Control - Counterclockwise .19°
Successful - Clockwise .45°
Unsuccessful - Clockwise 1.31°

Occlusal Plane:

Control - Counterclockwise .93°
Successful - Clockwise .16°
Unsuccessful - Clockwise 3.12°

Z-Angle:

Control - Increases 2.22°
Successful - Increases 10.51°
Unsuccessful - Increases 3.86°

Tables 4, 5, and 6 delineate the means of the differences for each sample and provided their level of significance.

In the non-treated sample, the change in before and after measurements of IMPA, ANB, and palatal plane were not statistical-

Means and Standard Deviations
Total Sample

Control (44)

	BEFORE	S.D.	AFTER	S.D.	CHANGE	S.D.
FMA	27.0	±5.08	25.5	±5.40	−1.42	±1.28
FMIA	58.38	±7.27	59.5	±8.08	1.12	±2.62
IMPA	94.90	±6.04	94.83	±6.82	−0.08	±2.52
SNA	80.42	±3.55	81.09	±3.57	0.67	±0.92
SNB	76.60	±3.35	77.35	±3.45	0.75	±1.02
ANB	3.79	±1.85	3.67	±1.83	−0.12	±0.99
Pal. Pl.	0.42	±2.99	0.22	±3.08	−0.19	±1.65
Occl. Pl	9.61	±3.27	8.68	±3.30	−0.93	±1.96
Z-angle	67.88	±7.47	70.11	±7.02	2.22	±4.72
PFH	46.65	±4.55	50.70	±4.51	4.05	±3.09
AFH	64.87	±4.72	67.90	±5.64	3.03	±1.52
$\overline{6\vert 6}$	32.24	±2.28	33.91	±2.63	1.66	±0.96
$\overline{1\vert 1}$	42.01	±2.80	43.52	±3.37	1.51	±1.02
$\underline{6\vert 6}$	21.83	±2.04	23.79	±2.35	1.95	±1.01
$\underline{1\vert 1}$	29.08	2.84	30.07	±3.18	0.99	±0.84
H $\underline{6\vert 6}$	26.73	3.38	29.59	±3.67	2.85	±1.62
H $\overline{6\vert 6}$	10.77	2.76	9.77	±2.82	−1.00	±1.61
M.R.			2.71	±1.92		

Table 1. Control - Means and Standard Deviations

Means and Standard Deviations
Total Sample
Good Results (40)

	BEFORE	S.D.	AFTER	S.D.	CHANGE	S.D.
FMA	28.17	±4.77	27.7	±4.57	−0.47	±2.07
FMIA	54.73	±6.96	63.52	±4.15	8.78	±6.61
IMPA	97.56	±5.91	88.75	±4.13	−8.81	±6.23
SNA	82.35	±2.96	80.13	±3.59	−2.21	±2.63
SNB	76.67	±2.72	77.35	±3.14	0.67	±1.65
ANB	5.65	±1.80	2.78	±1.68	−2.86	±2.37
Pal. Pl.	1.78	±4.06	2.23	±3.94	0.45	±3.72
Occl. Pl	12.16	±3.49	12.32	±3.56	0.16	±2.98
Z-angle	60.68	±7.29	71.20	±4.12	10.51	±5.09
PFH	43.01	±5.10	47.88	±4.68	4.87	±2.79
AFH	64.31	±4.23	67.57	±4.17	3.26	±2.28
$\overline{6\|6}$	32.21	±2.72	35.13	±3.18	2.92	±1.91
$\overline{1\|1}$	41.78	±3.49	41.64	±2.90	−0.14	±2.53
$\underline{6\|6}$	22.47	±1.95	23.66	±1.97	1.19	±2.09
$\underline{1\|1}$	30.82	±2.88	29.49	±2.68	−1.33	±2.53
H $\underline{6\|6}$	25.32	±3.15	27.77	±3.13	2.45	±2.46
H $\overline{6\|6}$	8.06	±2.22	6.02	±2.07	−2.03	±1.95
M.R.			3.87	±2.40		

Table 2. Successful - Means and Standard Deviations

Means and Standard Deviations
Total Sample

Poor Results (16)

	BEFORE	S.D.	AFTER	S.D.	CHANGE	S.D.
FMA	31.87	±4.54	34.84	±6.82	2.96	±3.10
FMIA	58.56	±6.33	57.65	±7.24	−0.90	±6.91
IMPA	89.62	±7.36	87.53	±4.83	−2.09	±5.68
SNA	81.78	±4.52	78.34	±3.26	−3.43	±2.21
SNB	76.06	±4.32	74.43	±3.31	−1.62	±2.24
ANB	5.53	±1.61	3.90	±1.09	−1.62	±1.81
Pal. Pl.	1.34	±3.75	2.65	±4.66	1.31	±4.40
Occl. Pl.	13.25	±2.88	16.37	±4.43	3.12	±3.30
Z-angle	60.91	±9.41	64.78	±6.71	3.86	±5.87
PFH	42.59	±4.27	46.13	±5.24	3.53	±4.21
AFH	63.61	±4.41	70.96	±5.44	7.35	±4.68
$\overline{6|}\,6$	31.03	±2.20	35.81	±2.34	4.77	±2.02
$\overline{1|}\,1$	40.41	±3.37	43.26	±3.57	2.85	±4.33
$\underline{6|6}$	21.80	±2.39	24.25	±2.60	2.45	±2.11
$\underline{1|1}$	30.31	±2.44	31.12	±2.98	0.80	±2.45
H $\underline{6|6}$	24.21	±3.71	24.50	±4.34	0.28	±2.94
H $\overline{6|}\,6$	8.03	±3.00	5.71	±2.35	−2.31	±2.58
M.R.			2.37	±2.41		

Table 3. Unsuccessful - Means and Standard Deviations

Means of the Differences
Control

	MEANS	S.D.	P (N=44)	RESPONSE
FMA	−1.42	±1.28	.00	Close
FMIA	1.12	±2.62	.00	Increase
IMPA	−0.08	±2.52	.83	NS
SNA	0.67	±0.92	.00	Increase
SNB	0.75	±1.02	.00	Increase
ANB	−0.12	±0.99	.40	NS
Pal. Pl.	−0.19	±1.65	.44	NS
Occl. Pl	−0.93	±1.96	.00	↻
Z-angle	2.22	±4.72	.00	Increase
PFH	4.05	±3.09	.00	Increase
AFH	3.03	±1.52	.00	Increase
$\overline{6\|6}$	1.66	±0.96	.00	↑
$\overline{1\|1}$	1.51	±1.02	.00	↑
$\underline{6\|6}$	1.95	±1.01	.00	↓
$\underline{1\|1}$	0.99	±0.84	.00	↓
H $\underline{6\|6}$	2.85	±1.62	.00	→
H $\overline{6\|6}$	−1.00	±1.61	.00	→
M.R.	2.71			→

Table 4. Control - Means of the Differences

Means of the Differences
Successful

	MEANS	S.D.	P (N=40)	RESPONSE
FMA	−0.47	±2.07	.15	NS
FMIA	8.78	±6.16	.00	Increase
IMPA	−8.81	±6.23	.00	Upright
SNA	−2.21	±2.63	.00	Decrease
SNB	0.67	±1.65	.01	Increase
ANB	−2.83	±2.37	.00	Decrease
Pal. Pl.	0.45	±3.72	.45	NS
Occl. Pl.	0.16	±2.98	.73	NS
Z-angle	10.51	±5.09	.00	Increase
PFH	4.87	±2.79	.00	Increase
AFH	3.26	±2.28	.00	Increase
$\overline{6 \vert 6}$	2.92	±1.91	.00	↑
$\overline{1 \vert 1}$	−0.14	±2.53	.71	NS
$\underline{6 \vert 6}$	1.19	±2.09	.00	↓
$\underline{1 \vert 1}$	−1.33	±2.53	.00	↑
H $\underline{6 \vert 6}$	2.45	±2.46	.00	→
H $\overline{6 \vert 6}$	−2.03	±1.95	.00	→
M.R.	3.87			→

Table 5. Successful - Means of the Differences

Means of the Differences
Unsuccessful

	MEANS	S.D.	P (N = 16)	RESPONSE
FMA	2.96	±3.10	.00	Opens
FMIA	−0.90	±6.91	.60	NS
IMPA	−2.09	±5.68	.16	NS
SNA	−3.43	±2.21	.00	Decrease
SNB	−1.62	±2.24	.01	Decrease
ANB	−1.62	±1.81	.00	Decrease
Pal. Pl.	1.31	±4.40	.25	NS
Occl. Pl	3.12	±3.30	.00	↻
Z-angle	3.86	±5.87	.01	Increase
PFH	3.53	±4.21	.00	Increase
AFH	7.35	±3.25	.00	Increase
$\overline{6\,|\,6}$	4.77	±2.02	.00	↑
$\overline{1\,|\,1}$	2.85	±4.33	.01	↑
$\underline{6\,|\,6}$	2.45	±2.11	.00	↓
$\underline{1\,|\,1}$	0.80	±2.45	.20	NS
H $\underline{6\,|\,6}$	0.28	±2.94	.70	NS
H $\overline{6\,|\,6}$	−2.31	±2.58	.00	→
M.R.	2.37			→

Table 6. Unsuccessful - Means of the Differences

Means of the Differences
Successful

	MEANS	S.D.	P (N=40)	RESPONSE
FMA	−0.47	±2.07	.15	NS
FMIA	8.78	±6.16	.00	Increase
IMPA	−8.81	±6.23	.00	Upright
SNA	−2.21	±2.63	.00	Decrease
SNB	0.67	±1.65	.01	Increase
ANB	−2.83	±2.37	.00	Decrease
Pal. Pl.	0.45	±3.72	.45	NS
Occl. Pl	0.16	±2.98	.73	NS
Z-angle	10.51	±5.09	.00	Increase
PFH	4.87	±2.79	.00	Increase
AFH	3.26	±2.28	.00	Increase
$\overline{6\vert 6}$	2.92	±1.91	.00	↑
$\overline{1\vert 1}$	−0.14	±2.53	.71	NS
$\underline{6\vert 6}$	1.19	±2.09	.00	↓
$\underline{1\vert 1}$	−1.33	±2.53	.00	↑
H $\underline{6\vert 6}$	2.45	±2.46	.00	→
H $\overline{6\vert 6}$	−2.03	±1.95	.00	→
M.R.	3.87			→

Table 5. Successful - Means of the Differences

ly significant. All other skeletal and dental changes were statistically significant after the growth period.

In the successfully treated sample the FMA, palatal plane, occlusal plane and height of the mandibular incisor all remained the same. All other variables changed in a direction complimentary to growth with the exception of SNA and maxillary incisor position. These changed in a direction opposite of growth but favorable to treatment goals.

In the unsuccessful treatment group there was no significant change in the FMIA, IMPA, palatal plane, height of the upper incisor and mesial movement of the maxillary molar. It is of interest that three variables, FMA, SNB, and occlusal plane, significantly changed, but in directions opposite to normal growth and opposite to treatment goals.

Tables 7, 8, and 9 provided the differences of the means between the samples:

Control versus successful comparison
1. There was no significant difference between the means of the control and successful samples in the SNB, palatal plane, PFH, AFH and mesial movement of maxillary molars.
2. Significant changes:
   a) FMA - the control closed more than in the successfuls.
   b) FMIA, IMPA, SNA, ANB and the Z-angle all changed in favorable directions relative to treatment goals.
   c) Occlusal plane. Counterclockwise change was noted in the control. There was no change in the successful sample.

Control versus unsuccessful comparison
1. No significant difference was seen between the control and unsuccessful samples with respect to FMIA, IMPA, Z-angle, PFH, maxillary molar vertical change, maxillary incisor vertical change and mandibular response.
2. The FMA, SNB, palatal plane, occlusal plane, AFH, mandibular molar and mandibular incisor all changed in direction or magnitude opposite of the desired treatment response.

Successful versus unsuccessful comparison
1. No significant difference was found between the samples with respect to SNA, ANB, palatal plane, PFH, and mesial movement of mandibular molars.
2. FMA, FMIA, IMPA, SNB, occlusal plane, Z-angle, AFH and all dental values except horizontal mandibular molar changes were significantly different between the samples with respect to direction and/or magnitude.

Results

Directional force systems were designed by Dr. Merrifield with the expectation that the direction of treatment response would be in close harmony with normal growth response. Deviation from normal response, should be favorable to treatment goals. The uniqueness of the data collected shows changes in each variable during normal growth of the Class II and Class I bimaxillary protrusion malocclusions. Those changes are compared to the treatment response in samples exhibiting successful and unsuccessful results.

The discussion in part 1 of this study will concentrate primarily on the effects of dental changes.

Effects of the Maxillary and Mandibular Molar Responses (Figure 3).

Vertical Response: In the control sample the maxillary molars erupted 1.9 millimeters on average. The mandibular molar average eruption was 1.6 millimeters. The combined vertical increase of the molars in this control group was 3.5 millimeters. In the successfully treated sample the vertical increase of the maxillary molars was 1.19 millimeters and the mandibular molar was 2.9 millimeters for a combined vertical increase of 4.1 millimeters. In the unsuccessfully treated sample the maxillary molar increase averaged 2.45 millimeters while the mandibular molar increase was 4.77 millimeters. The combined vertical increase was 7.2 millimeters.

The vertical changes in the molar area paralled the FMA and SNB responses in the

Differences of the Means
Control - Successful

	P (N=84)	RESPONSE
FMA	.01	Control — Closes more
FMIA	.00	Success — Increases
IMPA	.00	Success — Uprights
SNA	.00	Success — Reduces
SNB	.81	NS
ANB	.00	Success — ←
Pal. Pl.	.30	NS
Occl. Pl.	.04	Opposite Directions
Z-angle	.00	Success — Improves
PFH	.20	NS
AFH	.58	NS
$\overline{6\|6}$	.00	Success ↑
$\overline{1\|1}$	.00	Control ↑
$\underline{6\|6}$	.03	Control ↓
$\underline{1\|1}$	.00	Control ↓ Success ↑
H $\underline{6\|6}$	.37	NS
H $\overline{6\|6}$	.01	Success →
M.R.	01	Success →

Table 7. Control - Differences of the Means

Differences of the Means
Control - Unsuccessful

	P (N=60)	RESPONSE
FMA	.00	Unsuccessful Opens
FMIA	.10	NS
IMPA	.06	NS
SNA	.00	Unsuccessful — Reduces
SNB	.00	Unsuccessful ←
ANB	.00	Unsuccessful ←
Pal. Pl.	.05	Unsuccessful ↷
Occl. Pl.	.00	Unsuccessful ↷
Z-angle	.27	NS ↑
PFH	.60	NS ↑
AFH	.00	Unsuccessful — Increases
$\overline{6 \rceil 6}$	.00	Unsuccessful
$\overline{1 \rceil 1}$	.05	Unsuccessful
$\underline{6 \rfloor 6}$	.22	NS
$\underline{1 \rfloor 1}$	.65	NS
H $\underline{6 \rfloor 6}$	.00	Control →
H $\overline{6 \rceil 6}$	.02	Unsuccessful →
M.R.	57	NS

Table 8. Successful - Differences of the Means

Differences of the Means
Successful - Unsuccessful

	P (N=56)	RESPONSE
FMA	.00	Unsuccessful Opens
FMIA	.00	Success — Increases
IMPA	.00	Success — Uprights
SNA	.10	NS
SNB	.00	Unsuccessful ←
ANB	.06	NS
Pal. Pl.	.46	NS
Occl. Pl.	.00	Opposite Directions
Z-angle	.00	Success — Improves
PFH	.17	NS
AFH	.00	Unsuccessful — Increases
$\overline{6|6}$	.00	Unsuccessful ↑
$\overline{1|1}$	.00	Unsuccessful ↑
$\underline{6|6}$	.04	Unsuccessful ↓
$\underline{1|1}$	.00	Success ↑
H $\underline{6|6}$	.00	Success →
H $\overline{6|6}$	.66	NS
M.R.	04	Success — Forward

Table 9. Unsuccessful - Differences of the Means

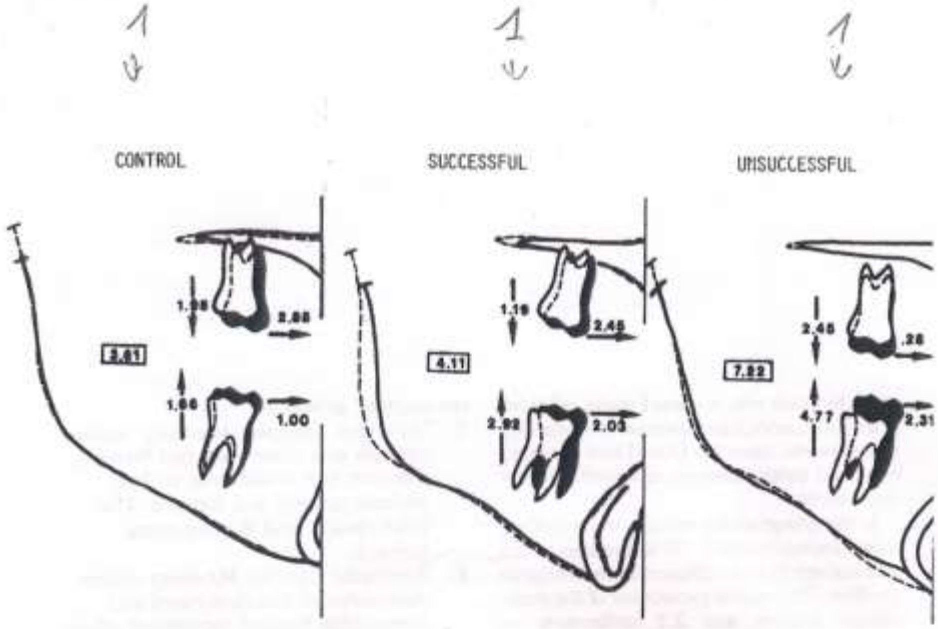

Figure 3. Effects of Maxillary and Mandibular Molar Response

three samples. The FMA in the untreated sample significantly closed 1.4° with a 3.5 millimeters vertical molar increase. The SNB significantly increased. *Therefore, the normal untreated growth response of the mandible is to close vertically and advance forward.* The FMA in the successful sample statistically remained the same by exhibiting a .47° closure with a 4.1° millimeters total molar increase. The SNB came forward to a statistically significant degree.

It is important to point out that *directional force mechanics significantly inhibit normal vertical development of the maxillary molars in successful treatment.* The FMA remained the same or changed in directions consistent with normal growth.

The FMA in the unsuccessful sample significantly opened 2.96° and B point dropped back 1.6° when a 7.2 millimeter total molar increase occurred. By comparing these figures to the non-treated sample, there is a 3.7 millimeters greater vertical increase than that of normal growth resulting in a 4.36° FMA differential response. In these unsuccessful cases, the vertical response of the molars resulted in an FMA change that was *not* in harmony with normal growth direction.

It should be pointed out that in the two treatment samples, vertical response was affected by leveling the curve of Spee and mesial relocation of the molars due to extractions. The growth sample maintains its curve of Spee, since leveling is not a factor.

Horizontal response: In the untreated sample, the maxillary molar moves mesially 2.8 millimeters while the mandibular molar moved mesially 1 millimeter. One would expect minimal mesial mandibular molar movement since there were no extractions in this sample. These dental measurements would suggest a worsening of the Class II molar relationship. Since the dental relationships remained the same, compensatory growth factors acted to maintain original relationships.

In the successful sample, the maxillary molar moved mesially 2.45 millimeters and the mandibular molar moved mesially 2 millimeters. Horizontal maxillary molar change was similar in magnitude and direction to the untreated sample. However, mandibular molar mesial response was greater than the untreated normals primarily due to the extraction of teeth. For these cases to finish with a Class I molar relation, a mesial mandibular resonse to treatment was essential since the Class I had not been achieved solely through differential molar movement.

In the unsuccessful sample, the maxillary molar moved mesially .28 millimeters which was not significantly different from its original position. The mesial movement of the mandibular molars was 2.3 millimeters — significantly more than the normals and about the same as the successful groups. This mandibular mesial movement was allowed due to extractions, and due to minor incisor repositioning as seen in the minimal IMPA change. The increased vertical molar changes found in this sample reversed the normal forward growth response of the mandible and forced the Class I corrections to be achieved soley through dental movements.

The vertical and horizontal responses of the maxillary and mandibular molars can be summarized as follows:

1. Untreated Sample. Maxillary molars relocate in a downward and forward direction and mandibular molars relocate upward and forward. The FMA closed, and B point came forward.
2. Successful Sample. Maxillary molars demonstrated less downward and comparable forward movement when compared to the untreated normals. The FMA remained the same, and B point came forward.
3. Unsuccessful Sample. Maxillary molars relocated significantly downward and minimally forward when compared to the untreated normals. The FMA opened, while B point moved backward.

Effects of the Mandibular Incisor Vertical and Horizontal Response (Figure 4)

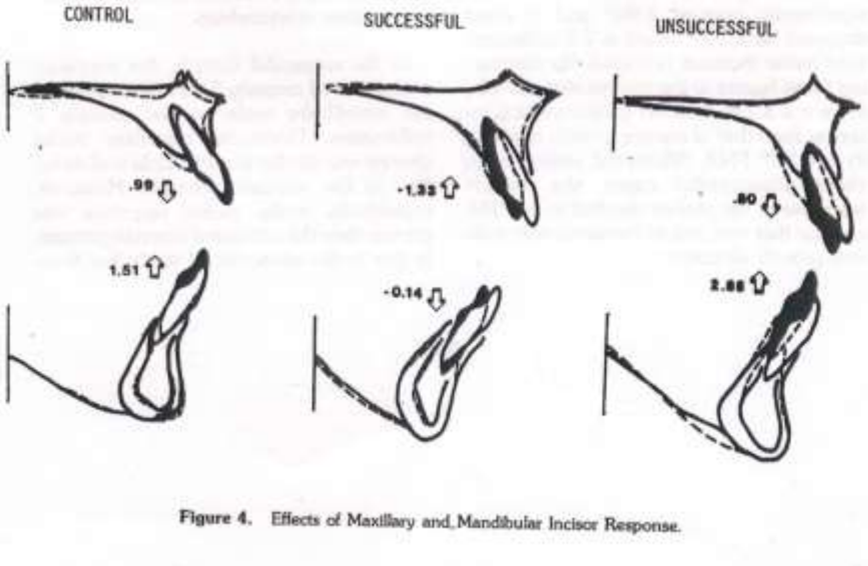

Figure 4. Effects of Maxillary and Mandibular Incisor Response.

Untreated Sample. The mandibular incisor significantly erupted 1.51 millimeters. The horizontal change was nonexistent as demonstrated by no change in the IMPA. Minimal FMIA changes were a result of closure of the FMA.

Successful Sample. The vertical change in mandibular incisor position was insignificant. However the horizontal change of the mandibular incisor was very significant as demonstrated by the $-8.8°$ change in the IMPA. The lingual uprighting of the mandibular incisors produced a significant positive response in the FMIA that allowed a favorable facial change to occur.

Unsuccessful Sample. The vertical change in the mandibular incisor was 2.85 millimeters, 1.31 millimeters more than observed during normal growth. Excessive vertical response of the mandibular incisor is necessary to compensate for the significant increase in AFH which occurred in unsuccessful treatment. There was minimal lingual horizontal change of the mandibular incisor as demonstrated by the IMPA change of $-2.09°$. This small lingual movement of the mandibular incisor together with the opening of the FMA prevented changes in the FMIA; only one degree in this group. The resultant effect produces little change in the Z-angle and, therefore, no facial change occurs.

Effects of the Maxillary Incisor Vertical and Horizontal Response

Untreated Sample. The maxillary incisor erupted .99 millimeters downward and forward in the untreated sample. There was no significant change in the palatal plane. The occlusal plane significantly changed in a counterclockwise direction (Figure 5).

Successful Sample. The maxillary incisor was intruded 1.33 millimeters while being retracted. There is a corresponding SNA decrease of 2.2°. The palatal and occlusal planes remained the same. For the maxillary incisor to relocate in a direction opposite to normal growth, a number of variables had to be maintained or improved to enhance

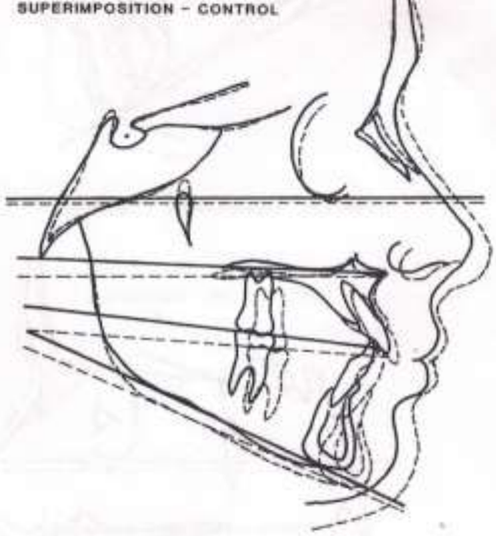

Figure 5. Superimposition - Control

4 copie

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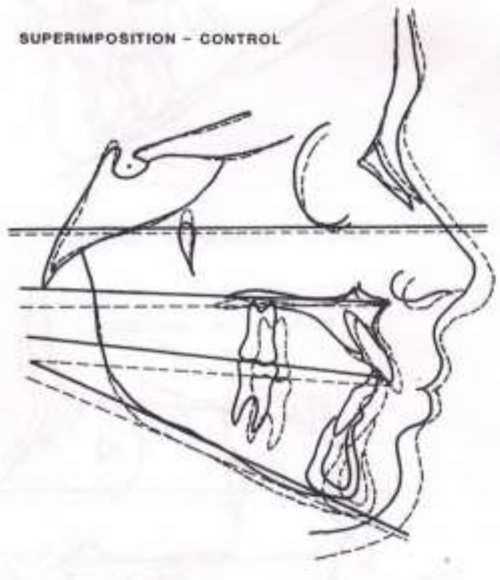


Figure 5. Superimposition - Control

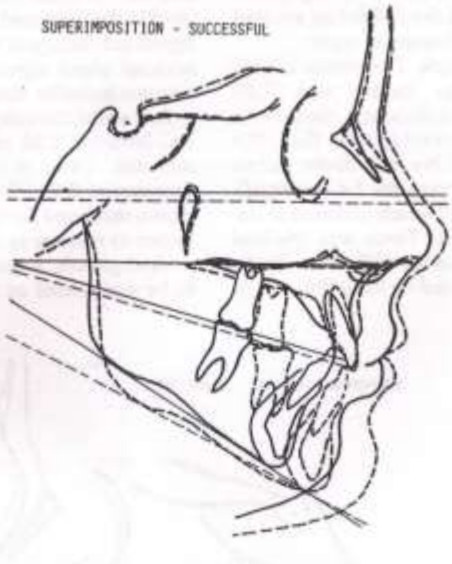


Figure 6. Superimposition - Successful

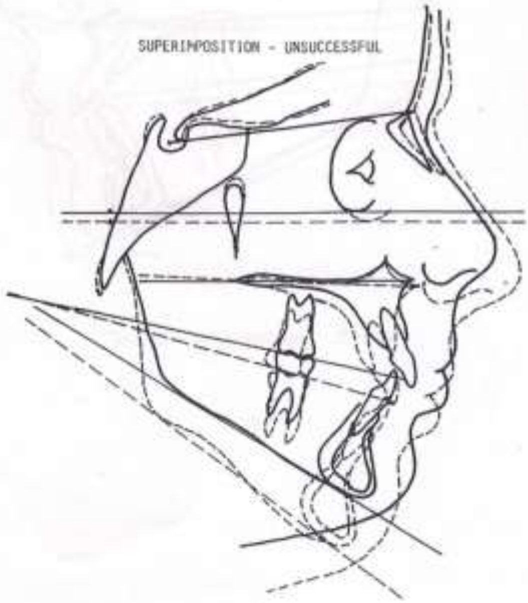


Figure 7. Superimposition - Unsuccessful

a more balanced dento-facial response (Figure 6):

FMA - was maintained or closed slightly.
FMIA - increased.
IMPA - decreased.
SNB - increased.

The palatal and occlusal planes remained the same.

Changes in the maxillary and mandibular molars should not exceed normal growth parameters and should be prevented from approaching normal eruptive values.

Lower incisor vertical height should be maintained.

It is apparent that in the treatment of Class II and Class I bimaxillary protrusion malocclusions, maxillary incisor directional control is the key to success. It can be achieved if a range of variables have responded favorably to proper directional management and control.

Unsuccessful Sample. The maxillary incisor responded to treatment in a downward direction. The magnitude with which the maxillary incisor responded is not significant. Of significance is the fact that it could not be intruded due to the additive effect of multiple directional changes not found to be in harmony with the normal growth response (Figure 7). To illustrate, the following changes have influenced these unsuccessful responses:

The FMA opened significantly due to the excessive vertical response of the mandibular molars and, to a lesser extent, the maxillary molars. The AFH responded by significantly increasing beyond the normal growth response.

SNB responded by relocating backward rather than forward.

The IMPA could not be reduced because the Class II molar relation was worsening. Space needed for IMPA improvement was utilized by the mesial relocation of the molars.

The occlusal plane changed in a clockwise direction preventing maxillary incisor intrusion.

Mandibular incisor extrusion had to occur to prevent an anterior open bite.

No change in IMPA.

Minimal Z-angle improvement resulting from lack of FMIA change.

Discussion

There can be many causes for an unsuccessful treatment response. Some are mouth-breathing habits, weak musculature, poor patient cooperation during anchorage preparation, lack of high-pull headgear wear to the maxillary anterior segment of the denture, and improper diagnosis and treatment planning. It is clear that use of the high-pull headgear is paramount for successful

CONTROL

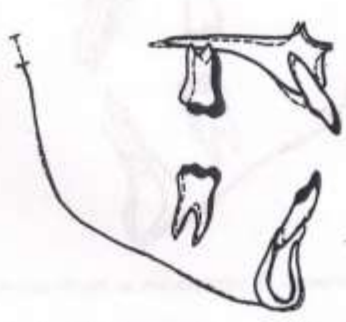


Figure 8. Control - Superimposition on Maxilla and Mandible

SUCCESSFUL

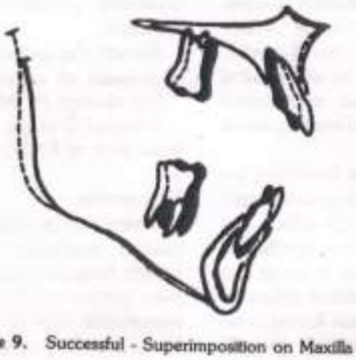


Figure 9. Successful - Superimposition on Maxilla and Mandible

UNSUCCESSFUL

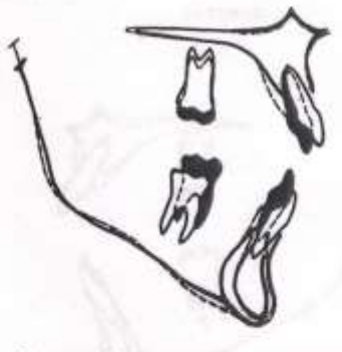


Figure 10. Unsuccessful - Superimposition on Maxilla and Mandible

treatment.

Minimal high-pull headgear wear to the maxillary anterior area of the denture forces the practitioner to obtain a Class I molar relationship through the extensive use of Class II and vertical elastics. These auxiliaries used for long periods will excessively tax mandibular anchorage, extruding the mandibular molars beyond normal limits. This type of treatment relies on a clockwise rotation of the occlusal plane to achieve a Class I dental relationship. It produces no facial improvement and guarantees relapse, since all posttreatment studies suggest that the occlusal plane changes directionally to its pretreatment value.

Figures 8, 9, and 10 display the superimposition once again on the maxilla and mandible. A profile of these samples suggests the following:

Control, or Normal Growth. The maxillary molar descends more than the man-

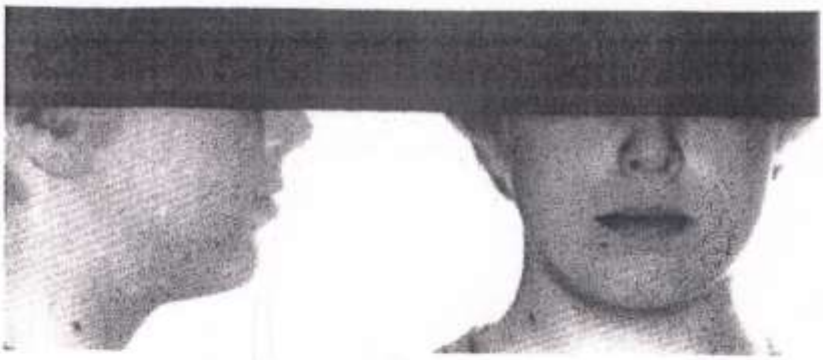


Figure 11. Facial Photographs - Before Treatment

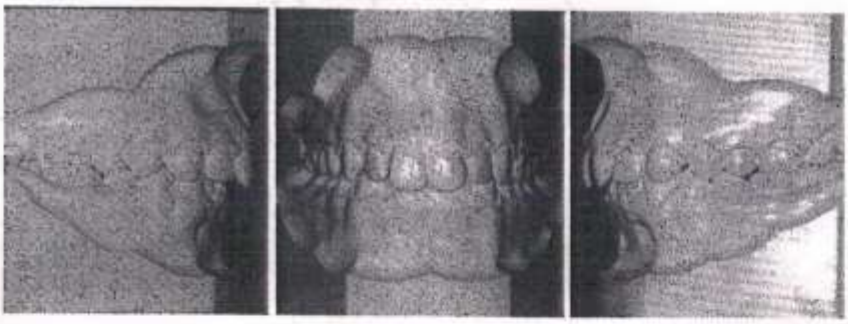


Figure 12. Pretreatment Models

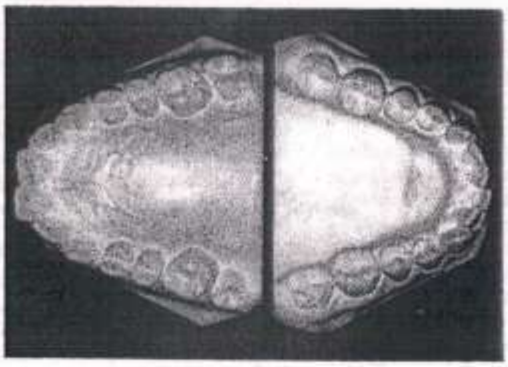


Figure 13. Pretreatment - Occlusal View

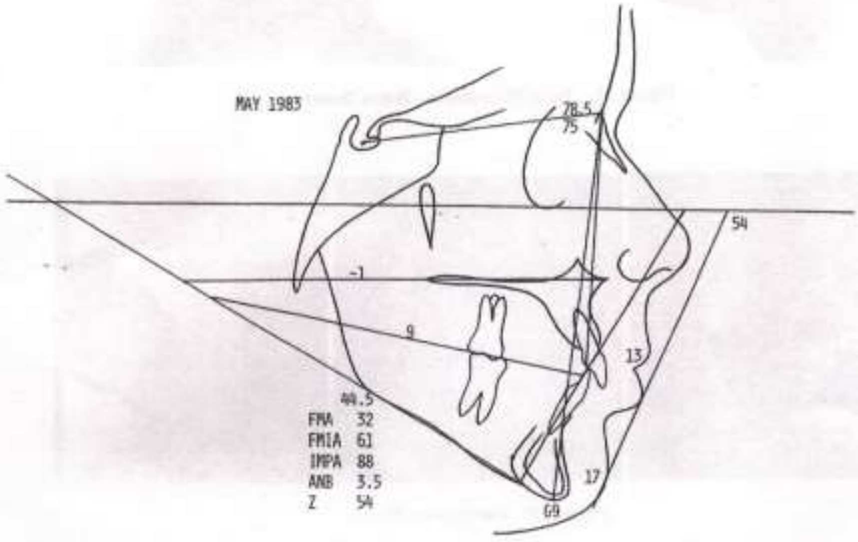


Figure 14. Pretreatment Headfilm Tracing

dibular molar erupts and the mandibular incisor erupts more than the maxillary incisor descends. The result is a counterclockwise change in the occlusal plane.

Successful Treatment. The maxillary molar descends less than the mandibular molar erupts and the maxillary incisor intrudes while the mandibular incisor remains the same. The occlusal plane remains the same and will rotate counterclockwise only if the lower molar and maxillary incisor are successfully controlled.

Unsuccessful Treatment. The maxillary molar descends less than the mandibular molar extrudes and both to a greater degree than during normal growth. The mandibular incisor extrudes more than the maxillary incisor descends. The magnitude of these changes force a clockwise rotation of the occlusal plane.

Conclusion

It is apparent from this study that the orthodontic specialist must be able to control individual dental elements of the denture as well as groups of dental elements. This control drastically influences the growth and development of the immature patient.

Two treated cases are shown, one selected from the unsuccessful sample, and one from the successful sample. The first case, from the unsuccessful sample, presents a young boy that has an acceptable profile but exhibits moderate fullness to his lips, with a retrognathic chin (Figure 11). The models before treatment present a Class I dental malocclusion exhibiting an excessive overjet and overbite (Figure 12). The occlusal view (Figure 13) displays moderate maxillary and mandibular crowding. The initial headfilm (Figure 14) shows the case was a high angle problem with FMA 32°, FMIA 61°, IMPA 88°, SNA 78.5°, SNB 75°, and Z-angle 54°.

The patient and his parents wanted treatment to "correct his protruding teeth" and "straighten the lower front teeth." Since the crowding was not that severe and the case was a dental Class I, non-extraction treatment was attempted. The family was advised that this minimally appearing dental problem was in fact quite challenging to treat

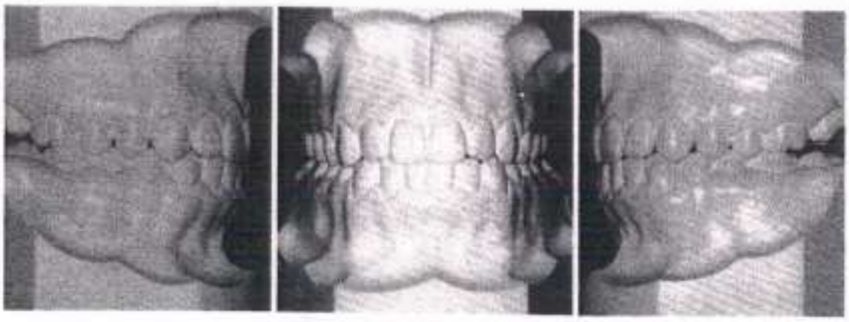


Figure 15. Posttreatment Models

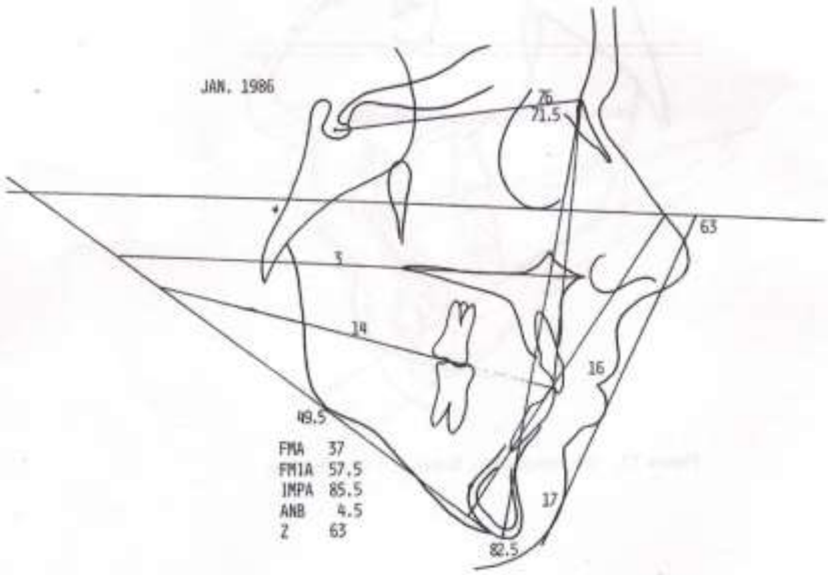


Figure 16. Posttreatment Headfilm Tracing

and would require excellent patient cooperation if treatment goals were to be achieved.

The immediate posttreatment models testify that an excellent dental occlusion was achieved (Figure 15).

A review of the cephalometric tracings reveals a tragedy (Figure 16). The FMA increased from 32° - 37°, FMIA decreased from 61° - 57°, and IMPA decreased from 88° - 85.5°. SNA went from 78.5° -76°, but SNB decreased from 75° - 71.5°, while Z-angle increased only 54° to 63°. There was an increase in PFH from 44.5 to 49.6 millimeters, and AFH increased from 69.3

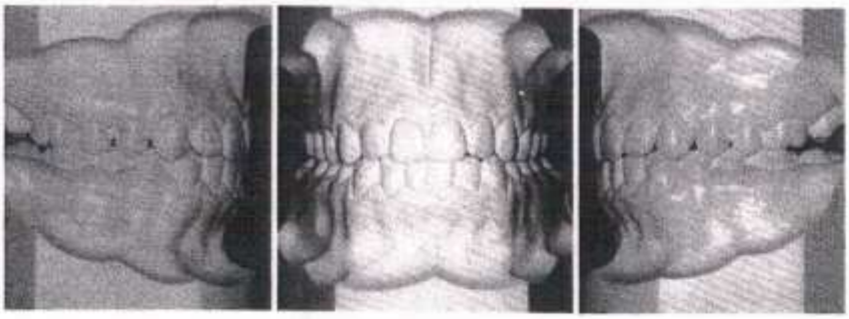
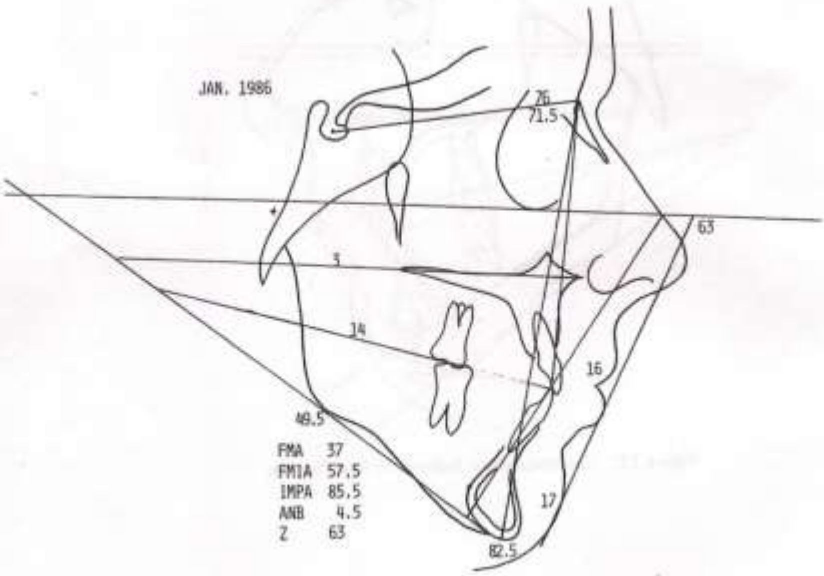


Figure 15. Posttreatment Models



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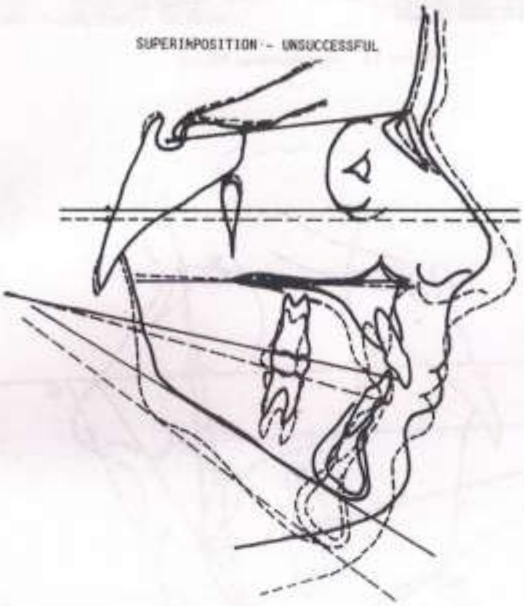

Figure 17. Superimposition: Before and After Tracings

UNSUCCESSFUL

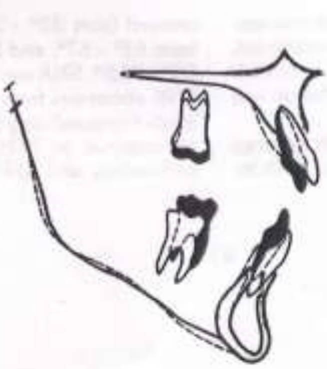

Figure 18. Superimposition on Maxilla and Mandible

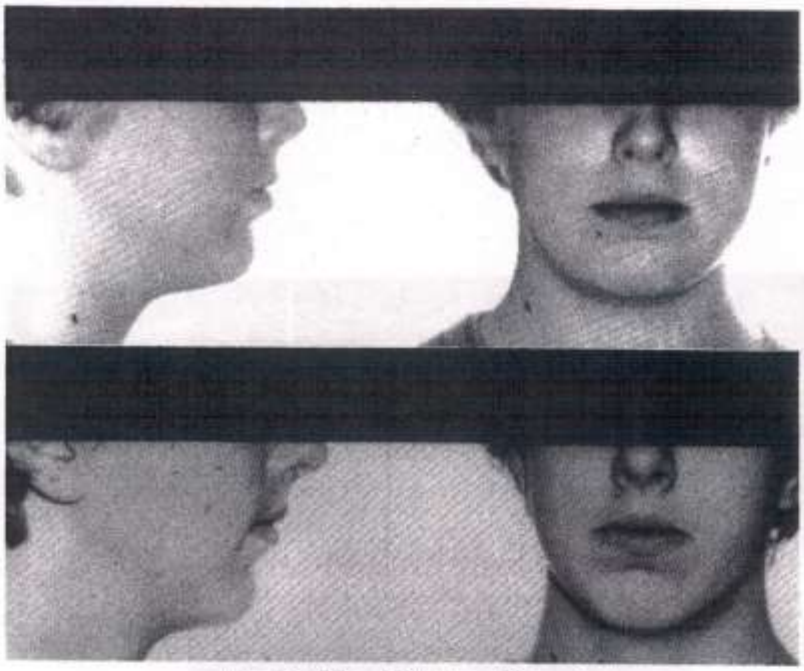

Figure 19. Pre and Posttreatment Photographs

Figure 20. Pretreatment Photographs

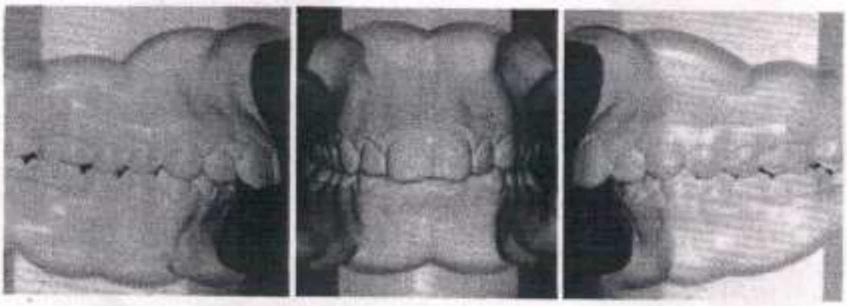

Figure 21. Pretreatment Models

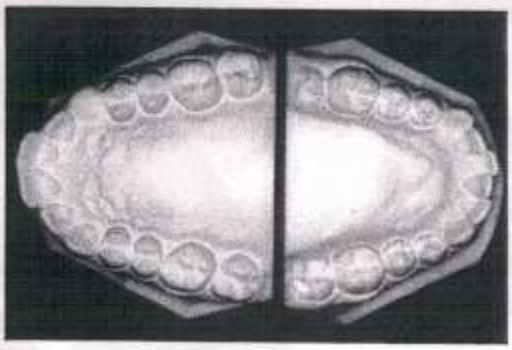

Figure 22. Pretreatment Occlusal View

to 82.5 millimeters. The palatal, occlusal and mandibular planes had rotated clockwise (Figure 17). Superimposition on the maxilla and mandible show that extrusion of all teeth beyond normal growth parameters has caused this negative result (Figure 18). After the fact, one could blame this result on mouthbreathing, poor cooperation, weak musculature or many other reasons, but ultimately, the primary cause must be addressed—improper diagnosis.

This case, if treated comprehensively in the first place, would be a second bicuspid extraction case. The effect of non-extraction treatment on the face is demonstrated in Figure 19. How many cases are being treated today where dental values are paramount and more important values are being ignored? Much can be learned from this case.

A more successful result was achieved for this little girl in figure 20. She was a Class II Division I bimaxillary protrusion problem. Her lips are very protrusive, distorting this pretty face.

The pretreatment models show a Class II dental relationship with an extreme overjet and impinging overbite (Figure 21). The occlusal view shows moderate mandibular crowding (Figure 22).

The cephalometric tracings reveal a lower mandibular angle case with a protrusive maxilla (Figure 23). The mandible was in a good relationship, but the maxillary anterior teeth were very protrusive. The case was diagnosed properly when upper first

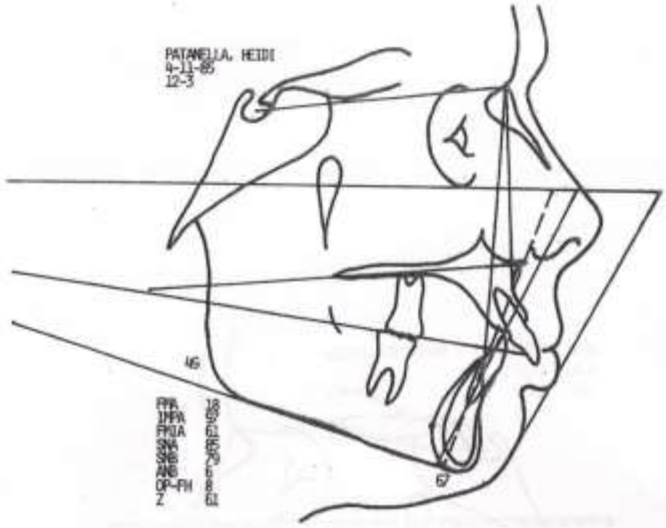

Figure 23. Pretreatment Headfilm Tracing

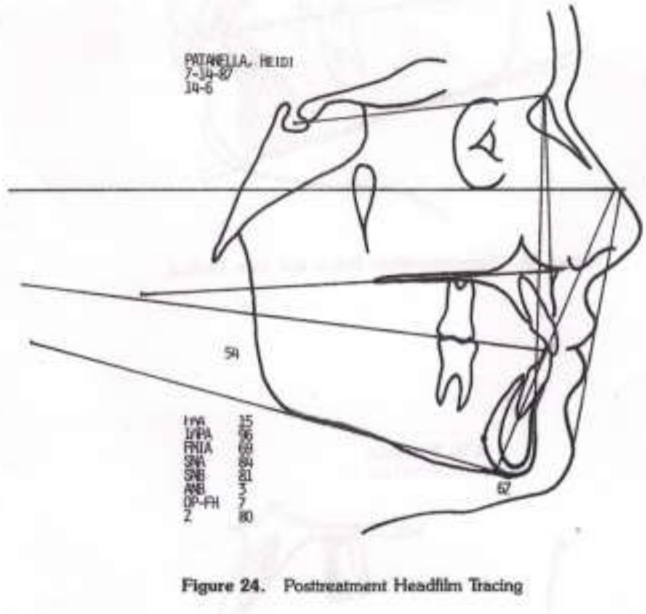

Figure 24. Posttreatment Headfilm Tracing

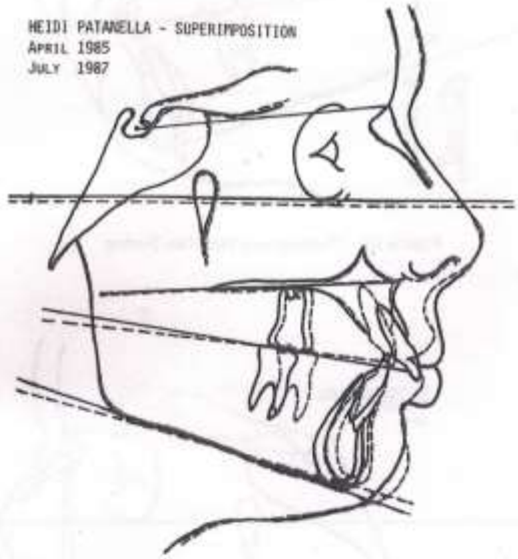

Figure 25. Superimposition: Before and After Tracings

Figure 26. Superimposition on Maxilla and Mandible

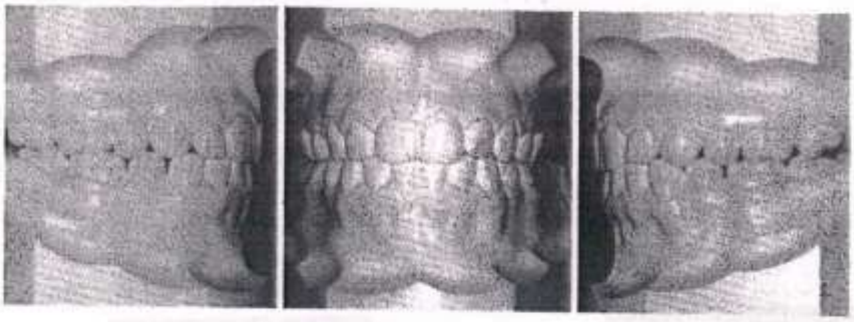

Figure 27. Posttreatment Models

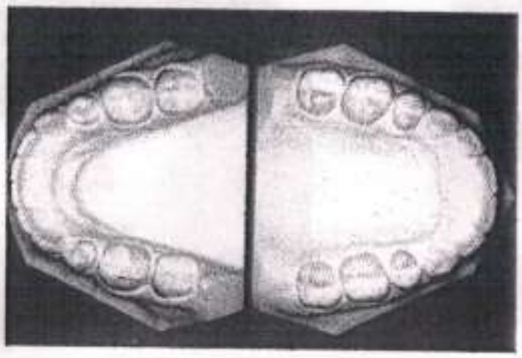

Figure 28. Posttreatment Occlusal View

bicuspid and lower second bicuspids were extracted. The treatment plan followed the protocol for such cases as taught at the Tweed course in Tucson. The posttreatment tracing reveals that the occlusal and mandibular planes rotated in a counterclockwise direction and the maxillary incisors were significantly intruded and retracted (Figure 24).

Superimpositions on the maxilla and mandible and before and after tracings show how these changes were facilitated (Figures 25 and 26). Note the minimal extrusion of the maxillary and mandibular molars and the substantial intrusion and retraction of the maxillary incisors. This was accomplished by proper anchorage preparation and superb high-pull headgear wear to the maxillary incisors.

The models after treatment show good dental relationships (Figure 27). The occlusal views display that original arch form has been maintained (Figure 28). The before and after facial photographs reveal that excellent facial balance has been achieved (Figure 29). She has a beautiful smile that accompanies her functional teeth.

This study clearly supports the view that orthodontic mechanics influence the dynamic development of skeletal and dental relationships. Direction of growth can be influenced to deviate from the normal course

Figure 29. Pre and Posttreatment Photographs

of development. Such deviation can be positive or negative relative to treatment objectives. Therefore, it becomes imperative that *diagnostic and treatment efforts* be constantly refined to produce more consistent positive effects.

660 Cadieux Road
Grosse Pointe, Michigan 48230

Analysis - Concepts and Values
Part II

L. Levern Merrifield, D.D.S., M.S.D.

Introduction

With the aid of the information reported in Part I, some interesting and valuable information has become apparent. The non-orthodontic treatment sample should be available to every serious orthodontic student so that an evaluation of dental and skeletal relationships can be made in patients of a similar age, before, during and after orthodontic treatment.

The data accumulated on less successful orthodontic treatment results is also very significant; the dental and skeletal values can be studied and evaluated and an interpretation made for both cause and effect.

The sample of successfully treated orthodontic patients gives information that needs careful analysis and interpretation. It can be used as a standard of performance and even a standard of perfection for the orthodontist who is sincerely interested in delivering a superior orthodontic service.

This data will be analysed as to its clinical significance according to the concepts of the teaching program of the Tweed Foundation. Dr. Tweed introduced the original philosophy of uprighting the incisors to improve stability of the denture and to achieve the maximum in balance and harmony of facial lines. He also taught that placing all the teeth upright over basal bone improved dental health and function; he originated the concept of anchorage preparation to improve denture control. Subsequently, dimensions of the denture, dimensions of the lower face, and new concepts in differential diagnosis and space analysis have been introduced. These concepts have led to more precise guidelines in diagnosis, treatment timing, and force systems application, including modern concepts of anchorage preparation and denture control.

It is incumbent to continually analyze treatment in light of present knowledge and experience. One important concept is that orthodontic treatment must be harmonious with normal growth and developmental patterns. Likewise, treatment must improve or compensate the less normal patterns. This is a serious responsibility for the orthodontic specialist since most patients are experiencing growth and development during treatment. It is also equally important on the non-growing patient to improve facial harmony, stability, health, and function of the areas under treatment influence.

Presented before the Seventeenth Biennial Meeting of the Charles H. Tweed International Foundation for Orthodontic Research; Washington, D.C., October 25, 1988.

Method

Eighteen measured values were selected which were important in analyzing each sample. In part I, various dental relationships and their influence on developmental changes have been described, as well as those changes influenced by orthodontic force systems. Like groups have been compared in these samples, but it is very apparent that each individual has a unique and singular pattern of development. Not one individual actually has developmental or growth changes that correspond to the means when more than one value is studied. There are so many variables that affect each sample, one must approach any study of living people with some trepidation.

The clinical relationship and analysis of these samples will be discussed in relation to the significant changes that occur in an approximate time frame of two and one half years and in relation to the significant differences between the three groups.

The values that are very familiar include the Frankfort mandibular angle (FMA), the incisor mandibular plane angle (IMPA), the Frankfort mandibular incisor angle (FMIA), the sella-nasion A point angle (SNA), the palatal plane, the occlusal plane and the Z-angle. These values are used constantly in diagnosis, treatment, and posttreatment analysis in the Tweed Foundation philosophy. They give a concept of both horizontal and vertical relationships that are critical to a better understanding of the patient and any necessary orthodontic service. They also give guidance in designing force systems that allow a harmonious response in growing children.

Anterior Facial Height and Posterior Facial Height

Some years ago, in a study of dimensions of the lower face, I pointed out the value of an anterior facial height measurement. The study was composed of samples from my practice and from Dr. Tweed's practice. I was attempting to develop a value that gave a better understanding to the vertical proportion of the lower face. The study indicated the mean anterior lower facial height measured from menton perpendicular to palatal plane should be around seventy millimeters at maturity with the female about five millimeters less and the male about five millimeters more. These values would be proportionally less in the immature patient. In the Michigan growth sample of non-orthodontic youngsters, the twelve year mean was 64.88 millimeters or about 65 millimeters and the fourteen year mean was 67.91 millimeters or about 68 millimeters. One would expect that original study of samples from Dr. Tweed's and my files would be closely paralleled by this group at maturity.

This value has been used for about fifteen years as a guide to the vertical proportion of the lower face. Its real clinical relevance had been missed until Ghislaine Radzimin-ski in her excellent paper, The Control of Horizontal Planes in Class II Treatment,[1] pointed out the significance of ramal height measurement in controlling the three horizontal planes: the palatal, the occlusal and the mandibular. She used (Ar-Go) articulare-gonion as a millimeter value.

Findings

The measurement used in this study is from articulare to mandibular plane tangent to the posterior border of the mandible. It is referred to as posterior facial height. Posterior facial height (PFH) and anterior facial height (AFH) are two vertical values that when related to each other and to dental movements, especially extrusive or vertical movements, have great significance (Figure 1). Figure 2 shows that an average for PFH is 46.65 millimeters and AFH is 64.87 millimeters at age twelve on the non-orthodontic control group, a difference of 18.22 millimeters. Two years later these measurements were 50.70 millimeters PFH and 67.90 millimeters AFH, a difference of 17.2 millimeters. Stated more simply, (Figure 3) the PFH increased 4.05 millimeters and AFH increased 3.03 millimeters or 1.02 millimeters more PFH than AFH. This accounted for the drop in FMA that is a natural developmental process in normal growth, and would be complimentary to Class I bimaxillary protrusion and Class II Division I malocclusion corrections.

Focusing on the unsuccessful treatment sample (Figure 2), the mean PFH before

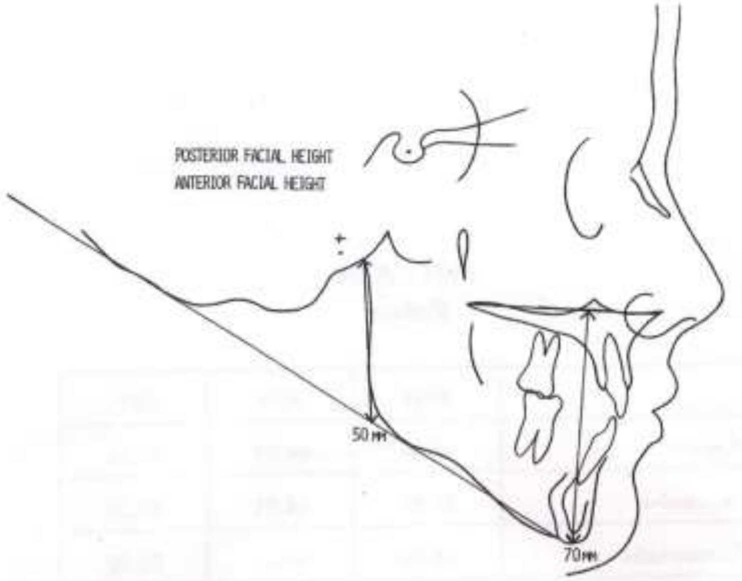

Figure 1. Line drawing showing the posterior facial height and the anterior facial height measurements.

treatment was 42.59 millimeters and the AFH was 63.61 millimeters. At treatment conclusion, PFH was 46.13 millimeters and AFH was 70.96 millimeters; a difference of 21.02 millimeters at the beginning and 24.83 millimeters at completion. There was an increase of 3.82 millimeters in AFH (Figure 3). The mean PFH had a 3.53 millimeter increase and AFH was 7.35 millimeters, which resulted in the FMA opening from 31.88 degrees to 34.84 degrees; a most antagonistic response in Class I and Class II treatments.

The increase in anterior facial height and its proportion to posterior facial height had the effect of increasing facial convexity and was the single most important factor in these cases being identified as unsuccessful treatments.

Studying the forty successful treatment sample the average PFH measured 43.01 millimeters and the AFH was 64.31 millimeters at beginning and 47.88 millimeters PFH with a 67.57 millimeters AFH at finish. This gives a differential of 21.3 millimeters at start and 19.69 millimeters at finish. PFH increased 4.87 millimeters and AFH increased 3.26 millimeters or 1.61 millimeters more PFH increase than AFH increase. This response allowed the FMA to close slightly. It parallels the non-orthodontic control sample and is complimentary to successful treatment in bimaxillary protrusion and Class II Division I treatment. It indicates treatment was harmonious with normal growth processes and would allow compensation in the less normal pattern.

PFH and AFH, when compared to each other, gives increased knowledge of the vertical components of the lower face. Their values determined on a progress headfilm and related to the beginning headfilm values would be very useful in final diagnostic decisions concerning the need for molar extractions. If AFH had increased more than PFH in a Class II malocclusion one should expect much greater difficulty in final corrections. In final evaluation, the relationship gives a

PFH - AFH
Before

	PFH	AFH	DIFF.
Control	46.65	64.87	18.22
Successful	43.01	64.31	21.30
Unsuccessful	42.59	63.61	21.02

PFH - AFH
After

	PFH	AFH	DIFF.
Control	50.70	67.90	17.20
Successful	47.88	67.57	19.69
Unsuccessful	46.13	70.96	24.83

Figure 2. Chart of the three samples showing the before and after values of anterior and posterior facial height values and the differences (All values are in millimeter measurements).

PFH - AFH
Change

	PFH	AFH	DIFF.
Control	4.05	3.03	1.02
Successful	4.87	3.26	1.61
Unsuccessful	3.53	7.35	(3.82)

Figure 3. Chart showing the posterior facial height and anterior facial height changes between the time interval of approximately two years and the differences. (All values are in millimeter measurements)

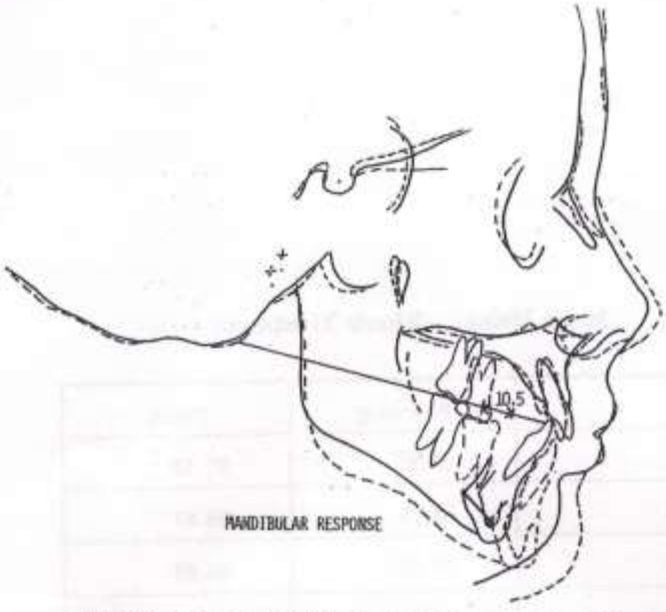

Figure 4. Line drawing showing the mandibular response in millimeters.

MANDIBULAR RESPONSE

	Means	Range
Control	2.72 mm	0 − 6.5 mm
Successful	3.88 mm	1 − 10.5 mm
Unsuccessful	2.38 mm	(1.5) − 6.5 mm

Figure 5. Chart of the three groups showing the mean and range of mandibular response. (All values are in millimeter measurements)

concept of the degree of denture control on the mature patient. In the immature patient the same determination of denture control can be noted, as well as the vertical growth response in the lower face.

Another value used in this study is identified as mandibular response. It was suggested and previously used by Dr. George Harris, and was taken from a study by Dr. Pete Witzke.[3] The study entitled, Longitudinal Cephalometric Evaluation of the Mandibular Dental Arch, developed the X point which is the most distal point on the lingual surface of the symphysis. It is pro-

Mean Values - Klontz Treatment

	Beginning	Finish
FMA	27.83	27.33
FMIA	54.75	63.67
IMPA	97.42	88.83
SNA	83.54	82.04
SNB	77.92	79.17
ANB	5.63	2.88
Pal. Pl.	1.38	1.21
Occ. Pl.	11.17	11.83
Z-angle	62.83	72.83
PFH	40.17 mm	46.71 mm
AFH	63.16 mm	67.08 mm
$\overline{6\ 6}$ Vert.	30.95 mm	33.49 mm
$\overline{1\ 1}$ Vert.	41.42 mm	40.01 mm
$\underline{6\ 6}$ Vert.	22.38 mm	24.39 mm
$\underline{1\ 1}$ Vert.	30.43 mm	30.36 mm
$\underline{6\ 6}$ Horiz.	25.91 mm	27.3 mm
$\overline{6\ 6}$ Horiz.	7.7 mm	6.58 mm
Mand. Response		5.04 mm

Figure 6. Chart showing all eighteen mean values of the Klontz treatment. (All angular values are in degrees. Other values are in millimeters)

	PFH		AFH		INCREASE	
	Before	After	Before	After	PFH	AFH
Control	46.65	50.71	64.87	67.91	4.06	3.03
Staff	44.23	48.39	64.80	67.78	4.18	2.98
Klontz	40.17	46.71	63.16	67.08	6.54	3.92

Figure 7. Chart showing the mean values before and after as well as the increase in the posterior facial height and anterior facial height. (All values are in millimeter measurements)

jected perpendicularly to the occlusal plane on the beginning headfilm tracing. The X point on the finish headfilm tracing is identified. With the two headfilms superimposed, it is projected perpendicularly to the original occlusal plane. The distance between the two points is measured in millimeters and indicates an immediate assessment of the horizontal movement of the mandible. If the X points are connected by a line with the headfilms superimposed, the directional movement of the mandible is noted (Figure 4). The length gives an idea of the magnitude of mandibular change.

The X point change in the non-orthodontic sample shows that the mandible had a mesial relocation of 2.72 millimeters from twelve to fourteen years of age (Figure 5). Normal developmental changes average this amount. The range varied from no change to 6.5 millimeters of mesial relocation. Five in the sample had no change. Six showed more than five millimeters of change and nineteen ranged from two to 4½ millimeters of change; the average mesial relocation was 3.3 millimeters. Therefore, three millimeters of mesial mandibular response is expected during a two year period from twelve to fourteen years of age.

The sample of sixteen unsuccessful treatments averaged 2.38 millimeters of mandibular response, and ranged from −1.5 to +6.5 millimeters. Two of the sixteen had negative values and two measured 6.5 millimeters of mesial relocation. Eight ranged between two and 4.5 millimeters with a mean of 3.1 millimeters. Lack of denture control could be responsible for the negative values. However, the small range variations in mandibular response probably was not the reason for the lack of success in most of these cases. The same clinicians who submitted the successful treatment records also submitted the unsuccessful treatment records; thus there was no question regarding the clinical skill utilized in the treatment. One must conclude patient cooperation was the primary reason for the unfavorable reaction.

The successful treatment sample of forty showed an average mandibular response of 3.88 millimeters, greater than either of the other groups. The range was also greater, from 1 millimeter to 10.5 millimeters. However twenty-two of the sample ranged from 3 millimeters to 7 millimeters with an average of 4.5 millimeters; about 1½ millimeters more than the non-orthodontic sample and the unsuccessfully treated group. If the samples could be considered as comparable, successful orthodontic treatment using the Foundation force systems enhances mesial mandibular response.

For many years I have admired the beautiful results exhibited by Dr. Herb Klontz. His records convinced me that he was precise, fundamentally sound, and that he consistantly produced excellent orthodontic treatment that reflected the teachings of the Foundation. In the belief that a very careful analysis of some of his treatment records might be helpful, he submitted records of a number of recently com-

Mandibular Response

Control	2.72
Staff	3.39
Klontz	5.04

Figure 8. Chart showing the millimeter values of mandibular response of the three sample groups.

pleted cases where differential diagnosis, total dentition space analysis, and sequential ten-two edgewise directional force systems were used. Twelve cases, all retained in July and August of 1987 were sent. The time frame between beginning and finish records was less than three years. They are a part of the sample of forty successful treatments, all of which were submitted by members of our teaching staff.

The mean recordings of the values used at the beginning of treatment of Dr. Klontz's twelve cases are (Figure 6): FMA 27.83 degrees, FMIA 54.75 degrees, IMPA 97.42 degrees, SNA 83.54 degrees, SNB 77.92 degrees, ANB 5.63 degrees, palatal plane 1.38 degrees, occlusal plane 11.17 degrees, and Z-angle 62.83 degrees. The millimeter values are: PFH 40.17 millimeters, AFH 63.16 millimeters, lower molar height from mandibular plane 30.95 millimeters, lower incisor height from mandibular plane 41.42 millimeters, upper molar distance from palatal plane 22.38 millimeters, upper incisor distance from palatal plane 30.43 millimeters, upper molar distance from the pterygo-maxillary fissure line 25.91 millimeters, and lower molar distance from a point on the occlusal plane that was an intersection of a perpendicular from X point to the occlusal plane of 7.7 millimeters. These values reflect the type of malocclusion that is profiled by these averages.

The twelve cases at the finish of treatment had the following mean recordings: FMA 27.33 degrees, FMIA 63.67 degrees, IMPA 88.83 degrees, SNA 82.04 degrees, SNB 79.17 degrees, ANB 2.88 degrees, palatal plane 1.21 degrees, occlusal plane 11.83 degrees, Z-angle 72.83 degrees, PFH 46.71 millimeters, AFH 67.08 millimeters, lower molar height from mandibular plane 33.49 millimeters, lower incisor height from mandibular plane 40.01 millimeters, upper molar distance to palatal plane 24.39 millimeters, upper incisor distance from palatal plane 30.36 millimeters, upper molar distance to pterygo-maxillary fissure line 27.3 millimeters, and lower molar distance from X line 6.58 millimeters. The mandibular response was 5.04 millimeters.

Results

Although the relationship of all of the eighteen values described were studied, the analysis of the Klontz treatment will be limited to the values previously discussed; PFH, AFH, and mandibular response. Figure 7 shows the Klontz sample at the beginning has an average PFH of 40.17 millimeters and an AFH value of 63.16 millimeters, a differential of 22.99 millimeters. The non-orthodontic sample had a PFH of 46.65 millimeters and an AFH of 64.87 millimeters, a differential of 18.22 millimeters. The sample of twenty-eight other successfully treated cases at the beginning had a PFH of 44.23 millimeters and an AFH of 64.80 millimeters, a difference of 20.57 millimeters.

Using the mean of the non-orthodontic sample as normal, it is apparent that the Klontz sample exhibited a short ramal height. The sample was distorted because of its size and because six of the twelve patients had very short ramal heights. In fact, of the sample of forty successfully treated cases only eight patients had a ramal height of less than 40 millimeters; the six lowest values were all in the Klontz sample. In the non-orthodontic sample of forty-four cases only five had a ramal height of less than 40 millimeters; one had an extremely short ramus.

Short ramal heights occur on both high FMA and low FMA patterns but the low FMA pattern also has a low AFH value whereas the high FMA pattern exhibits a normal or high AFH value.

At the completion of treatment, the Klontz sample had a mean PFH of 46.71 millimeters and an AFH of 67.08 millimeters, a differential of 20.37 millimeters. The growth sample after a two year interval had a mean PFH of 50.71 millimeters and an AFH of 67.91 millimeters, a difference of 17.2 millimeters. The twenty-eight cases submitted by our staff had a PFH of 48.39 millimeters and an AFH of 67.78 millimeters, a difference of 19.39 millimeters (Figure 7).

The significant data is the amount of PFH increase in relation to the AFH increase on these growing children. The Klontz sample had a PFH increase of 6.54 millimeters and an AFH increase of 3.92 millimeters, a difference of 2.62 millimeters. The growth sample had a PFH increase of 4.06 millimeters and an AFH increase of 3.03 millimeters, a difference of 1.03 millimeters. The staff sample had a PFH increase of 4.18 millimeters and an AFH increase of 2.98 millimeters, a difference of 1.20 millimeters.

In Dr. Klontz's sample six cases had low PFH values of less than forty millimeters and six patients had more normal PFH values. The more normal sample, PFH mean of 45.16 millimeters, more nearly reflects a parallel to the forty-four in the Michigan growth group. The Klontz group of six patients with normal PFH increased to 50.58 millimeters or an average of 5.42 millimeters. The AFH increased from a mean of 62.83 millimeters to 66.66 millimeters or an average increase of 3.83 millimeters. The increased PFH over AFH was 1.69 millimeters, a very favorable reaction to growth and treatment.

Of interest is the compensation which occurred on the low PFH group in both the Klontz sample and the control sample. The Klontz sample of six that had a lower PFH mean of 35.5 millimeters at beginning increased to 42.8 millimeters or a difference of 7.3 millimeters. The Michigan growth sample of five low PFH's had a mean of 37.4 millimeters. These values increased to 45.3 millimeters in the two year time frame, for an increased average of 7.9 millimeters. These were larger increases in PFH than any of the more normal patterns.

A study of the mandibular response on the different samples is also interesting. The Klontz sample of twelve had a mandibular response of 5.04 millimeters. The staff treated sample had a mandibular response of 3.39 millimeters and the non-orthodontic growth sample had a mandibular response of 2.72 millimeters (Figure 8). This is a very significant difference especially between the Klontz sample and the non-orthodontic group. The six low PFH group showed slightly more mandibular response, 5.16 millimeters, while the remaining six with normal PFH's had an average of 4.91 millimeters. The Michigan growth sample with a low PFH averaged only 1.8 millimeters of mandibular response, considerably less than the larger sample.

The time frame of the samples might favor the treated cases slightly, but one must conclude that properly controlled directional force systems treatment, compliments and enhances mandibular response on a growing child. The vertical changes reflected by the PFH-AFH values and the longitudinal changes reflected by the mandibular response value gives the orthodontist an assessment of treatment that emphasizes the importance of denture control.

Discussion

To illustrate and emphasize the main points of this discussion, clinical records of three cases submitted by Dr. Klontz follows:

1. Figures 9, 10, and 11 show headfilm tracings of KS. There has been an incisor uprighting of ten degrees and a Z-angle change from 64 degrees to 75 degrees, an eleven degree improvement. It is apparent the main improvement of facial harmony came, not from lip retraction, but from chin enhancement. This facial convexity reduc-

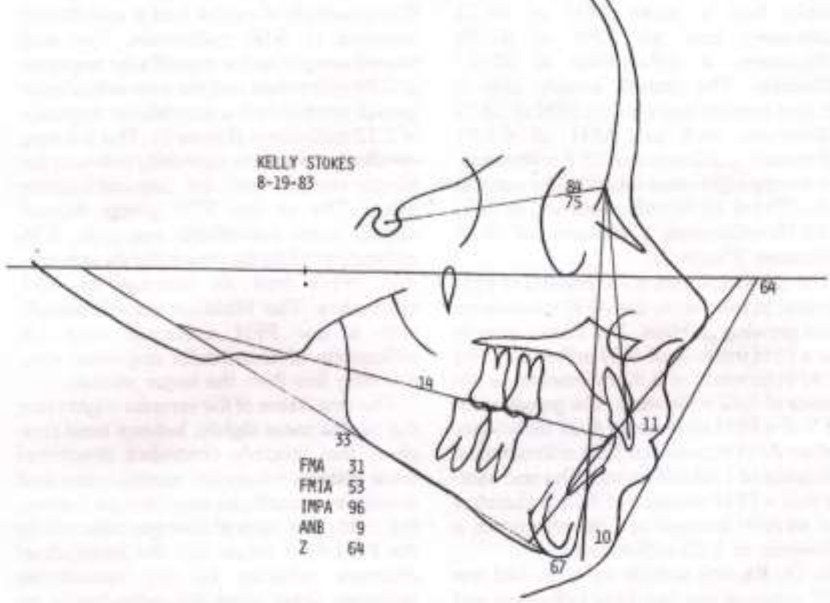

Figure 9. Cephalometric tracing of KS before treatment with pertinent values.

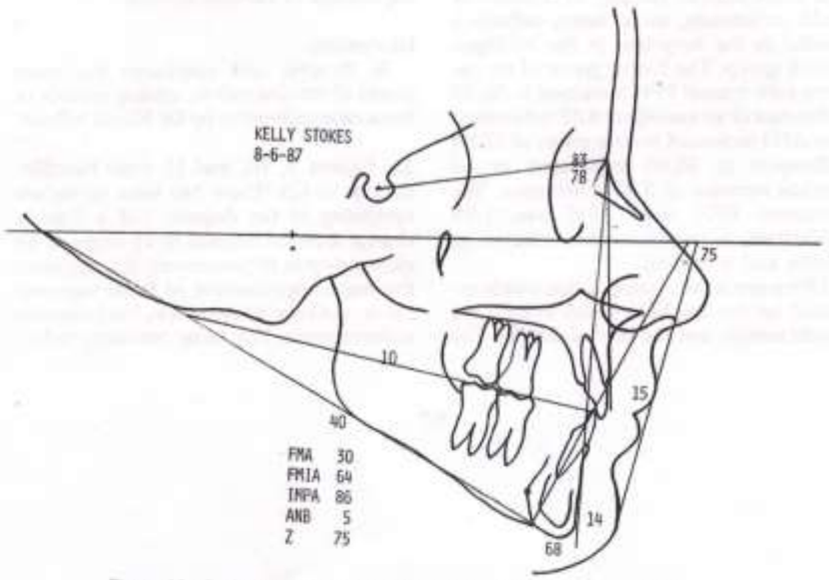

Figure 10. Cephalometric tracing of KS after treatment with pertinent values.

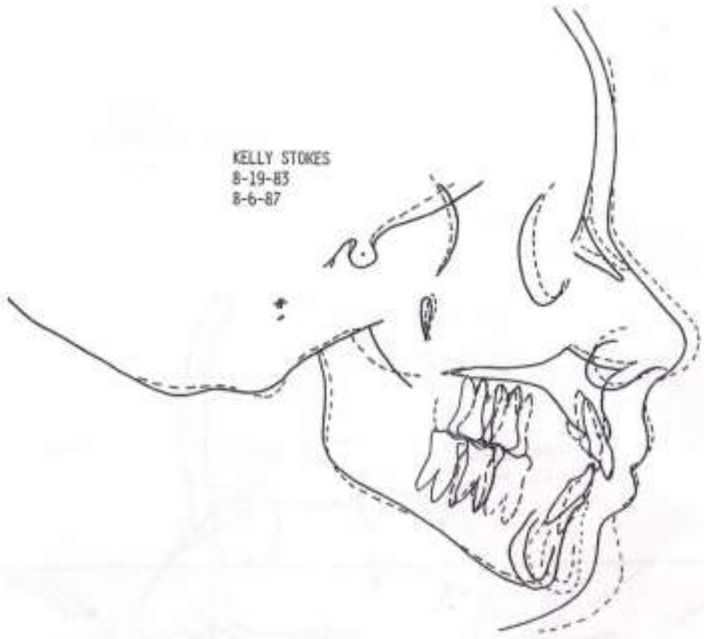

Figure 11. Line drawing of superimposed tracings of KS showing dental, skeletal and facial changes.

tion can be explained by the 7 millimeters increase in posterior facial height with only one millimeter of anterior facial height increase. The more severe the facial convexity in the growing child, the greater need for high-pull headgear against the maxillary anterior segment; posterior anchorage preparation should be increased to allow maximum posterior facial height increase.

The mandibular response on this patient was an outstanding 8 millimeters while the line connecting the X points is horizontal.

2. Patient SP is illustrated in figures 12, 13, and 14. This case, a bimaxillary protrusion Class II with a nine degree ANB, shows a 17 degree improvement in the Z-angle and an 18½ degree uprighting of the lower incisors. Lip recontouring and retraction occurred. The PFH increase of nine millimeters, compared to a five millimeter increase of the AFH value, allowed the mandibular response to be 4 millimeters. The X point shows the more normal growth direction downward and forward. The facial balance and harmony improved dramatically by recontouring the chin through lip retraction and through growth.

3. LS, figures 15, 16, and 17 is a high angle Class II case where the ANB was only reduced one degree. All three horizontal planes were controlled: the FMA reduced from 35 degrees to 33 degrees, posterior facial height increased 8 millimeters and anterior facial height increased 5 millimeters.

The mandibular horizontal response was 6 millimeters which allowed excellent chin enhancement and reduction of facial convexity. The Z-angle value of 57 degrees increased 12 degrees to 69 degrees with almost no change in lip relationship. The mandibular response vertically and horizontally gave good facial balance. It must be pointed out that excellent control of the lower molars, allowing an increase of only

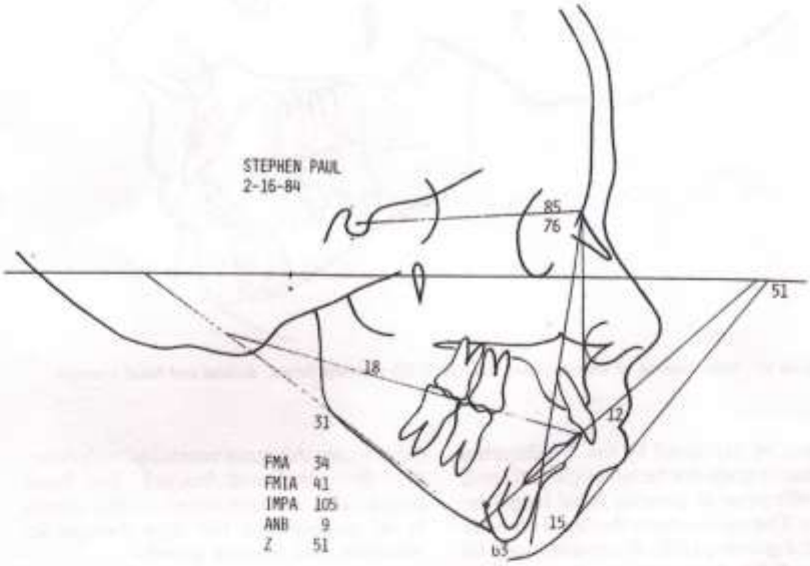

Figure 12. Cephalometric tracing of SP before treatment with pertinent values.

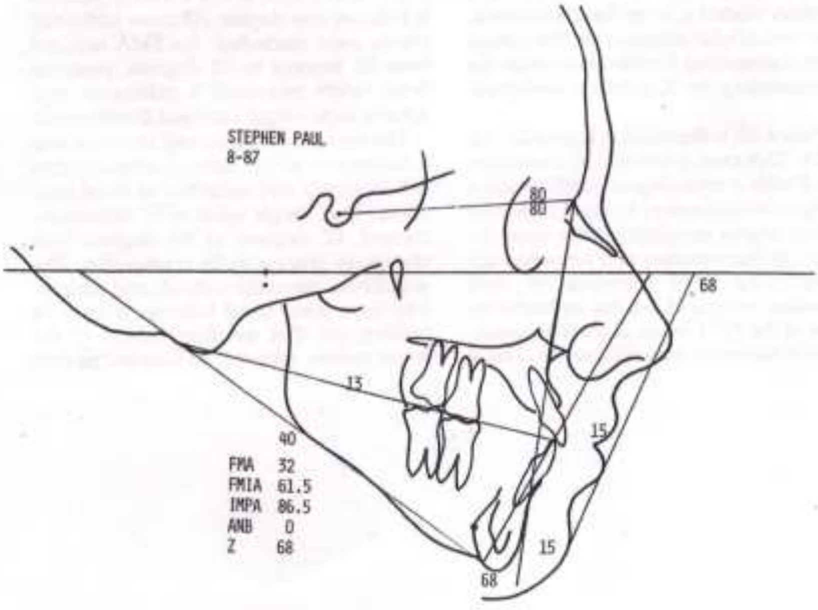

Figure 13. Cephalometric tracing of SP after treatment with pertinent values.

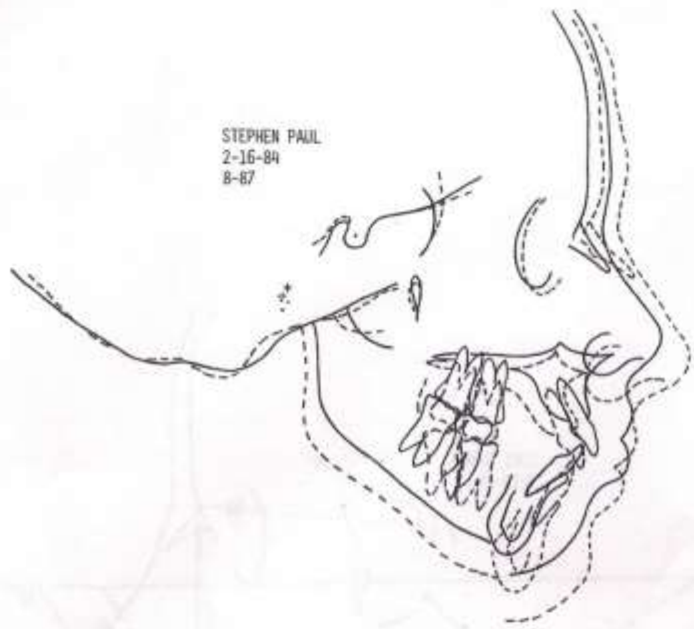

Figure 14. Line drawing of superimposed tracing of SP showing dental, skeletal and facial changes.

2 millimeters in leveling, and space management in this Class II correction coupled with upper incisor control in retraction, were critical to achieve this nice result.

Conclusion

Clinical analysis of these very successful treatments emphasize the values discussed in this paper. The study of these and all the other samples in the three groups leads to the following conclusions:

1. The normal sample gives fundamental information regarding growth and development during the critical time frame when the permanent teeth have fully erupted and during the succeeding two years.

2. The successful treatment sample group reiterates the concept that the Tweed Foundation's technology not only allows a continuation of normal growth and development, but in most cases enhances the favorable normal pattern and improves the less normal pattern.

3. The study of the less successful treatment sample gives additional knowledge of patterns that did not respond well. The most significant aspect of these cases was the amount of anterior facial height increase. These cases suggest less directional control of treatment forces, less cooperation from the patient, incorrect diagnostic decisions and perhaps most important, a growth response that made treatment more complex and difficult.

This study of the successful treatments of Class II and Class I bimaxillary protrusion cases with large facial convexities, have a number of characteristics that indicate commonalities, and tendencies not be ignored by the clinical orthodontist. They are careful, correct diagnosis, treatment management, and force system application.

1. Diagnosis—the recognition of the FMA value, the ANB value and the relationship

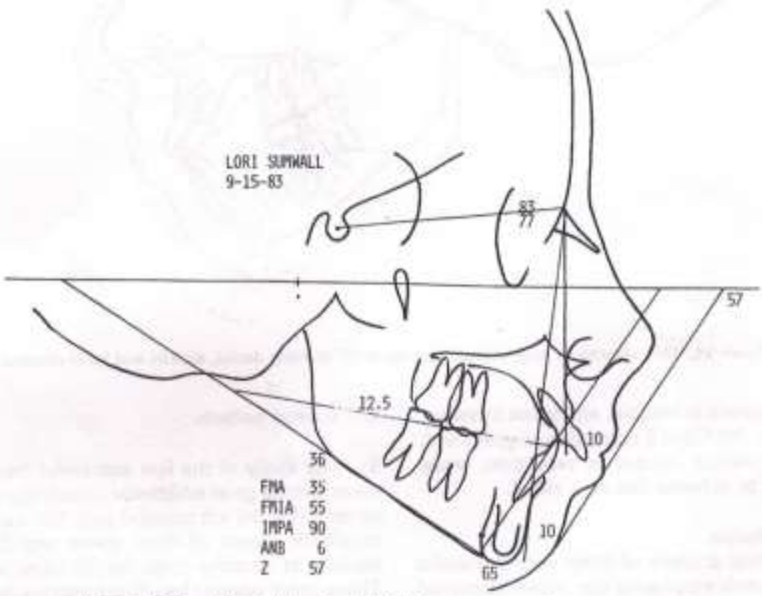

Figure 15. Cephalometric tracing of LS before treatment with pertinent values.

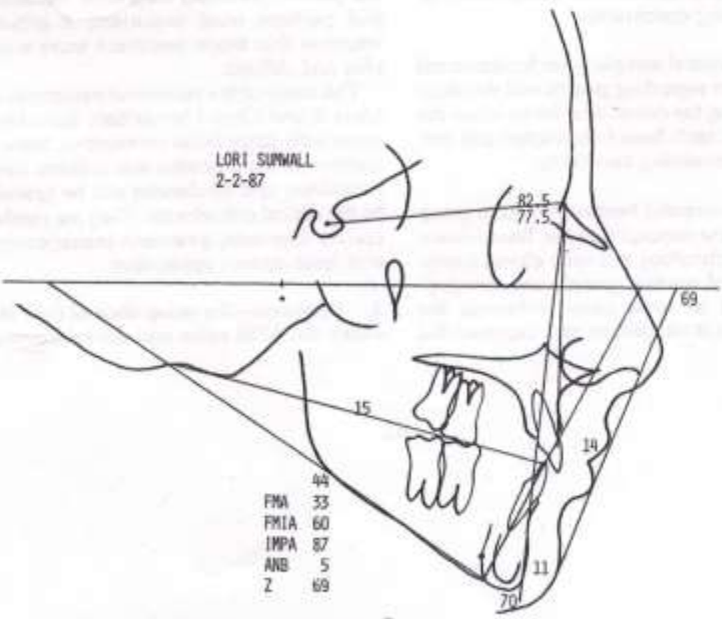

Figure 16. Cephalometric tracing of LS after treatment with pertinent values.

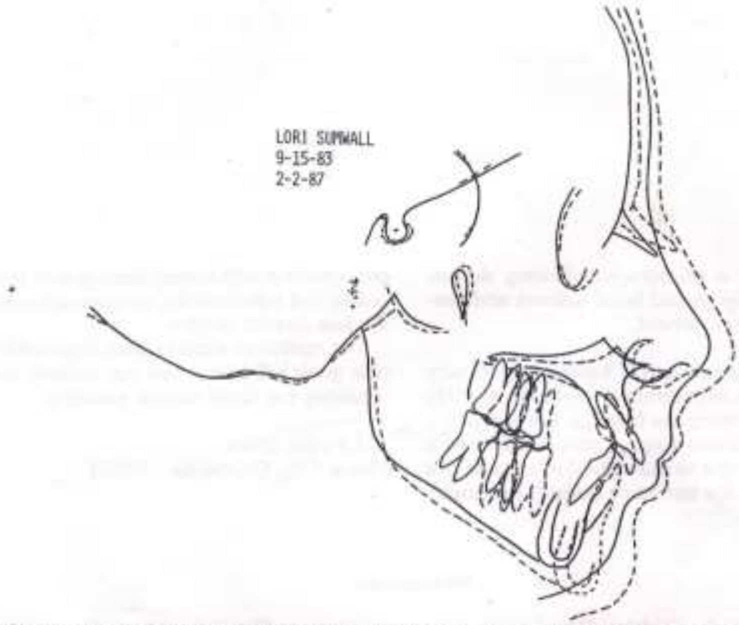

Figure 17. Line drawing of superimposed tracing of LS showing dental, skeletal and facial changes.

of posterior facial height to anterior facial height gives the clinician the proper information regarding horizontal and vertical development of the skeletal facial pattern. In convex Class II bimaxillary malocclusions one of the keys to successful treatment was the diagnostic decision to eliminate tooth material, primarily the four first bicuspids. This was apparent in this study since the lower incisors were uprighted an average of over eight degrees.

2. Treatment Management. The timing of full appliance treatment is clinically critical. The opportune time for maximum denture control and mandibular response coincides with the eruption of the twelve year molars in most children. Earlier pre-orthodontic guidance and serial extraction of deciduous and permanent teeth can facilitate easier, faster and higher quality treatment results.

3. Force system application becomes more important with the severity of the dental, skeletal and facial abnormality. The successful treatment study indicates that directional control is of extreme importance especially in two very critical areas.

a. The upper anterior segment. The high-pull headgear auxillary is absolutely essential in supporting the upper anterior teeth and the anterior segment of the maxilla. Control of the anterior vertical dimension allows a smaller increase in anterior facial height with a larger increase in horizontal mandibular response for Class II correction, chin enhancement and Z-angle improvement.

b. The ten-two system of anchorage preparation sequentially applied and supported anteriorly by the high-pull headgear is also of extreme importance in placing intrusive forces on the lower posterior dental segment. Minimal lower molar height increase is essential to horizontal mandibular response. Counter clockwise rotation of the mandible is encouraged allowing skeletal compensation and facial balance and harmony improvement.

Dr. Gebeck and I have enjoyed very much the opportunity of making this study and presenting our findings. We believe the study indicates that we now should add a fifth objective to our orthodontic goals. We must, on the immature patient, harmonize our correction with normal facial growth processes and maximize the compensation for the less normal pattern.

The continued effort to meet these attainable goals will assure that our patients are receiving the finest service available.

111 Patton Drive
Ponca City, Oklahoma 74601

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