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AN EVALUATION OF THE DENTOSKELETAL CHANGES OCCURRING DURING SCOLIOSIS THERAPY WITH A MODIFIED MILWAUKEE BRACE

by

SHELDON LAWRENCE PERSKY

Submitted in partial fulfillment of the requirements

for the Degree of Master of Science

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CASE WESTERN RESERVE UNIVERSITY

June 1972

AN EVALUATION OF THE DENTOSKELETAL CHANGES OCCURRING DURING SCOLIOSIS THERAPY WITH A MODIFIED MILWAUKEE BRACE

Abstract

by

SHELDON LAWRENCE PERSKY

A clinical investigation was conducted to determine what effect the modified Milwaukee brace has upon the dentition and surrounding maxillofacial structures during the treatment of scoliosis. Fifteen females and two males who were being treated for scoliosis at Rainbow Babies and Childrens Hospital (University Hospitals), Case Western Reserve University, consented to participate in this study.

The patients were examined initially within one month after being placed in the brace and again at the end of six and one-half months. Study casts and lateral and frontal cephalometric radiograms were taken at each appointment. Angular and linear measurements were recorded to determine what changes, if any, had taken place. Using the "t" statistic a comparison was also made between the modified and standard braces. Alexander's study (1966) was chosen for comparison as his sample had approximately the same age and sex distribution as the present study and was about six months in duration.

The results of this study show that in comparison with the conventional Milwaukee brace, the modified brace was associated with relatively little change in the dentition and surrounding structures at the conclusion of the experimental period. The changes, however, that were recorded were of such a small magnitude that they may be considered statistically non-significant and clinically negligible.

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DEDICATED

To My Family

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INTRODUCTION

Dentofacial orthopedics recently has aroused much interest, thought and discussion in orthodontic literature. It is now believed by many that heavy, interrupted forces against bone may be used successfully in orthodontic therapy. It is known that undesirable orthopedic changes in the dentition and surrounding maxillo-facial structures occurs secondarily to Milwaukee brace treatment of scoliosis. Although no orthodontist or orthopedist is pleased to see these undesirable changes, intraoral stabilizing appliances have proved generally ineffective. Recently, however, the Milwaukee brace has been modified. The present study has been undertaken to evaluate possible orofacial sequelae of this new appliance.

Scoliosis

Scoliosis is a lateral deformation of the axial skeleton. It seems to be related to the upright posture of man and, accordingly, has not been reported in lower animals (Harrington, 1963). Scoliosis is usually discovered in childhood, progresses until maturity, and then ceases. There are many types of scoliosis, the three most common being paralytic (post poliomyelitic), congenital (anomalous), and idiopathic, by far the most prevalent variety (Harrington, 1963). The degree of spinal curvature may increase at any time during the growth of the child. As a result, the trunk shortens and may displace the viscera

to such a degree that function is compromised. In extreme cases, digestion, respiration, and cardiac function are so impaired that death results.

Early Scoliosis Treatment

In the early 1900's, physical therapy was used for the passive correction of spinal curvatures. The patient received an hour or so of treatment several times a week. Although there was no doubt that the deformity could be improved by manipulation, correction usually relapsed at the end of the treatment period (Blount, 1967). As a result, the outlook for the successful treatment of scoliosis was so grim that orthopedic surgeons resorted to heroic operative approaches, such as spinal fusion after orthopedic correction with a turnbuckle cast. Many mistakes, however, were made in selection of fusion areas, and some spines were thrown out of balance by exaggerated compensatory curves (Hibbs, 1924).

Early braces failed because they were designed for passive correction of the deformity. For cosmetic reasons, the braces rarely included the head and were closely fitted so that they could be hidden by the clothing. Actually, the objective was merely to cover up the deformity rather than correct it; it is, therefore, not surprising that these braces were, in the long run, ineffective.

Contemporary Treatment

Treatment objectives today are, in general, aimed at straightening the vertebral column, holding it in that position until growth has ceased, and then, if necessary, fusing the defective vertebrae

to produce a rigid bar of bone so that the vertebral column can maintain its shape under muscular stress and the effect of gravity. These objectives may be achieved through the use of the so-called "Risser localizer cast," the "turnbuckle cast," the "Milwaukee brace," and surgery with spine instrumentation and spine fusion. Casts, made of plaster of Paris, though effective in the treatment of scoliosis, usually necessitate confinement to bed and have the added disadvantage of being unwieldy to the point of considerably hampering the child's activities. In contrast, the Milwaukee brace, as demonstrated by Blount, Schmidt, and associates in 1944 was less bulky than the plaster jackets and more effective than contemporary jackets of lighter materials. When an operation is necessary, the brace is removed and reapplied immediately after the operation. With this unique appliance patients can be ambulatory and, to some limited extent, carry on reasonable daily activities (Blount, Schmidt, Keever, and Leonard, 1958).

Milwaukee Brace

The Milwaukee brace differs from its predessors in providing active as well as passive correction. Active correction is responsible for some of the reduction in size of the major curves. Patients are encouraged to hyperextend the neck or to raise the head thus exerting an active corrective force to the vertebral column. As described by Blount and associates (1958), the Milwaukee brace is a leather and metal custom-made assembly consisting of a pelvic girdle,

three vertical bars, a collar, occipital, and chin pads. The pelvic girdle fits tightly around the waist exerting its main pressure over the crests of the ilium; the three vertical bars, two posterior and one anterior, connect the girdle with the collar. The collar supports a pad for the occiput and a pad for the lower border of the mandible (Plate I). The bars can be progressively lengthened so as to apply corrective forces to the collapsing spine. The traction thus exerted will apply considerable pressure (four pounds) to the base of the skull and the lower border to the mandible. Although orthopedists have been successful in treating scoliosis with the Milwaukee brace, accompanying its use are a variety of detrimental changes in the occlusion and possibly in the normal development of the lower face. With respect to these untoward side-effects Blount et al. (1958) stated:

> Prolonged use of the brace sometimes give rise to malocclusions and a prominence of the upper incisor and canine teeth, but this is a small and correctable price to pay in exchange for the prevention of a severe scoliosis.

External Pressure

Orthodontists have long been concerned about the possible effect of continuous external pressure on the developing face and dentition, which development occurs during the same time period in which scoliosis is best treated. Stallard (1930) has demonstrated dental anomalies and malocclusion caused by pressure habits such as thumbsucking or resting of the arm, hand or forearm against the face.

PLATE I

Conventional Milwaukee Brace with Chinpad.



Kjellgren (1926) examined experimentally the affects of habits on the dentition. He demonstrated a lateral deformation of maxillae with continuous application of pressure (fifty grams per square centimeter) by a seven centimeter rubber ball. Fifty grams per square centimeter is less than the force of a fist held against the face during sleep.

An appreciation of the plastic and adaptable nature of bone has led to a recognition that continuous pressures from an orthopedic cast or brace could change the shape of structures to which they are applied. Oppenheim (1930), Grey (1934), and many others have found that bone resorption occurs during periods of pressure and that repair occurs when pressure is released.

The forces (four pounds) exerted in the lower border of the mandible by the Milwaukee brace would seem, a priori, to be of sufficient magnitude to alter normal mandibular growth. Thompson (1949) claimed that retardation of the growth centers in the condyle either unilaterally or bilaterally can result in progressive alteration of the entire dental and craniofacial growth pattern. Weinmann and Sicher (1955) and Sicher (1957), have been persistent in their contention that the condyle is the major growth center of the mandible and that it serves to move the mandible away from the skull, thus creating a space between the maxillae and the mandible for normal translational growth of the midface. Until recently this has been the most widely accepted hypothesis concerning mandibular growth. There is now, how-

ever, evidence indicating that the condyle may be only a secondary growth site in the mandible. Moss and co-workers (1969) claim that the oral viscera serve as the dominant stimulus to facial skeletal growth. Growth and development of the oral, nasal, and pharyngeal spaces, according to Moss' formulation, stimulate the mandible to translate downward and forward within the facial capsule as demanded by the functional matrix concept. Koski and Rönning (1970) question the Weinmann-Sicher concept of similiarity of condylar cartilege to epiphyseal cartilege. Today the role of the condyle in mandibular translational growth is open to question; however, it has been well documented that the heavy orthopedic forces exerted by the Milwaukee brace will alter mandibular growth.

Orthopedic Forces

Today, there is much interest in the role of heavy forces for the correction of dental malocclusions. Graber (1967) advocated the use of extraoral force (three to four pounds) against bone to correct abnormal anteroposterior and vertical jaw relationships. In Class III malocclusions, his objective is to restrain all possible horizontal mandibular growth or at least redirect it to a more vertical direction; in Class II malocclusions, to restrict horizontal maxillary growth or redirect it to a more vertical direction. He also uses heavy interrupted forces for the correction of vertical jaw malrelationships such an anterior open bite. Graber claims to be successful using heavy, interrupted forces for the correction of

these basal jaw malrelationships.

Dental Aspects of Scoliosis Treatment

The first documented case was presented by Howard in 1926. He observed rapid vertical changes in a patient who had been fitted with a plaster body cast. Three weeks of cast pressure produced marked depression of the posterior teeth, and within six months there was a marked decrease in lower face height, presumably due to a depression of molars and premolars. He also observed a flairing and protrusion of the upper and lower anterior teeth. In order to oppose the orthopedic force, Howard employed a splint to maintain the proper relationships of the dental arches. The splint, however, did not prevent the depression of the teeth or the loss in vertical dimension in the lower third of the face.

Glass (1961) also observed a reduction in facial height and, like Howard, attributed it to intrusion and forward tipping of the teeth followed by a remodeling of the alveolar process. In contrast, however, he considered these changes reversible after the source of external pressure was removed.

With respect to the above problems, Bunch (1961) stated that "preventing and treating dental malocclusion rather than correcting it after it occurred would be consistent with thorough orthopedic treatment planning and case management." Accordingly, he introduced the use of a tooth positioner to stabilize the dental arches against the pressures of orthopedic appliances. Using this approach, he also attempted

corrective orthodontic movements. Each patient wore the positioner day and night and removed it only for cleaning, eating, and talking. Of the twelve cases in which he repositioned teeth, ten showed improvement. Two cases were classified as failures because of the patient's lack of cooperation. Since there were no controls to compare with Bunch's treated cases, it is impossible to estimate exactly what might have happened if no appliance had been worn.

The forces applied to the mandible by the Milwaukee brace was measured by Logan (1962) by means of a strain gauge. He noticed, in the majority of cases, that an average intermittent pressure of four pounds was produced, and observed a deepening of the bite, probably due to a depression of the molars and premolars into the alveolar bone. Further effects were labioversion and spacing of both upper and lower incisors, with widening of the maxillary arch in the molar and premolar region. These effects were greatest when the braces were applied at an early age and had to be worn for many years.

In one of the more definitive studies in the area, Alexander (1966) investigated the abnormal dental and skeletal changes resulting from Milwaukee brace therapy for the correction of moderate spinal curvatures. His sample consisted of fourteen Milwaukee brace patients and was divided evenly into experimental and control groups (six females and one male). Experimental patients were fitted with mouthpieces; controls were not. The mean age of the experimental group was 12.84 years and the mean age of the control group was 12.48 years. The duration of his study was approximately six months. He concluded that vertical growth is

altered by heavy orthopedic forces. Specifically, he reported: Depression of total anterior facial height, questionable depression of upper anterior facial height, depression of lower anterior facial height, depression of lower posterior facial height, elevation of the palatal plane with a tendency to flatten the palatal vault, increase in body structure at the mandibular angle, and abnormal forward and downward movement of the symphyseal area. Alexander concluded that the Milwaukee brace affects the dentition by extruding the incisor teeth and depressing the molars. A greater amount of depression was found in the lower molars.

In a recent thesis using implants, Eastham (1969) inferred that the loss of vertical dimension caused by pressure from the Milwaukee brace is associated with: sutural adaptation allowing upward and forward movement of the maxillae, upward and forward movement of the mandible, reduction of the mandibular angle caused by bone deposition on the posterior border of the ramus, redirection of condylar growth upward and forward, and partial inhibition of vertical condylar growth.

Cutler (1969) showed, on histologic examination of Macaca mulatta, that condylar growth was retarded by the pressure exerted by the Milwaukee brace. He inferred that interference with normal hypertrophic changes of the chondrocytes, a necessary step in endochondral ossification, may be responsible for this growth disturbance. He concluded that the normal tendency for appositional growth at the lower border of the mandible is inhibited by the external pressure

of the chin pad.

Gee (1969) said that the loss in vertical dimension usually leads to an increased labial inclination of the maxillary and mandibular incisors and a depression of the molars. After brace therapy these teeth tended to return to a more normal inclination, the amount of recovery, as well as the length of time required, varying from individual to individual. The changes demonstrated at the lower border of the mandible, however, did not show a tendency toward recovery.

The dental changes reported thus far present the dental profession with a formidable challenge. Bunch in 1961 introduced the idea of using a tooth positioner to stabilize the dental components against the pressures of orthopedic appliances. Since the introduction of the tooth positioner, many other appliances have been used: acrylic splints (Thørs, 1964), copolymer vinyl thermoplastic splints (Alexander, 1966), modified monobloc appliances (Roth, 1969), modified "vangard" appliances (Luedtke, 1970), and many others. Most of these appliances have been successful in preventing extrusion of anterior teeth and in enhancing the efficiency of the Milwaukee brace; however, no one appliance has been entirely successful. None prevent collapse of the lower facial height or depression of molars.

Statement of the Problem

One must be aware of the tremendous psychological and physical strain imposed by the Milwaukee brace. It almost seems un-

reasonable to expect that a Milwaukee brace patient wear oral appliances all or most of the time. A far more logical approach might be to redesign the Milwaukee brace so that orthopedic forces would be directed away from the mandible.

Recently (1969), the Milwaukee brace was modified when it was determined that constant distraction of the vertebral column was unnecessary for the correction of moderate spinal curvatures. Moderate curves of thirty-five to forty-five degrees in a growing child are usually treated non-operatively with the Milwaukee brace. The occipital pads were placed under the back of the head instead of behind it, and intermittent distraction was supplied by the impact of the head on the occipital pads. The throat mold (Plates II, III and IV) adjacent to the hyoid bone replaced the chin pad, its function being merely to maintain the position of the head over the occipital pads (Blount, 1972). Since the throat mold makes no sustained contact with the mandible the orthopedic forces are directed to the occiput and away from the mandible. This modification may in fact eliminate the malocclusions we see associated with Milwaukee brace therapy. The present study has been undertaken to evaluate the 1969 modification of the Milwaukee brace.

PLATE II

Modified Milwaukee Brace.

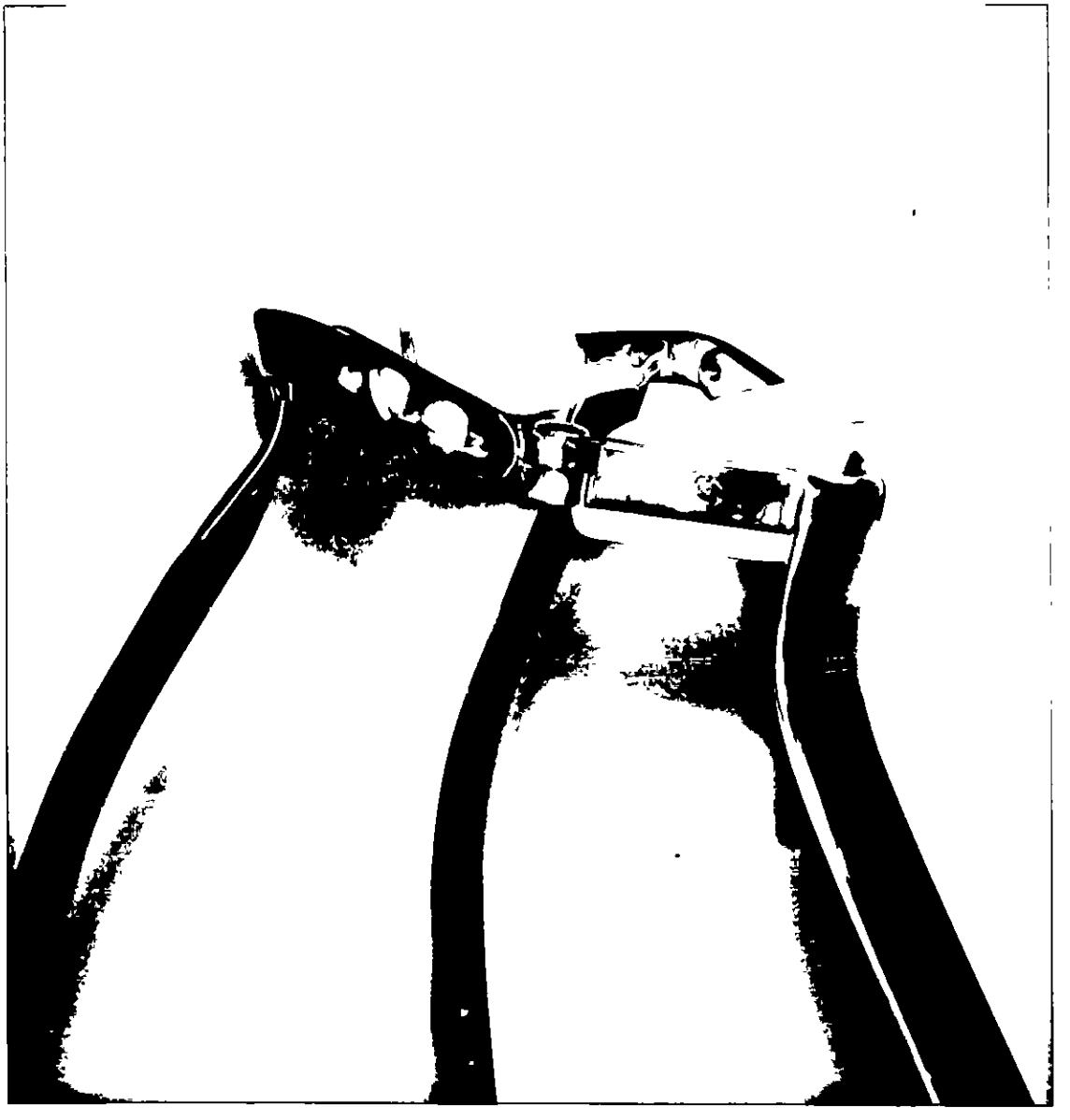


PLATE III

Patient Wearing a Modified Milwaukee Brace.

PLATE IV

Throat Mold Adjacent to Hyoid Bone



METHODS

Sample

Fifteen females and two males, ten to fifteen years of age, who were being treated with the new Milwaukee brace at Rainbow Babies and Childrens Hospital (University Hospitals), Case Western Reserve University were selected for this study. All the available subjects presenting for treatment of scoliosis were used. The nature of the study, and its significance were explained in detail to each subject and to his or her parents.

Clinical Procedure

Each patient was examined initially within one month after being placed on brace therapy, and a follow-up examination was taken at the end of six months. In addition to the clinical examination cephalometric radiographs and study casts were also taken.

Data Collection

Cephalometric Procedure

The patient, wearing his brace, was placed in a Cephalometer (Ortho X-ray Division; Ottawa, Illinois), and a lateral radiograph was taken with the patient in the rest position. The patient then removed the brace and radiographs were taken in the rest position, with the jaw wide open and in centric occlusion. A frontal radiograph was also taken.

A tracing was made on each "before" and "after" cephalogram with .003 inch matte cellulose acetate paper and 4H lead (Dental Corporation of America; Washington, D. C.). Linear measurements were obtained to the nearest .01 millimeter with the aid of a pointed vernier caliper (Dental Corporation of America; Washington, D. C.). Angular measurements were taken to the nearest .5 degree with the aid of a Baum protracter (Unitek Corporation; Monrovia, California). The anthropometric landmarks used are defined in Appendix I.

Areas of Measurement

I. Vertical relations (Figure 1)

A. The changes in anterior and posterior vertical dimension

1. Total Anterior Face Height--The distance along a line from nasion to gnathion.
2. Upper Anterior Face Height--The distance from nasion to the anterior nasal spine along a line from nasion to gnathion.
3. Lower Anterior Face Height--The distance from gnathion to the anterior nasal spine along a line from nasion to gnathion.
4. Lower Posterior Face Height--The distance along a line from articulare to gonion.

B. The changes in the position of the palatal plane were obtained by superimposing the serial tracings on S-N with S as registration point.

Figure 1

CEPHALOMETRIC LINEAR MEASUREMENTS

1 Total Anterior Face Height

2 Upper Anterior Face Height

3 Lower Anterior Face Height

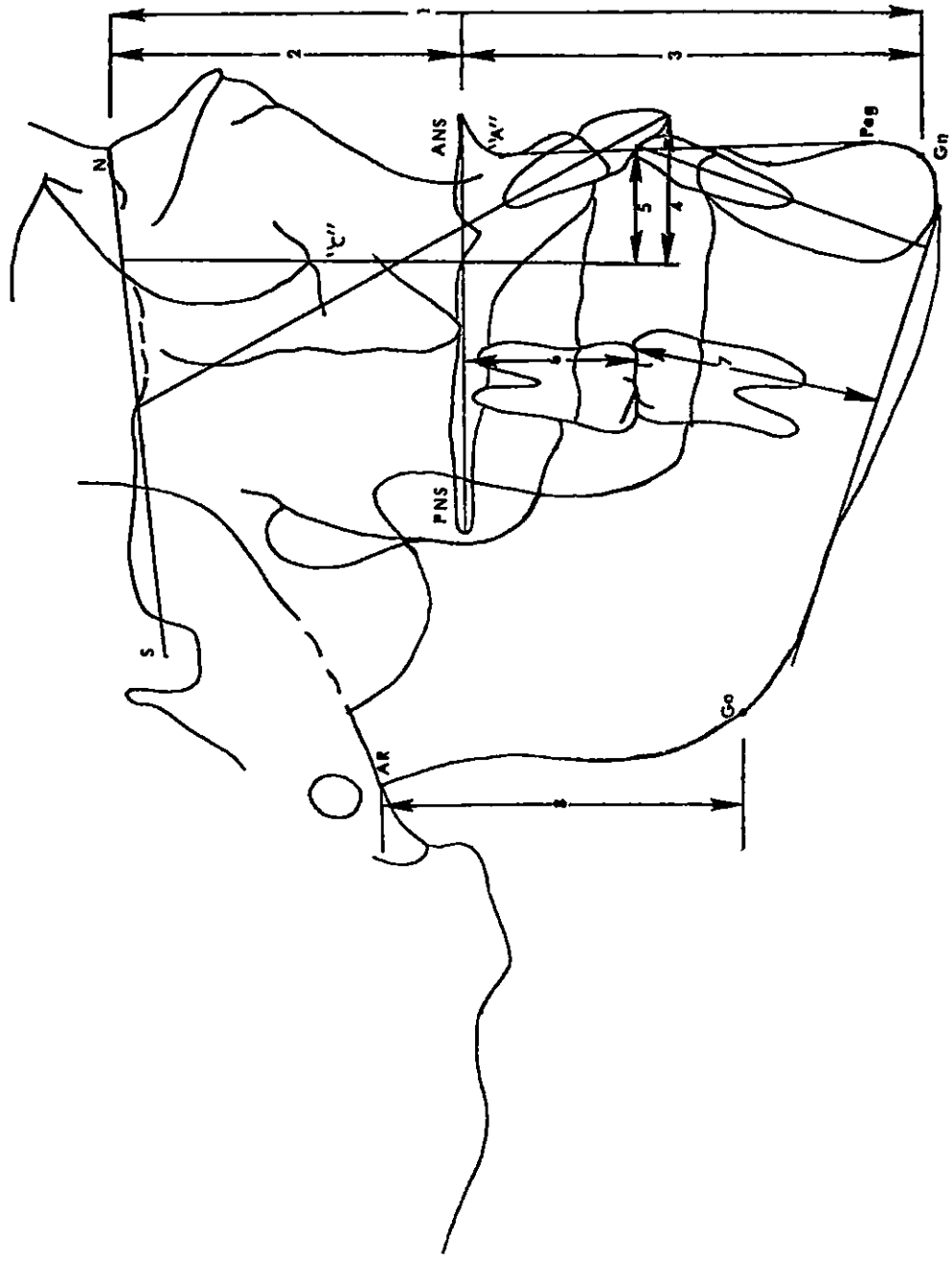
4 Upper Incisor to Construction Line "C"

5 Lower Incisor to Construction Line "C"

6 Upper Molar Height

7 Lower Molar Height

8 Lower Posterior Face Height


1
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3
N
ANS
"A"
Pog
Gn
"B"
5
4
PNS
S
Go
AR

II. Dentition

A. Intrusion of molars was measured on the lateral cephalometric radiograph with the mandible in the wide open position.

1. Lower Molar Height--The distance from the occlusal tip of most clearly discernible buccal cusp of the lower first molar perpendicular to the mandibular plane.

2. Upper Molar Height--The distance from the occlusal tip of the most clearly discernible buccal cusp of the upper first molar perpendicular to the palatal plane.

B. The relationship of the upper central incisors to the lower central incisors.

1. Upper Incisor to Lower Incisor--The inside angle formed by the intersection of lines representing the long axes of the most labial maxillary and mandibular incisors.

2. Overjet--The horizontal distance parallel to the occlusal plane, between the incisal edges of the upper central incisors and the lower central incisors.

3. Overbite--The vertical distance perpendicular to the occlusal plane, between the incisal edges of the upper central incisors and the lower central incisors.

C. The relationship of the upper central incisors and the lower central incisors to their skeletal basal bone (Figure 2).

1. Upper Incisor to Sella-Nasion--The angle of inclination of the upper incisor to a line connecting sella and nasion.
2. Lower Incisor to Mandibular Plane Angle—The angle of inclination of the mandibular incisor to a line drawn tangent to the lower border of the mandible.

D. The position of the upper and lower central incisors.

1. Upper Incisor to A-P Plane--The distance from the incisal edge of the upper incisor to the line connecting point "A" and pogonion.
2. Lower Incisor to A-P Plane--The distance from the incisal edge of the lower incisor to the line connecting point "A" and pogonion.
3. Upper Incisor to Construction Line "C"--The distance from the incisal edge of the upper incisor to a line from S-N through orbital and perpendicular to the Frankfort plane, "C." This line is drawn on a template and used for all serial radiographs of individual subjects. The template will be superimposed on the line S-N with the registration point being S.

Figure 2

CEPHALOMETRIC ANGULAR MEASUREMENTS

1 Sella-Nasion to point "A"

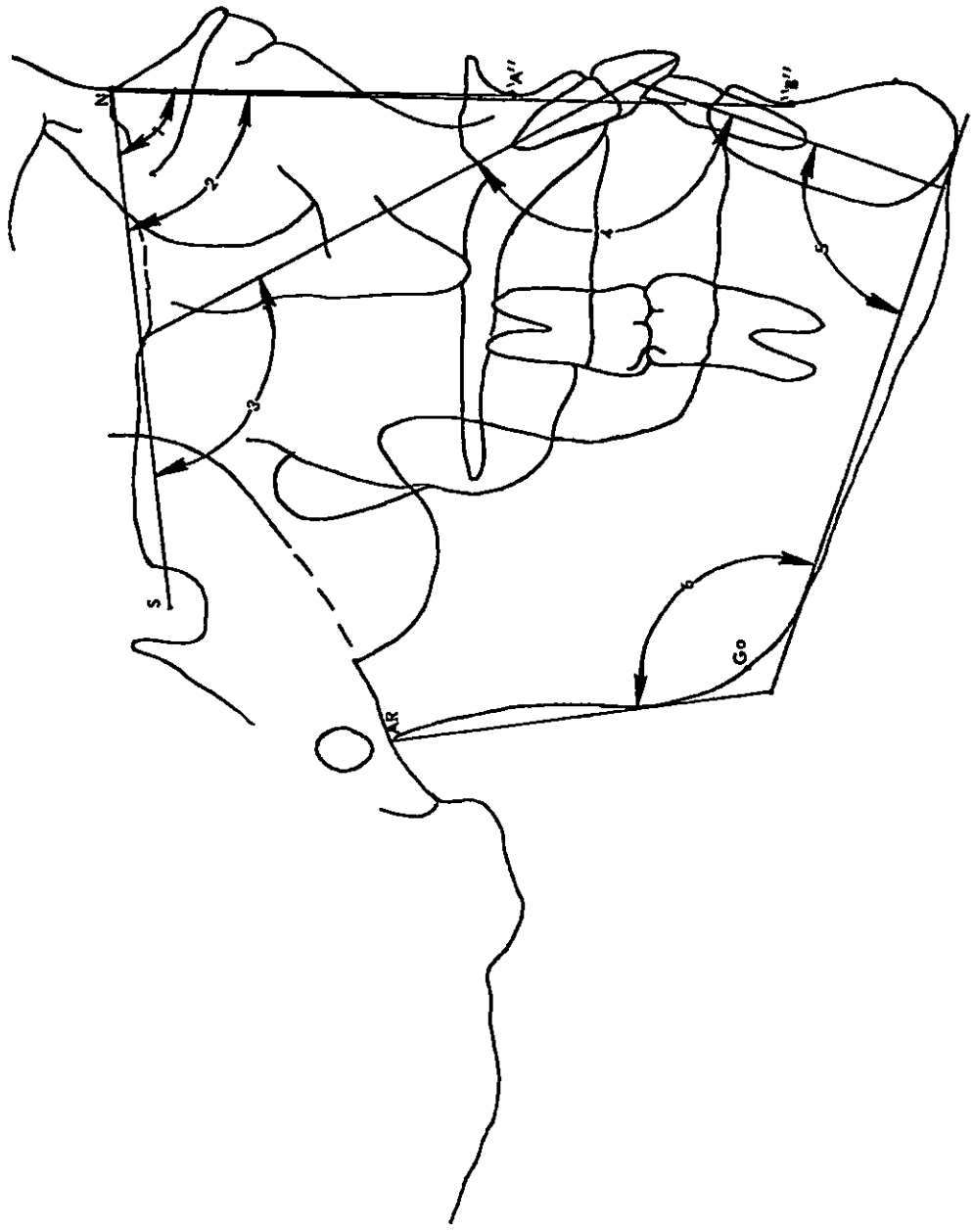
2 Sella-Nasion to point "B"

3 Upper Incisor to Sella-Nasion

4 Upper Incisor to Lower Incisor

5 Lower Incisor to Mandibular Plane

6 Gonial Angle


N
1
2
3
4
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6
KR

4. Lower Incisor to Construction Line "C"--The distance from the incisal edge of the lower incisor to construction line "C."

5. Regional Superimposition in Maxilla--Superimpose maxillae, registering on the palatal outline (keeping palatal planes parallel).

6. Regional Superimposition in Mandible--Superimpose mandibles registering on the lingual symphysis (keeping mandibular planes parallel).

III. Anterior posterior jaw relations.

A. SNA--The angle formed by the intersection of a line from sella to nasion with a line from nasion to point "A."

B. SNB--The angle formed by the intersection of a line from sella to nasion with a line from nasion to point "B."

IV. Miscellaneous

A. Gonial angle--The angle formed by the intersection of a line representing the most inferior border of the body of the mandible with a line drawn from articulare to the most posterior portion of the ramus near the mandibular angle.

B. Symmetry (obtained from the frontal radiograph)--The distance from right and left gonia to the line representing the midline of the skeletal face.

Study Cast Measurements

Study casts were made at the initial examination and at the end of six months. Readings were obtained to the nearest 0.01 millimeter with the aid of a pointed vernier caliper.

I. Vertical relations (vault height)--The distance from the deepest point on the palate to the level of the occlusal plane at the first molars.

II. Lateral relations

   A. Inter-canine width--The distance between the cusp tips of the canines in each arch.

   B. Inter-molar width--The distance between the tips of the mesio-buccal cusps of the first molars in each arch.

Data Reduction

Calculations were performed on an electronic calculator (Model 9100A; Hewlett-Packard Company; Loveland, California). Confidence intervals at the ninety-five percent level were calculated for each of the cephalometric and study cast measurements. Mean differences comparing the "before" and "after" measurements were utilized for these calculations. The confidence intervals were calculated as follows:

$$\bar{X}_d - t_{\alpha/2(df)} \frac{S}{\sqrt{N}} < \mu < \bar{X}_d + t_{1-\alpha/2(df)} \frac{S}{\sqrt{N}} \text{ where,}$$

$\bar{X}_d$ = mean difference

$t_{\alpha/2(df)}$ = the value of t.025 at N-1 degrees of freedom

$t_{1-\alpha/2(df)}$ = the value of -t.975 at N-1 degrees of freedom

S = sample standard deviation, and

N = the sample size

In other words, the confidence intervals calculated from the sample utilized will include μ ninety-five percent of the time.

The results of this study were then compared with that of Alexander (1966) which is considered by most a classical study in the area. The statistical design employed was a "t" test comparing the means of two populations which may be expressed as:

$$t = \frac{(\bar{X}_{d1} - \bar{X}_{d2}) - 0}{\sqrt{(S_1^2/N_1) + (S_2^2/N_2)}} \quad \text{where,}$$

$\bar{X}_{d1}$ = mean difference of sample 1

$\bar{X}_{d2}$ = mean difference of sample 2 (Alexander)

S_1 = standard deviation of sample 1

S_2 = standard deviation of sample 2

N_1 = number of patients in sample 1

N_2 = number of patients in sample 2

Since there is no reason to assume that the variance of the two samples are equal, the following formula was utilized to calculate the degrees of freedom (Dixon and Massey, 1969):

$$df = \frac{[(S_1^2/N_1) + (S_2^2/N_2)]^2}{\frac{(S_1^2/N_1)^2}{N_1} + \frac{(S_2^2/N_2)^2}{N_2}} .$$

RESULTS

The mean age of the patients was 13.24 years with a standard deviation of 1.29. The patients averaged six and one-half months in the brace at the completion of the study. The results of the present investigation will be presented under two headings: (1) Study cast measurements, and (2) Cephalometric measurements.

Study Cast Measurements

In Tables I and II five patients had no palatal vault change, while overall there was an increase of 0.11 millimeters. The upper inter-canine width remained the same in four patients while overall there was a mean increase of 0.09 millimeters. Six patients showed no change in the lower inter-canine width, while overall there was a mean decrease of 0.02 millimeters. The upper inter-canine width increased with a mean of 0.27 millimeters, however four patients exhibited no change. Six patients showed no change in lower inter-molar width, while overall there was a mean increase of 0.19 millimeters.

Note that the confidence interval for palatal vault height does not contain zero.

Cephalometric Measurements

In Tables III, IV, and V the total anterior facial height exhibited a mean decrease of 0.03 millimeters. The lower anterior facial height exhibited a mean decrease of 0.06 millimeters, while the upper

TABLE I

MODEL MEASUREMENTS
(millimeters)

Measurement	Patient								
	M.L.G.	B.B	B.H.	P.L.	N.H.	T.R.	E.W.	R.S.	J.B.
Vault Height									
After. . . .	14.80	12.90	15.90	15.20	15.20	15.40	16.40	16.20	14.40
Before . . .	14.80	12.70	15.70	15.00	15.10	15.40	16.30	16.10	14.30
Difference .	0.00	+.20	+.20	+.20	+.10	0.00	+.10	+.10	+.10
Max. 3-3 width									
After. . . .	33.05	36.40	32.00	32.80	40.50	35.15	32.75	34.60	35.35
Before . . .	33.45	36.20	31.85	32.80	40.40	35.10	32.70	34.60	35.30
Difference .	-.40	+.20	+.15	0.00	+.10	+.05	+.05	0.00	+.05
Mand. 3-3 width									
After. . . .	26.10	24.60	26.95	24.85	28.40	25.15	29.50	24.65	27.55
Before . . .	26.55	24.10	27.40	24.85	28.40	25.20	28.80	25.00	27.60
Difference .	-.45	+.50	-.45	0.00	0.00	-.05	+.70	-.35	-.05
Max. 6-6 width									
After. . . .	52.90	52.60	49.30	50.35	56.65	51.55	54.50	51.05	52.65
Before . . .	53.10	51.60	49.60	50.25	56.60	51.55	52.85	50.85	52.10
Difference .	-.20	+1.00	-.30	+.10	+.05	0.00	+1.65	+.20	+.55
Mand. 6-6 width									
After. . . .	46.45	44.70	43.50	44.20	48.80	46.20	48.40	44.15	46.55
Before . . .	46.60	44.70	43.55	44.20	48.80	46.40	46.80	44.15	46.30
Difference .	-.15	0.00	-.05	0.00	0.00	-.20	+1.60	0.00	+.25

TABLE I continued

Measurement	Patient							
	J.R.	S.D.	J.B.L.	M.P.	L.S.	L.H.	R.C.	S.H.
Vault Height								
After. . . .	18.70	16.60	15.80	16.70	14.20	15.70	15.40	14.60
Before . . .	18.70	16.40	15.80	16.60	14.10	15.50	15.40	14.40
Difference .	0.00	+.20	0.00	+.10	+.10	+.20	0.00	+.20
Max. 3-3 width								
After. . . .	32.55	34.10	32.45	34.70	30.30	35.90	33.10	34.90
Before . . .	32.55	34.10	32.10	34.65	30.20	35.30	32.95	34.80
Difference .	0.00	0.00	+.35	+.05	+.10	+.60	+.15	+.10
Mand. 3-3 width								
After. . . .	24.70	25.25	25.55	24.75	21.15	27.70	29.10	26.55
Before . . .	24.65	25.30	25.55	24.80	21.30	27.70	29.10	26.55
Difference .	+.05	-.05	0.00	-.05	-.15	0.00	0.00	0.00
Max. 6-6 width								
After. . . .	47.60	53.75	44.25	53.60	49.75	51.15	51.80	54.70
Before . . .	47.50	53.80	44.55	53.60	49.75	51.15	51.75	53.00
Difference .	+.10	-.05	-.30	0.00	0.00	0.00	+.05	+1.70
Mand. 6-6 width								
After. . . .	41.00	46.60	41.20	44.60	43.85	45.65	44.50	46.60
Before . . .	41.10	46.25	40.80	44.30	43.75	45.65	44.50	45.80
Difference .	-.10	+.35	+.40	+.30	+.10	0.00	0.00	+.80

TABLE II

DIFFERENCES IN MODEL MEASUREMENTS

Measurement	$\bar{X}_d$	S	95% Confidence Interval
Vault Height	+.11	.08	$.06<\mu<.15$
Canine Width Upper	+.09	.20	$-.01<\mu<.19$
Canine Width Lower	-.02	.28	$-.17<\mu<.13$
Molar Width Upper	+.29	.61	$-.05<\mu<.58$
Molar Width Lower	+.19	.44	$-.03<\mu<.42$

TABLE III

CEPHALOMETRIC MEASUREMENTS

(degrees)

Measurement	Patient								
	M.L.G.	B.B.	B.H.	P.L.	N.H.	T.R.	E.W.	R.S.	J.B.
Interincisal									
After. . . .	119.5	123.0	134.5	130.5	120.0	131.0	106.0	121.5	122.5
Before . . .	120.0	123.5	134.5	130.0	120.5	132.0	106.5	121.5	122.5
Difference .	-.5	-.5	0.0	+.5	-.5	-1.0	-.5	0.0	0.0
Upper Incisor to S-N									
After. . . .	105.0	108.0	103.0	101.0	109.0	100.0	123.5	105.5	101.0
Before . . .	105.0	107.5	103.0	101.0	109.0	100.5	123.0	105.0	101.0
Difference .	0.0	+.5	0.0	0.0	0.0	+.5	+.5	+.5	0.0
Lower Incisor to MP									
After. . . .	107.0	90.0	83.5	96.0	98.5	92.5	109.0	102.5	105.0
Before . . .	106.5	90.0	83.5	96.5	98.5	92.0	107.0	102.5	105.5
Difference .	+.5	0.0	0.0	-.5	0.0	+.5	+2.0	0.0	-.5
SNA									
After. . . .	88.0	81.0	79.0	84.5	85.0	78.0	86.5	84.0	78.5
Before . . .	88.0	81.0	79.5	84.5	85.0	77.5	86.5	84.0	78.5
Difference .	0.0	0.0	-.5	0.0	0.0	+.5	0.0	0.0	0.0
SNB									
After. . . .	83.5	77.0	79.0	80.0	81.5	76.5	81.5	79.0	75.0
Before . . .	83.5	76.5	79.0	80.0	82.5	76.0	81.5	79.5	75.0
Difference .	0.0	+.5	0.0	0.0	-1.0	+.5	0.0	-.5	0.0
ANB									
After. . . .	4.5	4.0	0.0	4.5	3.5	1.5	5.0	5.0	3.5
Before . . .	4.5	4.5	0.5	4.5	2.5	1.5	5.0	4.5	3.5
Difference .	0.0	-.5	-.5	0.0	+1.0	0.0	0.0	+.5	0.0
Gonial									
After. . . .	127.0	138.5	130.5	116.0	113.5	125.0	122.5	116.0	115.0
Before . . .	126.0	138.5	130.5	117.0	114.0	125.0	123.0	116.5	115.0
Difference .	+1.0	0.0	0.0	-1.0	-.5	0.0	-.5	-.5	0.0

TABLE III continued

Measurement	Patient							
	J.R.	S.D	J.B.L.	M.P.	L.S.	L.H.	R.C.	S.H.
Interincisal								
After. . . .	142.5	165.0	154.0	134.0	134.0	140.0	120.0	133.0
Before . . .	142.0	164.0	154.0	133.5	134.0	139.5	120.0	132.5
Difference .	+.5	+1.0	0.0	+.5	0.0	+.5	0.0	+.5
Upper Incisor to S-N								
After. . . .	92.0	91.0	96.0	110.5	104.0	87.0	113.5	107.0
Before . . .	92.0	91.0	96.5	111.5	103.5	87.0	113.5	107.0
Difference .	0.0	0.0	-.5	-1.0	+.5	0.0	0.0	0.0
Lower Incisor to MP								
After. . . .	92.0	77.5	76.0	85.5	83.0	104.5	96.0	96.0
Before . . .	92.5	78.0	76.0	85.5	83.0	105.0	96.0	97.0
Difference .	-.5	-.5	0.0	0.0	0.0	-.5	0.0	-1.0
SNA								
After. . . .	83.0	83.0	80.5	85.5	79.0	83.0	83.0	85.0
Before . . .	83.0	83.0	80.5	85.5	78.5	83.5	83.0	85.0
Difference .	0.0	0.0	0.0	0.0	+.5	-.5	0.0	0.0
SNB								
After. . . .	77.5	81.5	81.0	85.0	78.5	75.5	82.0	82.0
Before . . .	77.5	81.5	81.0	85.0	78.5	75.5	82.0	82.0
Difference .	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ANB								
After. . . .	5.5	1.5	-.5	.5	.5	7.5	1.0	3.0
Before . . .	5.5	1.5	-.5	.5	.0	8.0	1.0	3.0
Difference .	0.0	0.0	0.0	0.0	+.5	-.5	0.0	0.0
Gonial								
After. . . .	121.0	122.0	124.0	130.0	134.5	114.0	113.0	109.0
Before . . .	121.0	122.0	125.0	130.0	134.5	114.0	113.0	109.0
Difference .	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0

TABLE IV

SKELETAL CEPHALOMETRIC MEASUREMENTS
(millimeters)

Measurements	Patient					
	M.L.G.	B.B.	B.H.	P.L.	N.H.	T.R.
Total Anterior Face Height						
After. . . .	109.80	107.00	125.20	110.20	119.10	103.30
Before . . .	110.00	107.00	125.50	109.80	119.70	103.35
Difference .	-.20	0.00	-.30	+.40	-.60	-.05
Upper Anterior Face Height						
After. . . .	53.60	46.30	52.80	51.60	52.70	53.20
Before . . .	53.40	46.00	52.90	51.20	52.40	53.30
Difference .	+.20	+.30	-.10	+.40	+.30	-.10
Lower Anterior Face Height						
After. . . .	56.20	60.70	72.40	58.60		50.10
Before . . .	56.60	61.00	72.60	58.60	. .	50.05
Difference .	-.40	+.70	-.20	0.00		+.05
Lower Posterior Face Height						
After. . . .	43.10	35.80	42.30	42.00		42.95
Before . . .	41.20	36.30	42.30	41.90	. .	43.00
Difference .	+1.90	-.50	0.00	+.10		-.05
Lower Molar Height						
After. . . .	33.40	28.60	30.60	33.60	36.40	32.60
Before . . .	33.50	28.60	30.50	33.50	36.40	32.55
Difference .	-.10	0.00	+.10	+.10	0.00	+.05
Upper Molar Height						
After. . . .	21.60	20.60	20.60	21.10	22.50	22.75
Before . . .	21.60	20.60	20.40	20.70	22.50	22.75
Difference .	0.00	0.00	+.20	+.40	0.00	0.00
Gonial Width						
After. . . .	95.50	94.90	97.70	116.00	102.20	96.90
Before . . .	95.20	94.80	97.50	117.00	102.30	96.85
Difference .	+.30	+.10	+.20	-1.00	-.10	+.05

TABLE IV continued

Measurements	Patient					
	E.W.	R.S.	J.B.	J.R.	S.D.	J.B.L.
Total Anterior Face Height						
After. . . .	104.90	114.75	121.25	110.15	109.85	112.10
Before . . .	104.95	114.70	121.30	110.10	109.75	112.10
Difference .	-.05	+.05	-.05	+.05	+.10	0.00
Upper Anterior Face Height						
After. . . .	47.30	50.25	59.05	48.80	48.75	50.50
Before . . .	47.25	50.25	58.95	48.80	48.65	50.30
Difference .	+.05	0.00	+.10	0.00	+.10	+.20
Lower Anterior Face Height						
After. . . .	57.60	64.50	62.20	61.35	61.10	61.60
Before . . .	57.70	64.45	62.35	61.30	61.10	61.80
Difference .	-.10	+.05	-.15	+.05	0.00	-.20
Lower Posterior Face Height						
After. . . .	48.80	44.05	42.30	37.50	41.65	38.60
Before . . .	48.85	42.90	42.30	37.40	41.60	38.60
Difference .	-.05	+1.15	0.00	+.10	+.05	0.00
Lower Molar Height						
After. . . .	29.20	32.55	36.50	31.90	30.80	26.45
Before . . .	29.10	32.50	36.55	31.90	30.80	26.50
Difference .	+.10	+.05	-.05	0.00	0.00	-.05
Upper Molar Height						
After. . . .	19.90	22.35	19.70	23.60	21.75	22.40
Before . . .	20.00	22.35	19.70	23.60	21.70	22.40
Difference .	-.10	0.00	0.00	0.00	+.05	0.00
Gonial Width						
After. . . .	103.50	92.15	99.30	95.70	93.30	88.65
Before . . .	103.40	92.50	98.60	95.65	93.35	88.60
Difference .	+.10	-.35	-.70	+.05	-.05	+.05

TABLE IV continued

Measurements	Patient				
	M.P.	L.S.	L.H.	R.C.	S.H.
Total Anterior Face Height					
After. . . .	111.70	111.40	105.80	108.70	113.70
Before . . .	111.55	111.50	105.80	108.70	113.60
Difference .	+.15	-.10	0.00	0.00	+.10
Upper Anterior Face Height					
After. . . .	47.70	48.40	53.25	49.15	49.70
Before . . .	47.80	48.40	53.20	49.15	49.70
Difference .	-.10	0.00	+.05	0.00	0.00
Lower Anterior Face Height					
After. . . .	64.00	63.00	52.55	59.55	64.00
Before . . .	63.75	63.10	52.60	59.55	63.90
Difference .	+.25	-.10	-.05	0.00	+.10
Lower Posterior Face Height					
After. . . .	44.00	40.60	40.80	42.60	48.40
Before . . .	44.00	40.50	40.85	42.65	48.45
Difference .	0.00	+.10	-.05	-.05	-.05
Lower Molar Height					
After. . . .	28.40	27.20	29.10	32.10	35.00
Before . . .	28.35	27.20	29.10	32.10	34.95
Difference .	+.05	0.00	0.00	0.00	+.05
Upper Molar Height					
After. . . .	21.85	19.90	19.40	21.30	21.40
Before . . .	21.75	19.80	19.40	21.20	21.30
Difference .	+.10	+.10	0.00	+.10	+.10
Gonial Width					
After. . . .	93.15	102.35	102.10	82.30	104.10
Before . . .	93.10	102.30	102.15	82.20	103.90
Difference .	+.05	+.05	-.05	+.10	+.20

TABLE V

DENTAL CEPHALOMETRIC MEASUREMENTS
(millimeters)

Measurements	Patient								
	M.L.G.	B.B.	B.H.	P.L.	N.H.	T.R.	E.W.	R.S.	J.B.
UI-AP									
After. . . .	4.50	9.00	3.80	5.70		4.85	10.65	8.25	8.15
Before . . .	4.70	8.90	3.80	5.60	. .	4.85	10.60	8.30	8.20
Difference .	-.20	+.10	0.00	+.10		0.00	+.05	-.05	-.05
LI-AP									
After. . . .	2.20	3.80	1.90	3.20		1.95	2.80	4.50	3.90
Before . . .	2.20	3.50	1.90	3.20	. .	1.95	2.40	4.55	3.95
Difference .	0.00	+.30	0.00	0.00		0.00	+.40	-.05	-.05
UI-"C"									
After. . . .	17.00	28.50	15.50	22.20	24.20	20.65	22.80	20.50	22.55
Before . . .	17.00	28.40	15.50	22.20	24.20	20.60	22.85	20.50	22.55
Difference .	0.00	+.10	0.00	0.00	0.00	+.05	-.05	0.00	0.00
LI-"C"									
After. . . .	15.20	13.50	13.00	19.70	21.40	17.55	14.75	17.00	18.80
Before . . .	15.00	13.20	13.10	19.70	21.40	17.50	14.45	17.00	18.80
Difference .	+.20	+.30	-.10	0.00	0.00	+.05	+.30	0.00	0.00
Overbite									
After. . . .	3.20	5.00	1.50	4.00	2.45	4.15	6.10	3.50	5.65
Before . . .	3.20	5.00	1.20	4.00	3.00	4.15	6.10	3.50	5.65
Difference .	0.00	0.00	+.30	0.00	-.55	0.00	0.00	0.00	0.00
Overjet									
After. . . .	2.30	5.20	2.20	2.40	2.80	2.85	8.50	3.65	3.55
Before . . .	2.30	5.40	2.10	2.50	2.60	2.85	8.55	3.65	3.55
Difference .	0.00	-.20	+.10	-.10	+.20	0.00	-.05	0.00	0.00

TABLE V continued

Measurements	Patient								$\bar{X}$	s
	J.R.	S.D.	J.B.L.	M.P.	L.S.	L.H.	R.C.	S.H.		
UI-AP										
After.	5.00	0.00	2.55	3.95	7.85	3.60	7.70	6.85	-.022	
Before	5.00	0.00	2.55	4.00	7.85	3.70	7.80	6.90	(.06 → .02)	
Difference . .	0.00	0.00	0.00	-.05	0.00	-.10	-.10	-.05		.075
LI-AP										
After.	1.20	3.35	.80	1.40	3.70	1.20	5.20	2.10	.016	
Before	1.20	3.40	.85	1.40	3.80	1.15	5.30	2.20	(-.06 → .09)	
Difference . .	0.00	-.05	-.05	0.00	-.10	+.05	-.10	-.10		139
UI-"C"										
After.	20.00	14.05	22.35	16.85	21.70	12.20	23.40	22.90	.00	
Before	20.05	14.05	22.35	16.90	21.70	12.30	23.40	22.80	(-.03 → .03)	
Difference . .	-.05	0.00	0.00	-.05	0.00	-.10	0.00	+.10		.050
LI-"C"										
After.	16.80	10.55	19.80	14.70	17.50	9.30	21.10	18.30	.038	
Before	16.85	10.55	19.80	14.70	17.50	9.35	21.10	18.30	(-.02 → .10)	
Difference . .	-.05	0.00	0.00	0.00	0.00	-.05	0.00	0.00		.115
Overbite										
After.	6.25	7.80	3.70	3.70	5.35	7.30	2.70	5.60	.00	
Before	6.25	7.80	3.40	3.70	5.30	7.30	2.70	5.60	(-.09 → +.09)	
Difference . .	0.00	0.00	+.30	0.00	-.05	0.00	0.00	0.00		.174
Overjet										
After.	3.40	3.25	2.70	2.50	4.35	4.80	2.55	4.60	-.007	
Before	3.40	3.30	2.70	2.40	4.30	4.85	2.65	4.55	(-.05 → .04)	
Difference . .	0.00	-.05	0.00	+.10	+.05	-.05	-.10	+.05		091

anterior height exhibited a mean increase of 0.08 millimeters. The lower posterior facial height increased with a mean of 0.17 millimeters. Gonial width decreased with a mean of 0.06 millimeters. Both upper and lower molars exhibited mean increases of 0.06 and 0.02 millimeters respectively. The upper incisor to the A-P plane had a mean decrease of 0.02 millimeters. The lower incisor to the A-P plane exhibited a mean increase of 0.02 millimeters. Overbite had a 0.00 mean change, while overjet showed a slight decrease with a mean of 0.01 millimeters.

Note that patient N. H. was not included in four measurements for reasons that will be explained in the Discussion.

In Table III the interincisal angle showed a mean increase of 0.03 degrees with the upper incisor to S-N showing a mean increase of 0.06 degrees and the lower incisor to mandibular plane showing a mean decrease of 0.06 degrees. S.N.A. had a 0.00 mean change, while S.N.B. decreased by 0.03 degrees. The gonial angle showed a mean decrease of 0.15 degrees.

DISCUSSION

From an orthopedic viewpoint, the modified Milwaukee brace seems as effective as the conventional Milwaukee brace for the non-operative treatment of scoliosis (Blount, 1972; Nash, 1972). In fact, during the past year it has been used exclusively by the orthopedic staff at Rainbow Babies and Childrens Hospital (University Hospitals) Case Western Reserve University, for the non-operative treatment of scoliosis. If the modified brace corrects scoliosis to the same degree as the conventional brace without causing any untoward changes in the dentition and surrounding structures, then it would be the appliance of choice for the treatment of scoliosis.

Study Cast Measurements

All of the mean differences for the study cast measurements show a slight increase except for lower inter-canine width which showed a slight decrease. All of the confidence intervals at the ninety-five percent level contain zero except for palatal vault height which was on the positive side (Table II). Normally, one would expect palatal vault height to increase as the teeth erupt (Baume, 1950). However, Alexander (1966) in a classic study on the original Milwaukee brace demonstrated a mean palatal vault decrease of 1.6 millimeters. The mean difference for the study cast data are so small as to be considered clinically and statistically insignificant.

Cephalometric Measurements

Note that patient N. H. (Tables IV and V) was not included in four categories when it was determined on examination of the lateral cephalogram that her mandibular condyle was displaced anteriorly when the roentgenogram was taken. Comparison of the incisor relationship to the A-P plane and line "C" will verify this finding.

The mean differences (Table VI), whether positive or negative are so small that they may be considered clinically insignificant. All of the confidence intervals for the cephalometric measurements contain zero and are very small values. Since the results of this study indicate that the modified Milwaukee brace is associated with relatively little change in the dentition it was decided to compare these values statistically with corrected values obtained in the Milwaukee brace study of Alexander (1966)[1]. Alexander's study was chosen as his sample had approximately the same age and sex distribution as the present study and was about six months in duration. Utilizing the "t" statistic it was decided to compare the changes associated with the modified brace with those produced by the conventional brace, Alexander's control group. It was also decided to compare the changes associated with the modified brace with Alexander's experimental group, conventional Milwaukee brace patients wearing mouthpieces; heretofore splinting the teeth in some manner to oppose

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[1] On evaluation of Alexander's results it was determined that errors in computation were made. Utilizing his raw data, new means and standard deviations were calculated and used for comparison in this paper.

TABLE VI

TREATMENT CHANGES: A COMPARISON BETWEEN THE MODIFIED MILWAUKEE BRACE AND ALEXANDER'S EXPERIMENTAL AND CONTROL GROUPS

Measurement	Modified Brace			Alexander's Experimental			Alexander's Control		
	$\bar{X}_d$	S	95% Confid. Interval	$\bar{X}_d$	S	95% Confid. Interval	$\bar{X}_d$	S	95% Confid. Interval
	Angular								
Interincisal Angle	+.029	.514	$-.24<\mu<.29$	-3.4	5.2	$1.4<\mu<8.2$	-19.2	11.7	$-8.4<\mu<30.0$
UI to SN	+.059	.391	$-.14<\mu<.26$	+3.6	2.9	$-.92<\mu<6.3$	+12.0	9.1	$-3.5<\mu<20.4$
LI to MP	-.056	.635	$-.38<\mu<.27$	+2.6	4.4	$1.5<\mu<6.7$	+10.6	6.6	$-4.5<\mu<16.7$
SNA	.00	.25	$-.13<\mu<.13$	. .	. .	. .	. .	. .	. .
SNB	-.029	.329	$-.20<\mu<.14$	. .	. .	. .	. .	. .	. .
ANB	+.029	.374	$-.16<\mu<.22$	. .	. .	. .	. .	. .	. .
Gonial Angle	-.147	.460	$-.38<\mu<.09$	-4.7	1.8	$-3.0<\mu<6.4$	- 4.2	1.9	$-2.4<\mu<6.0$

TABLE VI continued

Measurement	Modified Brace			Alexander's Experimental			Alexander's Control		
	$\bar{X}_d$	S	95% Confid. Interval	$\bar{X}_d$	S	95% Confid. Interval	$\bar{X}_d$	S	95% Confid. Interval
	Linear								
Total Anterior Facial Height	-.029	.209	$-.14<\mu<.08$	-5.0	1.8	$-1.7<\mu<8.3$	-4.9	3.0	$-2.1<\mu<7.7$
Upper Anterior Facial Height	+.082	.150	$-.00<\mu<.16$	+ .6	3.6	$.05<\mu<1.3$	- .5	.8	$.24<\mu<1.2$
Lower Anterior Facial Height	-.063	.162	$-.15<\mu<.02$	-5.6	3.3	$-2.6<\mu<8.7$	-4.4	2.5	$-2.1<\mu<6.7$
Lower Posterior Facial Height	+.166	.565	$-.13<\mu<.47$	-4.1	3.0	$-1.3<\mu<6.9$	-5.5	3.8	$-2.0<\mu<9.0$
Lower Molar Height	+.018	.056	$-.01<\mu<.05$	-2.1	1.1	$-1.9<\mu<3.1$	-2.4	1.2	$-1.3<\mu<3.5$
Upper Molar Height	+.056	.112	$-.00<\mu<.11$	-1.4	1.1	$-.38<\mu<2.4$	-1.2	0.8	$-.46<\mu<1.9$
Upper Incisor to A-P	-.022	.075	$-.06<\mu<.02$	. .	. .	. .	. .	. .	. .

TABLE VI continued

Measurement	Modified Brace			Alexander's Experimental			Alexander's Control		
	$\bar{X}_d$	S	95% Confid. Interval	$\bar{X}_d$	S	95% Confid. Interval	$\bar{X}_d$	S	95% Confid. Interval
	Linear								
Lower Incisor to A-P	+.016	.139	-.06<μ<.09	. .	. .	. .	. .	. .	. .
Upper Incisor to "C"	.00	.115	-.03<μ<.03	. .	. .	. .	. .	. .	. .
Lower Incisor to "C"	.038	.334	-.02<μ<.10	. .	. .	. .	. .	. .	. .
Gonial Width	-.059	.174	-.23<μ<.11	. .	. .	. .	. .	. .	. .
Overbite	.00	.091	-.09<μ<.09	. .	. .	. .	. .	. .	. .
Overjet	-.003		-.05<μ<.04	. .	. .	. .	. .	. .	. .

these orthopedic forces was the only palliative that orthodontists have been able to devise.

Alexander (1966) concluded that Milwaukee brace forces are powerful enough to alter vertical facial development. He reported a depression of the total anterior facial height, questionable depression of upper anterior facial height, depression of lower anterior facial height, and a depression of lower posterior facial height. Normally, one would expect these values to increase. There was a significant difference in total anterior face height and lower anterior face height on comparison with Alexander's values (Table VII). This is interpreted to mean that the modified brace did not cause the decreases in total anterior face height and lower anterior face height that was so characteristic of conventional Milwaukee brace therapy. There were no significant differences on comparison of upper anterior face height, however, the small mean differences in this dimension indicate that it is not significantly altered by Milwaukee brace therapy. The modified brace was significantly superior to the conventional brace on preventing decrease of lower posterior face height. Since the copolymer vinyl thermoplastic mouthpiece of Alexander was unable to prevent collapse of the anterior and posterior vertical dimension the above values were significant on comparison of the modified brace with both his experimental and control values.

Alexander also reported a decrease in both upper and lower molar height. Normally, one would also expect these values to increase. Again, there is a significant difference in values obtained

TABLE VII

STATISTICAL DATA COMPARING t VALUES OF MODIFIED BRACE WITH ALEXANDER'S EXPERIMENTAL AND CONTROL GROUPS

Measurement	Alexander's Experimental Group		Alexander's Control Group	
	t Value[a]	Degrees of Freedom[b]	t Value[a]	Degrees of Freedom[b]
Interincisal Angle	1.741	7	4.347**	7
Upper Incisor to S-N	-3.219*	7	-3.470*	7
Lower Incisor to M-P	-1.591	7	-4.264**	7
Gonial Angle	6.600**	7	5.580**	7
Total Anterior Facial Height	3.651**	7	4.292**	7
Upper Anterior Facial Height	-1.940	7	1.911	7
Lower Anterior Facial Height	4.437**	7	4.586**	7
Lower Posterior Facial Height	3.733**	7	3.926**	7
Lower Molar Height	5.092**	7	5.329**	7
Upper Molar Height	3.495*	7	4.137**	7

[a] $t_{(7).95} = \pm 2.365$; $t_{(7).99} = \pm 3.499$

[b] rounded to nearest whole number.

from this study on comparison with both the experimental and control values of Alexander. Patients wearing the modified brace actually exhibited a slight mean increase in both the upper and lower molar height.

Modified brace patients did not show a significant difference in interincisal and IMPA values in comparison with Alexander's experimental group, but did show a significant difference on comparison with his control group. This is because the mouthpiece was able to stabilize the interincisal angle and prevent lower incisor flairing in the experimental group. The modified brace caused significantly less change in the upper incisor angulation on comparison with both the experimental and control values, apparently because the mouthpiece was not as effective in preventing upper incisor flairing in the experimental group.

It has been well documented that there is a definite, irreversible reshaping of the lower border of the mandible, presumably from the orthopedic pressures exerted by the chin pad (Alexander, 1966; Cutler, 1969; Gee, 1969; Luedtke, 1970). Alexander also reported a decrease in the gonial angle in both the experimental and control groups. In comparison with both Alexander's experimental and control groups the modified Milwaukee brace is associated with no significant change in the gonial angulation.

Reliability of Measurements

The present study revealed that patients wearing a modified

Milwaukee brace over a six and one-half month period exhibited a general pattern of little or no change in the dental and skeletal structures. The mean differences for all measurements are so small that they may be considered clinically insignificant. The possible errors in tracing, patient orientation, and measurement of the cephalometric radiographs are certainly of the magnitude of mean differences obtained in this study (Hatton, 1958; Savara, 1966; Baumrind and Frantz, 1971a,b).

Importance of Appliance Design

Undesirable dental and skeletal changes occurring secondarily to Milwaukee brace therapy has been well documented in the studies of previous investigators (Alexander, 1966; Eastham, 1969; Cutler, 1969; Luedtke, 1970), and many others. At best splinting the dental arches with appliances designed to oppose the orthopedic forces directed to the mandible was the only solution to the problem. These appliances were effective in controlling axial inclination and spacing of the upper and lower anterior teeth, but did not significantly prevent the loss of face height, molar depression, or change in the gonial angulation (Howard, 1926; Thørs, 1964; Alexander, 1966; Roth, 1969; and Luedtke, 1970). Since orthopedic forces are still directed to the mandible one almost wonders if "splint-like" appliances actually accentuate the intrusion of the anterior teeth and molars, and may be the wrong type of appliance to oppose these forces. The modified Milwaukee brace, in contrast, does not exert orthopedic forces directly

to the lower border of the mandible and by virtue of this modification in design changes in the dentition and surrounding maxillo-facial structures would not be anticipated.

SUMMARY AND CONCLUSIONS

The conventional Milwaukee brace has been shown to produce marked detrimental effects upon the occlusion. Recently, orthopedic surgeons have demonstrated the modified Milwaukee brace to be as effective as the conventional Milwaukee brace in the non-operative treatment of scoliosis. This study was conducted to determine what effect the modified Milwaukee brace has upon the dentition and surrounding maxillo-facial complex during the treatment of scoliosis. Beginning and progress study casts, and frontal and lateral cephalograms were taken of seventeen patients who were being treated for scoliosis with the modified brace.

Linear and angular measurements were recorded and analyzed to determine what effect, if any, the modified brace had upon the dentition and the vertical growth of the face. The data collected were also compared statistically with data obtained from patients undergoing conventional Milwaukee brace therapy.

In general, the data indicate that the modified Milwaukee brace was associated with no significant detrimental changes to the dentition or surrounding maxillo-facial complex over the six and one-half month period that the study was in progress. Statistically the modified brace was associated with significantly less change in the dentition and surrounding structures as compared to more conventional braces.

Given the assumption that both forms of Milwaukee brace correct scoliosis to the same degree, and that the modified brace causes no detrimental changes in the occlusion, then it only seems logical that the modified form of Milwaukee brace should be employed in the non-operative treatment of scoliosis.

The results can be summarized as follows:

(1) The modified form of Milwaukee brace led to no significant change in the dentition and surrounding maxillo-facial complex.

(2) The modified brace, when compared with the effects of the conventional brace, was associated with significantly less change in the dentition and surrounding structures.

APPENDIX I

Definition of cephalometric anthropometric landmarks for the lateral radiograph. When bilateral structures appeared on the cephalogram an unbiased attempt was made to bisect these images (Krogman and Sassouni, 1957).

ANTERIOR NASAL SPINE (ANS)--The tip of the anterior nasal spine.

ARTICULARE (AR)--The point of intersection of the dorsal contours of the articular processes of the mandible and the temporal bone.

GNATHION (Gn)--The midpoint between the most anterior and inferior points on the bony chin.

GONION (Go)--The point midway between the most inferior and most posterior points on the angle of the jaw.

NASION (N)--The most anterior portion of the nasofrontal suture.

ORBITALE (Or)--The lowermost or deepest point on the inferior margin of the orbit.

POGONION (Pog)--The most anterior point of the bony chin.

POSTERIOR NASAL SPINE (PNS)--The tip of the posterior spine of the palatine bone in the hard palate.

SELLA (S)--The midpoint of sella turcica.

SUBSPINALE (Downs' point "A")--The deepest midline point on the premaxilla between the anterior nasal spine and prosthion.

SUPRAMENTALE (Downs' point "B")--The most posterior point on the outer contour of the mandibular alveolar process.

APPENDIX II

Definition of planes of orientation for the lateral radiograph (Krogman and Sassouni, 1957).

FACIAL PLANE--A line connecting nasion and pogonion.

FRANKFORT PLANE--A line connecting porion and orbitale.

MANDIBULAR PLANE--A tangent to the lower border of the mandible.

PALATAL PLANE--A line connecting the tip of anterior nasal spine with the tip of posterior nasal spine.

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