MILWAUKEE BRACE TREATMENT OF SCOLIOSIS: A CROSS-SECTIONAL INVESTIGATION OF THE EFFECTS ON FACE HEIGHT AND AXIAL INCLINATION OF THE INCISORS

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INTRODUCTION

Scoliosis is the term designating a lateral curvature of the vertebral column. (Fig. 1 & 2). Many authorities believe that scoliosis has been with man since he first achieved upright posture. In 400 B.C. the term scoliosis was used by Hippocrates, who recommended distraction and counter-pressure to correct the lateral deviation of the spine.[1]

The curvature is usually progressive during the period of growth of the spine and in most cases does not progress after the spine has completed its growth.[2] In 1936, Risser[3] observed that the end of the growth of the spine is coincidental with the ossification and closure of the iliac apophysis. The completion of closure is approximately age 14 for females and age 16 for males and is used as a guide for the timing of treatment.

Scoliosis can lead to a lifelong cosmetic problem and the curve may become so severe as to impair respiration, circulation and digestion. It has been reported to lead to secondary emphysema, cor pulmonale and heart failure at an early age.[1] Although more than thirty etiologic factors have been listed for this disease, it will usually be in one of the following categories: congenital, neuropathic,

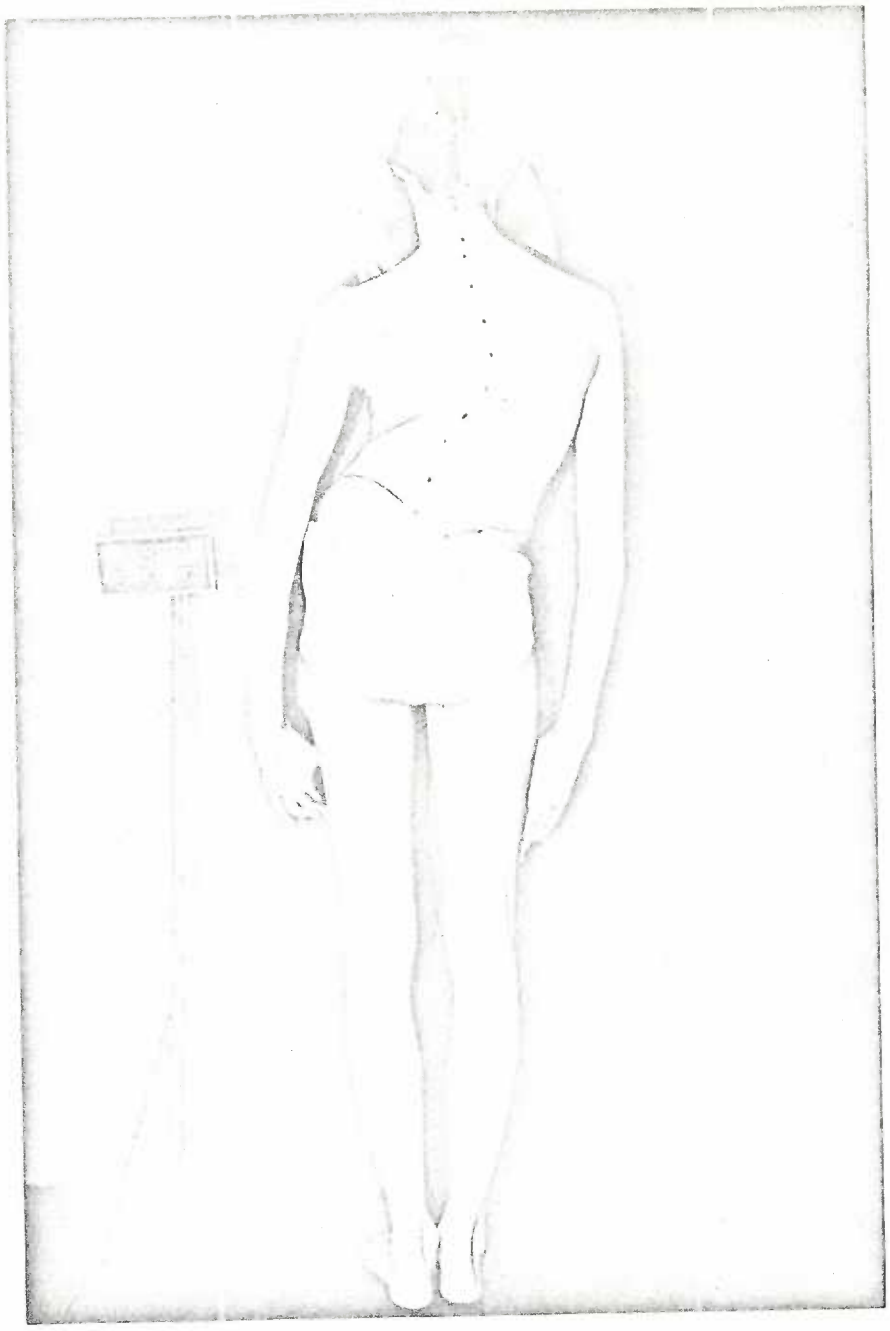

Figure 1. - Female, age 15 years, 3 months with severe scoliosis.

(Photograph courtesy of Shriner's Hospital for Crippled Children, Portland, Oregon.)

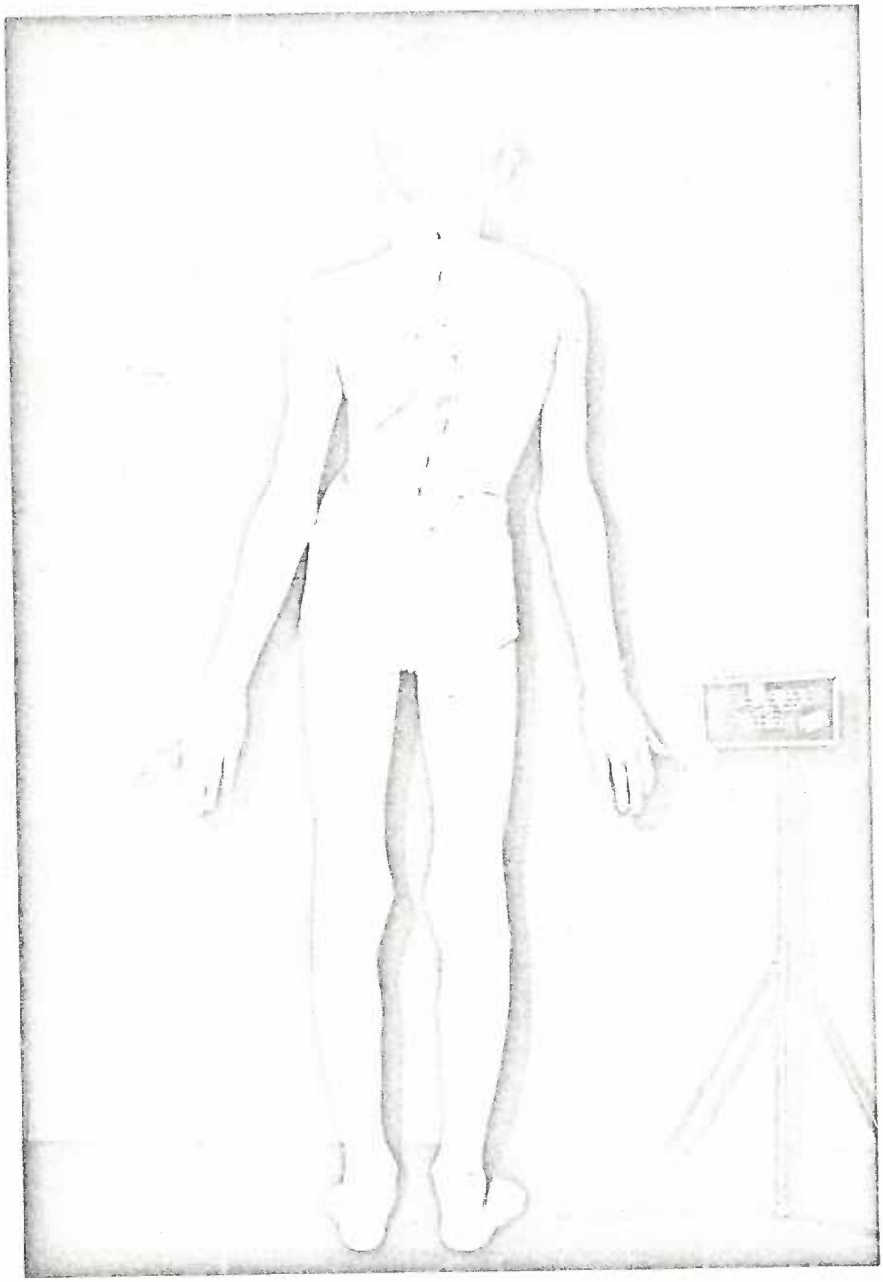

Figure 2. - Male, age 10 years, 1 month.
Scoliosis prior to Milwaukee brace therapy.

(Photograph courtesy of Shriner's Hospital
for Crippled Children, Portland, Oregon.)

post-poliomyelitis, neurofibromatosis, muscular dystrophy other myopathic conditions and idiopathic. The majority of scoliosis cases are listed as idiopathic (75-80%) and females account for 85% of all idiopathic cases. No sex difference has been found in post-paralytic scoliosis.

The principal aim of the treatment of scoliosis is the arresting of the advance of the curvature, and secondarily to correct the original curve and maintain as much of the correction as possible. Prior to the turn of the century five approaches to treatment were employed either in combination or singularly. These were: 1) prolonged bed rest, 2) head and pelvic traction while reclining, 3) muscle resection on the concave side, 4) exercises for the weak muscles on the convex side and 5) bracing of the spine with corsets, either with or without pressure pads and plaster body casts.[3] The first three types of treatment have been discarded and exercises are used to a minor degree today. The first effective treatment involving fusion of the spine was reported in 1914 by Hibbs.[4] It remained a problem to correct the curve prior to the fusion. Modifications of this original surgical approach are used today, with increased articular areas being fused and often with the addition of bone to the fusion site. It has been reported that the fusion site may increase in length if done in young children.[5]

Recently Risser[3] has written, "The theory behind the cast correction without surgery of the scoliotic spine is based on Hueter-Volkmann's epiphyseal pressure rule; that is if pressure is taken off the concave side of the curve and the borders of the vertebral bodies are paralleled, growth will be symmetric and there will be no further wedging of the vertebral bodies." In order to achieve this, a corrective force must be exerted long enough and constant enough to control subsequent growth in the spine.

In the 1920's this was accomplished by placing hinges and turnbuckles on the plaster cast. The correction was obtained by means of traction and lateral bending. The cast then served to immobilize the post-surgical fusion site for a period of three to nine months.

The Milwaukee brace was introduced by Blount[4,6,7] in 1946. It allowed the patient to be ambulatory while providing traction by an adjustable extension from the pelvic girdle to the occiput and the inferior border of the mandible. (Fig. 3). The orthopedist has been successful in treating scoliosis with the Milwaukee brace, both with and without subsequent spinal fusion. Consequently, it has found a wide acceptance in the orthopedic profession. The interest from an orthodontic standpoint is in what effect the long term pressure on the mandible will have on the dentition and the maxillo-facial complex.

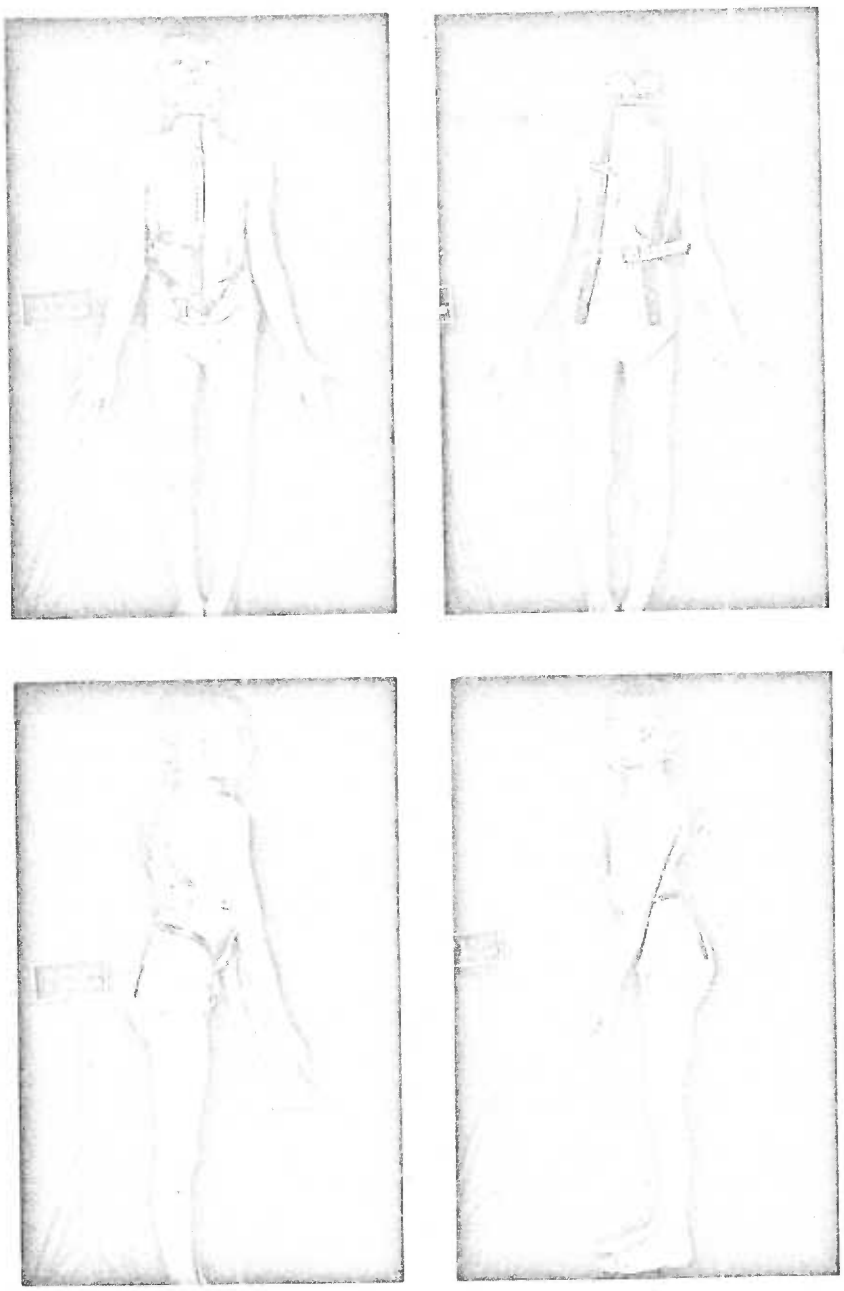

Figure 3. - Four views of the Milwaukee Brace on the same patient as in Fig. 2. (Photograph courtesy of Shriner's Hospital for Crippled Children, Portland, Oregon.)

REVIEW OF THE LITERATURE: SCOLIOSIS TREATMENT AND ITS EFFECT ON THE DENTITION

One of the earliest documentations in the literature of change in the dentition associated with treatment of scoliosis, was by Howard[8] in 1926. The patients were in plaster body casts and photographs showed a shortening of the lower face height. In 1929 Howard[9] reported on the follow-up of his earlier cases, 1 year after the removal of the casts. He noted only a slight tendency to return to normal and proceeded to treat them orthodontically at that time. In attempting to prevent the shortening of the face, Howard fabricated removable splints assuming that the teeth united as a single unit would offer more resistance than individual teeth. He found that the tendency for the crowns of anterior teeth to tip labially was prevented but that the depression of the teeth and subsequent reduction in face height was not prevented. In 1961, Bunch[10] reported on a 3½ year study where rubber dental positioners were used in forty patients, thirty-five of the forty cases maintained the original dental relationships. The patients were instructed to wear the positioner 24 hours/day and only to remove it to eat, clean the teeth and for limited talking. Some minor tooth movement was accomplished in the anterior

region by using a series of positioners. In 3 cases where there was a total lack of cooperation, the occlusal relationship was not maintained. Bunch recommended the placement of the positioner prior to the institution of the brace or cast therapy.

Thørs[11] reported that through the use of a simple acrylic splint, that changes in occlusion and cuspal interdigitation were considerably restricted. "As regards the vertical relations it is too early to say whether the use of the splint tends to prevent or accentuate the intrusion."

Alexander[12] fabricated a vinyl thermoplastic mouthpiece for seven patients. It was inserted on the day the Milwaukee brace was instituted. The material covered the palate and had an occlusal index for the mandibular teeth to occlude in. Seven patients not wearing a mouthpiece were used as controls and similar cephalometric radiographs, photographs and study models were obtained. "Progress reports indicated that the mouthpiece stabilized the denture but did not prevent loss of vertical height." Those patients not wearing the mouthpiece showed statistically significant differences from the mouthpiece group, in all measurements relating to the inclination of the incisors.

Logan [13,14] has reported on the dental changes he observed in 50 patients wearing the Milwaukee brace, with

no attempt at stabilization of the dentition. The major effect was deepening of the bite. Further effects were labial inclination and spacing of the crowns of both the upper and lower incisors. Widening of the maxillary arch was reported in the molar and pre-molar region due to buccal tipping of the crowns. The lower arch showed little increase in width, but the greatest depression of molars and pre-molars. Logan believes the effects he has observed are spontaneously reversible. He does not indicate the extent to which he believes it is reversible and is apparently concerned only with the malocclusion and not the possible effect on maxillo-facial growth. Logan did measure the force being applied to the mandible by incorporating a strain gauge into the chin piece and obtained an intermittent pressure averaging four pounds.

In 1963, Thørs [11] reported on nine patients who had metallic implants placed in their maxilla and mandible (after the method of Bjork[15]) prior to the placement of the Milwaukee brace. After 1 year of brace therapy he reports three growth disturbances: 1) intrusion of upper and lower teeth, 2) compression of the sutures of the upper face, or an induced change in the direction of growth of these sutures, 3) inhibition of growth at the condyles of the mandible. Whether this reduction in face height is only temporary should be shown in the follow-up of this study.

Weinmann and Sicher[16] propose that undue pressure on the connective tissue coverings of the condyles might decrease or prevent its contribution to the growth of the condylar cartilages, since connective tissue is, in contrast to cartilage, not well adapted to resist pressure.

In 1965 an abstract was published of a paper presented to the Orthopedic profession by Hodges, Atwood and Blair[17] of Newington Hospital for Crippled Children. Through the use of cephalometric roentgenograms it was determined that when changes did occur they tended to return towards the original after the cast was removed. This implied the use of some form of body cast and not the Milwaukee brace, but since it involved pressure on the mandible the effect should be similar. The commonest change was for the maxillary and mandibular teeth to assume a more horizontal position. The duration of the immobilization (and consequently duration of pressure) appeared to be the most important factor, with the maximum recovery being within one year of the cast removal.

Blount[7] and his associates introduced the Milwaukee brace to the orthopedic profession, and have stated that the prolonged use of the brace will sometimes give rise to malocclusion and prominence of the upper incisor and canine teeth, but that this was a small (and correctable)

price to pay in exchange for the prevention of severe scoliosis.

Alexander[12] has summarized his feelings on potential recovery, of the changes reported, in his discussion of the effects on growth. "It is possible that this retarded vertical growth would be reversible. This does not seem feasible, however, since the horizontal growth change effected with the headgear is not considered reversible. Also to prevent a relapse of the spinal curvature, the Milwaukee brace is worn until growth is completed. By the same logic, it seems doubtful that the affected structures in the lower face will revert to their original growth pattern when the abnormal pressure is relieved. The teeth will seek more stable positions, but the directional change in growth may be permanent."

From the literature cited there should be no question on whether or not the pressure from the brace can cause changes in the dentition. The more important question is the degree of reversibility of these changes in the dentition and in the maxillo-facial complex.

METHODS AND MATERIALS

The sample of patients consisted of a group of American-born caucasian children, apparently of Northwest European ancestry. The total sample of 34 patients included 29 females and 5 males. The sample was made up of 17 patients from Shriner's Hospital For Crippled Children (Portland, Oregon), 14 patients from orthodontists in the Portland area and 3 patients who were being seen at the University of Oregon Dental School.

A diagnosis of scoliosis of the spine (in varying degrees of severity) had been made on all the patients in this study. The records were obtained after a varied period of treatment with the Milwaukee brace. The mean treatment time was 10.5 months. The records on the patients at Shriner's Hospital consisted of lateral cephalometric head-films and a recording of age, sex, length of time the brace had been worn, molar relation, overbite, overjet, crowding or spacing and whether in the mixed or permanent dentition.

A constant target/film distance and patient mid-sagittal/film distance was used. This allowed for the calculation of an enlargement factor using a metal ruled scale. (13.5% enlargement on Shriner's patients, 8.5% on dental school patients). Because these distances had not been held constant on the head-films secured from private orthodontists, this part of the sample had to be limited to angular measurement:

The following reference points were indicated on acetate film: 1) nasion, 2) anterior nasal spine, 3) junction of the labial alveolar bone with the cementum or enamel of the maxillary central incisor, 4) junction of the labial alveolar bone and the cementum or enamel of the lower central incisor, 5) the most inferior point of the mandibular symphysis, 6) orbitale, 7) porion, 8) long axis of the maxillary and mandibular central incisors. The Frankfort horizontal was drawn (orbitale to superior curve of porion) and a reference line was constructed perpendicular to it and anterior to the facial skeleton. Lines parallel to Frankfort horizontal were constructed from anatomical landmarks (1,2,3,4,5) and projected to intersect the vertical reference line. The measurements along the vertical reference line were made and compared with the norms for vertical face height that had been reported by Jones and Meredith,[18] using this measurement method. (fig. 4). Because of the limited number of patients in each age group, no statistical comparison was attempted of the means of the components of vertical face height. Instead, the distribution of this data was plotted, with millimeter measurements on the vertical axis and age in years on the horizontal axis. The linear measurements were made with a boley gauge reading to the nearest 0.1 mm. and recorded for total face height. Later the measurements were made for nasal height, maxillary subnasal height, dental height and mandibular height. The measurements of the 4 components of the total face height

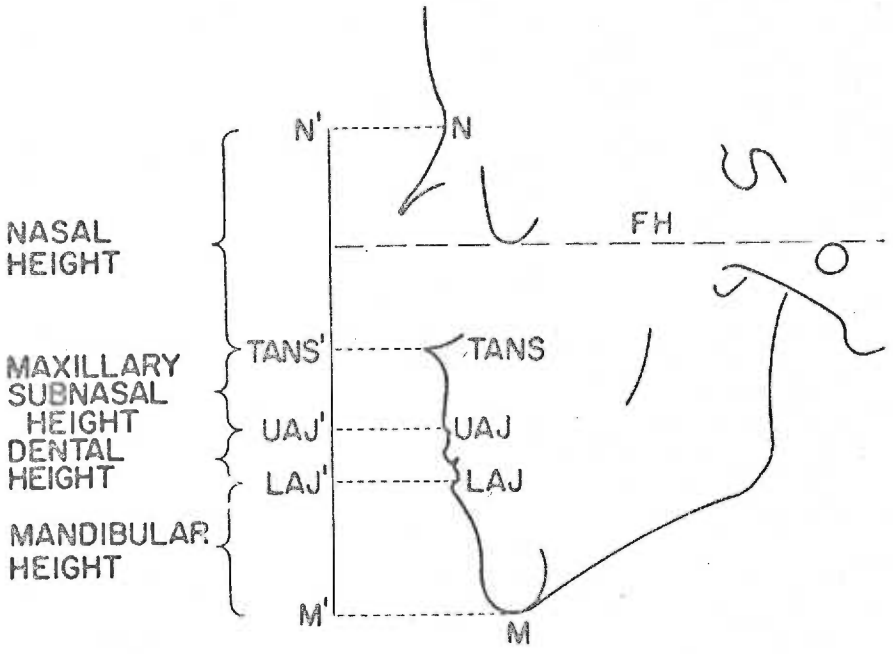

Figure 4. - Diagram showing the five skeletal landmarks used to divide the vertical face height into four components.
N - Naso-frontal suture.
TANS- Tip of anterior nasal spine.
UAJ - Upper alveolar-incisor junction.
LAJ - Lower alveolar-incisor junction.
M - The most inferior point of the mandibular symphysis.

(Illustration - Jones and Meredith[18])

were then totaled and if there was a discrepancy between the sum of the 4 components and the total face height, the dimensions were measured again to locate the error. The angular measurements were made with a large protractor reading to the nearest 0.5 degree. The three angular measurements recorded were: 1) inter-incisal, 2) long axis of maxillary incisor to Frankfort horizontal, 3) long axis of mandibular incisor to Frankfort horizontal. A similar cross check on the accuracy of measurement was done by computing the following formula: Inter-incisal angle = 180° - upper incisor angle to F.H. + lower incisor angle to F.H. If both sides of the equation were not equal, the angles were measured again. The measurement error was not computed because of this method of checking the independent measurements. It was further assumed that the tracing error was random.

FINDINGS

Treatment Group I, Shriner's Hospital (N=17)

Treatment Group II, Orthodontic Patients (N=17)

Measurements of axial inclinations of the maxillary and mandibular central incisors.

Table I

Interincisal angle	Mean	S.D.	Probability
(Downs) Norm	135.4	5.76	
Treatment group I	116.89	11.4	.00001
Treatment group II	117.5	19.3	.0001
Combined groups I and II	117.19	15.35	.00001

Table II

Maxillary incisor to Frankfort	Mean	S.D.	Probability
(Reidel) Norm	110.0	4.9	
Treatment group I	119.03	13.64	.005
Treatment group II	119.44	8.83	.00001
Combined groups I and II	119.23	11.23	.00001

Table III

Mandibular incisor to Frankfort	Mean	S.D.	Probability
(Sassouni) Norm	65	4	
Treatment group I	55.91	8.56	.00001
Treatment group II	54.79	13.67	.005
Combined I and II	55.35	11.11	.00001

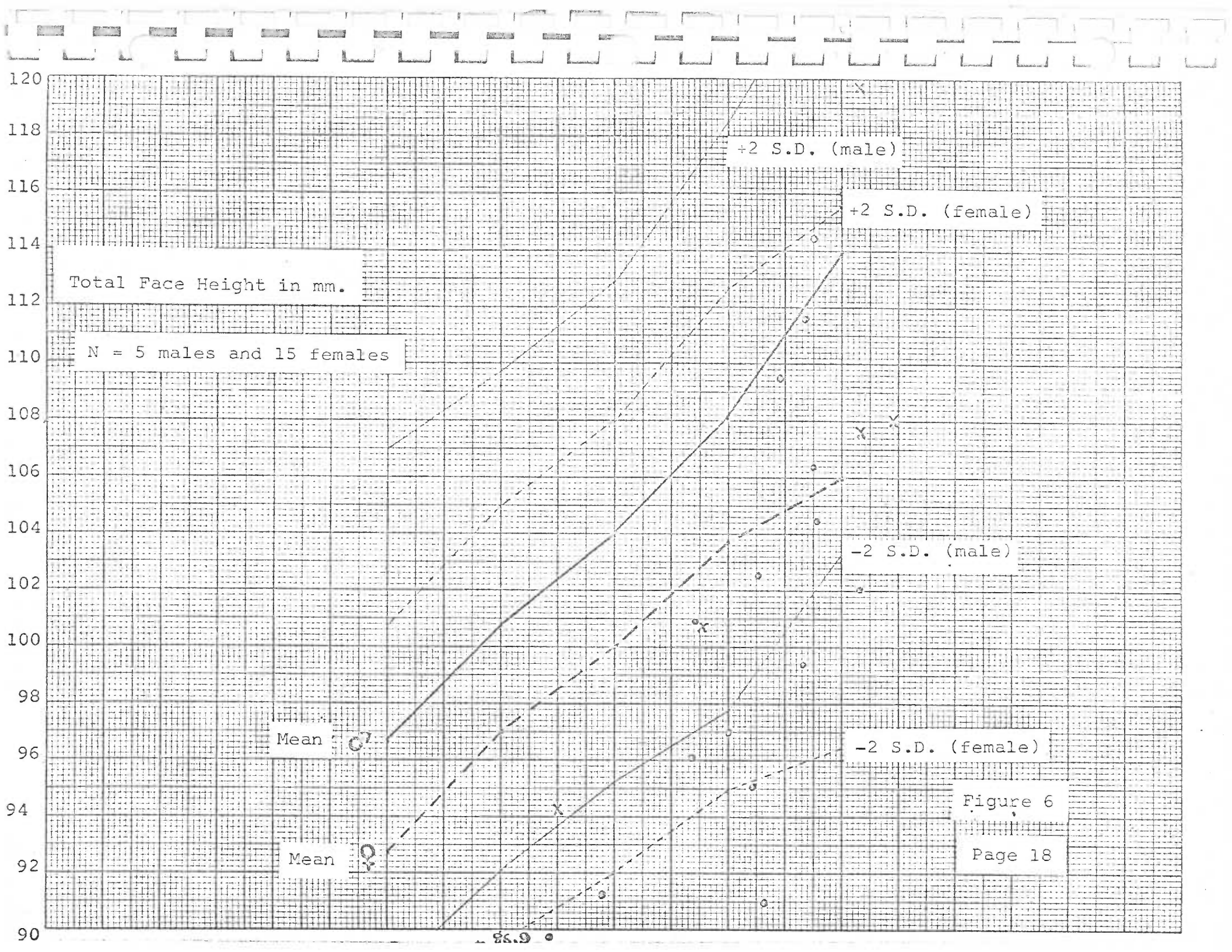
120
118
116
114
112
110
108
106
104
102
100
98
96
94
92
90
Total Face Height in mm.
N = 5 males and 15 females
+2 S.D. (male)
+2 S.D. (female)
-2 S.D. (male)
-2 S.D. (female)
Mean ♂
Mean ♀

Figure 6

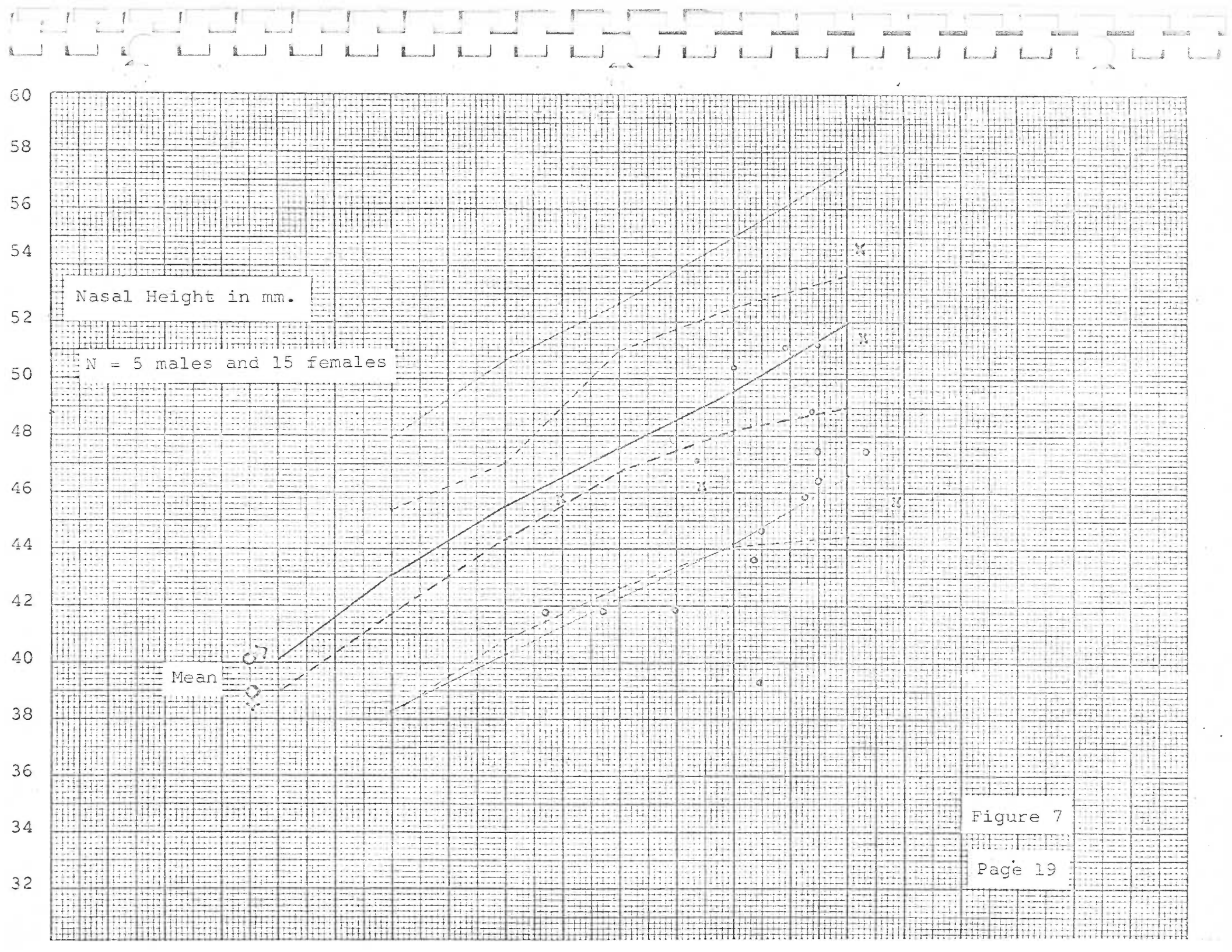
60
58
56
54
52
50
48
46
44
42
40
38
36
34
32
Nasal Height in mm.
N = 5 males and 15 females
Mean
♂
♀

Figure 7

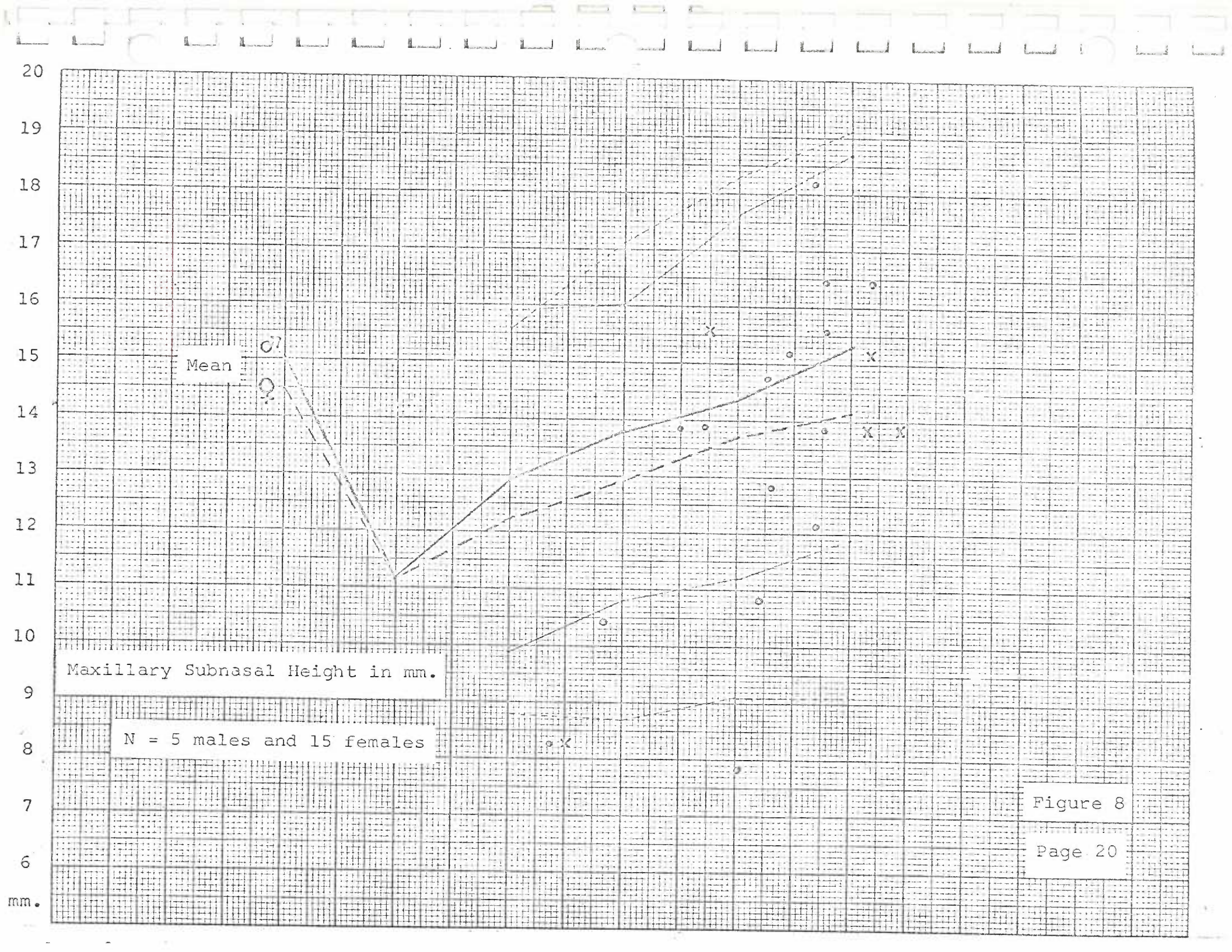
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
mm.
Mean
♂
♀
Maxillary Subnasal Height in mm.
N = 5 males and 15 females

Figure 8

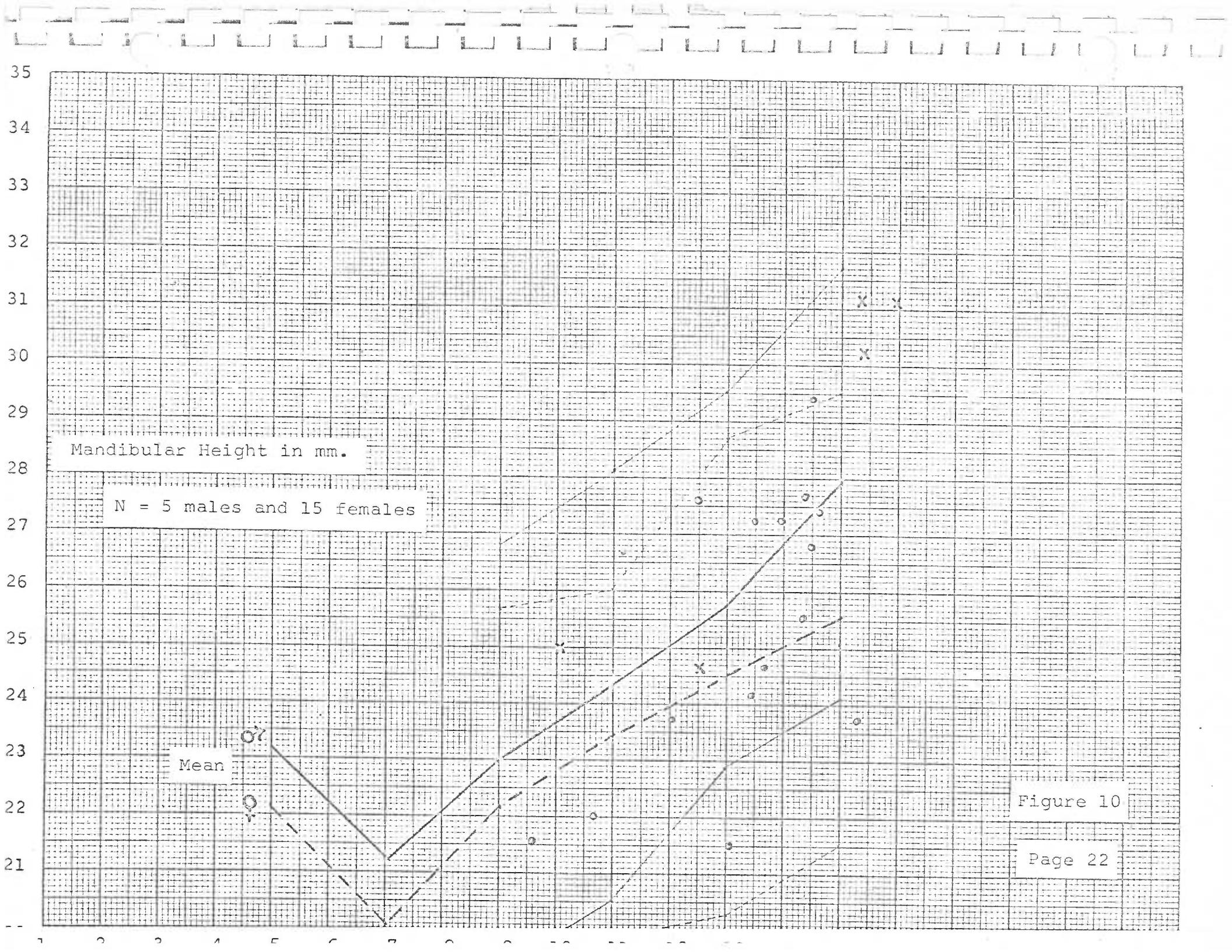
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
Mandibular Height in mm.
N = 5 males and 15 females
Mean
♂
♀

Figure 10

DISCUSSION

Since this project is cross-sectional, it lacks the ability to show individual changes with age and can only show the trend of the population that the sample represents. The face height data has been plotted against means that have been established for males and females in an earlier longitudinal study.[18] The discussion is limited to interpretation of the distribution of the data relative to the means with known standard deviations. The distribution for total face height is shown in Fig. 5. The distribution shows 4 females above the mean and 11 below the mean. The ratio is similar in the males with only one being above the mean and 4 below. This implies that the distribution has been skewed towards a decreased total face height.

In examining Fig. 6, nasal height, a similar distribution is seen, 3 females above mean, 1 on the mean and 11 below the mean; 1 male above the mean and 4 below. It appears that a reduced nasal height is accounting for part of the decrease in total face height.

Fig. 7, maxillary subnasal height, appears to be more randomly distributed. There are 8 females above the mean and 9 below; males showed 1 above and 4 below. No trend is evident from this distribution.

Fig. 8, dental height, shows the most skewed distribution with only 2 females above the mean, 1 on the mean and 12 below the mean. Males showed 1 on the mean and 4 below. It appears that the dental component of face height is definitely contributing to the trend towards reduction in total face height.

In Fig. 9, mandibular height, the random distribution is again apparent with 8 females above the mean and 7 below. The males are actually distributed towards the increased height of this dimension with only 1 out of the 5 being below the mean.

The group data gives the general interpretation of a reduction in total face height as a result of a decrease in the nasal height and dental height components.

Alexander[12] did not show the reduction in upper face height in his study, although he did show a reduction in total face height and a tipping of the hard palate. This may be a reflection of the difference in the mean length of time the brace had been worn. One of his groups had worn the brace for 5.4 months and the other for 6.7 months while the mean time for this group was 10.5 months. Another variable that might account for this could be the different pressures that are being applied by the various orthopedic staff.

Thør's[11] study shows a similar reduction in the nasal component of face height by noting a reduction in the measurement from nasion to the implants in the maxilla. The mean treatment time in his study was 12 months.

The reduction in dental height is partially a result of the decreased inter-incisal angulation and increased labial inclination. The means of the maxillary and mandibular incisors relative to Frankfort horizontal and to each other were compared to the norm means by using the Students "t" Test. The differences were found to be statistically highly significant, at the .005 probability level or less. (Tables I, II & III.) The group being seen at the Shriner's Hospital might be considered a more random sample in that they had not sought orthodontic consultation because of some obvious dental change. However, no statistically significant difference could be shown between the means of the group being seen by the orthodontists and those being seen at the Shriner's Hospital.

The change in incisor angulation plus the intrusion reported by both Thørs[11] and Alexander[12] would account for the reduction observed in dental height.

It does appear that there is a difference in the tendency for change in some individuals compared to others. It seems that individuals with small inter-incisal angulation tend to have more labial inclination during brace therapy

than when the teeth are oriented more vertically. In patients having a reduced number of teeth to distribute the pressure, a more rapid change may be anticipated. In those malocclusions where the mandibular incisors lack contact with the maxillary incisors and are instead contacting the palate, a stabilizing mouthpiece is definitely indicated.

A syndrome is implied in some of the earlier writings on scoliosis, that Class II, div. I malocclusion was associated with scoliosis. In the group examined for this project, only 6 out of the 25 patients showed Class II, div. I malocclusion. In those cases observed after the brace was discontinued, the severe labial inclination of the upper incisors was maintained if the lower lip was contacting the lingual surface of the upper incisors. In the patients being treated by the Milwaukee brace, not only is the face height not developing vertically on the average, but the pressure is overcoming the normal increment of growth, with a resulting mean reduction of the face height attained during earlier growth. The normally developing face continues to grow downward and forward at varying independent rates. (Bjork)[15]. From age 11 years to 15 years the face height normally increases on the average 10 mm. in males and 6 mm. in females.[18]

Obviously, there are wide ranges of physiologic response to the long-term pressure applied by the Milwaukee brace. The patient seen in Fig. 10, showed the most severe reduction in face height of all the patients included in this study. She had worn the Milwaukee brace for 3 years. In the one year period following the completion of brace therapy, there has been only minor recovery of the dentition and face height.

Consideration should be given to some method of reducing or eliminating the length of time of pressure being applied to the mandible. A modification incorporating a strap across the forehead to keep the occipital pads in position might be a possibility. Presently a combined approach of orthopedic therapy for the scoliosis correction and orthodontic stabilization of the dentition with some form of mouthpiece, would appear to be in the best interest of the scoliosis patient.

Figure 10. - Patient showing the most severe reduction in face height.
Upper left - Pre-brace, full face view.
Upper right- Full face view after 3 years of Milwaukee brace therapy.
Lower left - Profile view after 3 years of Milwaukee brace therapy.
Lower right- Full face view, Milwaukee brace being worn.

(Photographs courtesy of Dr. Franklin D. Piacentini, Portland, Oregon.)

SUMMARY AND CONCLUSIONS

1) The patients being treated with the Milwaukee brace showed a tendency towards a reduction in total face height.

2) The nasal height component and the dental component distributions were skewed towards a mean reduction, while the maxillary subnasal and mandibular heights were more normally distributed.

3) The axial proclination of maxillary and mandibular central incisors were significantly different from the previously established norms, at a probability of .005 or less.

4) Reduction in face height appears to be associated with the length of time the Milwaukee brace is worn.

The literature supports the use of some form of stabilizing mouthpiece to prevent the changes in the axial inclinations of the dentition. It would appear that the amount of material between the occlusals should be kept to a minimal thickness in order to reduce any tendency to cause additional intrusion.

Further research, particularly longitudinal research incorporating the use of metallic implants to serve as bone markers, is needed. We will then better answer some of the questions concerning the long term effects of the Milwaukee brace on the dentition and the maxillo-facial complex.

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