FACIAL HEIGHT AND INTERDENTAL RELATIONSHIPS:

A LONGITUDINAL INVESTIGATION

OF THE EFFECTS OF BITE PLATE AND ARCH WIRE TREATMENTS

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INTRODUCTION

The relationships of the anatomic parts of the human face have been studied since man became aware of his own image. The changes in appearance during our progress from infancy to maturity have been ascribed to herédity and environmental influences.[3,9] Attempts to modify our genetic components have not been acceptable in our present society. Changing our environment has been much more common and has been useful in the progress of man.

Orthodontic treatment has concentrated its attention on modifying the form, function, and esthetics of the human face and dentition. Plaudits have been accepted when a pleasing and functional result has been achieved. "Bad growth" and "poor cooperation" have been blamed for a less satisfactory conclusion. Individual variation has intervened to upset our carefully planned modification of the environment.

OBJECTIVES

To help us understand the effects of our treatment upon the human craniofacial complex, an investigation was undertaken of the facial height and interdental relationships. One concept of overbite treatment has involved the use of biteplates to allow over eruption of the posterior teeth. In contrast, another type of treatment has attempted to intrude the anterior teeth with arch wires. Clinical evaluation has enabled us to judge effective results, but treatment effects in relation to adjacent structures could not be objectively evaluated.

Several fundamental questions were asked. Did orthodontic treatment affect facial height? Was this effect on the maxillary or mandibular component? Did arch wire or bite plate therapy more effectively reduce overbite? Could teeth be permanently intruded? Answers to these questions would materially help orthodontists in achieving treatment goals.

METHODS AND MATERIALS

The sample for this study was obtained from the treatment records of a private orthodontic practice. The sample consisted of a group of American-born white children, predominantly of northwest European ancestry and above average socioeconomic status.

Acceptance into the study was dependent upon adequate serial records being available of "before treatment" and "at completion of" orthodontic treatment. These records consisted of lateral cephalometric films taken by the Broadbent[1] method, fullmouth intraoral periapical films, study casts, and treatment proceedures. Final lateral cephalometric films and study models were obtained by recalling each individual to the University of Oregon Dental School. A visual examination and consultation determined the present occlusal status and the time orthodontic retainers were removed.

Age differences were minimized by limiting acceptance to those individuals born in 1947. The arch wire sample was composed of 16 series, 2 boys and 14 girls, with an average age of 118.1 months (9 years 10.1 months) at the start of treatment, and 152.1 months (12 years, 8.1 months) at the completion of treatment. The bite plate sample consisted of 12 series, 4 boys and 8 girls, with an average age of 114.7 months (9 years, 6.7 months) at the start of treatment and 148.5 months (12 years, 4.5 months) at the end of treatment. The final records were obtained during February, 1964, at which time the average age was 200.7 months (16 years, 8.7 months) for the whole study. An analysis of the treatment group ages utilizing the "F" and "t" test, showed there were no statistically significant differences in age at any period of observation. (Table I).

Since the lateral cephalometric films were taken with different xray equipment and at different cassette distances from the individual, it was necessary to correct for the enlargement of all linear measurements in each film. A metalic pointer to the bridge of the nose was present in each film taken before and at the end of treatment. The size was calibrated for varying cassette distances from the pointer by comparison to the enlargement measured on a lead ruled scale (Wehmer). A regression line, $Y = 12.68 + 0.127X$, was plotted from this data and the percent of enlargement was determined for any size of pointer. (Fig. I).

Roentgenographic Analysis

The following roentgenographic reference points and lines were used. (Fig. 2).

Nasion (N): The anterior junction of the frontal and nasal bones.

Anterior nasal spine (ANS): The spinous process of the maxilla forming the most anterior projection of the floor of the nasal cavity.

Posterior nasal spine (PNS): A point located on the floor of the nasal cavity distal to the roots of the maxillary first permanent molar.

Palatal Plane (PP): The extension of a line through the anterior nasal spine and posterior nasal spine.

Superior Incisor (SI): The incisal point of the most prominent medial maxillary incisor.

Inferior Incisor (II): The incisal point of the most prominent medial mandibular incisor.

Pogonian (P): The most prominent point on the symphysis of the mandible.

Menton (M): The junction of the most inferior point of the symphysis with the lower border of the mandible.

Mandibular plane (MP): A line thru menton (M) tangent to the lowest point of the bony contour at the gonial angle.

Facial plane (FP): A line from nasion (N) to pogonian (P).

Using these points and lines, the following measurements were made:

1. Nasal height: Nasion to anterior nasal spine.
2. Subnasal height: Anterior nasal spine to menton.
3. Facial height: Nasion to menton.
4. Superior incisor height: Anterior nasal spine to the incisal edge of the superior incisor.
5. Inferior incisor height: Menton to the incisal edge of the inferior incisor.
6. Overbite: The distance between the perpendicular projections of the superior incisor tip and inferior incisor tip on the facial plane.
7. Subnasal angle: The angle between the palatal plane and the mandibular plane.

Landmarks were located on one complete series of films for an individual and marked by piercing the film with a sharp needle. Marking and measuring was completed for each subject at one sitting to minimize point location error. Readings estimated to the nearest 0.1mm. were made with a boley gauge, and to the nearest 0.001 inch with a Dixon caliper. Both instruments were calibrated before, during, and after measuring the films with a John Bull caliper (British Indicators, Ltd.). When the xray image of the inferior incisal point was indistinct, direct measurements were taken from the casts.

The error of the method was determined by independent double determinations on nine subjects with two films. The linear measurement error was 0.24mm. and the angular measurement error was 0.36 degrees.

The dimensions were compared before treatment, stage 1, at the end treatment, stage 2, and out of retention, stage 3. The changes from stages 1 to 2, 2 to 3, and 1 to 3 were also investigated. The 0.05 level of significance was used to determine significant differences.

Biostatistical Analysis

A biostatistical analysis[4] was utilized to determine the significance of the data. To find the relationship of pointer size to percent enlargement, a regression line was calculated, $Y = A + bX$, where

$$A = \frac{(\Sigma Y)(\Sigma X^2) - (\Sigma X)(\Sigma XY)}{N \Sigma X^2 - (\Sigma X)^2}$$

$$b = \frac{N \Sigma XY - (\Sigma X)(\Sigma Y)}{N \Sigma X^2 - (\Sigma X)^2}$$

The error of the method was determined by calculation from

$$SEmeas = \left(\frac{\Sigma (Diff)^2}{2N} \right)^{\frac{1}{2}}$$

which gives us the average difference from the average of any measurement.

The arithmetic mean is a measure of central tendency.

$$\bar{X} = \frac{\Sigma X}{N}$$

The standard deviation is an indication of the range of the measurements. One standard deviation on either side of the mean will include 68.3% of the sample; two standard deviations will include 95.4% and three standard deviations will include 99.7% of the sample.

$$Sd^2 = \frac{(X - \bar{X})^2}{N - 1} = \frac{N \Sigma X^2 - (\Sigma X)^2}{N (N - 1)} \qquad Sd = (Sd^2)^{\frac{1}{2}}$$

The standard error of the mean gives the range within which the true mean will be found.

$$e\ (M) = Sd / N^{\frac{1}{2}}$$

The ratio of the variances of two samples may be compared to determine if they may be pooled.

$$F = Sd_1{}^2 / Sd_2{}^2$$

at any level of confidence α. The critical regions are:

$$F_{\frac{1}{2}\alpha}(N_1 - 1)(N_2 - 1) > F > F_{1 - \frac{1}{2}\alpha}(N_1 - 1)(N_2 - 1)$$

The "t" test determines the probabilities of the means of two samples being significantly different.

$$t = \frac{\overline{X}_1 - \overline{X}_2}{(S_1^2 / N + S_2^2 / N_2)^{1/2}}$$

This ratio has a $t\ (N_1 + N_2 - 2)$ distribution with critical regions determined by α as

$$t_{1/2\alpha}(N_1 + N_2 - 2) > t > t_{1 - 1/2\alpha}(N_1 + N_2 - 2)$$

where $(N_1 + N_2 - 2)$ is the degrees of freedom.

The coefficient of Variation (CV) indicates the relative variation of the sample dimension when compared to its mean.

$$CV = \frac{Sd}{M} \times 100$$

FINDINGS

V=16 - [illegible]
V=17 - Headgear

TABLE I

VARIATION OF THE SAMPLE AGE

	ARCH WIRE				BITE PLATE						
Stage	Mean months	e(M)	Sd	CV %	Mean months	e(M)	Sd	CV %	$M_1 - M_2$ months	F	t
I	118.1	± 2.25	9.0	7.6	114.7	± 3.45	11.9	10.4	3.4	.57	.84
II	152.1	± 2.9	11.3	7.4	148.5	± 8.36	12.4	8.3	3.6	.83	.79
III	201.3	± 0.7	2.9	1.4	200.2	± 1.3	4.4	2.2	1.1	.44	.75
	$F_{.95}(16,12) = 2.60$				$t_{.95}\ (26) = 2.056$						

TABLE II

ENLARGEMENT OF SAMPLE XRAYS

Stage	Mean %	e(M) %	Sd %	CV %
I	5.64	±0.13	0.69	12.2
II	6.65	±0.91	0.91	13.7
III	7.25	±0.16	0.28	3.9

TABLE III

DIMENSIONAL CHANGES DURING PERIOD OF OBSERVATION

Dimension Stage	ARCH WIRE Mean mm	e(M) mm	Sd mm	CV %	BITE PLATE Mean mm	e(M) mm	Sd mm	CV %	M_1-M_2 mm	F	t
N / ANS											
I	46.3	± 0.51	2.05	4.4	45.6	± 0.77	2.7	5.9	0.7	0.59	0.81
II	48.9	± 0.76	3.05	6.2	48.9	± 0.72	2.5	5.1	0.0	1.51	0.00
III	50.4	± 0.79	3.18	6.3	51.7	± 1.06	3.7	7.1	1.3	0.64	0.93
I-II	2.6	± 0.42	1.69	65.5	3.3	± 0.44	1.5	69.7	0.7	1.24	1.30
II-III	1.5	± 0.21	0.86	57.0	2.8	± 0.36	2.1	155	1.3	0.18	2.04
I-III	4.1	± 0.50	1.85	45.1	6.1	± 0.66	2.3	86.6	2.0	0.65	2.41**
ANS / M											
I	59.7	± 1.11	4.43	7.4	57.9	± 1.03	3.6	6.2	1.8	1.54	1.20
II	63.1	± 1.24	4.97	7.9	60.1	± 1.20	4.1	6.8	3.1	1.47	2.23**
III	65.1	± 1.30	5.19	8.0	64.5	± 1.37	4.8	7.4	0.6	1.18	0.32
I-II	3.4	± 0.62	2.50	73.5	2.2	± 0.42	1.5	68.2	1.2	2.85*	1.6
II-III	2.0	± 0.43	1.74	87.0	4.3	± 0.69	2.4	55.3	3.2	6.49*	3.95**
I-III	5.4	± 0.75	3.03	56.1	6.5	± 0.90	3.2	49.1	1.1	0.90	0.92
Total Face Height N / M											
I	104.5	± 1.30	5.40	5.2	101.3	± 1.30	4.6	4.6	3.2	1.35	1.70
II	110.8	± 1.70	6.60	5.9	107.2	± 1.42	4.9	4.6	3.6	1.83	1.60
III	114.1	± 1.60	6.45	5.7	114.0	± 1.90	6.5	5.7	0.1	0.98	0.00
I-II	6.3	± 0.82	3.30	52.4	5.9	± 0.70	2.4	40.7	0.4	0.92	0.37
II-III	3.3	± 0.44	1.80	54.5	6.8	± 1.13	3.9	57.4	3.5	0.21	2.92**
I-III	9.6	± 0.79	3.16	32.9	12.7	± 1.37	4.8	37.4	3.1	0.44	1.96
Ratio N-ANS / ANS-M x 100											
I	77.8	± 1.29	5.17	6.6	78.9	± 1.81	6.3	7.9	1.1	0.68	0.48
II	77.8	± 1.63	6.53	8.4	81.7	± 1.78	6.2	7.5	3.9	0.89	1.59
III	77.8	± 1.75	6.98	9.0	80.4	± 1.83	6.3	7.9	2.6	0.84	1.02

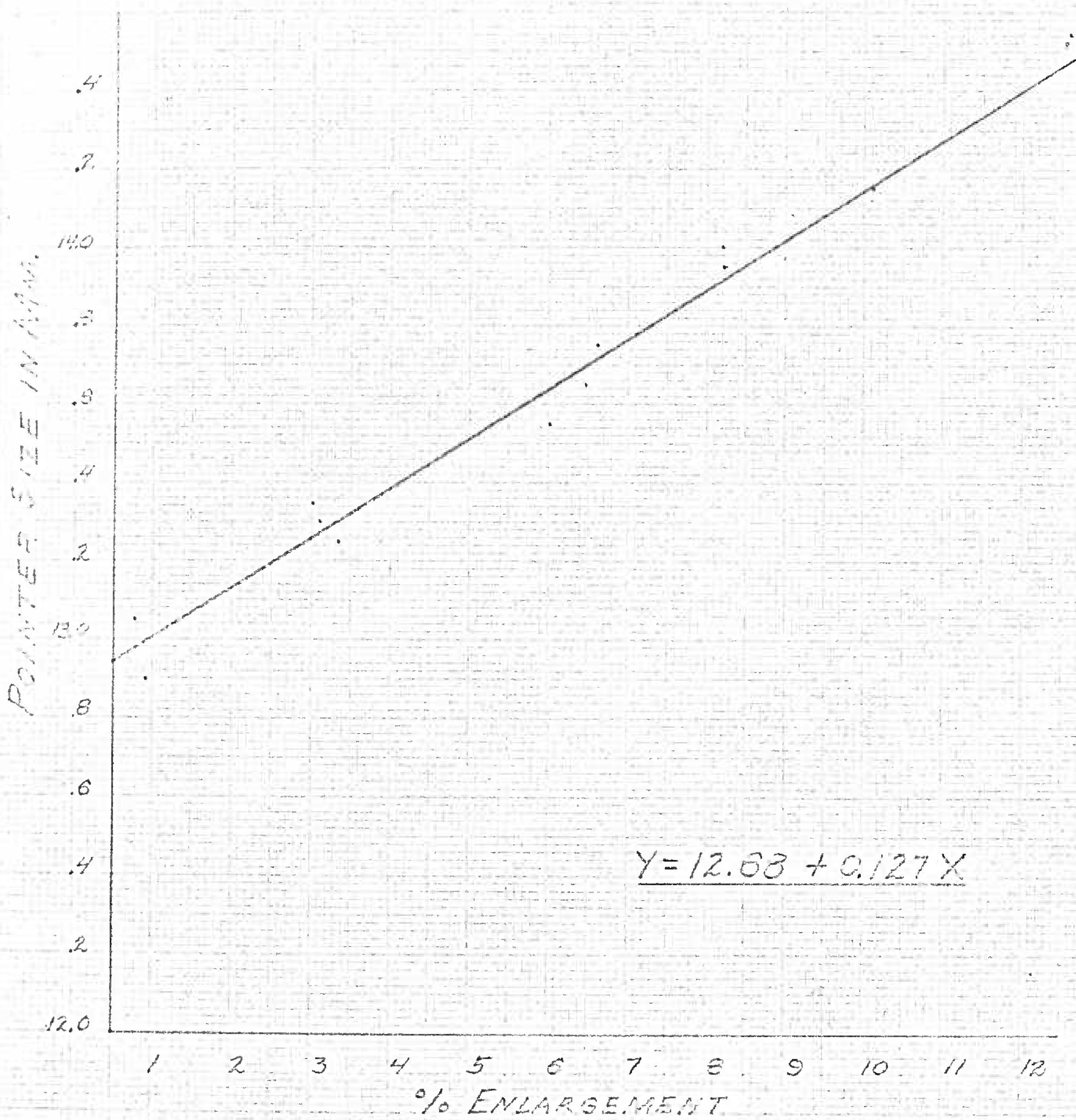
$F_{.95}(16,12) = 2.60$ $t_{.95}(26) = 2.056$

TABLE III

DIMENSIONAL CHANGES DURING PERIOD OF OBSERVATION

Dimension Stage	ARCH WIRE Mean mm	e(M) mm	Sd mm	CV %	BITE PLATE Mean mm	e(M) mm	Sd mm	CV %	M_1-M_2 mm	F	t
ANS / SI											
I	26.4	± 0.57	2.25	8.5	25.6	± 1.08	3.7	14.6	0.8	0.36	0.66
II	27.4	± 0.73	2.90	10.6	26.5	± 0.73	2.6	9.6	0.9	1.30	0.87
III	28.4	± 0.63	2.50	8.8	27.9	± 0.73	2.5	9.1	0.5	1.00	0.52
I-II	1.0	± 0.30	1.20	120	0.9	± 0.48	1.7	184	0.1	0.52	0.18
II-III	1.0	± 0.23	0.85	85.0	1.4	± 0.26	0.9	57.9	0.4	0.90	1.12
I-III	2.0	± 0.35	1.40	70.0	2.3	± 0.41	1.4	62.6	0.3	0.90	0.56
M / II											
I	37.9	± 0.62	2.50	6.6	37.9	± 1.83	6.4	16.8	0.0	0.16	0.00
II	37.4	± 0.73	2.90	7.8	39.4	± 1.87	6.5	16.4	2.0	0.20	1.00
III	39.4	± 0.70	2.80	7.1	42.6	± 1.96	6.8	15.9	3.2	0.17	1.53
I-II	-0.5	± 0.21	0.86	172	1.5	± 0.26	0.9	60.7	2.0	0.90	5.88**
II-III	2.0	± 0.23	0.97	48.5	3.2	± 0.57	2.0	61.3	1.2	0.25	1.95
I-III	1.5	± 0.37	1.50	93.8	4.7	± 0.60	2.1	44.5	3.2	0.53	4.38**
Overbite											
I	4.3	± 0.51	2.10	48.8	3.1	± 0.61	2.1	67.7	1.2	1.10	1.52
II	1.8	± 0.26	1.04	57.8	3.9	± 0.35	1.2	31.3	2.1	0.72	4.82**
III	3.2	± 0.4	1.60	50.0	4.4	± 0.45	1.5	35.1	1.2	1.11	2.00
I-II	-2.5	± 0.47	1.90	76.0	0.8	± 0.20	0.7	86.3	3.3	7.48*	6.47**
II-III	1.4	± 0.28	1.13	80.7	0.5	± 0.17	0.6	136	0.9	5.16*	2.72**
I-III	-1.1	± 0.26	1.03	93.6	1.3	± 0.30	1.0	79.5	2.4	1.04	6.00**
PP / MP Angle in degrees											
I	27.8	± 1.12	4.50	16.2	26.8	± 1.74	1.9	7.0	1.0	0.55	0.48
II	27.5	± 1.21	1.52	5.5	25.9	± 1.33	4.6	17.9	1.6	1.08	0.89
III	25.8	± 1.36	1.72	6.7	25.5	± 1.43	5.6	22.0	0.3	0.95	0.14
I-II	-0.3	± 0.36	1.45	483	-0.9	± 0.35	1.2	133	0.6	1.46	1.20
II-III	-1.7	± 0.51	2.03	119	-0.4	± 0.35	1.2	297	1.3	2.90*	2.10**
I-III	-2.0	± 0.55	2.20	110	-1.3	± 0.42	1.5	111	0.7	2.30	1.01

$F_{.95}(16,12) = 2.60$ $t_{.95}(26) = 2.056$



Calibration of Enlargement in

Treatment Lateral Films

Fig. 1

ROENTGENOGRAPHIC LANDMARKS

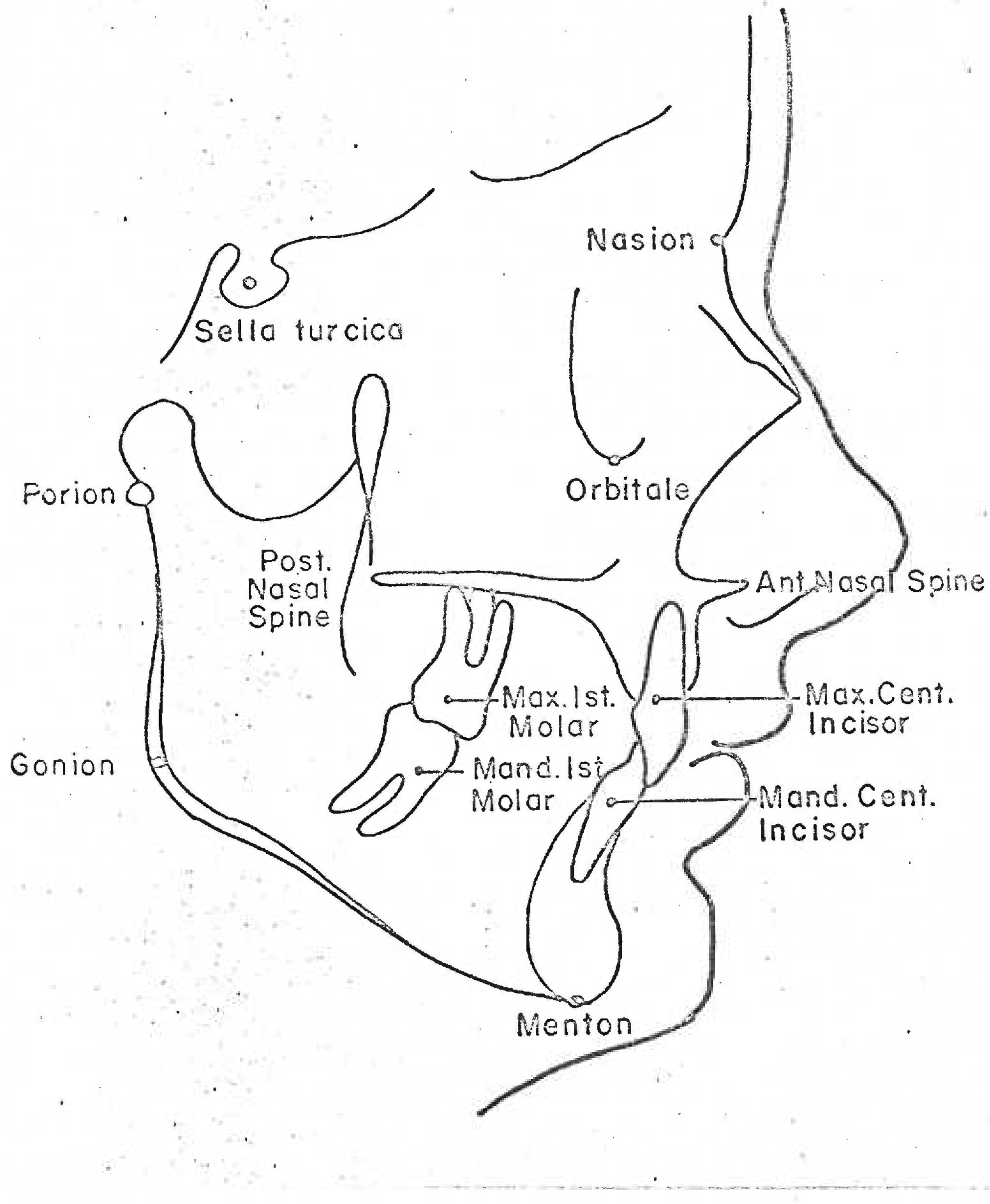
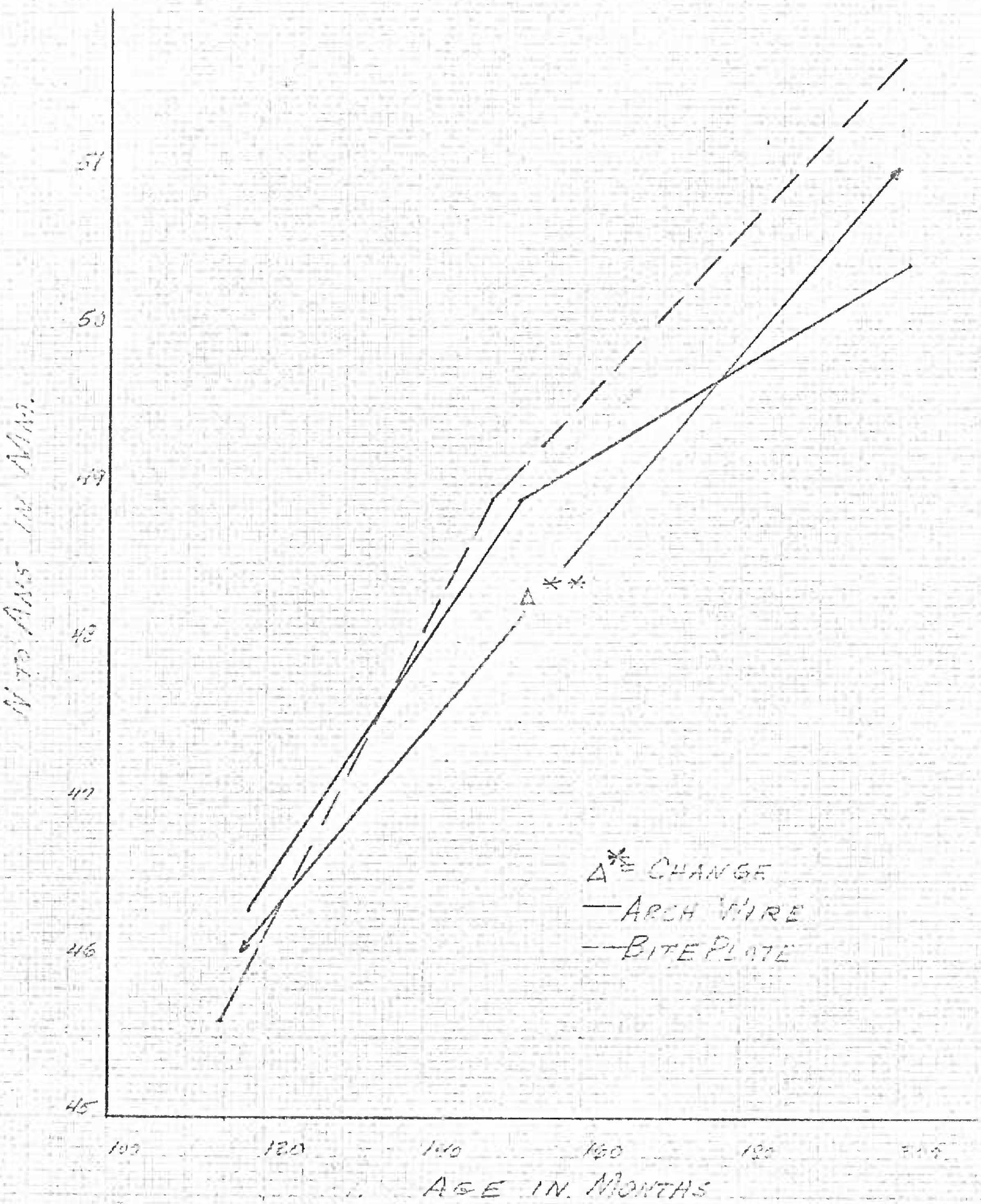


Figure 2

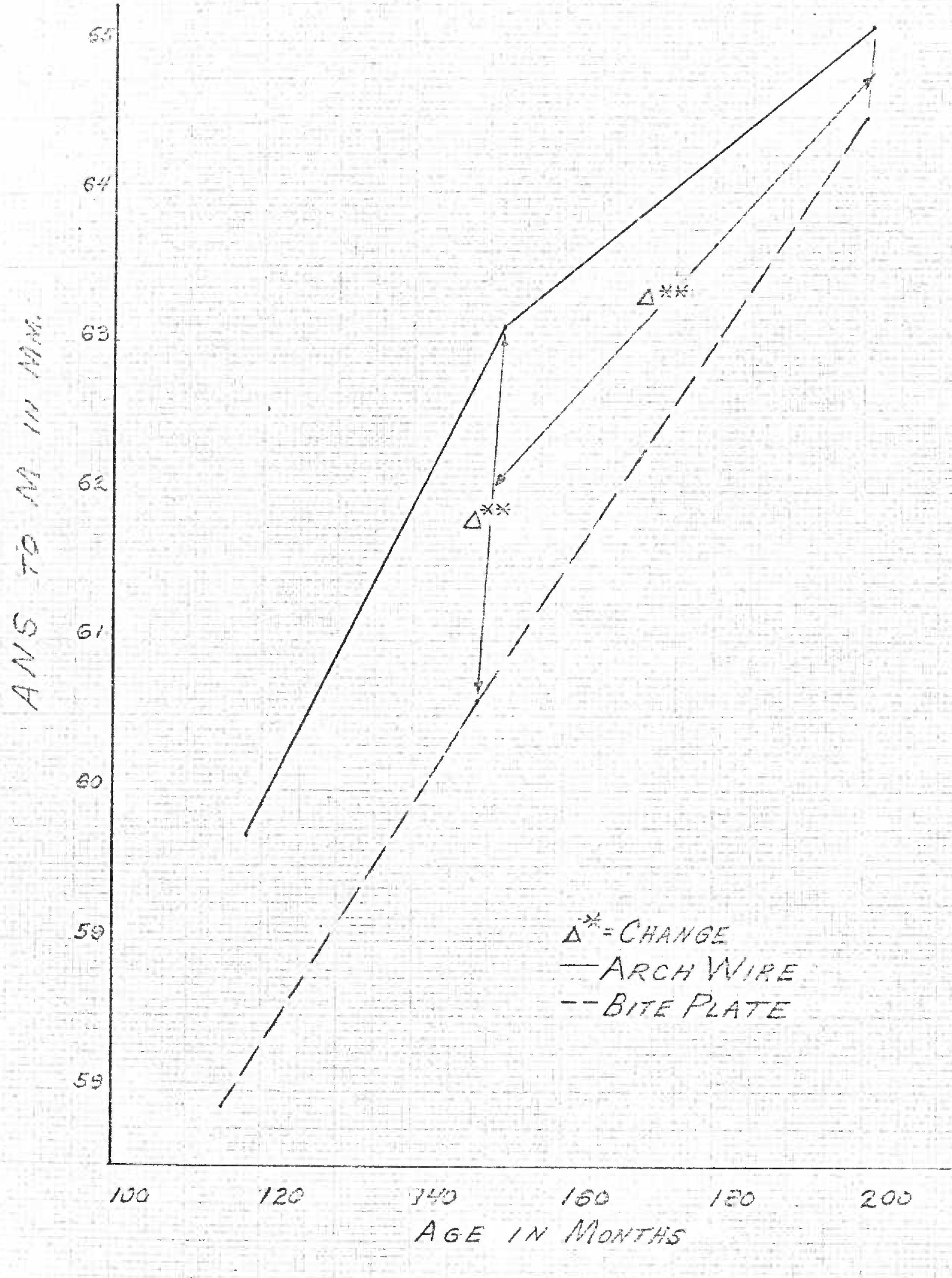


NASION TO ANTERIOR NASAL SPINE

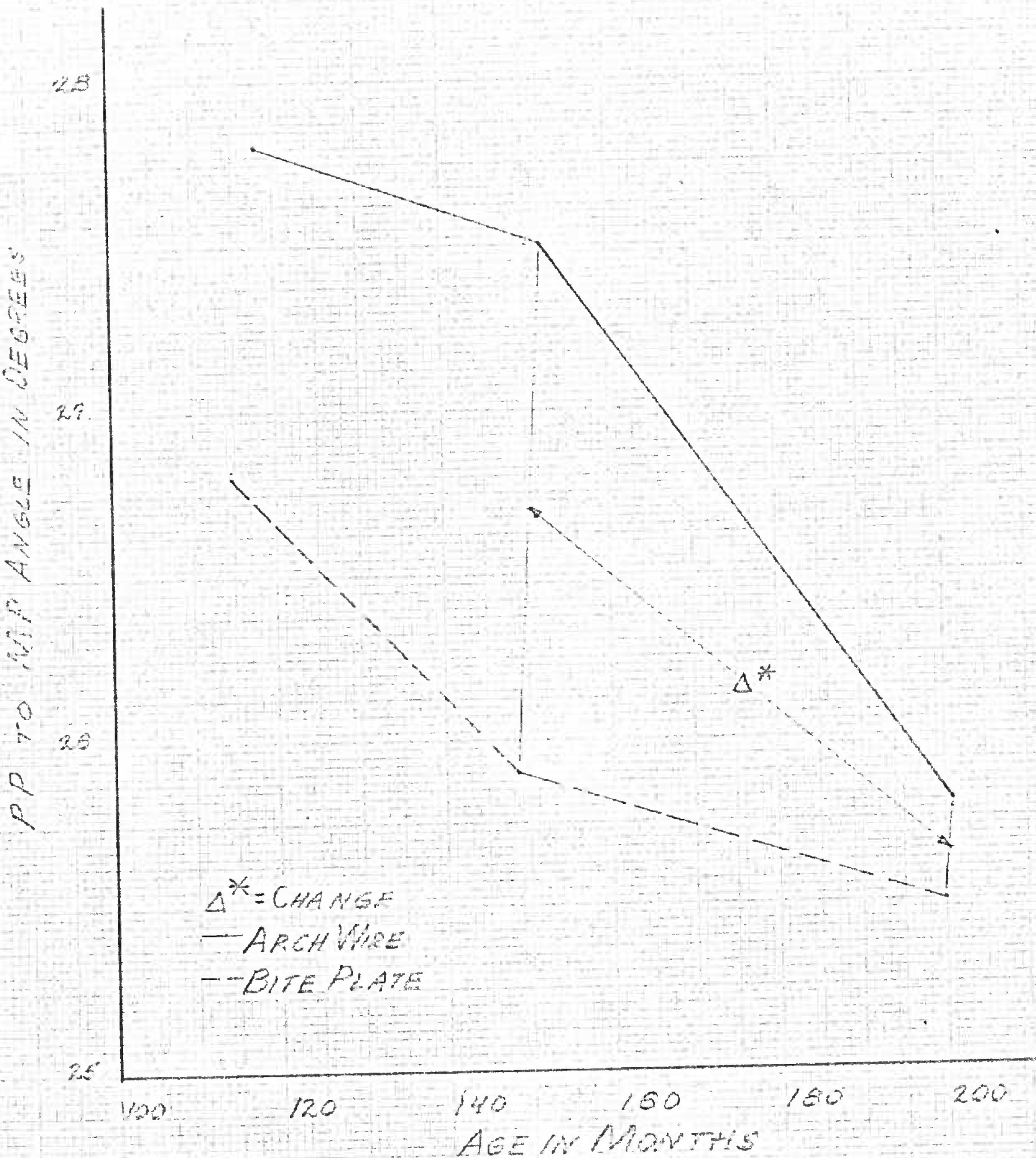
DIMENSIONAL CHANGES DURING

PERIOD OF OBSERVATION

FIG. 3



ANTERIOR NASAL SPINE TO MENTON
DIMENSIONAL CHANGES DURING
FIG. 4 PERIOD OF OBSERVATION

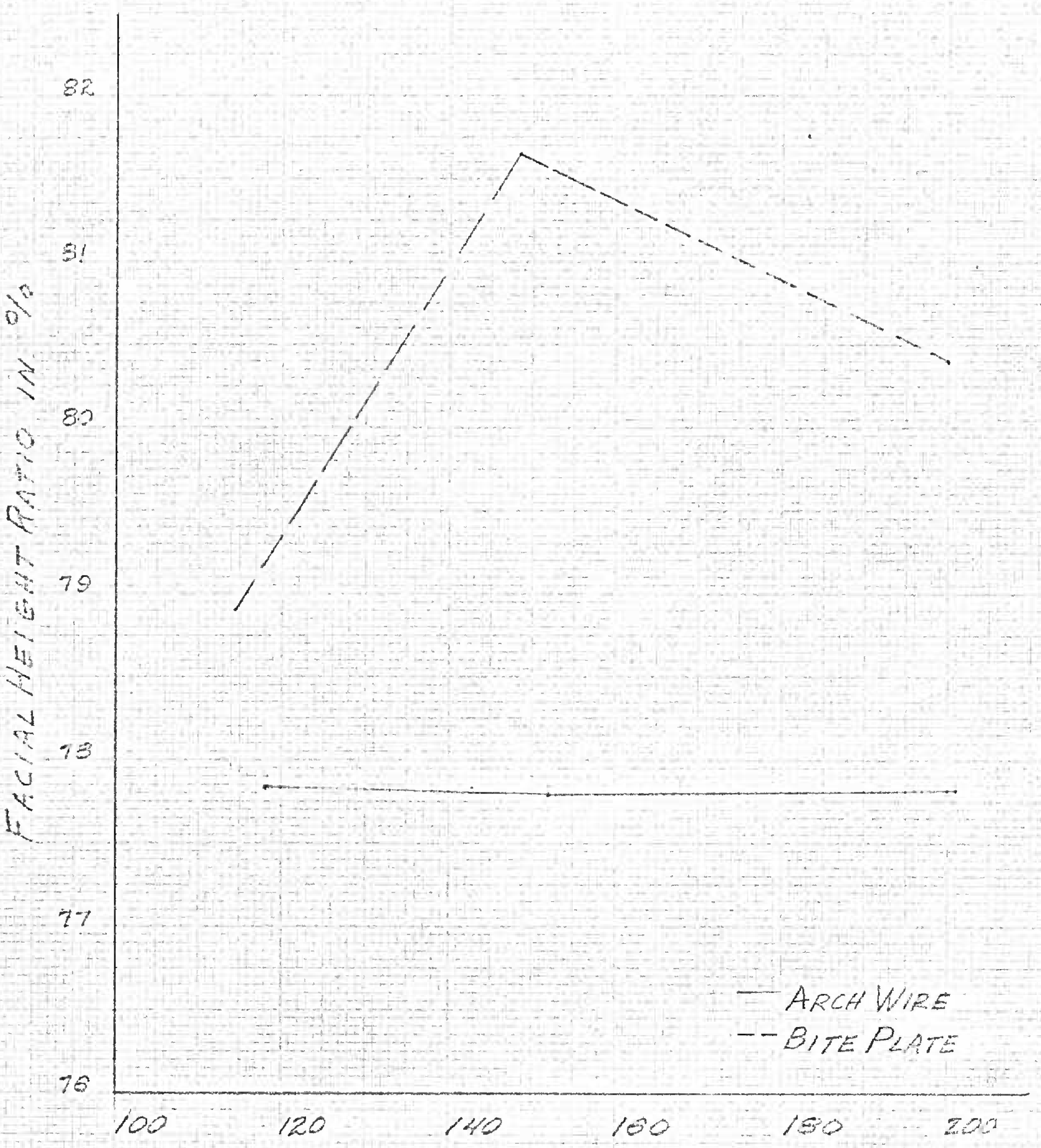


OCCLUSAL PLANE TO MANDIBULAR PLANE ANGLE

ANGULAR CHANGES DURING

PERIOD OF OBSERVATION

FIG. 5

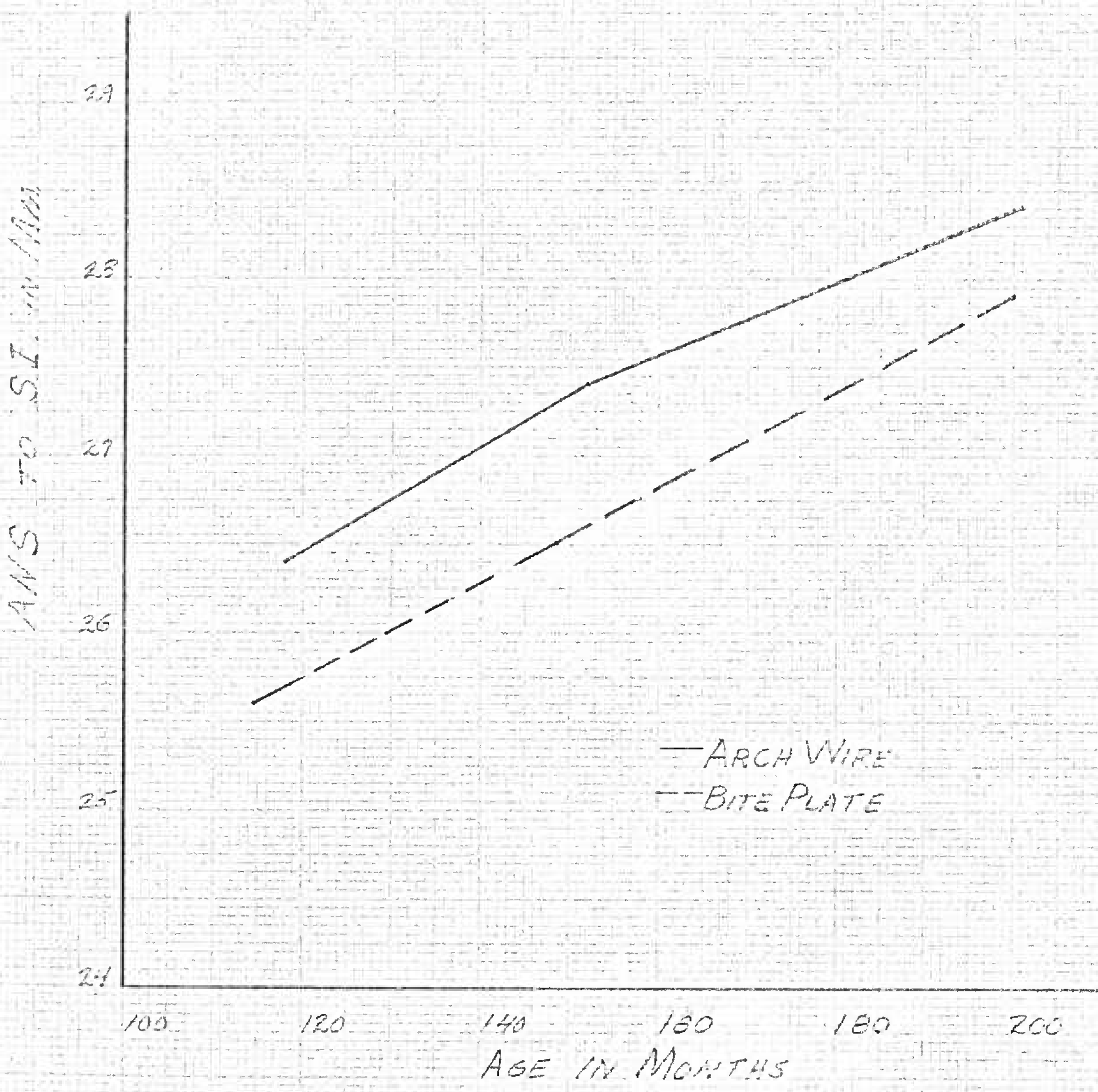


RATIO $\frac{\text{NASAL HEIGHT}}{\text{SUBNASAL HEIGHT}} \times 100$

PERCENT CHANGES DURING

PERIOD OF OBSERVATION

FIG. 7

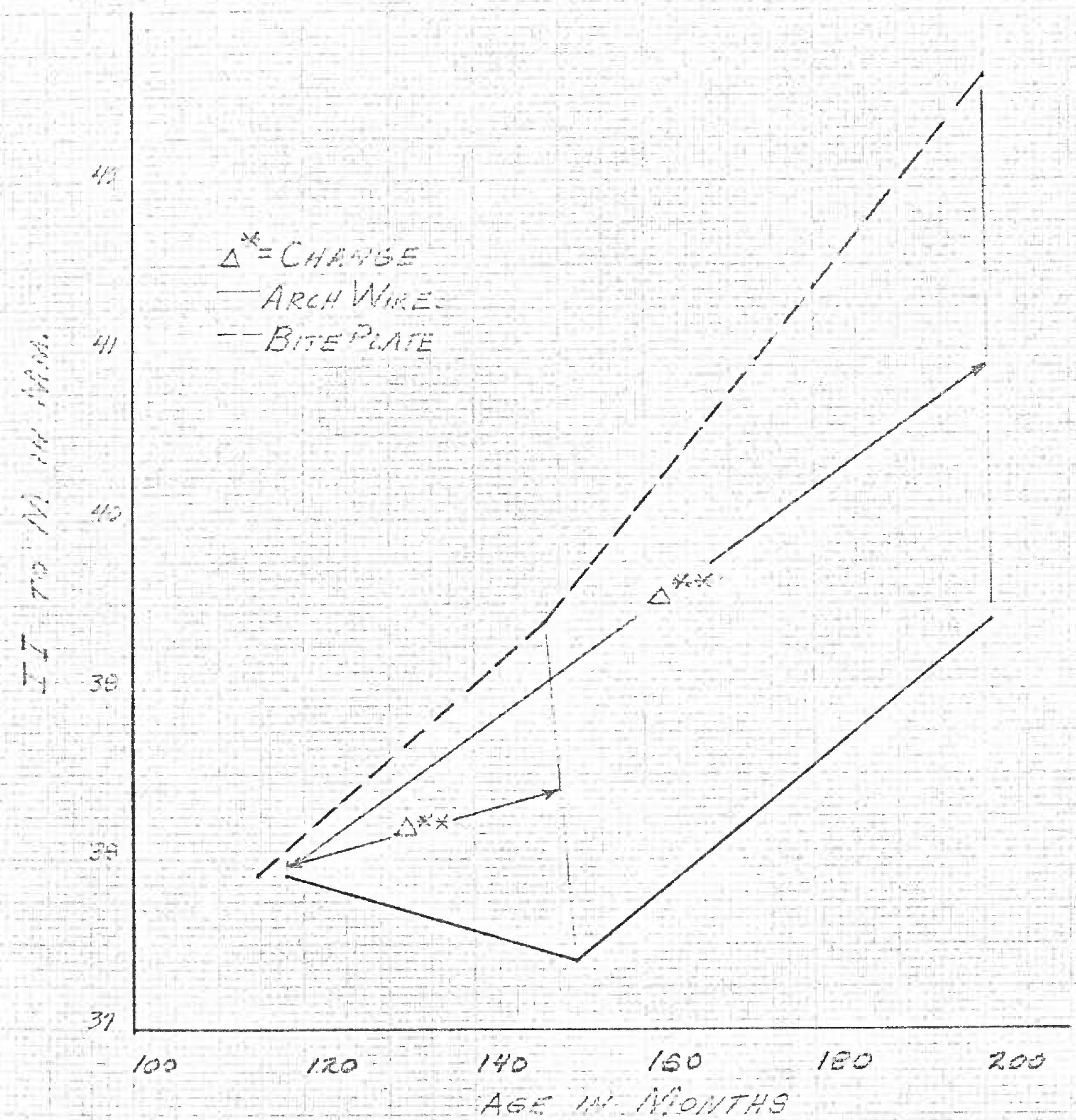


ANTERIOR NASAL SPINE TO SUPERIOR INCISOR.

DIMENSIONAL CHANGES DURING

PERIOD OF OBSERVATION

FIG. 8

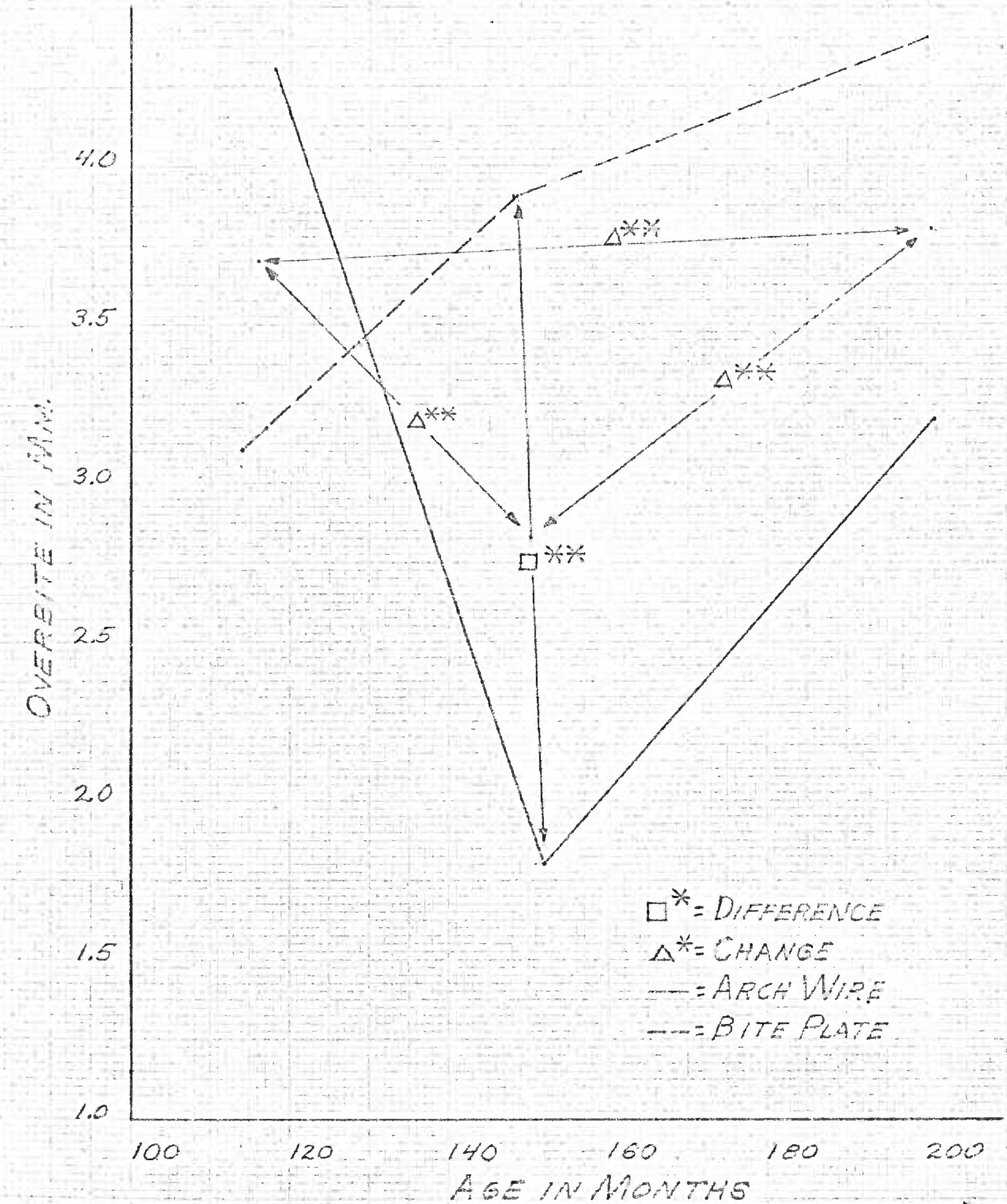


Inferior Incisor to Menton

Dimensional Changes During

Period of Observation

Fig. 9



OVERBITE – SUPERIOR INCISOR TO INFERIOR INCISOR

DIMENSIONAL CHANGES DURING

PERIOD OF OBSERVATION

FIG. 10

DISCUSSION

A comparison of the sample treated with full orthodontic appliances and the sample treated with bite plates and cervical head gear, disclosed a wide range of individual changes. However, there were no statistically significant differences found for any dimensional or angular measurements between the two groups before orthodontic treatment was instituted. The findings will be discussed in relation to facial height and interdental changes.

Facial Height Changes

Analysis of the treatment effects on facial height disclosed several correlated trends. The N to ANS dimension showed a significant difference in the change from "before treatment" to "out of retention", (Fig. 3). The bite plate group started out smaller and was larger at the final examination. The rate of growth from "end of treatment" to "out of retention" was less in the arch wire group.

Changes in the subnasal height from ANS to M were also evident. Fig. 4). A significant difference was found between the sample groups at the "end of treatment" stage. This difference could have been explained on the basis that the bite was "propped open" more by arch wire treatment than by bite plate treatment. From the "end of treatment" stage the bite plate sample had significantly more change. The arch wire group showed a slower rate of growth, and there was no significant difference at the time of final observation.

Another index of the subnasal height tested was the angle of the palatal plane with the mandibular plane. There was consistant decrease in this value during the period of observation. (Fig. 5). Treatment effects were observable at stage 2, end of treatment, where the rate of angular change was greater for the bite plate sample. This trend leveled off as the angular change from stage 2 to "out of retention" was significantly greater for the arch wire group. A comparison of this data with the increase in the absolute dimension of anterior nasal spine to menton indicated a negative correlation. (Fig. 4). The MP / PP angle was influenced more by a relative lowering of the anterior nasal spine point on the palatal plane or a dropping of the gonial point on the mandibular plane. These relative changes had more influence on the MP / PP angle than the growth increases in the subnasal height.

Recent observations by Bjork,[10] utilizing implants have disclosed the unreliability of the lower border of the mandible or the floor of the nose as constant reference planes. An investigation of the effects of head-gear therapy on the craniofacial complex by Wieslandar,[8] showed a rotational effect on the sphenoid bone. A tipping of the anterior part of the palatal plane was evident. A concommitant counter rotation of the mandible around the extruded maxillary molar tended to keep the mandibular plane angle constant. These counteracting forces compensated for a significant increase in subnasal height in the headgear treated sample when compared with the control group. This study supported the observation of increased subnasal height with decreased mandibular plane angle during treatment.

These treatment trends were correlated with the overall facial height changes from nasion to menton. (Fig. 6). The bite plate group displayed a steady height increase while the arch wire treatment showed an increased rate of change up to the "end of treatment" stage. Then the rate of change slowed for the arch wire group, but continued for the bite plate sample which resulted in a significantly greater rate of change to the "end of treatment" stage.

The percent ratio of nasal height to subnasal height also reflected these changes. The "archwire" ratio remained relatively constant at 77.8 per cent. (Fig. 7). The increased subnasal height dimension due to bite "propping open", was matched by nasal height growth at all stages of observation. The bite plate group showed a greater nasal height ratio at all stages, but appreciably larger at the "end of treatment" stage, due to a greater upper than lower nasal height increase. These ratios varied from 78.9 at stage 1 (9 years, 617 months), 81.65 at stage 2 (12 years, 4.5 months), and 80.41 at stage 3 (16 years, 8.7 months). (Table III).

Merideth, Knott, and Hixon[6] found nasal height ratios of 77.5 at age 9 years and 79.2 at 12 years. A ratio computed from the data of Bjork[2], was 77.5 at age 12 years for Swedish boys. Smythe and Young[7] measured anthropometric points on English school children. A comparable rate was computed from their data on the dimensions nasion to subnasal point and nasion to submental point. For boys the ratio was 72.8 at age 9 years and 75.6 at age 12 years. These various ratios demonstrated a general increase in values with age, but showed no close correlation in absolute quantities.

Analysis of the facial height changes between the two treatment groups shows a greater overall increase in the bite plate sample and the difference in change from "end of treatment" to "out of retention" was significant. Treatment increased the subnasal height significantly in the arch wire group, probably by "propping open" the bite. But the PP / MP angle decreased consistently during the period of observation. The nasal height ratio remained constant in the arch wire group. A higher ratio was found in the bite plate sample and increased due to a relatively greater nasal height than subnasal height at the "end of treatment".

Interdental Changes

An investigation of the treatment changes in interdental relations disclosed several related trends. The distance from the superior incisor tip (SI) to the anterior nasal spine (ANS) remained relatively constant in both treatment groups. (Fig. 8). This analysis did not detect any difference in positioning of the upper incisor between treatment methods as related to ANS.

The position of the inferior incisor tip in relation to menton showed marked changes from "before treatment" to "end of treatment". (Fig. 9). A significant difference in the direction of change was found with an "arch wire" average intrusion of 0.5 mm. and a "bite plate" eruption of 1.5 mm. The difference between groups from "before treatment" to "out of retention" was found to be highly significant. A trend toward significance between treatment methods at stage 3 was found. The absolute difference of 3.2 mm. would be clinically helpful.

The overbite was found to be very sensitive to arch wire treatment and also showed a marked tendency to return to the original value. (Fig. 10). Significant differences between treatment methods were found at all stages of observation. This was reflected clinically in an increase in overbite with bite plate treatment and a decrease in overbite with arch wire treatment. The absolute clinical difference was 2.1 mm. at the end of treatment. Observation at the "out of retention" stage, disclosed a constant overbite of 4.4 mm. for the bite plate group and a return of the overbite to 3.2 mm. for the arch wire group. The average difference in treatment at the final observation was 1.2 mm. These values were comparable with the data of Fleming[5] who found a mean overbite of 3.75 mm. at age 16 on an untreated sample. No evidence was found in this study of overbite reduction with bite plate treatment.

SUMMARY AND CONCLUSIONS

The influence of orthodontic treatment on facial height and interdental relations was investigated. The effect of bite plate and head-gear therapy was compared to the effect of full orthodontic treatment with the extraction of four first bicuspids and arch wire appliances.

Overall facial height increased more in the bite plate sample with a significant difference in change from the end of treatment to observation out of retention. Arch wire treatment increased subnasal height more than bite plate treatment. The PP / MP angle decreased consistently in both groups. The nasal height ratio (N-ANS / ANS-M) was relatively constant at 77.8 per cent for the arch wire group. The bite plate group had a higher ratio which increased during the treatment period. A greater upper than lower nasal height increase contributed to this change.

Interdental correlations showed no difference between groups in the position of the superior incisor as related to ANS. Arch wire treatment produced significant depression of the inferior incisor. A treatment difference of 3.2 mm. was observed out of retention. Overbite was significantly reduced by arch wire treatment and increased during bite plate therapy. A strong tendency for overbite to return was shown by the treatment difference of 1.2 mm. at the final observation. No evidence was found in this study of overbite reduction with bite plate treatment.

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