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Activator Growth Augmentation : A Long-Term Perspective

William Emmerson

Abstract

ACTIVATOR GROWTH AUGMENTATION - A LONG-TERM PERSPECTIVE

by

William Emmerson

A sample of twenty-three activator treated patients, in the growth years up to age eighteen were evaluated at three time intervals, before treatment, end of treatment, and five years post-treatment. The average time period of the post-treatment evaluation period was 5.7 years after the end of active therapy. The patients' ages ranged from 8.4 to 13.3 years at the beginning of activator treatment.

In the correction of the Class II malocclusion, no other form of orthopedic mechanics were utilized in this sample. In some cases full banding was used to align and level the arches prior to the activator therapy.

The beginning lateral cephalometric radiographs (T_1 records) with predicted growth were compared to the finished treatment (T_2 records) in order to discover the orthopedic and orthodontic effects of the treatment. Post-treatment cephalometric radiographs (T_3 records) were

evaluated on all patients in order to determine the long-term stability and effects of the treatment.

Comparisons of the end of treatment and post-treatment records were evaluated with the growth forecast records to determine the effects of the activator treatment. The eleven factor Ricketts' Analysis of each case was statistically analyzed to determine the significance of the treatment.

The data indicated a significant increase in mandibular growth with activator treatment in brachyfacial patients over that predicted in normal growth. The major increase in growth was in the vertical dimension, primarily in the condyle and ramus area, with no adverse rotation of the mandible.

The data suggest that activator therapy did not have any significant inhibiting effect on the growth of the maxilla.

The growth of the mandible increased more than expected during the active treatment period and continued to grow at the rate expected during the post-treatment period. The comparison of the end of treatment to the post-treatment records indicated that there was virtually no relapse of the molar relationship in the treated cases.

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Each person whose signature appears below certifies that this manuscript in his opinion is adequate, in scope and quality, in lieu of a thesis for the degree Master of Science.

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INTRODUCTION

Much information concerning the diversity of methods of correcting Class II malocclusion has been published in the clinical and scientific orthodontic literature. Differences of opinion have been reported concerning the effects and results of functional appliance therapy. Various investigators have determined that functional appliance therapy augments the growth of the mandible in the condylar region,[1,6,8,10,18,23,25,29,33] while other investigators indicate that condylar growth is not influenced by this treatment.[2,11,14,17,35]

In the treatment of Class II Division 1 malocclusions with normal maxillas and deficient mandibles, the options have generally been: 1) headgear to the maxilla, 2) extraction of maxillary first bicuspids, 3) surgical advancement of the mandible or retraction of the premaxilla, or 4) some compromise in the treatment goal and stability.

The correction of the Class II molar relationship by the use of a removable appliance, such as an activator, is an accepted procedure.[6,9,10,13,17,18,23,29,34,35] While the activator appliance has been modified throughout the years, its basic design remains quite similar to the

"Monobloc" appliance developed by Pierre Robin.[28] Along with the evolution of the varied appliance designs have come the varied interpretations of the appliances' effects.

Several studies[14,17,34] that investigated the skeletal effects of activator treatment have failed to relate the skeletal changes to the cranial landmarks. While other studies[1,6,8,10,29] found that the activator therapy augmented mandibular growth, the investigators did not consider the long-term effects and stability of the treatment.

One four year post-retention study[35] provided some confusing information regarding the effects of activator treatment. It was reported that activator therapy caused a significant reduction of the ANB angle without a significant change in the maxilla or mandibular position. The study, however, did show an increase in lower face height and correction of molar relationship with no sign of relapse after the retention period.

The purpose of the present study is to observe if any useful predictions can be made about mandibular growth augmentation with activator appliances and also to evaluate the long-term stability of such treatment.

MATERIAL AND METHODS

Lateral cephalometric radiographs before treatment (T_1 records), end of treatment (T_2 records) and post-treatment (T_3 records) of twenty-three activator treated cases (eighteen female and five male) were evaluated. All cases were Class II Division 1 malocclusions treated with a removable activator appliance, worn 12 to 14 hours a day, and were in treatment for an average of 29.5 months (2.5 years) with a range of 17 to 48 months (Table I). Cases with long-term records were selected at random from four sources: Dr. Burton Fletcher, Dr. Karl Nishimura. Dr. Guy Taylor, and Dr. Karin Vargervik. The following stipulations were applied to all cases:

1. All patients must be growing children between the ages of six and eighteen years of age. The ages of the female patients were not to exceed fourteen years and male patients not to exceed eighteen years of age for the active appliance treatment period.[5]

2. Complete records must be available at each time point.

3. No other orthopedic or orthodontic treatment mechanics such as headgear or intermaxillary elastics were to be utilized during the time period in question. Fully banded cases with edgewise brackets were permitted in order to align and level arches prior to the correction of the Class II malocclusion. All bands were removed

prior to the activator therapy.

4. The bite impression of an attempted anterio-posterior edge-to-edge protrusive bite was recorded. The degree of opening was dependent on the rest position of the mandible and the size of the overjet. The bite in all cases was opened a minimum of five to six millimeters beyond the freeway space. The required degree of forward positioning of the mandible determined the height of the bite necessary to prevent the lower jaw from slipping out of the appliance when the musculature relaxed.

The lateral cephalometric radiographs were submitted to Rocky Mountain Data Systems (RMDS) for tracing utilizing the modified Downs' or Ricketts' Analysis (Figure 1). Growth forecasting to maturity was projected from the T_1 records in order to determine the amount of skeletal growth without treatment (Figure 2).

To determine the effects of the activator treatment, the following cephalometric measurements were evaluated from the T_1, T_2 and T_3 records.

1. Lower Face Height
   The angle from anterior nasal spine to the center of the ramus (XI) to Pogonion.

2. Mandibular Arc
   The angle between the corpus and condyle axes.

3. Corpus Length
   The distance between XI and PM--a linear measurement of the body of the mandible

4. Condyle Length

The distance between the center of the ramus (XI) to the center of the condyle neck on the Nasion-Basion plane - measures a portion of the condyle and ramus along the condylar axis

5. Mandibular Plane
   The angle of the lower border of the mandible to Frankfort Horizontal

6. Maxillary Depth
   The angle formed by the Frankfort Horizontal and the Nasion-Basion plane to Point A - indicates the horizontal position of the maxilla

7. Facial Depth
   The angle between the facial plane and Frankfort Horizontal - locates the chin horizontally

8. Upper Molar Position
   The distance from the pterygoid vertical to the distal of the maxillary first molar - used as a guide to maxillary changes

9. Posterior Facial Height
   The distance between Gonion and CF point - used to determine the height of the ramus

10. Facial Axis
    The angle between the facial axis and Nasion-Basion plane. A line from PT point to GN point, and expresses the direction of growth of the chin and molars, as well as expressing the ratio of facial height to depth

11. Lower Incisor Protrusion
    The distance from the tip of the mandibular incisor to the APO plane

12. Upper Incisor Protrusion
    The distance from the tip of the maxillary incisor to the APO plane

13. Molar Relationship
    The distance between the distal surfaces of the maxillary and mandibular molars measured

along the occlusal plane

14. Convexity
    The distance between Point A and the facial plane

The growth without treatment forecast tracings were evaluated for the following measurements:

1. Lower Face Height
2. Mandibular Arc
3. Corpus Length
4. Condyle Length
5. Maxillary Depth
6. Facial Depth
7. Convexity
8. Posterior Facial Height

Comparison of T_1, T_2, T_3 records and growth forecast without treatment was accomplished to determine the effects of the activator treatment. Composite tracings representing the mean changes were completed in order to make a visual comparison of the beginning of treatment with end of treatment and the post-treatment. Statistical analysis of the data, including the mean, standard deviation, and "t" tests were calculated.

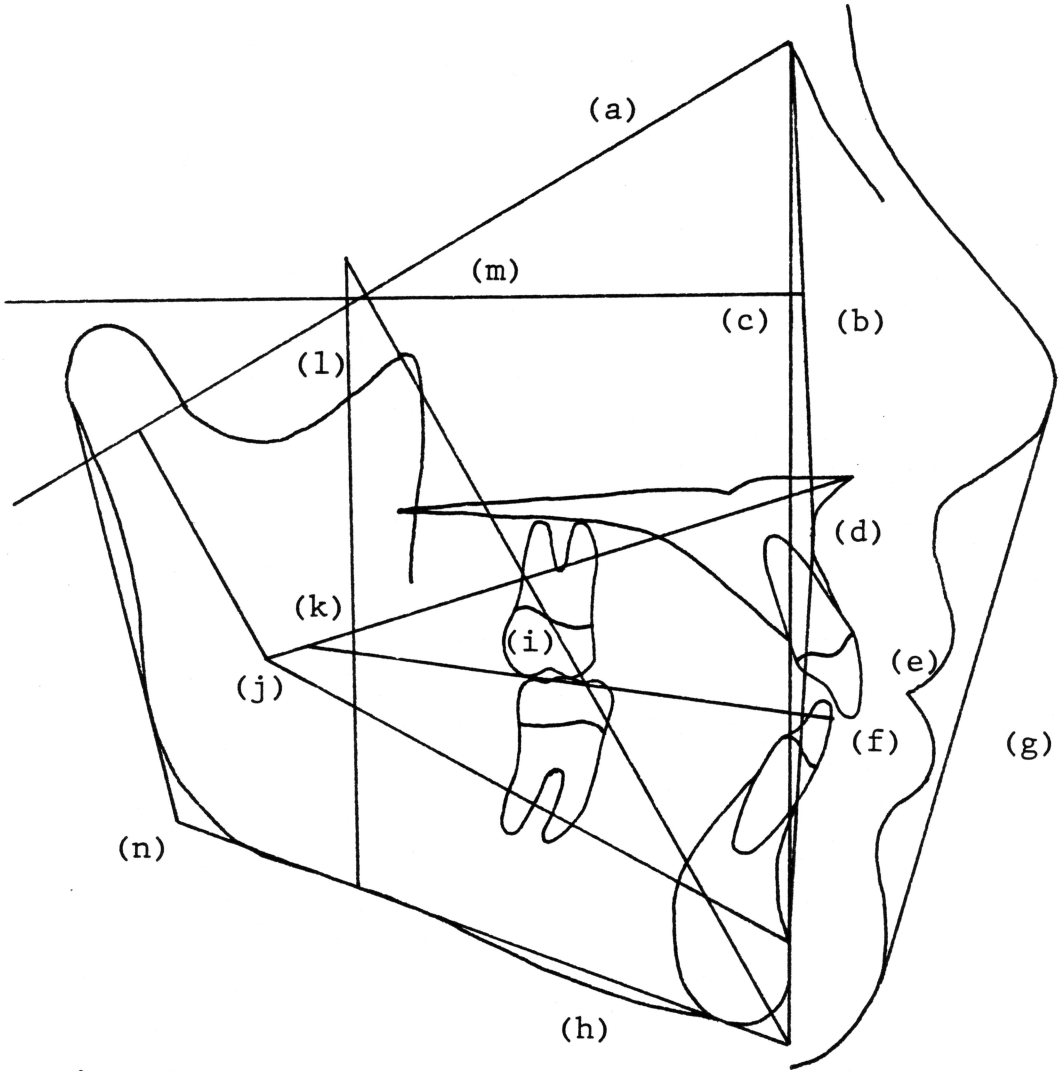
TABLE I

ACTIVATOR TREATMENT TIME AND
POST-TREATMENT TIME EVALUATION

Patient	Sex	Race	Date Treatment Started	Date Treatment Finished	Treatment Period (months)	Post-Treatment (months)
1	M	Cauc	4-66	1-68	21	166
2	F	Cauc	12-70	12-74	48	83
3	F	Cauc	11-72	7-75	32	75
4	F	Cauc	2-72	7-73	17	101
5	F	Cauc	6-73	10-75	28	72
6	F	Cauc	4-74	2-77	34	48
7	M	Cauc	11-70	5-73	30	102
8	F	Cauc	2-69	9-72	43	109
9	M	Cauc	11-67	10-70	35	88
10	M	Cauc	12-68	6-72	42	51
11	F	Cauc	3-74	3-77	36	37
12	M	Cauc	1-75	9-76	21	60

Patient	Sex	Race	Date Treatment Started	Date Treatment Finished	Treatment Period (months)	Post-Treatment (months)
13	F	Cauc	4-74	12-76	32	43
14	F	Cauc	10-72	1-75	27	84
15	F	Cauc	8-71	2-73	18	84
16	F	Cauc	12-70	11-72	24	32
17	F	Cauc	6-71	12-73	30	74
18	F	Cauc	12-72	6-74	18	42
19	F	Cauc	6-69	8-71	26	59
20	F	Cauc	6-70	12-72	30	30
21	F	Cauc	2-73	7-74	17	30
22	F	Cauc	7-70	1-74	42	42
23	F	Cauc	2-71	7-73	29	57
			Average in Months		29.6	68.2
			Average in Years-Months		2.5	5.7

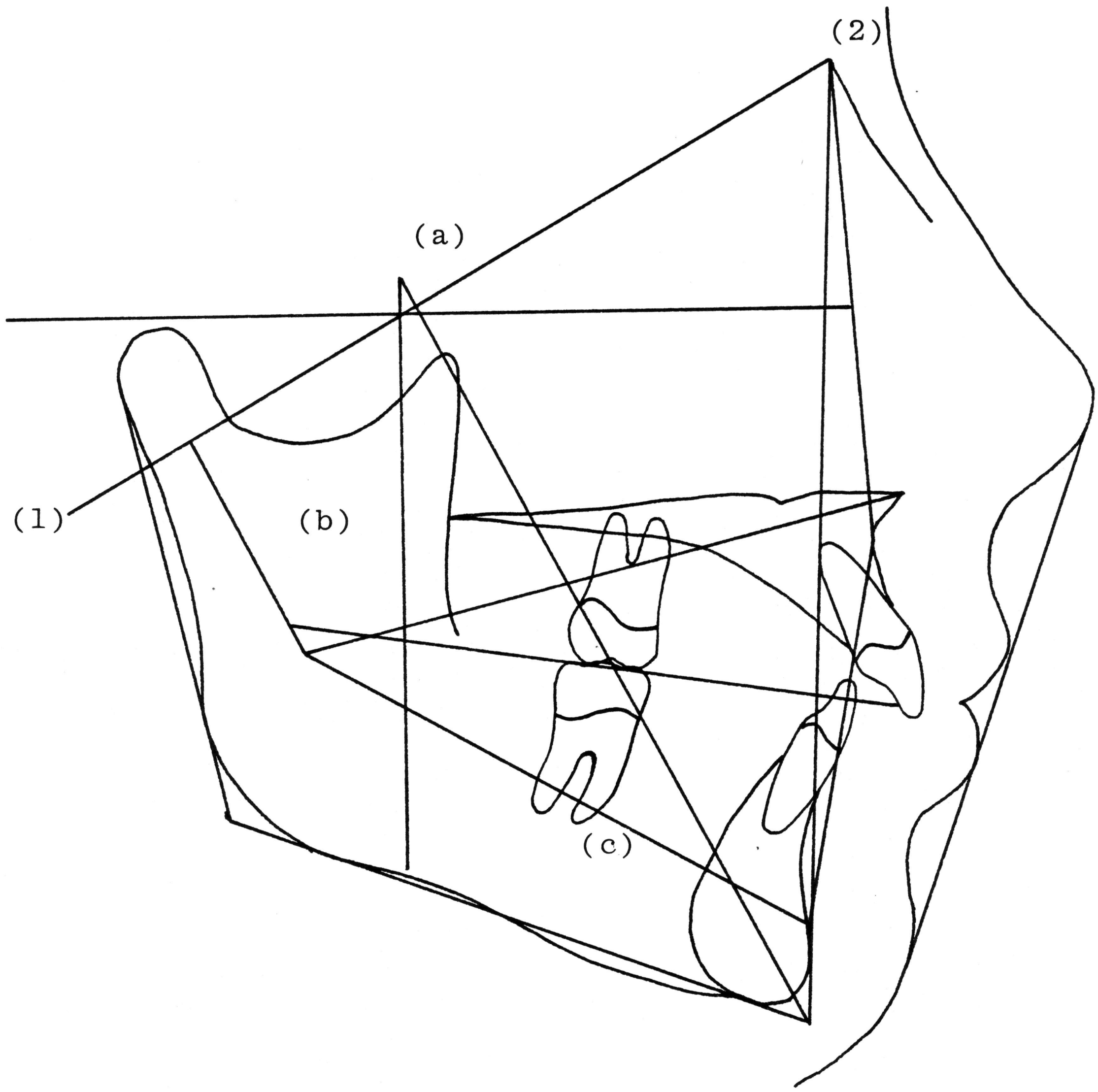
FIGURE 1 - Ricketts' Cephalometric Norms



Ricketts' Cephalometric Norms and Analysis for a 9 Year Old

(a)	Anterior Cranial Base	55mm ± 2.5mm	Increases .8mm/yr
(b)	Maxillary Depth	90° ± 3°	No change with age
(c)	Facial Depth	86° ± 3°	Increases 1°/3 yrs
(d)	Convexity of Point A	2mm ± 2mm	Decreases 1mm/3 yrs
(e)	Upper Incisor to APO	3.5mm ± 2.3mm	No change with age
(f)	Lower Incisor to APO	1mm ± 2mm	No change with age
(g)	Lower Lip to E Plane	-2mm ± 2mm	Less protrusive with growth
(h)	Mandibular Plane	26° ± 4.5°	Decreases 1°/3 yrs
(i)	Upper Molar to PTV	Age + 3mm ± 3mm	Increases 1mm/yr
(j)	Mandibular Arc	26° ± 4°	Increases .5°/yr
(k)	Lower Face Height	47° ± 4°	No change with age
(l)	Facial Axis	90° ± 3.5°	No change with age
(m)	Cranial Deflection	27° ± 3°	No change with age
(n)	Posterior Facial Height	55mm ± 3.3mm	Corrected for size

FIGURE 2 - Ricketts' Growth Forecasting



Ricketts' Growth Forecasting Norms

(a) Nasion-Basion Axis
- (1) Approximately 1 mm growth per year at Basion
- (2) Approximately 1 mm growth per year at Nasion

(b) Condylar Axis - 1 mm growth per year

(c) Corpus Axis - Approximately 2 mm growth per year

RESULTS

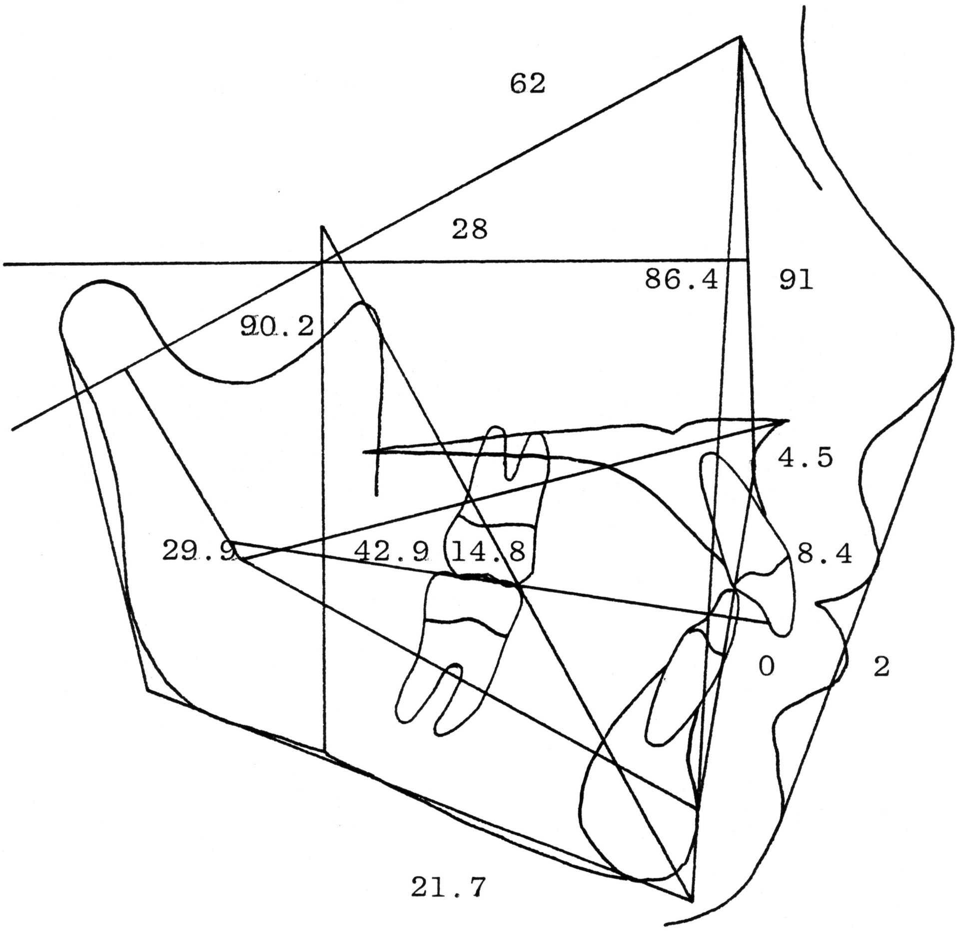
The results of the present study suggest that cases treated with activator therapy exhibit increased condylar length, corpus length, posterior facial height, and lower face height when compared to projected growth (Figures 3, 4 and 5). When comparing the five year post-retention records with those at the end of treatment, there was virtually no relapse in the treated cases (Table II). It was discovered that growth was accelerated during treatment, and then growth continued at the normal rate until maturity was reached (Tables IV and V).

Maxillary depth remained constant throughout the treatment period and the post-treatment evaluation period (Table II). The upper molar position increased from the beginning of treatment to the end of treatment and continued to increase at the normal rate during the post-treatment period (Table II).

The mandible did not adversely rotate since the facial axis measurement remained constant during the treatment period and the post-treatment period (Table II).

Growth during the period between the end of treatment and the post-treatment period did not significantly differ from the projected growth (Table V).

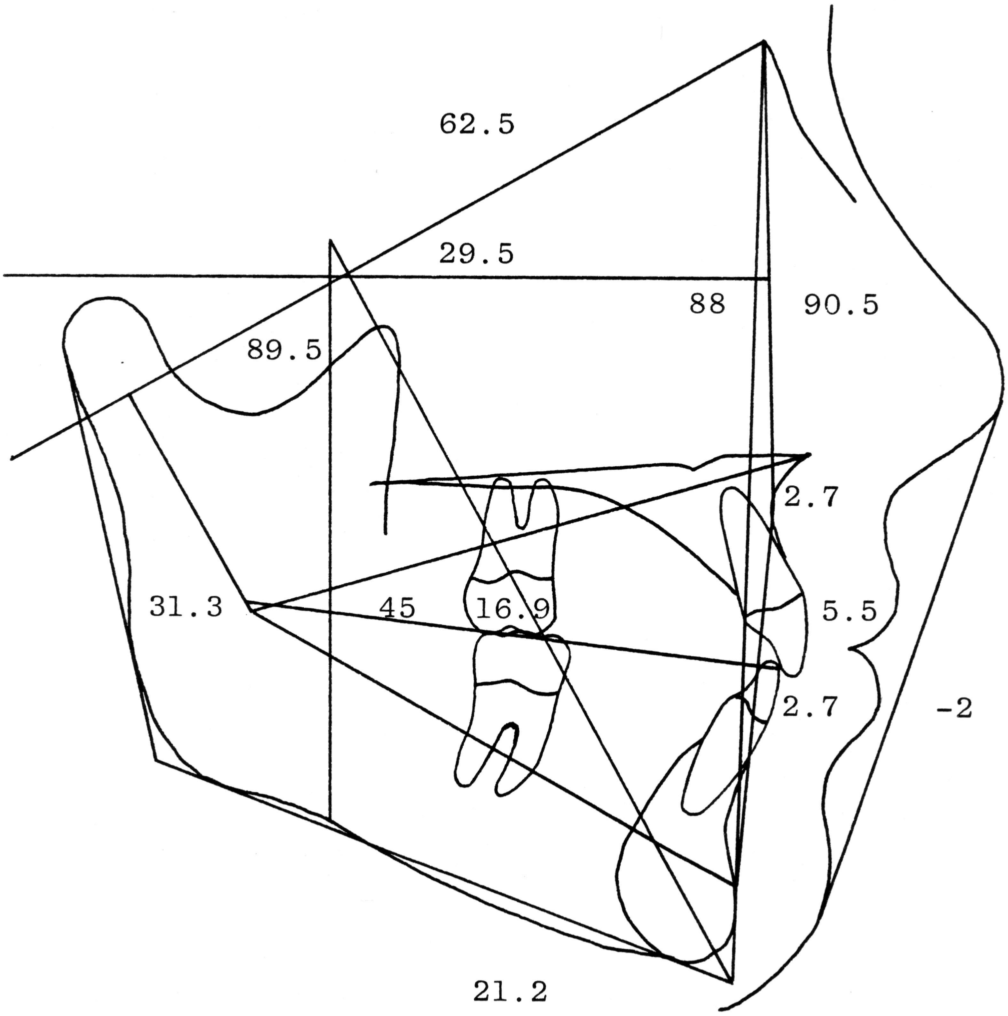
FIGURE 3 - Composite Tracing - Before Treatment



Beginning of Treatment

Caucasian - Age (Yrs) 10.5

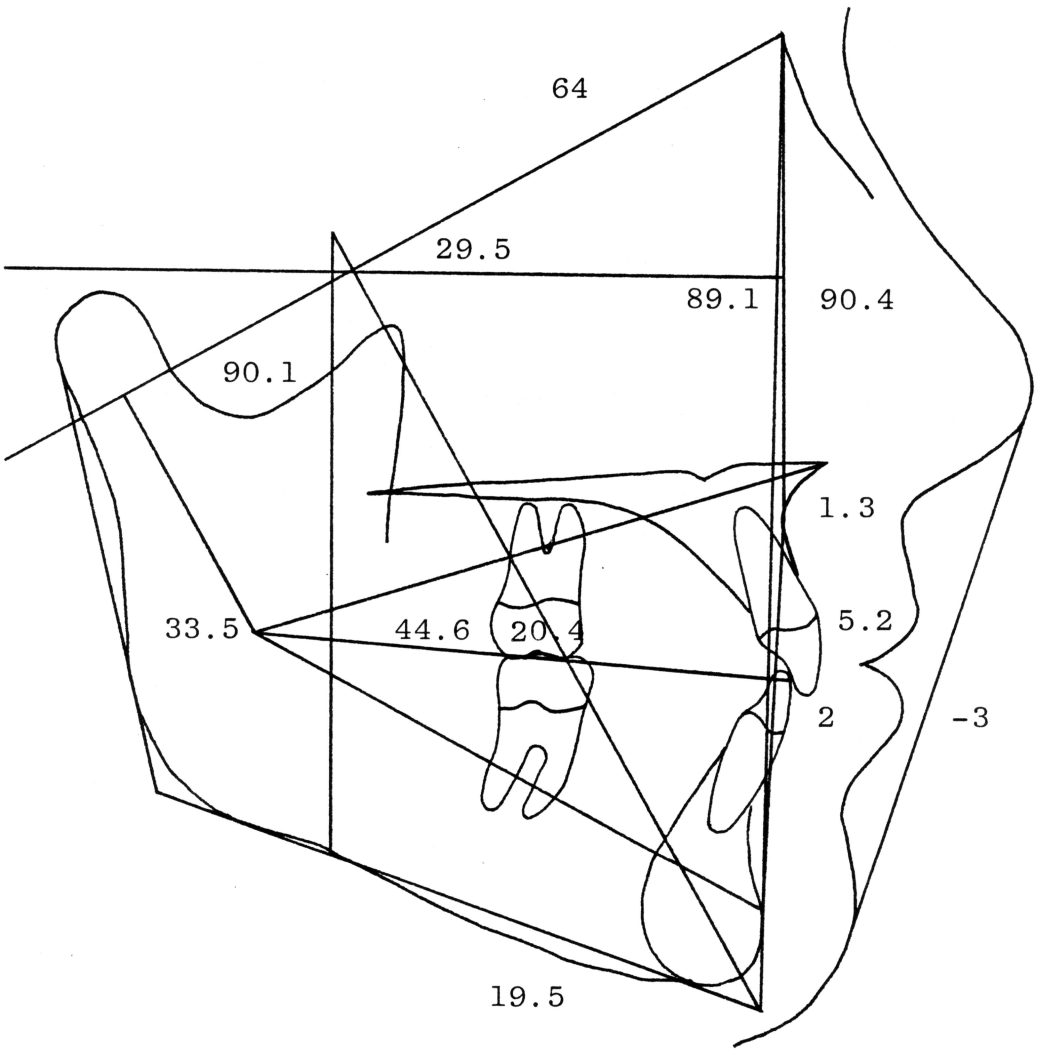
FIGURE 4 - Composite Tracing - End of Treatment



End of Treatment

Caucasian - Age (Yrs) 14.0

FIGURE 5 - Composite Tracing - Post-Treatment



Post-Treatment

Caucasian - Age (Yrs) 19.0

TABLE II

MEAN AND STANDARD DEVIATION

	T_1 Records	T_2 Records	T_3 Records	Growth Forecast
Lower Face Height	43.05±3.82	45.20±3.41	44.92±3.55	43.11±3.85
Mandibular Arc	29.61±3.27	30.99±4.53	33.53±4.12	33.46±3.39
Corpus Length	67.79±4.01	72.59±4.85	76.22±4.54	76.41±3.86
Condyle Length	28.41±2.65	32.20±2.61	34.09±2.31	32.98±2.16
Mandibular Plane	21.79±4.03	21.45±4.75	19.62±4.35	19.80±3.97
Maxillary Depth	90.64±3.58	90.26±3.32	90.55±3.44	
Facial Depth	86.33±2.79	87.93±3.02	89.19±2.89	
Upper Molar Position	14.90±2.78	16.51±3.41	20.38±3.07	
Convexity	4.50±2.63	2.46±2.35	1.54±2.84	2.11±2.85
Nasion-Basion Length	108.15±4.41	111.87±5.25	114.09±5.35	115.71±4.52
Posterior Facial Height	60.22±4.30	66.66±6.89	71.33±6.25	70.89±5.67
Facial Axis	90.24±3.62	89.62±3.75	89.97±3.72	
Lower Incisor Protrusion	-0.63±2.08	2.43±2.09	2.01±2.19	
Upper Incisor Protrusion	8.25±3.04	5.16±2.26	5.05±2.28	
Molar Relation	1.37±1.32	-1.71±2.13	-1.62±1.16	
Age	10.56±1.41	14.18±3.29	19.17±3.97	

Superimposition	$T_2 - T_1$	$T_3 - T_2$
Lower Molar Position - Corpus	-0.02±2.07	1.15±1.53
Lower Incisor Position - Corpus	-0.26±2.07	-1.00±1.52
Upper Incisor Position - Palate	-2.15±2.89	0.26±1.74

TABLE III

MEAN AND STANDARD DEVIATION

	$T_2 - T_1$	$T_3 - T_1$	$T_3 - T_2$	$GF - T_3$
Lower Face Height	2.15±1.98	1.87±2.67	-0.28±1.54	-1.81±2.63
Mandibular Arc	1.38±2.78	3.91±2.52	2.53±2.82	0.18±2.04
Corpus Length	4.80±2.81	8.43±3.23	3.63±2.77	0.19±2.25
Condyle Length	3.78±1.89	5.67±2.19	1.89±1.80	-1.11±1.21
Mandibular Plane	-0.34±1.89	-2.17±2.40	-1.83±2.01	-0.07±2.53
Maxillary Depth	-0.38±2.12	-0.09±2.21	0.29±1.26	
Facial Depth	1.60±1.24	2.86±1.57	1.26±1.49	
Upper Molar Position	1.60±2.10	5.48±2.89	3.87±2.88	
Convexity	-2.04±1.54	-2.96±1.93	-0.92±1.49	0.57±2.02
Nasion-Basion Length	3.72±3.47	5.93±3.69	2.22±2.17	1.63±2.83
Posterior Facial Height	6.44±4.61	11.11±4.05	4.67±3.56	
Facial Axis	-0.62±1.74	-0.27±2.20	0.36±1.62	
Lower Incisor Protrusion	2.47±1.71	2.06±1.89	-0.52±1.37	
Upper Incisor Protrusion	-3.09±2.30	-3.20±1.92	-0.11±1.27	
Molar Relation	-3.04±2.35	-3.00±1.42	0.10±1.83	
Corpus Length/Nasion-Basion	1.89±1.32	1.59±1.68	1.56±1.55	1.15±0.13
Condyle Length/Nasion-Basion	1.67±1.32	-0.53±0.76	0.67±1.20	0.61±0.12

TABLE IV

"t" TESTS ADJUSTMENTS

These values were used as a μ instead of 0 $$t = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}}$$

	$T_2 - T_1$	$T_3 - T_1$	$T_3 - T_2$
Mandibular Arc	1.75	3.25	1.50
Mandibular Plane	-1.05	-1.95	-0.90
Facial Depth	1.16	2.16	1.00
Upper Molar Position	3.50	6.50	3.00
Convexity	-0.70	-1.30	-0.60
Posterior Facial Height	5.40	8.50	3.10

For all other measurements 0 was utilized

$T_2 - T_1 = 3.5$ years

$T_3 - T_1 = 8.5$ years

$T_3 - T_2 = 3.0$ years - 60 percent adjustment factor since some patients at the post-treatment record period were adults

Corpus Length/Ba-Na - 1.0 used as μ

	Ratio	SD	t-value	significance level
$T_2 - T_1$	1.8892	1.3159	3.10	.01
$T_3 - T_1$	2.0400	1.94515	2.57	.05
$T_3 - T_2$	1.5594	1.5529	1.57	--

"t" TESTS - continued

Condyle Length/Ba- Na- 0.5 used as μ

	Ratio	SD	t-value	significance level
$T_2 - T_1$	1.6704	1.3219	4.40	.01
$T_3 - T_1$	1.5861	1.6800	3.10	.01
$T_3 - T_2$	0.6744	1.2025	0.63	--

"t" test to determine if Corpus Length and Condyle Length ratios to Ba-Na are equal at $T_3 - T_1$ and GF - T_1

	t-value	significance level
Corpus Length	2.20	.01
Condyle Length	2.77	.01

TABLE V

"t" TESTS

	$T_2 - T_1$		$T_3 - T_1$		$T_3 - T_2$		$GF - T_3$	
	t value	sig. level	t value	sig. level	t value	sig. level	t value	sig. level
Lower Face Height	5.22	.01	3.36	.01	-0.87	--	3.20	.01
Mandibular Arc	-0.63	--	1.26	--	1.74	.10	-0.13	--
Corpus Length							3.20	.01
Condyle Length							2.17	.05
Mandibular Plane	1.80	.10	-1.73	.10	-2.20	.05	0.43	--
Maxillary Depth	-0.87	--	-0.20	--	1.11	--		
Facial Depth	1.68	--	2.13	.05	0.84	--		
Upper Molar Position	-4.33	.01	-1.69	--	1.46	--		
Convexity	-4.16	.01	-4.13	.01	-1.02	--	1.34	--
Posterior Facial Height	1.08	--	3.09	.01	2.11	.05		
Facial Axis	-1.71	--	-0.58	--	1.05	--		
Lower Incisor Protrusion	6.90	.01	5.13	.01	-1.79	.10		
Upper Incisor Protrusion	-6.46	.01	-7.98	.01	-0.41	--		
Molar Relationship	-6.06	.01	-10.09	.01	0.26	--		

DISCUSSION

The activator appliances for the treatment of a Class II malocclusion are often modified by the various clinical practitioners; however, they are all designed to posture the mandible forward into a Class I molar relationship and open the bite to initiate a stretch reflex of the muscles of mastication. All the appliances utilized in this study were classified as activators, and the only difference in the treatment was the appliance design and the amount the mandible was postured open.

The sample studied contained skeletal patterns which were all brachyfacial or mesofacial with brachyfacial tendencies (Table II). While the sample cases were selected on a random basis, some type of clinical judgment by the practitioners may have been made concerning the most effective facial type for activator treatment. The before treatment composite tracing (Figure 3) clearly exhibits the typical patient in this study as one that falls into the brachyfacial pattern category.

There has been virtually no discussion of functional appliance case selection with respect to facial type. In previous studies[10,25,29,33] the typical successfully treated cases with functional appliances have been brachyfacial skeletal patterns. The orthodontic literature is lacking in the reporting of cases treated with functional appliances consisting of mesofacial and dolichofacial skeletal patterns.

A study has been reported by Ricketts in which facial and denture changes in fifty treated Class II cases were analyzed with a combination of cephalometrics and laminagraphy. It was shown that many similar malocclusions, receiving identical treatment, responded dissimilarly in different facial types when related to cranial landmarks. In that study it was concluded that the explanation of the variety of facial changes lies within the temporomandibular complex.[30]

When investigating growth augmentation, two methods of evaluation or comparison are available, and limitations are associated with each. The two comparisons are a treated case sample compared with a similar untreated sample and prediction or growth forecasting. The untreated patient sample was unavailable during the study, and consequently the projected growth forecast method was utilized.

The reliability of projected growth forecasting has been questioned with respect to the changes in growth velocity during normal growth. In a longitudinal study of twenty-two males and eighteen females between four and twelve years of age, Harris reported that both the male and female samples demonstrated periodic acceleration and deceleration in growth patterns.[13] While questions have been raised concerning late or delayed growth periods, other studies concerning the reliability and accuracy of growth forecasting have been investigated.

The reliability of visual growth forecasting has been studied by Greenberg and Johnston,[12] Schulhof and Bagha,[32] and Carter.[7] Schulhof and Bagha obtained ten year records of fifty patients from the University of Michigan Center for Growth Studies in evaluating growth forecasting and have shown that the RMDS visual computerized forecast was the most accurate of the growth forecasting methods studied. Carter[7] utilized eighty-four sample cases from Dr. Robert Ricketts' cases on file for research at RMDS; and when comparing actual growth and the projected growth for the combined total sample, the findings were better than 96 percent accurate. The accuracy of the individual was in the 80 percent range; and while the accuracy of the individual proved to be less, it was within one clinical deviation.

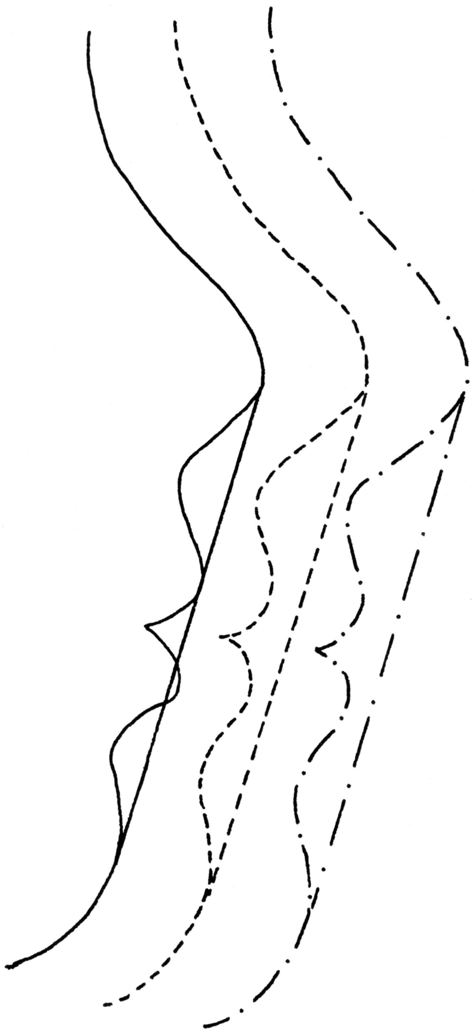
In the original sample of twenty-eight cases, there were four Japanese patients and one Latin. There has not been adequate data developed to accomplish a reliable growth forecast with the Japanese and Latin patients; so these individuals were omitted from the study. The mandibular plane angle measurement on these patients, for instance, becomes significantly larger with maturity, when in actuality the mandibular plane angle in the Caucasian brachyfacial skeletal pattern decreases with age. Kuroda[24] conducted a longitudinal cephalometric study on the craniofacial development of Japanese children and found that when compared with Caucasian growth patterns, the Japanese child tends to have more vertical growth.

In order to investigate whether growth augmentation of the mandible was accomplished with activator treatment, the growth of the condyle and corpus axes were compared to the growth of the Nasion-Basion of the cranial base. Previous studies by Ricketts and Bjork have shown that the Nasion-Basion axis increases approximately one millimeter each year at Nasion and Basion until maturity is reached.[31,3] Since the yearly growth rate of the Nasion-Basion axis length has been established and the axis length would not change with treatment, it was possible to establish proportional comparisons of the condyle and corpus axes growth of the mandible to the cranial base growth. The Nasion-Basion axis length was measured in all samples at all three time intervals so that the comparisons with the mandibular growth could be accomplished. It was therefore possible to remove the variability of total growth of the individual and determine the proportional amount of growth augmentation of the mandible as it relates to the cranial base growth.

The effects of the functional appliance or activator treatment on the growth potential of the mandible agree with the previous short-term investigations.[9,10,23,25,29,33] It was found that the condylar length at the post-treatment period (T_3) grew significantly (Table V) from what was predicted with normal growth (t-value, 2.17; P=0.01), and the corpus length also showed a significant increase (t-value 3.20; P=0.05) during the study period.

The greatest amount of growth augmentation of the mandible was found to be in a vertical direction. This increased growth is apparently in the condyle and ramus portion since there was no mandibular rotation (Table II). The mandible descends along the facial axis in normal growth, and this was also observed in the study sample of activator treated cases. The amount of increase of corpus length was 25 percent (1.7 millimeters) over the predicted growth and a 42 percent (2.3 millimeters) increase in condylar length over the growth prediction. It must be noted that condylar axis length only measures a portion of the ramus and condyle, yet it shows a much greater percentage

FIGURE 6 - Superimposition - Lip Change from E Plane

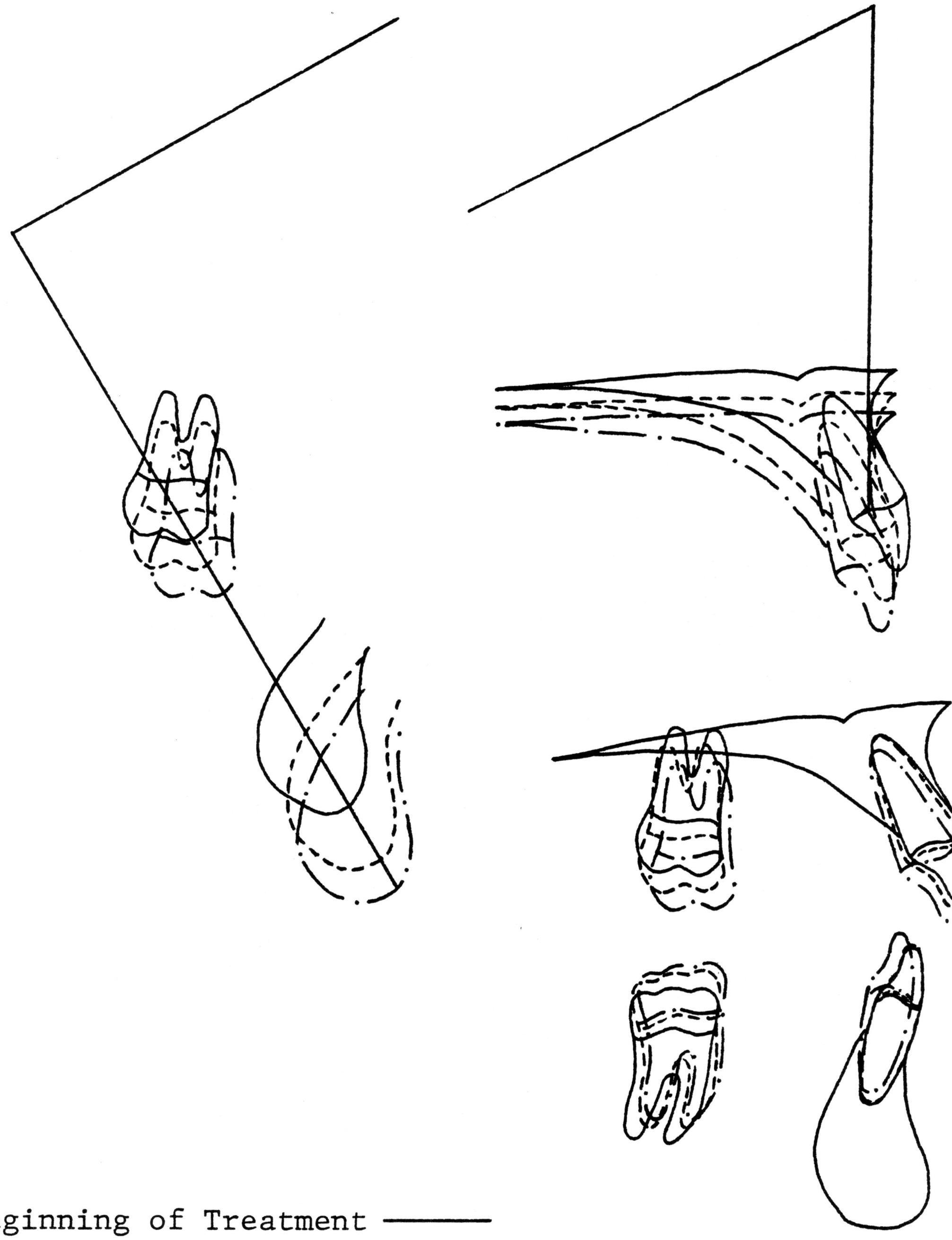


Beginning of Treatment ———

End of Treatment ------

Post-Treatment ——·——

FIGURE 7 - Superimposition - Direction of Facial Change, Skeletal Behavior of Maxilla, Behavior of Upper Molar, Upper and Lower Denture Changes

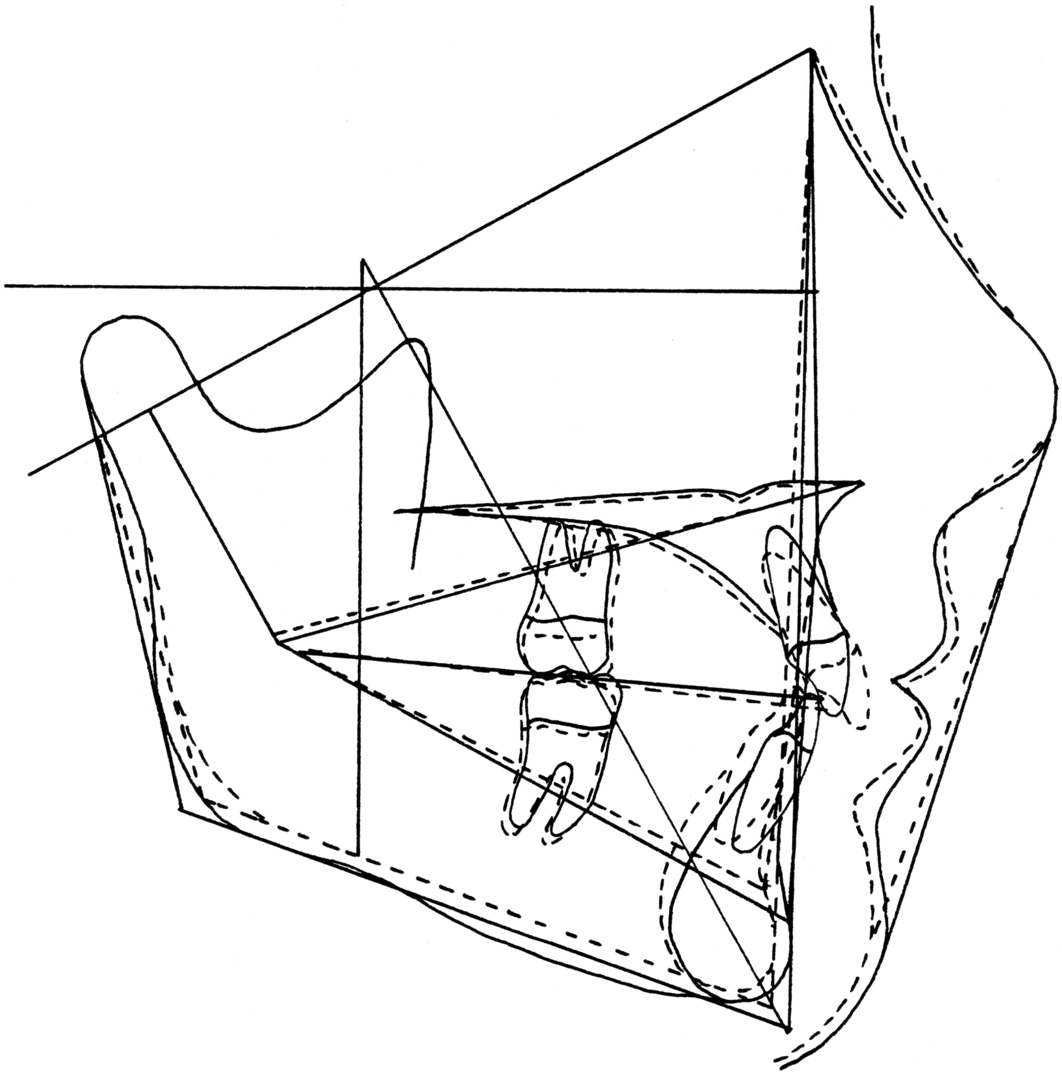


Beginning of Treatment ———

End of Treatment ------

Post-Treatment —·—

FIGURE 8 - Comparison of Growth Forecast with Post-Treatment Composite



Growth Forecast -----

Post-Treatment ———

of growth than the corpus axis length which measures the entire length of the body of the mandible. Therefore, the greatest amount of growth occurred in the ramus and condyle and not the body.

Levy in a study to determine if there was more than the normal amount of mandibular growth following the correction of a deep overbite and an unfavorable incisor inclination, studied thirty-four growing individuals with Class II, Division 2 malocclusion. The data indicated that the interincisal angle and overbite measurements can be used as reliable predictors of excessive mandibular growth. The greater the degree of interincisal angle and the greater the amount of overbite, there is a greater probability for increased mandibular growth.[19] The RMDS growth forecast was programmed to correct for these measurements.

There has been considerable debate over the mechanism of the increased growth of the condylar region. Baume, Haupl, and Stellmach[1] reported on an infant affected with Pierre Robin Syndrome on whom normal jaw relationships were established after five months of mandibular protrusive therapy. The child later died of unrelated causes at age nine months, and a histological analysis of the temporomandibular joints revealed that the condylar head showed growth in both vertical and horizontal dimensions which exceeded the normal rate and without any traumatic injuries to the capsular structures. Earlier studies by Breitner,[4] Haupl and Psansky[15] and Hoffer[16] showed similar histological changes in experimental monkeys.

Petrovich and his co-workers,[26,27] in several studies have shown when hyperpropulsing the mandible of laboratory rats, a thickening of the chondroblastic zone is quite evident after four weeks. In 1973, McNamara conducted a study on sixty-four Mulatta monkeys in which he induced a forward and vertical displacement of the mandible. The average growth increments of the treated sample, measured at condylion, was 50 percent higher than that measured in the control group.[21,22]

Lower face height increased with the use of the activator and the amount of increase remained virtually stable five years after treatment (Table V). The measurement was found to be greater with the activator cases when compared to the growth forecast by 1.8 degrees (Table II). This increased measurement was accomplished by an increase in posterior facial height of 3.6 millimeters over the growth forecast, and this was accomplished with posterior vertical growth without mandibular rotation as shown by the facial axis measurement (Table II).

Facial axis measurement was not altered to any significant amount during the treatment phase (Table II), and the post-treatment measurement remained constant from the beginning of treatment measurement. This would indicate that the Class II molar correction was accomplished without any adverse rotation of the mandible.

Maxillary depth remained virtually constant throughout the treatment period and the post-treatment evaluation period (Table II), and the upper molar position increased from the beginning of treatment to the end of treatment 1.9 millimeters and continued to increase at the normal rate during the post-treatment period. This indicates an insignificant effect on the maxilla in a posterior direction and suggests that activators do not inhibit maxillary growth.

This finding is in direct conflict with Jakobsson,[17] Trayfoot,[34] and Harvold and Vargervik.[14] Jakobsson[17] found that the activator "had, in a posterior direction, a definite influence on the basal parts of the maxilla." Trayfoot[34] and Harvold and Vargervik[14] found that the activator restricted the forward growth of the maxilla.

The Class II molar relationship was corrected, and the position of the corrected molar remained stable (Table II). When the "t" tests for this measurement were evaluated, it was found that between T_1 and T_2 the t-value was -7.43 (P=0.01) and when comparing T_3 to T_1 records that the t-value was -10.58 (P=0.01). In order to show the stability of this denture change, the five year post-treatment period was compared with that of the end of treatment and found that it remained stable (t-value 0.03).

The original study sample consisted of Class II, Division 1 deep bite patients (Figure III). The deep bite is corrected with the activator treatment by properly grinding the acrylic in the molar and premolar regions of the mandibular arch, thus promoting their eruption. The end of treatment composite tracing exhibits the proper amount of overbite and overjet relation and an interincisal angle of 130 degrees. The maxillary incisor inclination is 24.9 degrees, and the clinical norm is 28.0 degrees, exhibiting a -0.8 clinical deviation from the norm (Tables VI, VII and VIII). In the treatment of deep bite cases, McAlpine[20] reported that the brachyfacial skeletal pattern with the short lower face height and low mandibular plane angle show the greatest amount of relapse. Additionally, McAlpine found that deep bite cases which finished to an interincisal angle between 125 and 130 degrees showed the greatest stability. The post-treatment tracing (Figure 7) shows a slight relapse toward a deep bite tendency yet a quite stable dentition (maxillary incisor inclination--22.9

degrees, -1.3 clinical deviation and an interincisal angle of 134 degrees).

The present study of the long-term effects of activator treatment on brachyfacial skeletal pattern patients has been shown to be stable over a five year post-treatment period (Table II). The effects on the mesofacial and dolichofacial skeletal patterns remain unknown. Additional investigation will be necessary to investigate the effects and stability of activator treatment on these facial types.

SUMMARY

The results of the present long-term study of activator treated Class II, Division 1 patients indicate the following:

1. Greater than projected growth in the condylar and corpus axes of the mandible. The amount of growth was greater than projected during the treatment phase and then continued to grow at the normal growth rate until maturity.
2. A significant increase in the lower face height.
3. A significant increase in the posterior facial height.
4. An insignificant effect on the maxilla suggesting that the activator did not inhibit maxillary growth.
5. Stability of the increased condyle axis length, corpus axis length, lower face height, and posterior facial height over the five year post-treatment period.

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FIGURE 9 - Composite Tracing - Growth Forecast

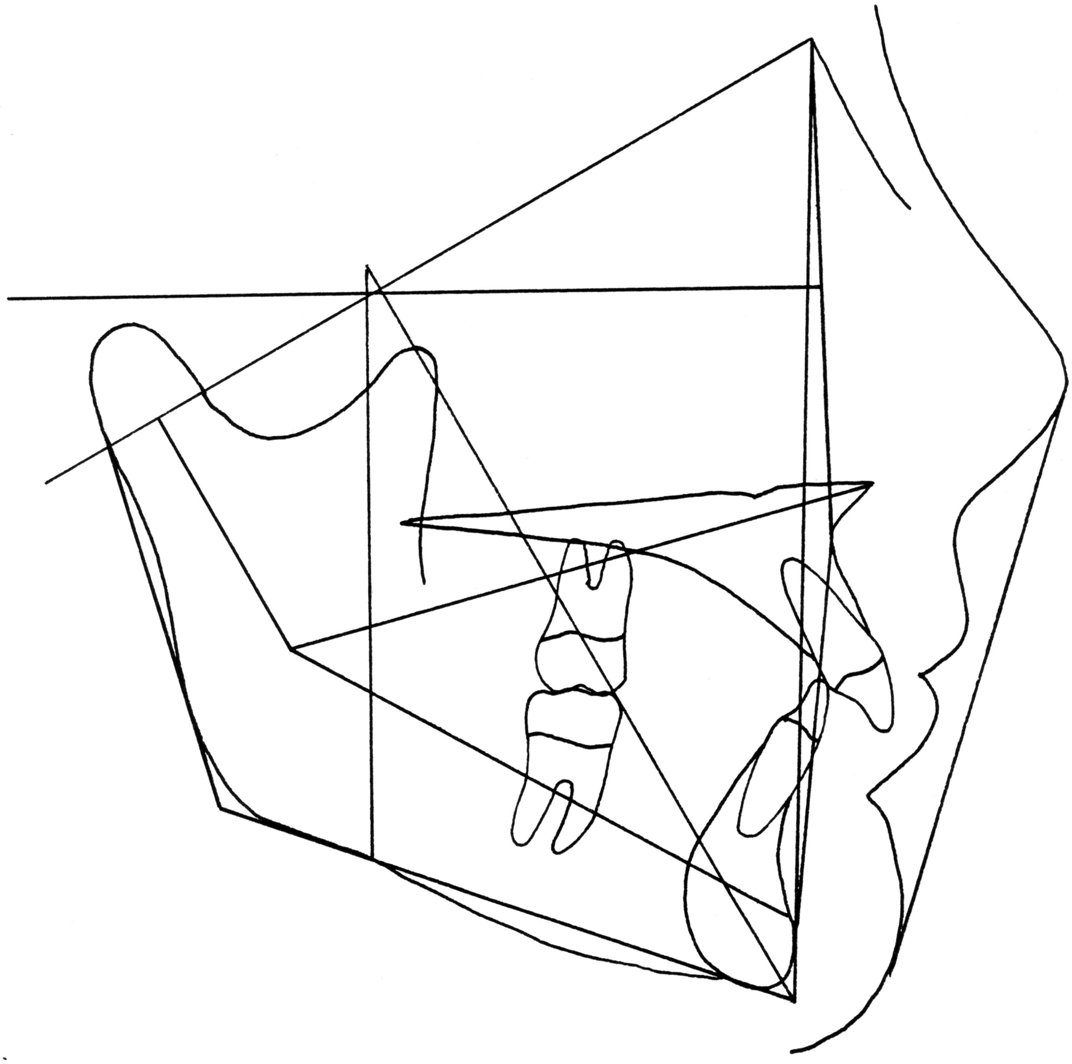

TABLE VI

COMPREHENSIVE CEPHALOMETRIC DESCRIPTION -

BEFORE TREATMENT

Factor	Measured Value	Clinical Norm	Clinical Deviations from Norm
Field I: The Denture Problem (Occlusal Relation)			
01-Molar Relation	1.4 mm	-3.0 mm	1.5 *
03-Canine Relation	2.9 mm	-2.0 mm	1.6 *
05-Incisor Overjet	8.1 mm	2.5 mm	2.2 **
07-Incisor Overbite	5.1 mm	2.5 mm	1.3 *
09-Mandibular Incisor Extrusion	3.8 mm	1.3 mm	1.3 *
11-Interincisal Angle	128.1 deg	130.0 deg	-0.3
Field II: The Skeletal Problem (Maxillo-Mandibular Relation)			
13-Convexity	4.5 mm	3.1 mm	0.7
15-Lower Facial Height	42.9 deg	47.0 deg	-1.0 *
Field III: Denture to Skeleton			
18-Upper Molar Position	14.8 mm	13.5 mm	0.4
20-Mandibular Incisor Protrusion	0.2 mm	1.0 mm	-0.4
22-Maxillary Incisor Protrusion	8.4 mm	3.5 mm	2.2 **
24-Mandibular Incisor Inclination	19.3 deg	22.0 deg	-0.7
26-Maxillary Incisor Inclination	32.6 deg	28.0 deg	1.2 *
27-Occlusal Plane-Ramus (XI)	1.9 mm	0.1 mm	0.6
28-Occlusal Plane Inclination	20.4 deg	23.4 deg	-0.7
Field IV: Esthetic Problem (Lip Relation)			
29-Lip Protrusion	1.1 mm	-1.4 mm	1.2 *
30-Upper Lip Length	24.4 mm	24.7 mm	-0.1
31-Lip Embrasure-Occlusal Plane	-3.4 mm	-3.0 mm	-0.2
Field V: The Determination Problem (Cranio-Facial Relation)			
32-Facial Depth	86.4 deg	87.1 deg	-0.2
34-Facial Axis	90.2 deg	90.0 deg	0.1

Factor	Measured Value	Clinical Norm	Clinical Deviations from Norm
35-Facial Taper	72.0 deg	68.0 deg	1.1 *
36-Maxillary Depth	91.0 deg	90.0 deg	0.3
37-Maxillary Height	53.7 deg	53.7 deg	0.0
38-Palatal Plane (FH)	3.7 deg	1.0 deg	0.8
39-Mandibular Plane (FH)	21.7 deg	25.5 deg	-0.9
Field VI: The Internal Structure Problem (Deep Structure)			
40-Cranial Deflection	28.3 deg	27.0 deg	0.4
42-Cranial Length Anterior	60.1 mm	56.9 mm	1.3
44-Posterior Facial Height	60.3 mm	57.1 mm	1.0
46-Ramus Position	74.5 deg	76.0 deg	-0.5
48-Porion Location (TMJ)	-41.1 mm	-39.7 mm	-0.6
50-Mandibular Arc	29.9 deg	26.9 deg	0.7
51-Corpus Length	67.5 mm	67.5 mm	0.0

TABLE VII

COMPREHENSIVE CEPHALOMETRIC DESCRIPTION -

END OF TREATMENT

Factor	Measured Value	Clinical Norm	Clinical Deviations from Norm
Field I: The Denture Problem (Occlusal Relation)			
01-Molar Relation	-1.7 mm	-3.0 mm	0.4
03-Canine Relation	-0.7 mm	-2.0 mm	0.4
05-Incisor Overjet	2.8 mm	2.5 mm	0.1
07-Incisor Overbite	2.4 mm	2.5 mm	0.0
09-Mandibular Incisor Extrusion	1.8 mm	1.3 mm	0.3
11-Interincisal Angle	130.8 deg	130.0 deg	0.1
Field II: The Skeletal Problem (Maxillo-Mandibular Relation)			
13-Convexity	2.7 mm	2.0 mm	0.3
15-Lower Facial Height	45.0 deg	47.0 deg	-0.5
Field III: Denture to Skeleton			
18-Upper Molar Position	16.9 mm	17.0 mm	0.0
20-Mandibular Incisor Protrusion	2.7 mm	1.0 mm	0.7
22-Maxillary Incisor Protrustion	5.5 mm	3.5 mm	0.9
24-Mandibular Incisor Inclination	24.3 deg	22.0 deg	0.6
26-Maxillary Incisor Inclination	24.9 deg	28.0 deg	-0.8
27-Occlusal Plane Ramus (XI)	0.9 mm	-1.7 mm	0.9
28-Occlusal Plane Inclination	22.6 deg	25.2 deg	-0.6
Field IV: Esthetic Problem (Lip Relation)			
29-Lip Protrusion	-1.7 mm	-2.1 mm	0.2
30-Upper Lip Length	25.3 mm	26.4 mm	-0.6
31-Lip Embrasure-Occlusal Plane	-4.1 mm	-3.0 mm	-0.6
Field V: The Determination Problem (Cranio-Facial Relation)			
32-Facial Depth	88.0 deg	88.3 deg	-0.1
34-Facial Axis	89.5 deg	90.0 deg	-0.1

Factor	Measured Value	Clinical Norm	Clinical Deviations from Norm
35-Facial Taper	70.8 deg	68.0 deg	0.8
36-Maxillary Depth	90.5 deg	90.0 deg	0.2
37-Maxillary Height	55.7 deg	55.1 deg	0.2
38-Palatal Plane (FH)	3.5 deg	1.0 deg	0.7
39-Mandibular Plane (FH)	21.2 deg	24.5 deg	-0.7
Field VI: The Internal Structure Problem (Deep Structure)			
40-Cranial Deflection	29.1 deg	27.0 deg	0.7
42-Cranial Length Anterior	62.4 mm	61.7 mm	0.3
44-Posterior Facial Height	67.0 mm	62.5 mm	1.3 *
46-Ramus Position	76.8 deg	76.0 deg	0.3
48-Porion Location (TMJ)	-41.8 mm	-42.5 mm	0.3
50-Mandibular Arc	31.3 deg	28.7 deg	0.7
51-Corpus Length	72.6 mm	73.7 mm	-0.4

TABLE VIII

COMPREHENSIVE CEPHALOMETRIC DESCRIPTION -

POST-TREATMENT

Factor	Measured Value	Clinical Norm	Clinical Deviations from Norm
Field I: The Denture Problem (Occlusal Relation)			
01-Molar Relation	-1.7 mm	-3.0 mm	0.4
03-Canine Relation	-0.4 mm	-2.0 mm	0.5
05-Incisor Overjet	3.2 mm	2.5 mm	0.3
07-Incisor Overbite	3.5 mm	2.5 mm	0.5
09-Mandibular Incisor Extrusion	1.9 mm	1.3 mm	0.3
11-Interincisal Angle	134.7 deg	130.0 deg	0.8
Field II: The Skeletal Problem (Maxillo-Mandibular Relation)			
13-Convexity	1.3 mm	0.5 mm	0.4
15-Lower Facial Height	44.6 deg	47.0 deg	-0.6
Field III: Denture to Skeleton			
18-Upper Molar Position	20.4 mm	21.0 mm	-0.2
20-Mandibular Incisor Protrusion	2.0 mm	1.0 mm	0.5
22-Maxillary Incisor Protrusion	5.2 mm	3.5 mm	0.8
24-Mandibular Incisor Inclination	22.4 deg	22.0 deg	0.1
26-Maxillary Incisor Inclination	22.9 deg	28.0 deg	-1.3 *
27-Occlusal Plane-Ramus (XI)	-0.8 mm	-3.7 mm	0.9
28-Occlusal Plane Inclination	24.0 deg	27.2 deg	-0.8
Field IV: Esthetic Problem (Lip Relation)			
29-Lip Protrusion	-2.7 mm	-2.9 mm	0.1
30-Upper Lip Length	26.3 mm	27.4 mm	-0.6
31-Lip Embrasure-Occlusal Plane	-3.4 mm	-3.0 mm	-0.2
Field V: The Determination Problem (Cranio-Facial Relation)			
32-Facial Depth	89.1 deg	89.6 deg	-0.1
34-Facial Axis	90.1 deg	90.0 deg	0.0

Factor	Measured Value	Clinical Norm	Clinical Deviations from Norm	
35-Facial Taper	71.3 deg	68.0 deg	0.9	
36-Maxillary Depth	90.4 deg	90.0 deg	0.1	
37-Maxillary Height	56.3 deg	56.7 deg	-0.2	
38-Palatal Plane (FH)	3.9 deg	1.0 deg	0.8	
39-Mandibular Plane (FH)	19.5 deg	23.3 deg	-0.8	
Field VI: The Internal Structure Problem (Deep Structure)				
40-Cranial Deflection	29.3 deg	27.0 deg	0.8	
42-Cranial Length Anterior	64.0 mm	64.4 mm	-0.1	
44-Posterior Facial Height	71.5 mm	65.6 mm	1.8	*
46-Ramus Position	77.0 deg	76.0 deg	0.3	
48-Porion Location (TMJ)	-42.3 mm	-44.0 mm	0.8	
50-Mandibular Arc	33.5 deg	30.7 deg	0.7	
51-Corpus Length	76.3 mm	77.2 mm	-0.3	