A CEPHALOMETRIC INVESTIGATION OF THE HARD AND SOFT TISSUE CHANGES ASSOCIATED WITH THE SUBCONDYLAR OSTECTOMY SURGICAL CORRECTION OF MANDIBULAR PROGNATHISM

by

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INTRODUCTION

The facial deformity caused by mandibular prognathism has long been of great mutual interest to both the orthodontist and the oral surgeon. The deformity of the lower jaw is readily expressed as a profile disfigurement, since the soft tissues of the face depend on the lower jaw for much of their contour. The dental literature is replete with various surgical techniques for the correction of mandibular prognathism, along with numerous excellent case reports of successful procedures. However the great majority of these reports are characterized by a lack of complete records. An objective evaluation, over a period of years after the completion of surgery, of the changes of the hard and soft tissues in response to these surgical procedures for the correction of mandibular prognathism, has been almost totally neglected. Evaluation of results has usually been on a subjective basis. There is a dire need for an evaluation on an objective rather than subjective basis of all the various aspects of these surgical procedures. Full face and profile photos , and impressions of the teeth in occlusion before and after the surgical correction, usually constitute the major records for evaluation of the surgical procedure. It is surprising that with such an excellent research tool as the cephalometer[1], that so little use of it has been made in evaluating the surgical correction of mandibular prognathism.

Goldstein[2], in 1947, was the first to evaluate a series of surgically treated cases with orientated cephalometric headplates. After observation of these cases for a sufficient period of time, he discussed the ultimate success or failure of the various surgical procedures. Since that time, little has been done with a cephalometer and orientated headplates in investigation of the changes occurring as a result of these surgical procedures. Most publications have been subjective evaluations of surgically treated cases, noting gross changes which are observed on casual inspection of photographs, study models, or unorientated radiographs. Unless the patient's head is accurately positioned, so orientated pre-operative and post-operative cephalometric headplates can be made, there can be little accuracy in an investigation of the changes occurring in these surgical procedures.

It is the purpose of this study to investigate cephalometrically the changes of facial contour and of some of the hard and soft tissue structures of the face, which are associated with the subcondylar osteotomy surgical procedure for the correction of mandibular prognathism. In addition it is the purpose of this study to demonstrate the need for future investigation, on a cephalometric measurement basis, of all the facets of surgical correction of mandibular prognathism.

REVIEW OF THE LITERATURE

The surgical correction of mandibular prognathism falls into two categories. Mandibular osteotomy, which involves sectioning of the ramus of the mandible at various locations, and mandibular ostectomy, which involves the removal of a section of bone from the mandible.

The first report of a surgical procedure used in the correction of a mandibular deformity was by Hullihen[3] in 1849. He described an ostectomy procedure which effectively lengthened the body of the mandible. In 1898 Blair[4], who pioneered the surgical correction of mandibular prognathism in this country, reported on a resection of the mandible in the bicuspid area, a procedure which severed the nerve and blood supply of the mandible.

Babcock[5], in 1910, reported on a horizontal osteotomy of the mandible above the mandibular sulcus, an operation which preserved the mandibular vessels.

Harsha[6], in 1912, reported on a mandibular body ostectomy posterior to the last molar tooth, which also preserved the mandibular nerve and artery.

Limberg[7], in 1925, was one of the first to describe orthodontic treatment performed before the necessary surgical procedure.

Kostecka[8], in 1934, described a subcondylar osteotomy procedure for open bite, and Schaeffer[9] adapted this procedure for the correction of mandibular prognathism in 1941.

Dingman[10], in 1944, refined the ostectomy procedure by introducing a two stage bilateral ostectomy of the mandible. Intraoral cuts were made to the level of the mandibular canal, and after a suitable healing interval, the external sectioning of the mandible, and subsequent repositioning of the mandibular fragments was accomplished.

Moose[11], in 1945, wrote on a strictly intraoral approach to a horizontal osteotomy of the ramus of the mandible with a special power driven Cayo saw.

Kazanjian[12], in 1951, advocated an extraoral approach to a horizontal osteotomy of the ramus, in a position superior to the inferior alveolar vessels.

Reiter[14], in 1951, presented an osteotomy of the neck of the condylar process of the mandible using a Gigli saw with a blind approach.

Caldwell and Letterman[15], in 1954, described a more complicated procedure of an open vertical osteotomy of the ramus from the sigmoid notch to the lower border of the mandible.

Smith and Robinson[16], in 1954, described an open subsigmoid notch ostectomy through a preauricular incision, with a sliding condylotomy primarily concerned with the upper third of the ramus as the surgical area.

The above procedures clearly indicate that there are many approaches to the surgical correction of mandibular prognathism. It is not intended to discuss the advantages or deficiences of these procedures, but rather to bring attention to the paucity of objective evaluation of changes brought about by these procedures from the time of surgery to a period of years after surgery.

Verne[17] and his co-workers published a report of fifty-two cases treated by the subcondylar osteotomy surgical procedure perfected by Reiter. The patients were evaluated over a ten year period post-operatively by direct observation whenever possible, or by a comprehensive questionaire. The evaluation was concerned with general satisfaction with the procedure, paresthesia, paralysis, improved masticatory function, and open bite evaluation.

Winter[18] discussed fifty surgically treated cases of mandibular prognathism from similar standpoints, following them up to sixteen months after the surgical procedure. This evaluation was characterized by photos and radiographs taken at various angulations.

Waldron[19] reported on different surgical procedures used on a large number of cases. The cases were evaluated for the most part from lateral and full face photos, study models, and un-orientated radiographs.

Kazanjian[13] reported on his impressions gained from his experience in the surgical treatment of approximately sixty-five cases of mandibular prognathism. He evaluated two surgical techniques and described the merits of each technique from a strictly operative standpoint.

The four previous reports, although well done, typify the many reports in the literature on the surgical correction of mandibular prognathism. The evaluation of the changes occurring in the cases in these reports, was entirely on a subjective basis.

Goldstein[2] was the first to objectively evaluate mandibular prognathism cases which were surgically corrected. He evaluated seven cases treated by combined surgical and orthodontic methods. Orientated cephalometric headplates, photos, and study models comprised his records for evaluation. He evaluated bony union, function, and position of the mandibular fragments after surgery.

Biederman[20], in 1954, was the first to apply commonly used cephalometric measurement standards to surgically treated cases. He investigated five surgically treated cases of mandibular prognathism using orientated lateral headplates, and came to the conclusion that facial esthetics and occlusion of these cases were markedly improved. However comparison of the post-operative measurements to commonly used cephalometric measurements, showed that in many cases these measurements actually deviated more from the norms post-operatively than they did pre-operatively. He stated, " The profound and favorable changes as a result of the successful treatment of macrognathia are not reflected adequately, consistently, or reliably in the changes of value of commonly used cephalometric norms."

Lubowitz[21], in 1957, presented an excellent case report, on the surgical correction of mandibular prognathism, using cephalometric measurements as a basis for his report, along with photos of the patient and of study casts.

Other than the reports by Goldstein[2], Biederman[20], and Lubowitz[21], little has been done cephalometrically evaluating the changes occurring in these surgical procedures for the correction of mandibular prognathism. The investigation of the success of the surgical procedures for treating mandibular prognathism cases with open bite, patients who are edentulous, or patients who have very few remaining teeth, are areas of investigation that should be undertaken. Comparisons, using cephalometric measurements, of the changes occurring in one surgical procedure with those of other surgical procedures has been totally neglected. It will be necessary to investigate these areas in the future.

The use of cephalometric diagnostic criteria in the evaluation of these mandibular prognathism cases pre-operatively, and subsequent review of the changes brought about by the various surgical procedures, might lead to a better understanding of the advantages, disadvantages, indications, and contraindications of the application of certain procedures to specific cases. Photos, study models, and unorientated radiographs play only part of the role in the assessment of these procedures. A continued cephalometric investigation of these surgical procedures might lead to establishment of standards of measurement. These might be applied in a more accurate diagnosis of these cases, in order to determine the surgical procedure of choice in any given case. Also, this cephalometric investigation would be an accurate way to evaluate the stability of a surgical procedure over a period of years.

MATERIALS AND METHODS

Material for the evaluation of the subcondylar osteotomy surgical procedure, consisted of orientated lateral cephalometric headplates of sixteen adult individuals who underwent this surgical procedure for the correction of mandibular prognathism. There were eleven females and five males. The age range of these individuals was from 18 to 34 years. Pre-operative headplates were taken before the surgical procedure, and the post-operative headplates were taken up to sixteen weeks after the completion of surgery. The length of fixation of the mandible varied from seven to nine weeks. The patients were apparently normal except for the mandibular prognathism which was surgically corrected.

The cephalometric headplates used in this study were obtained from the files of Western Reserve University Department of Orthodontics, Mount Sinai Hospital Department of Oral Surgery, and from the files of several orthodontists and oral surgeons in the Cleveland, Ohio area.

The subcondylar osteotomy surgical procedure used on the cases in this study was described by Spilka[22]. He stated:

> After all preliminary arrangements, such as grinding of the teeth, the wiring of splints to the teeth, or the cementing of orthodontic bands, have been completed, the temporal region is shaved.
>
> The anesthetic is a matter of personal preference. . . .
>
> The patient is prepared and draped according to the accepted surgical technique. The area of the first incision, located halfway between the angle of the mandible and the lobe of the ear and behind the posterior border of the ramus, is marked with methylene blue. An incision about one-half inch in length is made over the area of the first marking on the right side of the neck. A curved aneurysm needle is inserted through the first

incision to the inner aspect of the ramus. The needle is kept in close contact with the ramus because of the proximity of the internal maxillary artery which lies back of the neck of the mandible. The needle is moved forward through the sigmoid notch and brought onto the face through a stab incision. A Gigli saw is fastened to the aneurysm needle by means of a ligature wire to the eyelet in the end of the needle and carried back through the first incision. Two metal cuffs are inserted to protect the soft tissue. The neck of the mandible is then severed with the Gigli saw by a back-and-forth motion through the incisions. Caution must be taken to stop as soon as the neck of the mandible is severed, because of the relationship of the temporal vessels and the facial nerve. The Gigli saw is removed and any bleeding which persists usually can be controlled with pressure. The right mandible is easily shifted posteriorly. Fine silk sutures are used to approximate the skin margins.

The condylar neck of the opposite side is severed in a similar manner. The mandible is then repositioned into proper occlusion and held with elastic traction.

The cephalometric headplates used in this study were selected on the following criteria: (1) Good hard and soft tissue structures revealed, (2) Teeth in full occlusion, (3) Lips resting in natural position.

The anatomical points, cephalometric angles, planes, and linear dimensions measured and used, are defined in the glossary and illustrated in figures 1 and 2.

In tracing the headplates, if bilateral structures appeared as two shadows, the average point or plane between them was drawn. This tended to minimize errors of positioning of the patient's head and also provided a method of measuring all landmarks as midline structures.

The angular measurements investigated were made directly on the pre-operative and post-operative tracings and were recorded.

The linear measurements of the change in position of the various points investigated were made in the following manner. The post-operative tracing was placed directly over the pre-operative tracing and the tracings were orientated on points sella turcica (S), nasion (N), and the Frankfort Horizontal plane (FH). As the individuals being investigated were in the adult age group, where little if any growth would be expected, and the time interval between the taking of the pre-operative and post-operative headplates was relatively short, no discrepancy between the two tracings was noted in any of the cases, except in the areas directly effected by surgery. The maxilla, cranial base, and soft tissue profile above the upper cutaneous lip remained static.

To determine the net anterior or posterior displacement of a point (Figure 3), the palatal plane, a line from the posterior nasal spine (PNS) through the anterior nasal spine (ANS) extending beyond the soft tissue tracing of the profile, was used as a base for measurement. Perpendiculars from the palatal plane were drawn to the points being considered. A direct measurement in millimeters on the palatal plane was then made of the distance between the pre-operative and post-operative position of the point being considered.

To determine the net upward or downward displacement of a point (Figure 4), the length, in millimeters, of the perpendiculars to the pre-operative and post-operative position of the point under consideration, was measured. The length of the perpendicular to the post-operative position of the point was then subtracted from the length of the perpendicular to the pre-operative position of the point. A positive calculation indicated an upward change in the post-operative position of the point, and a negative calculation indicated a downward change in post-operative position of the point under consideration.

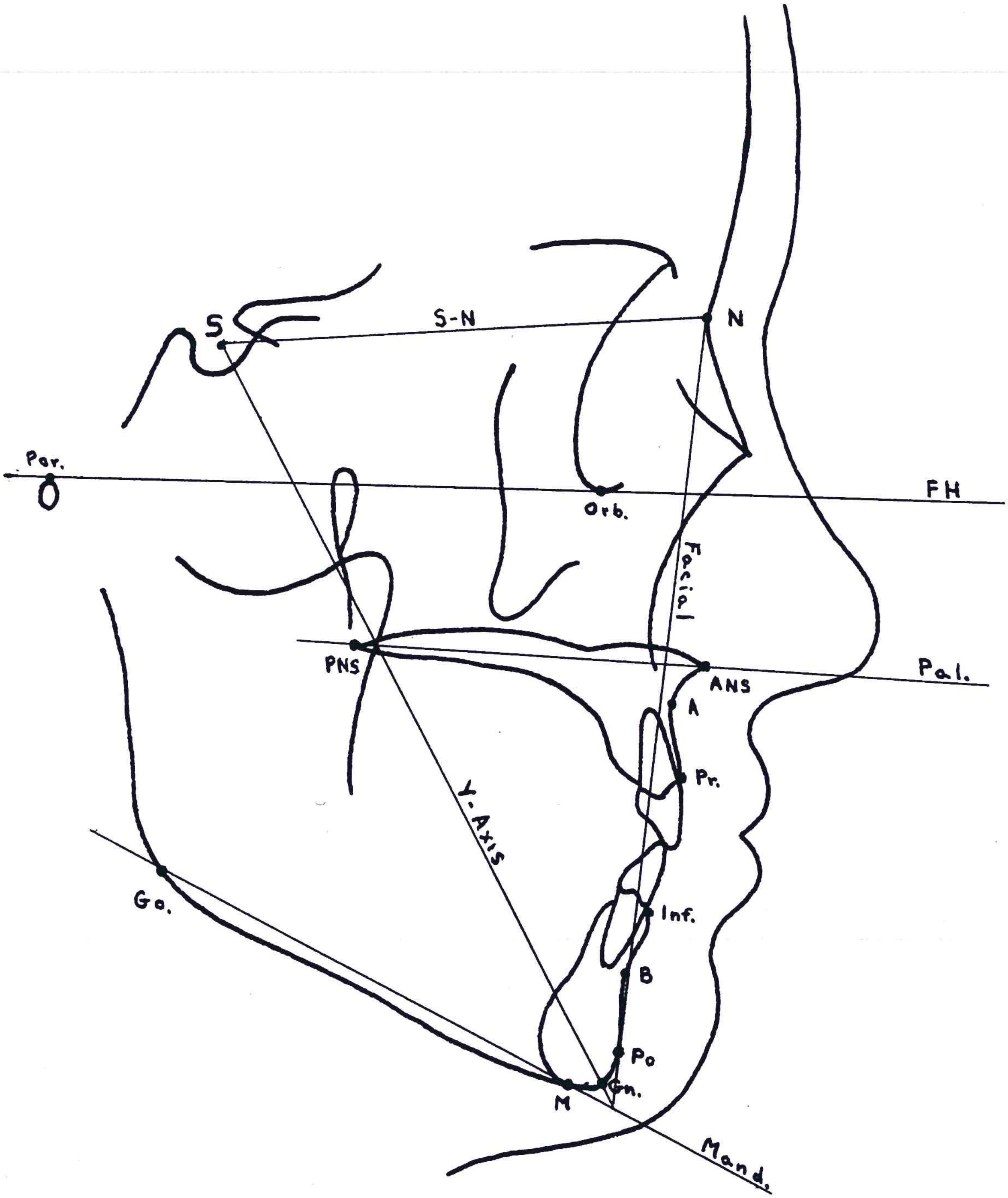


Figure 1. Skeletal points and planes of reference used in this study.

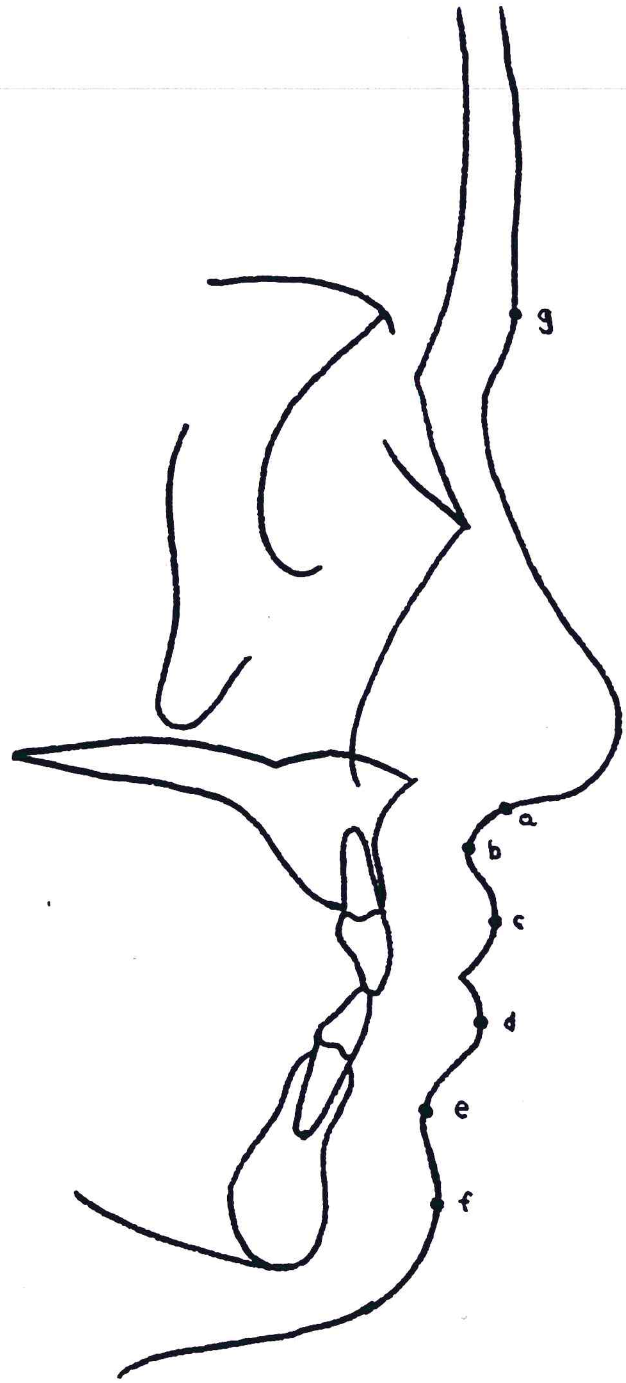


Figure 2. Soft tissue points used in this study.

Figure 3. The method of linear measurement, on the extended palatal plane, of the anterior or posterior displacement of a specific point, from its pre-operative position to its post-operative position.

Note: To determine the net anterior or posterior displacement of a point (in this instance point d), the palatal plane, a line from the posterior nasal spine (PNS) through the anterior nasal spine (ANS), extending beyond the soft tissue profile tracing, was used as a base for measurement. Perpendiculars from the palatal plane were drawn to the points being considered. A direct measurement in millimeters on the palatal plane was then made of the distance between the pre-operative and post-operative position of the point under consideration.

The solid line indicates the initial or pre-operative tracing. The broken line indicates the final or post-operative tracing of the changes that have taken place as a result of the surgery.

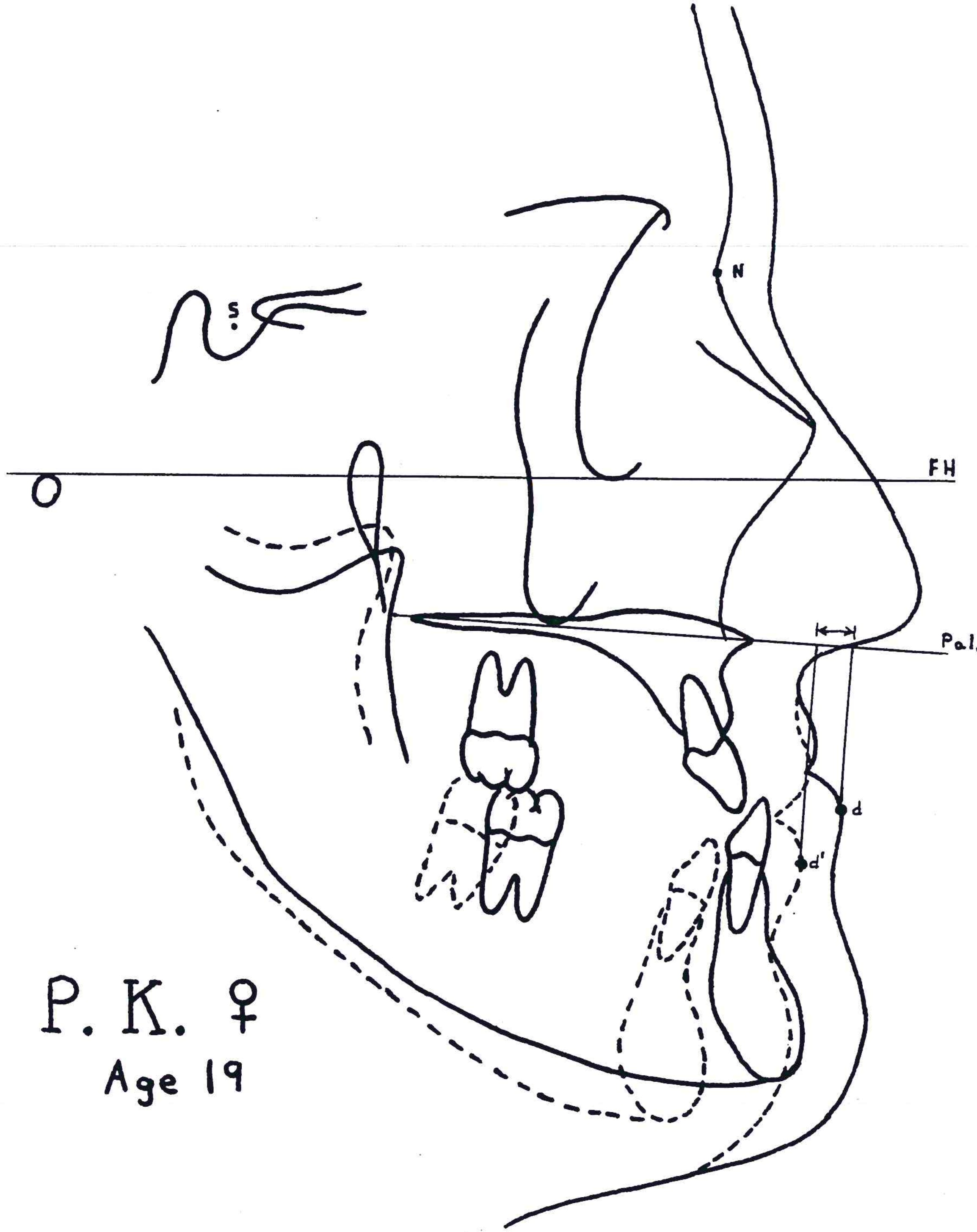


Figure 3.

Figure 4. The method of linear measurement of the upward or downward displacement of a specific point, from its pre-operative position to its post-operative position.

Note: To determine the net upward or downward displacement of a point (in this instance point d), the length, in millimeters, of the perpendiculars to the pre-operative and post-operative position of the point under consideration was measured. The length of the perpendicular (y) to the post-operative position of the point, was then subtracted from the length of the perpendicular (x) to the pre-operative position of the point. A positive calculation indicated an upward displacement of the post-operative point, and a negative calculation indicated a downward displacement of the post-operative point.

The solid line indicates the initial or pre-operative tracing. The broken line indicates the final or post-operative tracing of the changes that have taken place as a result of the surgery.

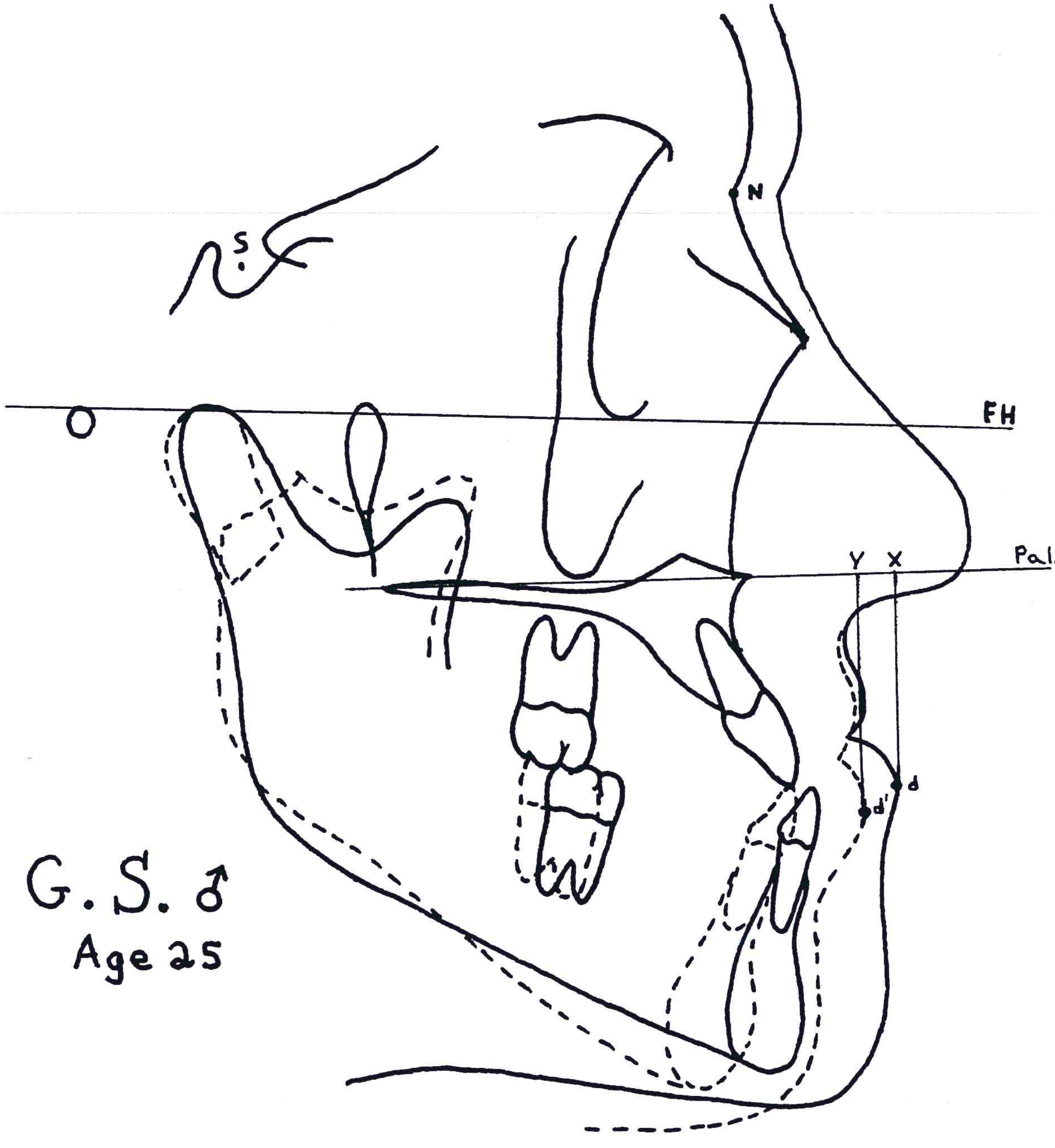


Figure 4.

Glossary of Terms

Skeletal Points

1. Sella Turcica (S): The center of sella turcica as determined by inspection.

2. Nasion (N): The most anterior point on the naso-frontal suture.

3. Porion (P): The midpoint on the upper edge of the external auditory meatus.

4. Orbitale (Orb.): A point midway between the lowest points on the inferior margins of both orbits.

5. Anterior Nasal Spine (ANS): The tip of the median sharp process formed by the prolongation of the two maxillae at the lower margin of the anterior aperature of the nose.

6. Posterior Nasal Spine (PNS): The tip of the posterior spine of the palatine bone in the hard palate.

7. Subspinale (Point A): The deepest point on the maxillary midline between the anterior nasal spine and prosthion.

8. Supramentale (Point B): The deepest midline point on the mandibular symphysis between infradentale and pogonion.

9. Prosthion (Pr.): The most anterior interdental point on the alveolar border in the median plane between the maxillary central incisors.

10. Infradentale (Inf.): The highest interdental gum point between the mandibular central incisors.

11. Pogonion (Po.): The most anterior point in the midline of the mandibular symphysis.

12. Menton (M): The most inferior point on the symphysis of the mandible in the median plane.

13. Gonion (Go.): A point on the gonial angle of the mandible determined by bisecting the angle formed by tangents to the lower border and the posterior border of the mandible.

14. Gnathion (Gn): A point on the chin located by bisecting the angle formed by the intersection of the facial and mandibular planes.

Skeletal Planes

1. S-N Plane : A line connecting points S and N, which delineates the anterior portion of the cranial base.

2. Frankfort Horizontal Plane (FH): The plane which connects orbitale and the two cephalometric porion points.

3. Palatal Plane (Pal.): A line connecting points ANS and PNS.

4. Mandibular Plane (Mand.): A line connecting menton and gonion.

5. Facial Plane: A line from nasion through pogonion.

6. AB Plane : A line drawn from point A to point B.

7. Y-Axis : A line from sella turcica to gnathion.

Soft Tissue Points (Burstone[24])

1. Frontal Point (g): The most prominent point in the midsagittal plane of the forehead.

2. Subnasale (a): The point at which the nasal septum between the nostrils merges with the upper cutaneous lip in the midsagittal plane.

3. Superior Labial Sulcus (b): The point of greatest concavity in the midline of the upper lip between subnasale and labrale superius.

4. Labrale Superius (c): The median point in the upper margin of the upper membranous lip.

5. Labrale Inferius (d): The median point in the lower margin of the lower membranous lip.

6. Inferior Labial Sulcus (e): The point of greatest concavity in the midline of the lower lip between labrale inferius and menton.

7. Menton (f): The most prominent or anterior point on the chin in the midsagittal plane.

Angular Skeletal Measurements Made

1. Facial Plane Angle (Downs[23]): The posterior-inferior angle formed by the intersection of the Frankfort Horizontal plane and the facial plane.

2. Angle of Convexity (Downs[23]): The angle formed by a line from nasion to point A to pogonion. The angle is plus if point A falls outside the facial plane, and the angle is minus if point A falls inside the facial plane.

3. AB to the Facial Plane Angle (Downs[23]): The angle formed by a line from point A to point B as it intersects the facial plane. The angle is plus if point A falls outside the facial plane, and minus if point A falls inside the facial plane.

4. Mandibular Plane Angle (Downs[23]): The angle formed by the intersection of the mandibular plane and the Frankfort Horizontal Plane.

5. Y-Axis Angle (Downs[23]): The anterior-inferior angle formed as a line from sella to gnathion intersects the Frankfort Horizontal Plane.

6. ANB Angle: The angle formed by a line from point A to nasion to point B.

Angular Soft Tissue Measurements Made (Burstone[24])

1. Total Facial Contour Angle (gaf): The angle formed by a line from point g to point a to point f.

2. Maxillary Sulcus Contour Angle (abc): The angle formed by a line from point a to point b to point c .

3. Mandibular Sulcus Contour Angle (def): The angle formed by a line from point d to point e to point f .

Linear Skeletal Measurements Made

1. Posterior Displacement of Pogonion : The distance, in millimeters, that pogonion is displaced posteriorly.

2. Upward or Downward Displacement of Pogonion : The distance,in millimeters, that pogonion is displaced upward or downward.

Note: The method of the linear measurement of the anterior, posterior, upward, or downward displacement of a specific point, is discussed and illustrated in detail in figures 3 and 4, pages 13 to 16.

Linear Soft Tissue Measurements Made

1. Anterior or Posterior Displacement of Subnasale (a) : The distance, in millimeters, that subnasale is displaced anteriorly or posteriorly.

2. Upward or Downward Displacement of Subnasale (a) : The distance, in millimeters, that subnasale is displaced upwardly or downwardly.

3. Anterior or Posterior Displacement of the Superior Labial Sulcus (b): The distance, in millimeters, that the superior labial sulcus is displaced anteriorly or posteriorly.

4. Upward or Downward Displacement of the Superior Labial Sulcus (b): The distance, in millimeters, that the superior labial sulcus is displaced upwardly or downwardly.

5. Anterior or Posterior Displacement of Labrale Superius (c): The distance, in millimeters, that labrale superius is displaced anteriorly or posteriorly.

6. <u>Upward or Downward Displacement of Labrale Superius (c)</u>: The distance, in millimeters, that labrale superius is displaced upwardly or downwardly.

7. <u>Anterior or Posterior Displacement of Labrale Inferius (d)</u>: The distance, in millimeters, that labrale inferius is displaced anteriorly or posteriorly.

8. <u>Upward or Downward Displacement of Labrale Inferius (d)</u>: The distance, in millimeters, that labrale inferius is displaced upwardly or downwardly.

9. <u>Anterior or Posterior Displacement of the Inferior Labial Sulcus (e)</u>: The distance, in millimeters, that the inferior labial sulcus is displaced anteriorly or posteriorly.

10. <u>Upward or Downward Displacement of the Inferior Labial Sulcus (e)</u>: The distance, in millimeters, that the inferior labial sulcus is displaced upwardly or downwardly.

11. <u>Anterior or Posterior Displacement of Menton (f)</u>: The distance, in millimeters, that menton is displaced anteriorly or posteriorly.

12. <u>Upward or Downward Displacement of Menton (f)</u>: The distance, in millimeters, that menton is displaced upwardly or downwardly.

Note: The method of the linear measurement of the anterior, posterior, upward, or downward displacement of a specific point, is discussed and illustrated in detail in figures 3 and 4, pages 13 to 16.

FINDINGS

Measurements of the various changes occurring in the skeletal or hard tissues, revealed the following:

1. Facial Plane Angle: There was a decrease in the facial plane angle in all cases, ranging from 2 to 10 degrees (Average 5.8 Degrees).

2. Angle of Convexity: There was a decrease in the angle of convexity in all cases, ranging from 9 to 21 degrees (Average 12.0 degrees).

3. AB to Facial Plane Angle: There was a decrease in the AB to facial plane angle in all cases, ranging from 2 to 14 degrees. (Average 8.2 degrees).

4. Y-Axis Angle: There was an increase in the Y-axis angle in all cases, ranging from 1 to 9 degrees (Average 4.1 degrees).

5. Mandibular Plane Angle: There was an increase in the mandibular plane angle in fourteen of the sixteen cases investigated, ranging from 1 to 15 degrees (Average 6.8 degrees). The two decreases in the mandibular plane angle were of 1 and 2 degrees respectively (Average 1.5 degrees).

6. ANB Angle: There was a decrease in the ANB angle in all cases, ranging from 2 to 10 degrees (Average 5.9 degrees).

7. Displacement of Pogonion: There was a posterior displacement of pogonion in all cases, ranging from 3 to 22 millimeters (Average 10.1 millimeters). There was no upward or downward

displacement of pogonion in two cases. There was an upward displacement of pogonion in six cases, ranging from 1 to 6 millimeters (Average 2.8 millimeters). There was a downward displacement of pogonion in eight cases, ranging from 1 to 9 millimeters (Average 4.4 millimeters).

Examples of skeletal changes occurring in several cases of this sample are illustrated in figures 3 to 8.

Measurements of the various changes occurring in the soft tissue profile revealed the following:

1. Subnasale (a): There was no displacement of subnasale exhibited in any case.

2. Superior Labial Sulcus (b): Six cases exhibited no posterior displacement, nine cases exhibited posterior displacement ranging from 1 to 3 millimeters (Average 1.6 millimeters), and one case exhibited an anterior displacement of 1.5 millimeters. Fourteen of the sixteen cases exhibited no upward or downward displacement. Two cases exhibited a downward displacement of 1 millimeter.

3. Labrale Superius (c): One case exhibited no posterior displacement. Fourteen cases exhibited a posterior displacement ranging from 1 to 4 millimeters (Average 1.9 millimeters), and one case exhibited an anterior displacement of 2 millimeters. Eight cases exhibited no upward or downward displacement. Seven cases exhibited a downward displacement ranging from 1 to 5 millimeters (Average 2.9 millimeters), and one case exhibited an upward displacement of 2 millimeters.

4. Labrale Inferius (d): There was a posterior

displacement in all cases ranging from 2 to 14 millimeters (Average 7.0 millimeters). Four cases exhibited no upward or downward displacement, and twelve cases exhibited a downward displacement ranging from 1 to 9 millimeters (Average 3.7 millimeters).

5. Inferior Labial Sulcus (e): There was a posterior displacement exhibited in all cases ranging from 4 to 17 millimeters (Average 9.4 millimeters). Three individuals exhibited no upward or downward displacement, while thirteen individuals exhibited a downward displacement ranging from 2 to 11 millimeters (Average 4.2 millimeters).

6. Menton (f): There was a posterior displacement exhibited in all cases, ranging from 3 to 19 millimeters (Average 10.3 millimeters). There was no upward or downward displacement in six cases, while there was a downward displacement exhibited in ten cases, ranging from 1 to 9 millimeters (Average 3.2 millimeters).

7. Total Facial Contour Angle (gaf): The total facial contour angle decreased in all cases, ranging from 3 to 19 degrees (Average 10.3 degrees).

8. Maxillary Sulcus Contour Angle (abc): The maxillary sulcus contour angle remained the same in one case, increased in twelve cases, ranging from 2 to 26 degrees (Average 8.7 degrees), and decreased in three cases, ranging from 1 to 22 degrees (Average 9.3 degrees).

9. Mandibular Sulcus Contour Angle (def): The mandibular sulcus contour angle remained the same in two cases, decreased in twelve cases, ranging from 3 to 30 degrees (Average 11.4 degrees), and increased in two cases of 5 and 9 degrees respectively (Average 7.0 degrees).

Examples of soft tissue changes occurring in cases of this sample are illustrated in figures 9 and 10.

TABLE I

NET CHANGE OF THE VARIOUS MEASUREMENTS OF THE SKELETAL ANALYSIS

Name	PK	AS	EF	VP	FT	AS	KK	LG
Age	19	18	26	29	25	18	18	20
Sex	F	F	F	M	M	F	F	F
Change of the facial plane angle in degrees	-8	-3	-10	-5	-10	-6	-3	-7
Change of the angle of convexity in degrees	-16	-7	-21	-14	-20	-12	-7	-10
Change of the AB to facial plane angle in degrees	-8	-8	-14	-8	-14	-9	-5	-7
Change of the mandibular plane angle in degrees	+11	-1	+15	+2	+12	+2	+1	+7
Change of the Y-axis angle in degrees	+6	+1	+8	+4	+9	+2	+2	+4
Change of the ANB angle in degrees	-7	-4	-10	-6	-10	-7	-3	-7
Posterior displacement of pogonion in millimeters	-11	-6	-9	-6	-22	-11	-7	-12
Upward or downward displacement of pogonion in millimeters	-5	+2	-3	0	-9	0	-1	+3

Note: All negative numbers denote a decrease in angulation of an angle, a posterior displacement of a point, or a downward displacement of a point. All positive numbers denote an increase in angulation of an angle, an anterior displacement of a point, or an upward displacement of a point.

TABLE I - Continued

Name	EG	JM	BW	MZ	TP	HS	JP	GS
Age	25	26	20	22	30	34	21	25
Sex	F	F	M	F	M	F	F	M
Change of the facial plane angle in degrees	-4	-2	-6	-4	-7	-8	-6	-4
Change of the angle of convexity in degrees	-10	-4	-11	-10	-15	-12	-13	-9
Change of the AB to facial plane angle in degrees	-6	-2	-13	-6	-10	-7	-10	-4
Change in the mandibular plane angle in degrees	+6	-2	+2	+5	+7	+9	+6	+10
Change in the Y-axis angle in degrees	+4	+1	+4	+3	+5	+4	+5	+4
Change in the ANB angle in degrees	-4	-2	-8	-6	-6	-6	-6	-3
Posterior displacement of pogonion in millimeters	-9	-3	-15	-8	-12	-12	-12	-7
Upward or downward displacement of pogonion in millimeters	+1	+2	+3	+6	-4	-4	-5	-4

Note: All negative numbers denote a decrease in angulation of an angle, a posterior displacement of a point, or a downward displacement of a point. All positive numbers denote an increase in angulation of an angle, an anterior displacement of a point, or an upward displacement of a point.

TABLE II

NET CHANGE OF THE VARIOUS MEASUREMENTS OF THE SOFT TISSUE ANALYSIS

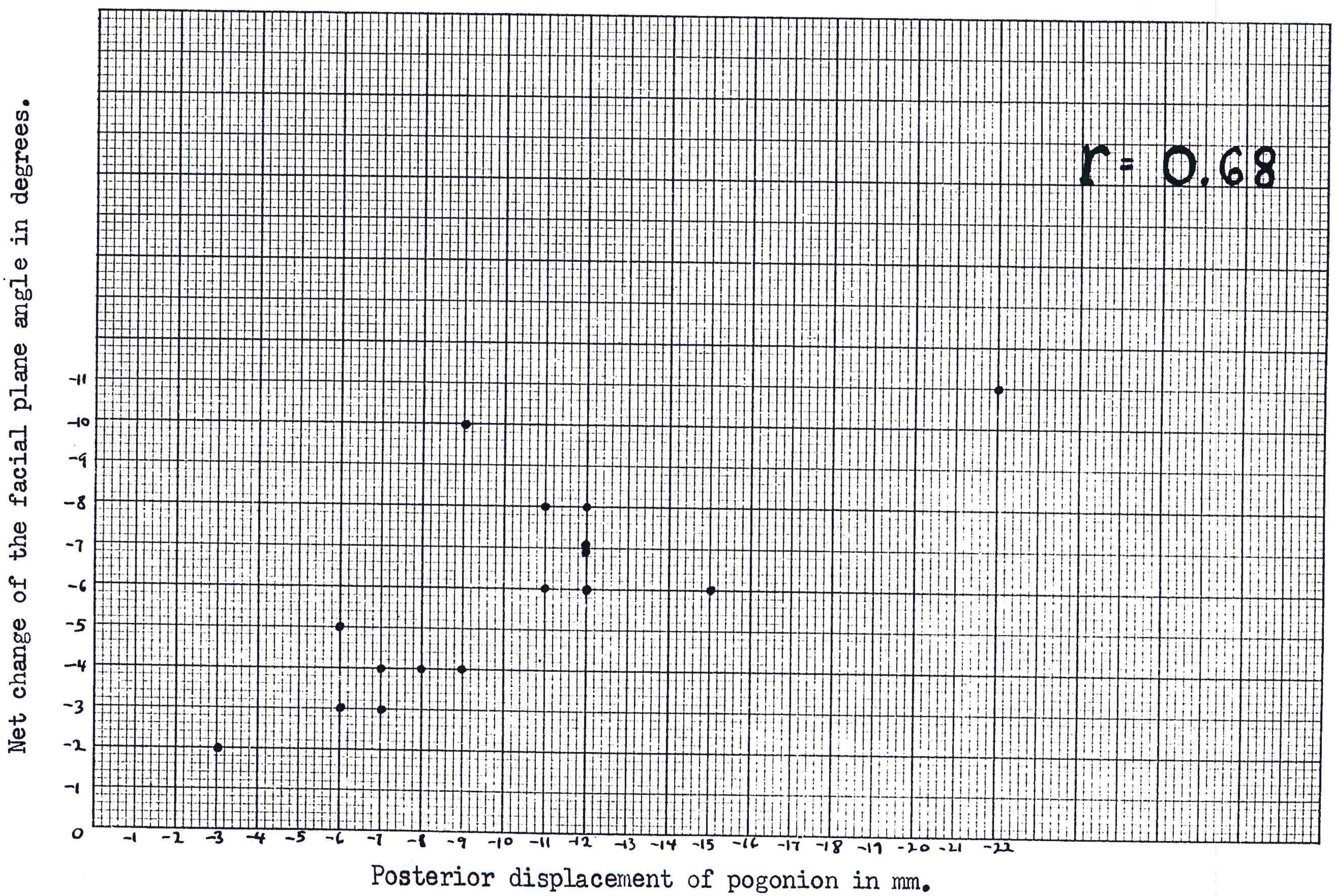
Name	PK	AS	EF	VP	FT	AS	KK	LG
Age	19	18	26	29	25	18	18	20
Sex	F	F	F	M	M	F	F	F
Anterior or posterior displacement of subnasale (a) in mm.	0	0	0	0	0	0	0	0
Upward or downward displacement of subnasale (a) in mm.	0	0	0	0	0	0	0	0
Anterior or posterior displacement of superior labial sulcus (b) in mm.	0	0	-1	0	-2	0	-1	0
Upward or downward displacement superior labial sulcus (b) in mm.	0	0	0	0	0	0	0	0
Anterior or posterior displacement of labrale superius (c) in mm.	-1	-1	-1	0	-3	-1	-2	-2
Upward or downward displacement of labrale superius (c) in mm.	-5	0	-2	0	2	-1	0	0
Anterior or posterior displacement of labrale inferius (d) in mm.	-6	-4	-10	-2	-13	-6	-7	-8
Upward or downward displacement of labrale inferius (d) in mm.	-5	0	-3	-1	-9	-8	0	-1
Anterior or posterior displacement of inferior labial sulcus (e) in mm.	-9	-8	-15	-4	-17	-11	-8	-10
Upward or downward displacement of inferior labial sulcus (e) in mm.	-9	-3	-2	0	-11	-2	0	-2
Anterior or posterior displacement of menton (f) in mm.	-12	-7	-17	-5	-19	-9	-11	-11
Upward or downward displacement of menton (f) in mm.	-4	0	-2	0	-9	-2	0	-3
Total facial contour angle (gaf) change in degrees	-13	-10	-10	-18	-19	-10	-8	-12
Maxillary sulcus contour angle (abc) change in degrees	+14	+6	-1	0	+2	+8	+2	11
Mandibular sulcus contour angle (def) change in degrees	-5	-25	-20	-13	-5	0	-30	-4

Note: All negative numbers denote a decrease in angulation of an angle, a posterior displacement of a point, or a downward displacement of a point. All positive numbers denote an increase in angulation of an angle, an anterior displacement of a point, or an upward displacement of a point.

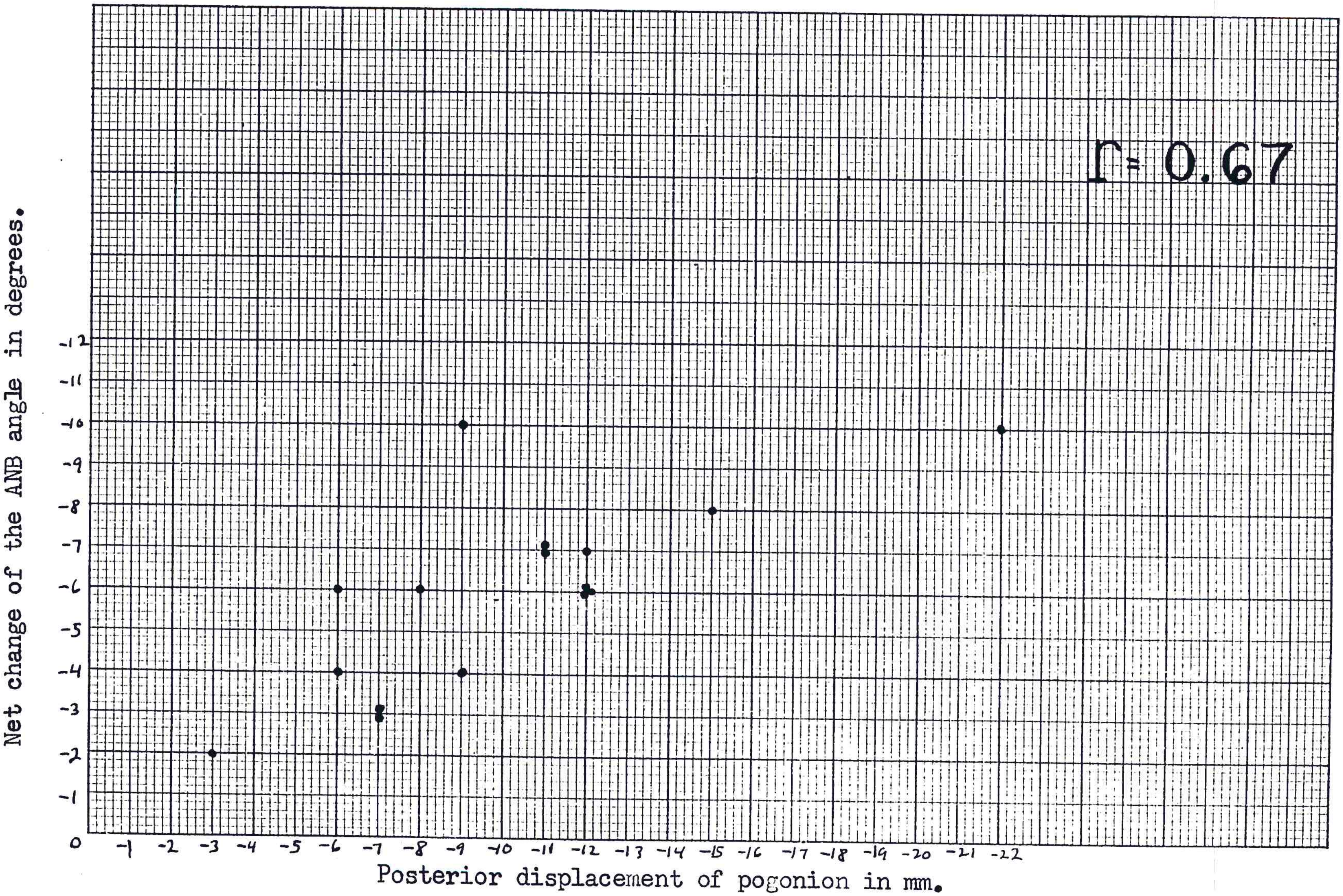
TABLE II - Continued

Name	EG	JM	BW	MZ	TP	HS	JP	GS
Age	25	26	20	22	30	34	21	25
Sex	F	F	M	F	M	F	F	M
Anterior or posterior displacement of subnesale (a) in mm.	0	0	0	0	0	0	0	0
Upward or downward displacement of subnasale (a) in mm.	0	0	0	0	0	0	0	0
Anterior or posterior displacement of superior labial sulcus (b) in mm.	-3	-1	0	+1	-2	-1	-2	-1
Upward or downward displacement of superior labial sulcus (b) in mm.	0	0	0	0	0	0	-1	-1
Anterior or posterior displacement of labrale superius (c) in mm.	-4	-1	-3	+2	-4	-1	-1	-2
Upward or downward displacement of labrale superius (c) in mm.	0	0	-2	0	-3	0	-3	-4
Anterior or posterior displacement of labrale inferius (d) in mm.	-5	-4	-10	-4	-9	-6	-14	-4
Upward or downward displacement of labrale inferius (d) in mm.	0	0	-2	-1	-5	-5	-1	-3
Anterior or posterior displacement of inferior labial sulcus (e) in mm.	-9	-4	-14	-7	-10	-8	-7	-9
Upward or downward displacement of inferior labial sulcus (e) in mm.	0	-3	0	-2	-3	-4	-3	-6
Anterior or posterior displacement of menton (f) in mm.	-9	-3	-14	-8	-13	-11	-12	-10
Upward or downward displacement of menton (f) in mm.	0	0	0	-3	-3	-2	-1	-3
Total facial contour angle (gaf) change in degrees.	-8	-3	-12	-9	-10	-11	-12	-9
Maxillary sulcus contour angle (abc) change in degrees.	-5	+2	+15	-22	+26	+3	+2	+13
Mandibular sulcus contour angle (def) change in degrees.	-3	-4	+5	-12	0	-3	+9	-13

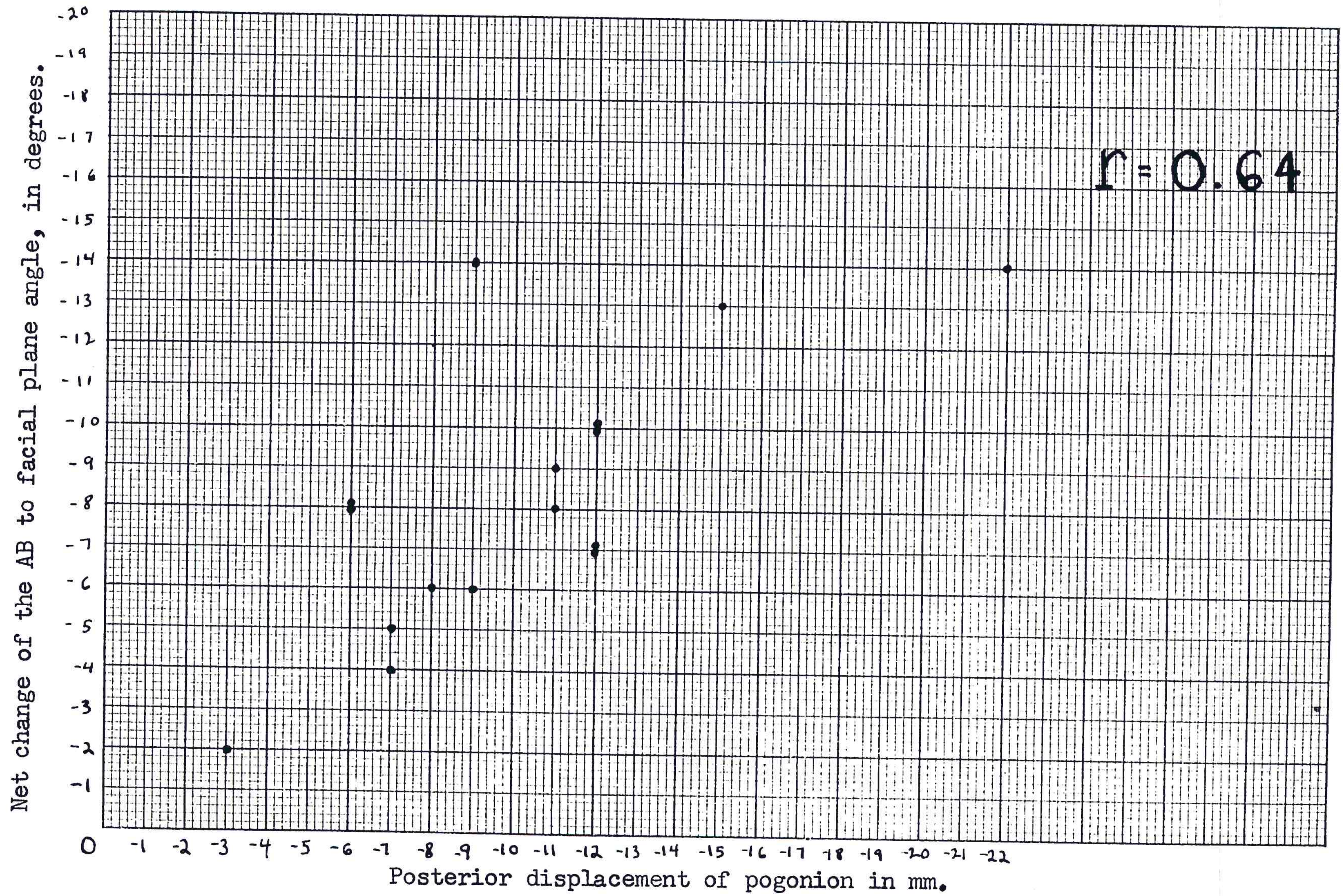
Note: All negative numbers denote a decrease in angulation of an angle, a posterior displacement of a point, or a downward displacement of a point. All positive numbers denote an increase in angulation of an angle, an anterior displacement of a point, or an upward displacement of a point.



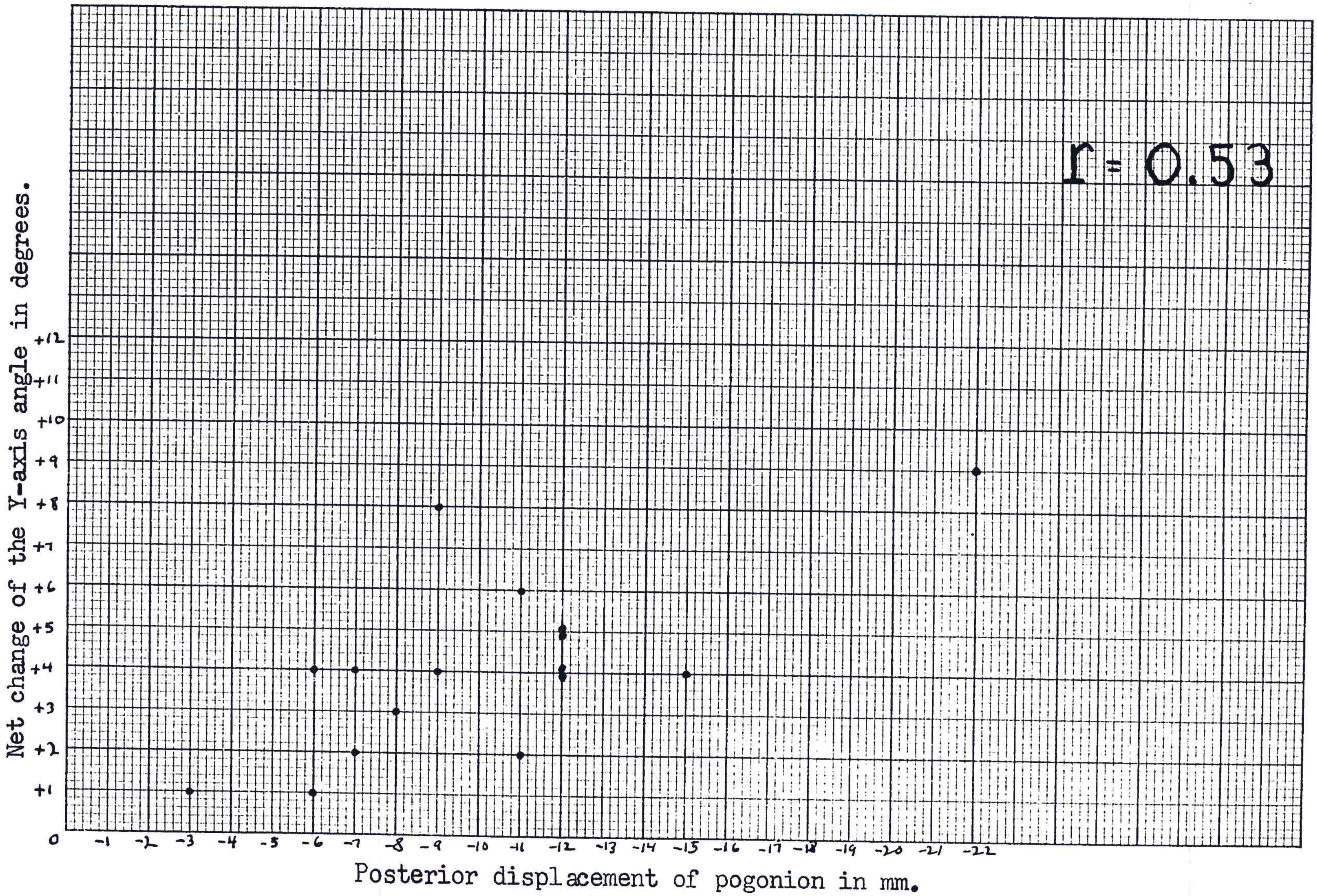
Scattergram 1: Relationship between the posterior displacement of pogonion and the net change in angulation of the facial plane angle.



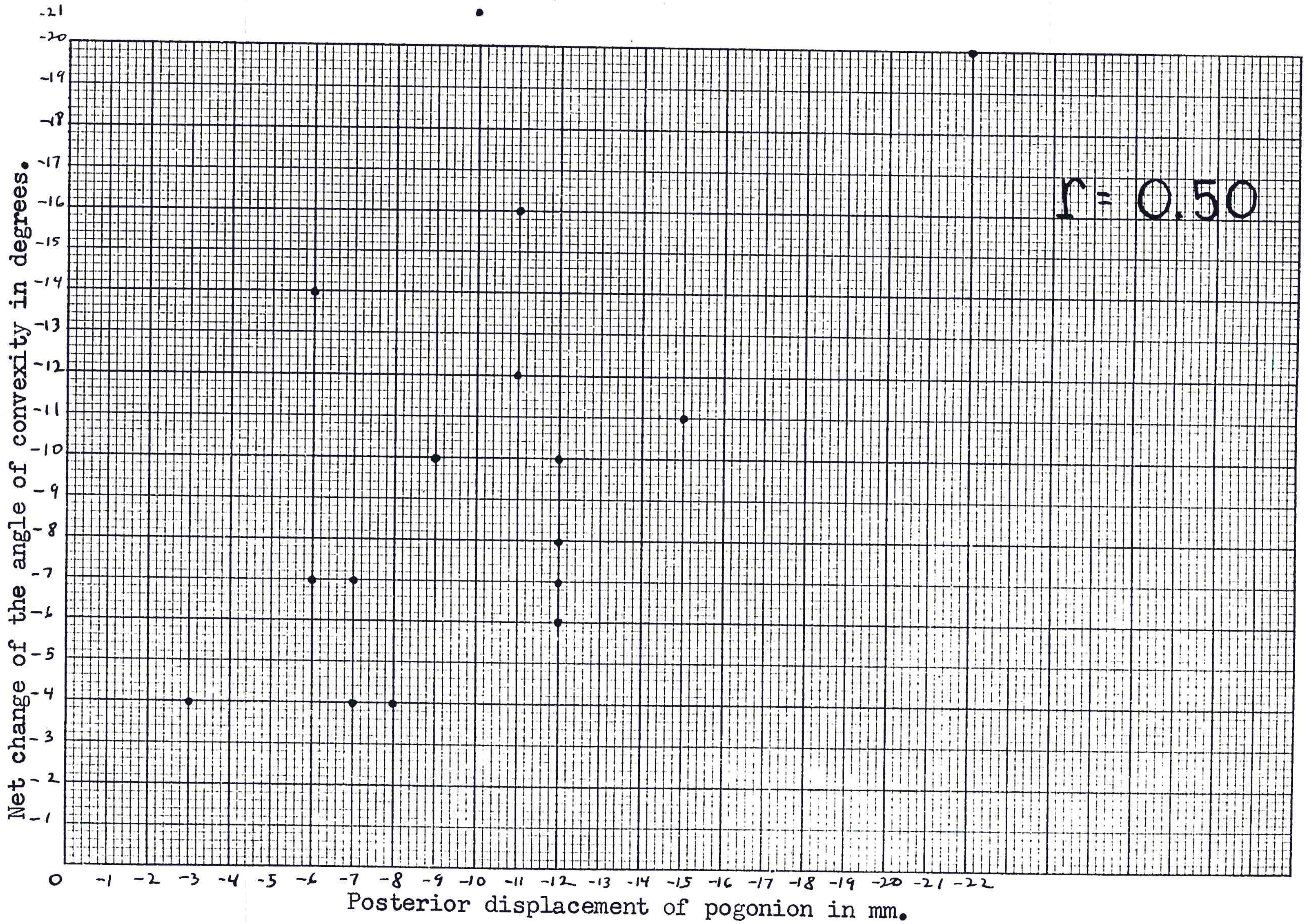
Scattergram 2: Relationship between the posterior displacement of pogonion and the net change in angulation of the ANB angle.



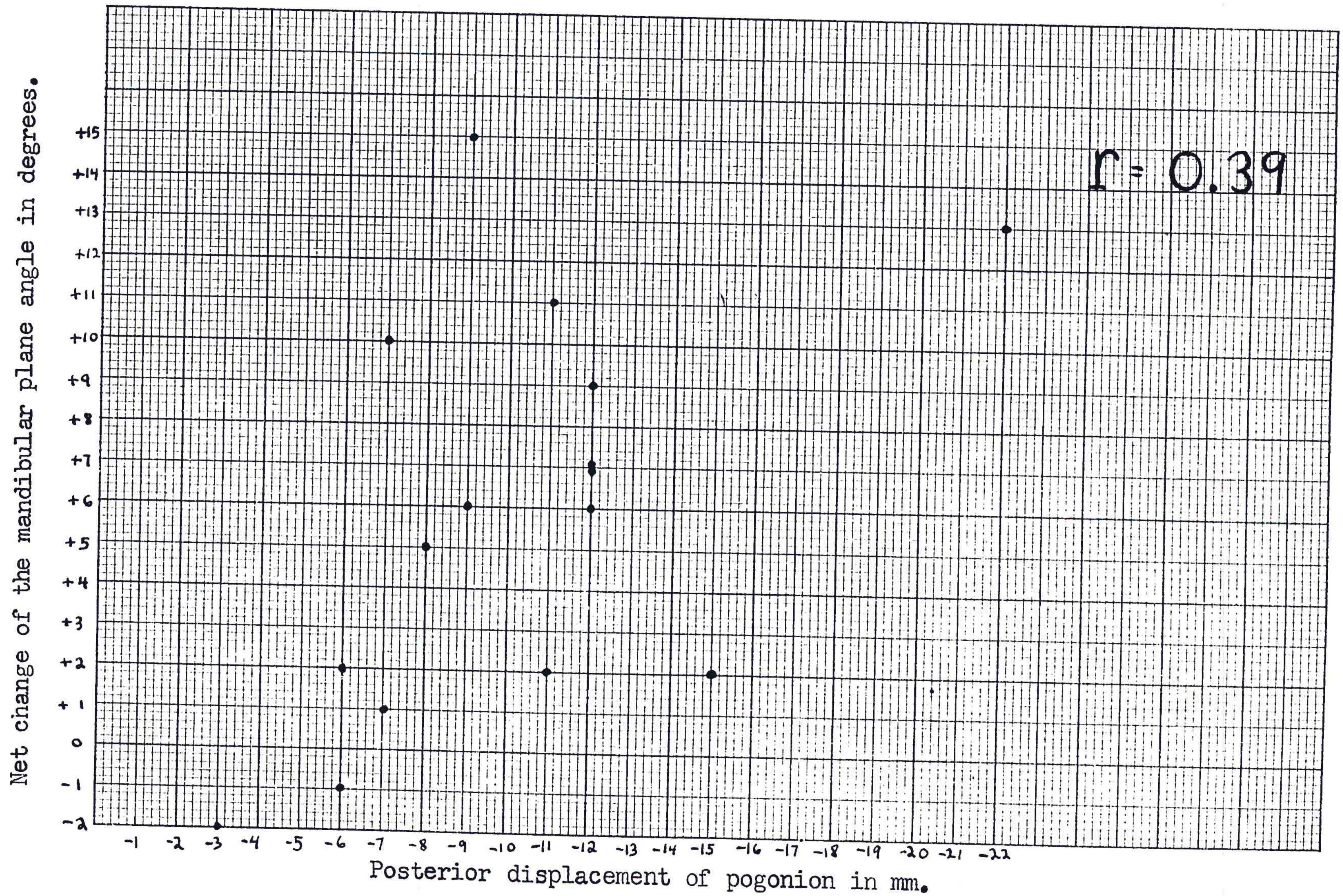
Scattergram 3: Relationship between the posterior displacement of pogonion and the change in angulation of the AB to Facial plane angle.



Scattergram 4: Relationship between the posterior displacement of pogonion and the change in angulation of the Y-axis angle.



Scattergram 5: Relationship between the posterior displacement of pogonion and the change in angulation of the angle of convexity.



Scattergram 6: Relationship between the posterior displacement of pogonion and the change in angulation of the mandibular plane angle.

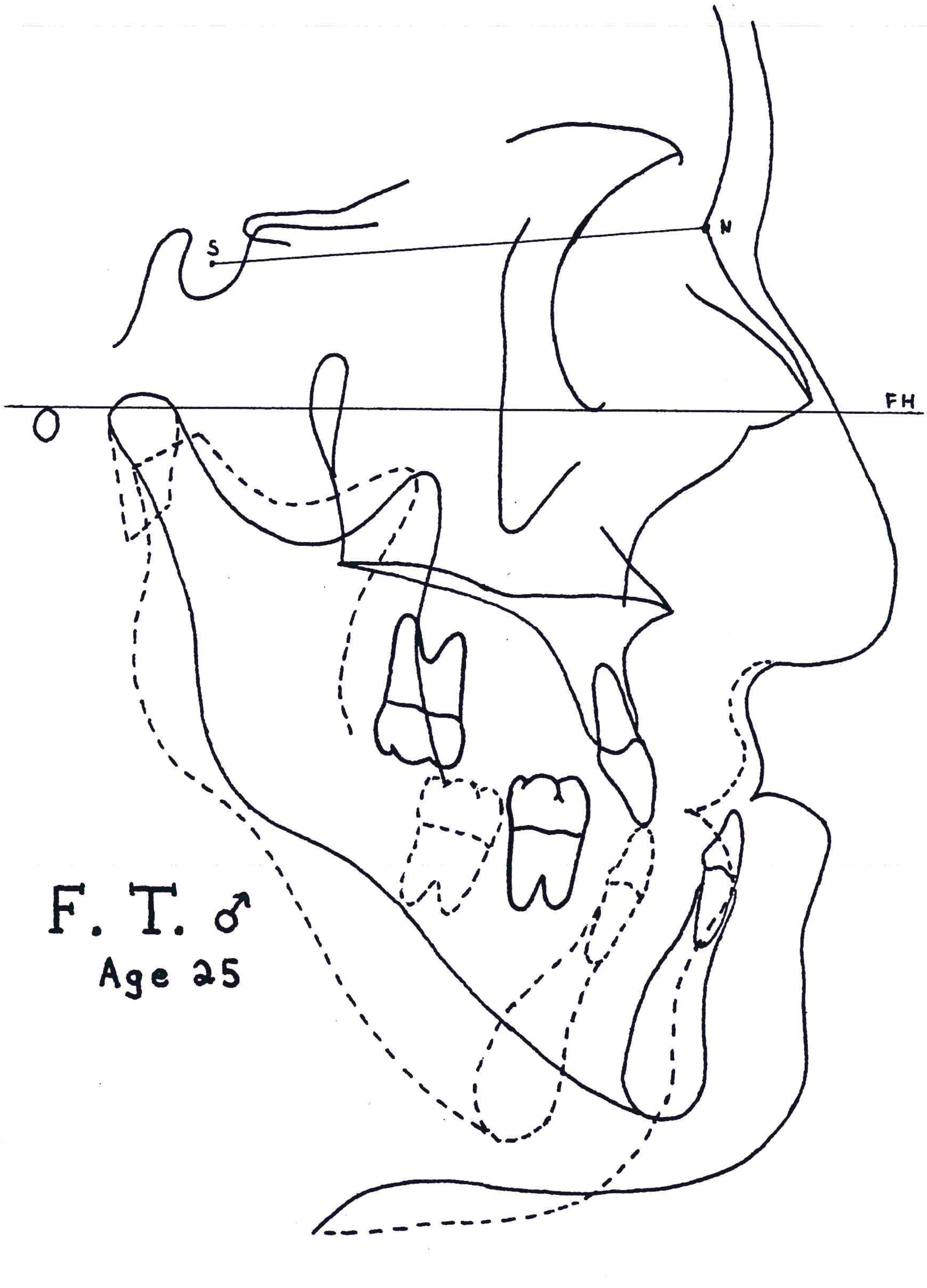


Figure 5. Cephalometric tracings of the surgical correction of case (F.T.).

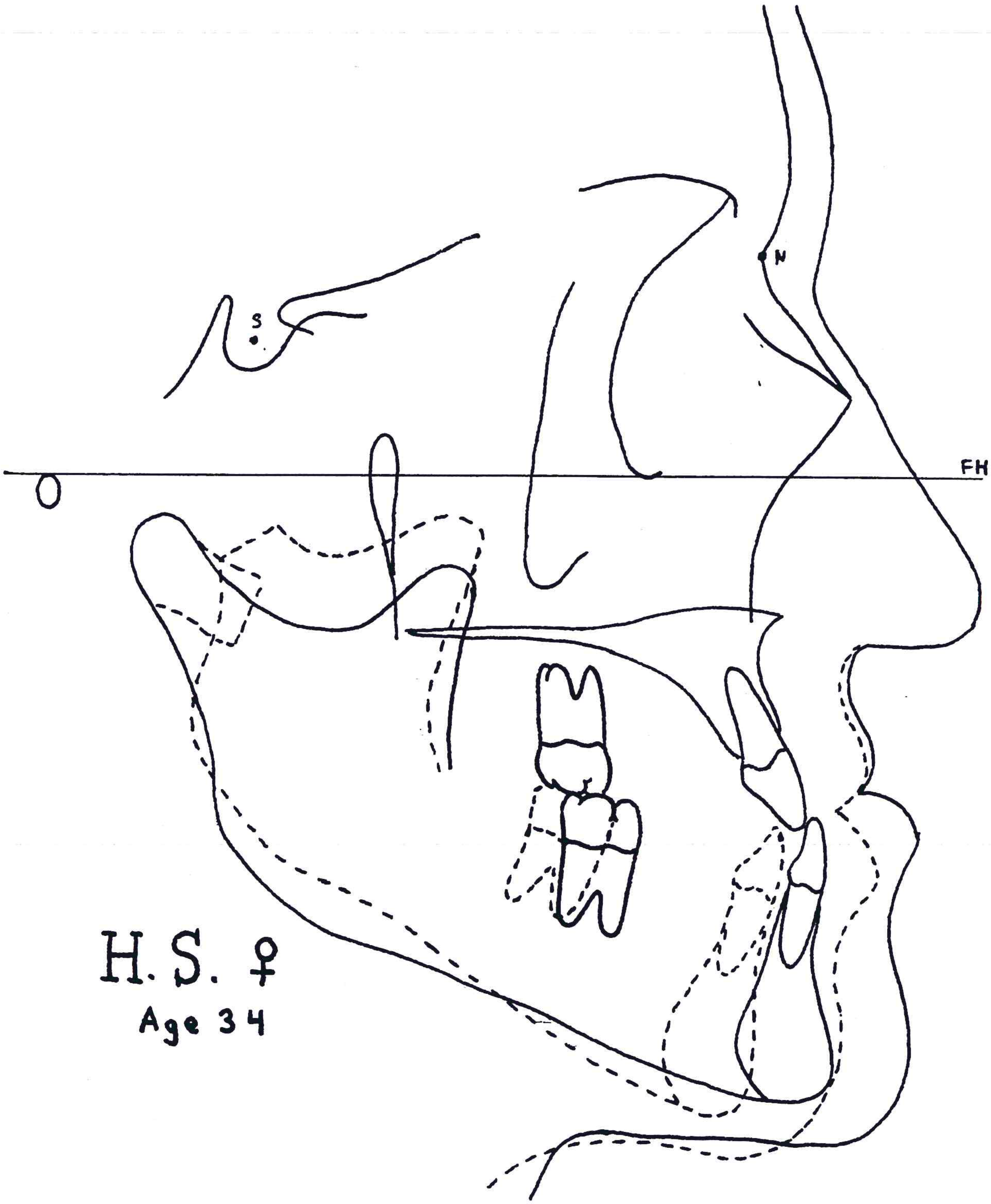


Figure 6. Cephalometric tracings of the surgical correction of case (H.S.).

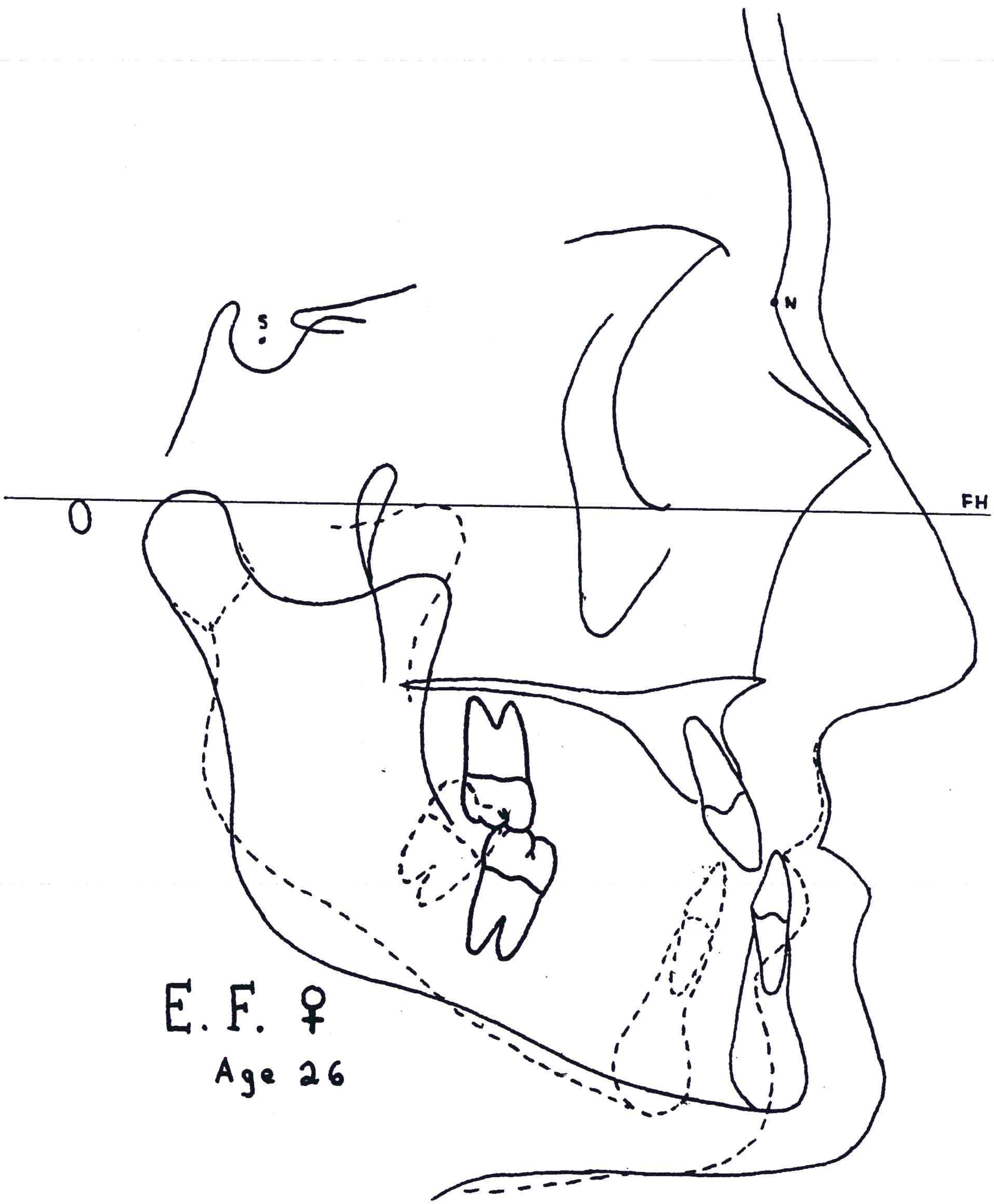


Figure 7. Cephalometric tracings of the surgical correction of case (E.F.).

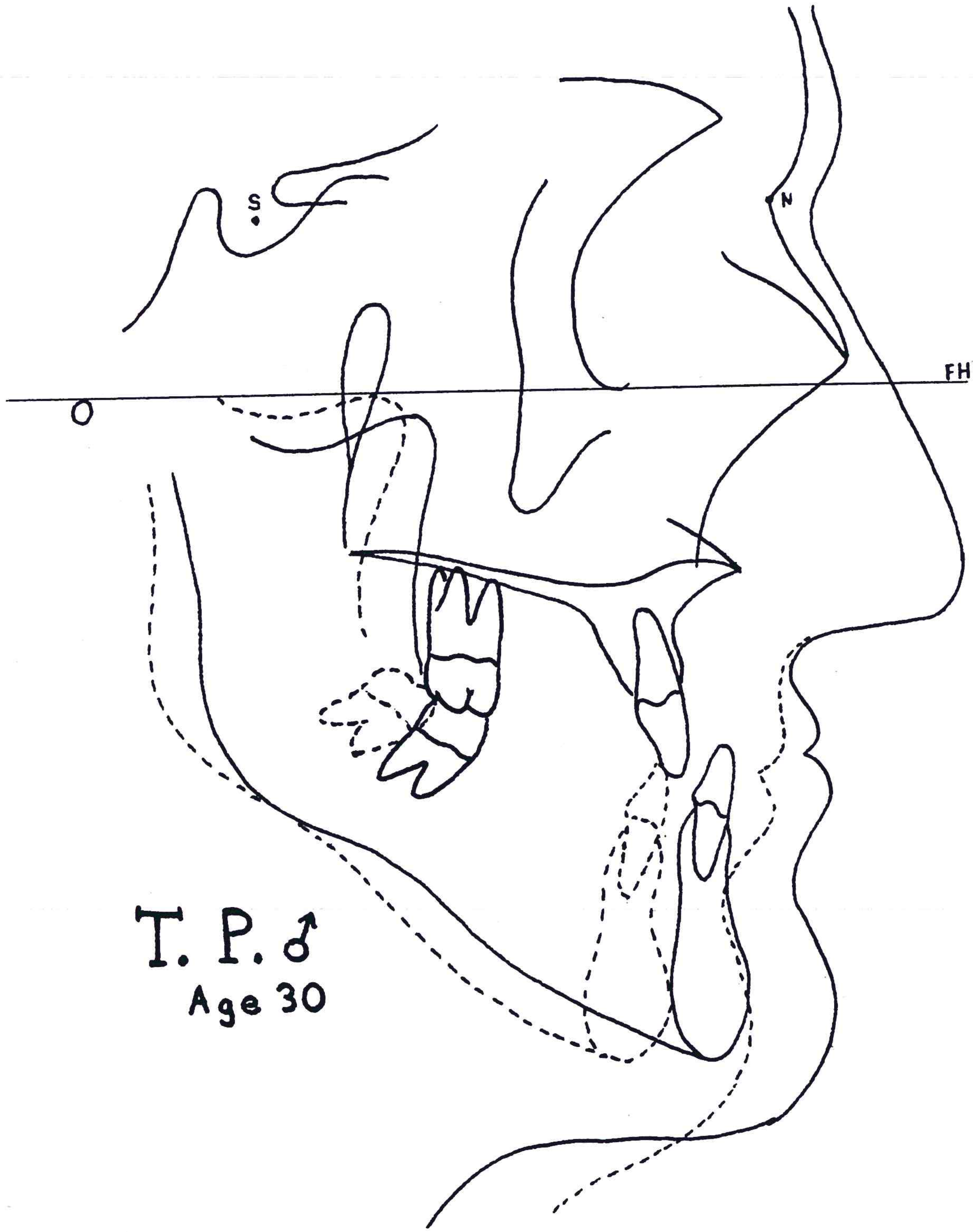


Figure 8. Cephalometric tracings of the surgical correction of case (T.P.).

Figure 9. Soft tissue changes occurring after the surgical correction of mandibular prognathism.

Note: The top row of illustrations depict the greatest amount of change of the soft tissue profile, occurring after the surgical correction was completed. The bottom row of illustrations depict intermediate amounts of change of the soft tissue profile, occurring after the surgical correction was completed.

The illustrations were made in the following manner. The pre-operative tracing and the post-operative tracing were orientated on points sella turcica (S), nasion (N), and the Frankfort Horizontal plane (FH). Another sheet of tracing paper was then placed over the orientated tracings, and the outlines of the pre-operative and post-operative soft tissue profiles were traced. The area between the outlines of the pre-operative and post-operative soft tissue profiles was then inked in with black ink. This area depicts the place of change and the amount of change occurring in the soft tissue profile after completion of the subcondylar osteotomy surgical procedure.

The illustrations of this figure are orientated on the Frankfort Horizontal plane.

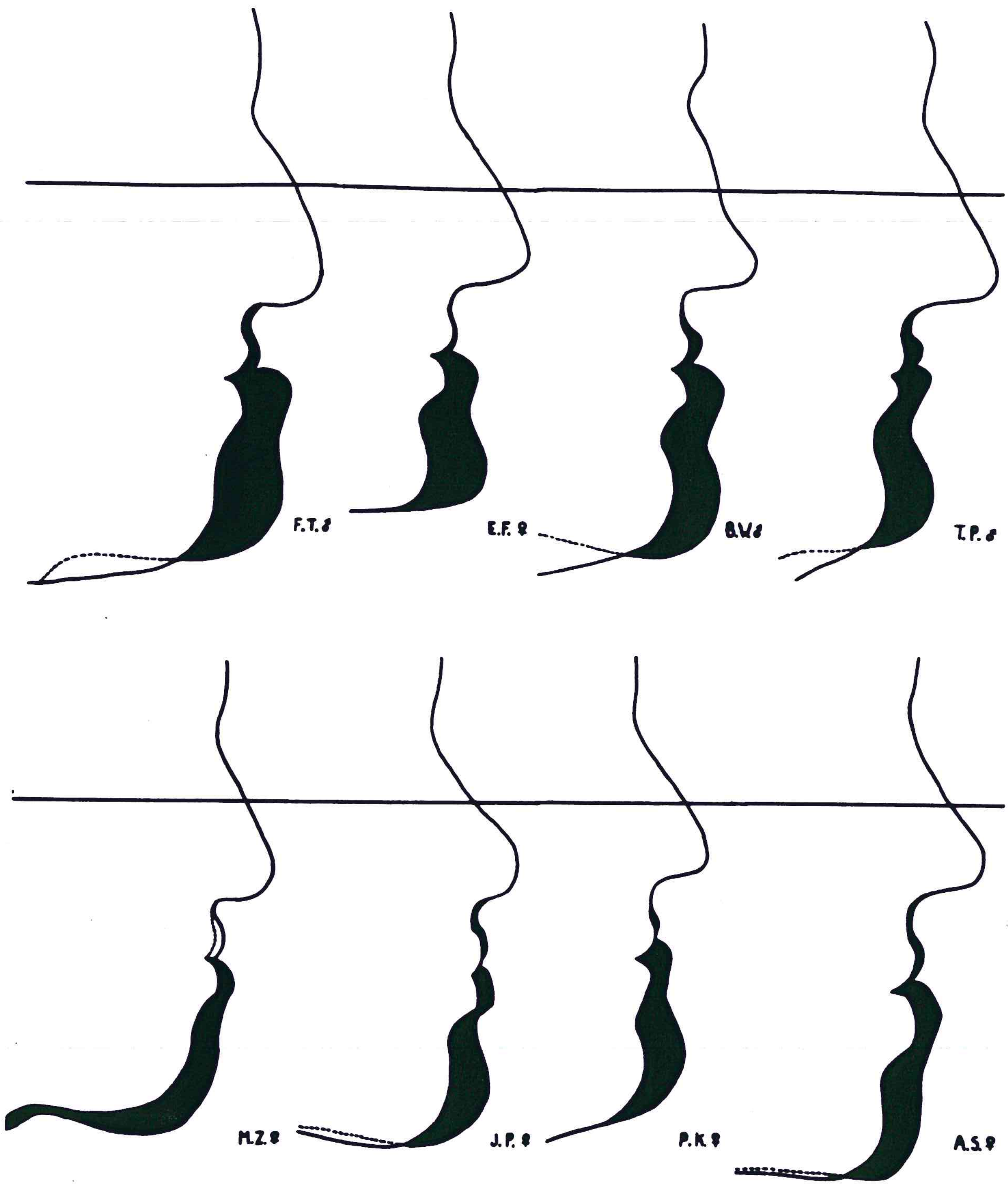


Figure 9.

Figure 10. Soft tissue changes occurring after the surgical correction of mandibular prognathism.

Note: The top row of illustrations depicts intermediate amounts of change in the soft tissue profile, occurring after the surgical correction was completed. The bottom row of illustrations depicts the least amount of change of the soft tissue profile, occurring after the surgical correction was completed.

The illustrations were made in the following manner. The pre-operative tracing and the post-operative tracing were orientated on points sella turcica (S), nasion (N), and the Frankfort Horizontal plane (FH). Another sheet of tracing paper was then placed over the orientated tracings, and the outlines of the pre-operative and post-operative soft tissue profiles were traced. The area between the outlines of the pre-operative and post-operative soft tissue profiles was then inked in with black ink. This area depicts the place of change and the amount of change occurring in the soft tissue profile after completion of the subcondylar osteotomy surgical procedure.

The illustrations of this figure are orientated on the Frankfort Horizontal plane.

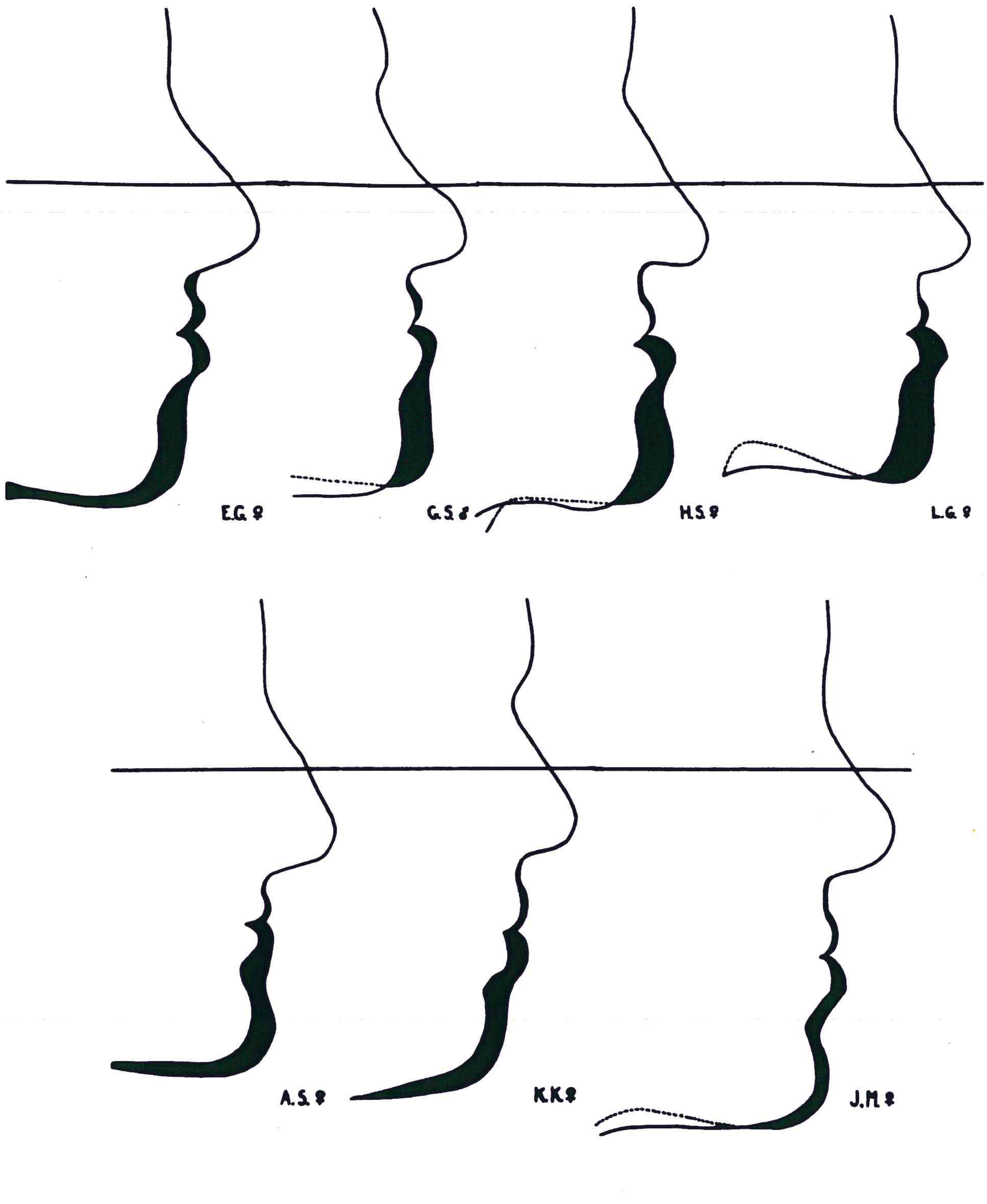


Figure 10.

DISCUSSION

The findings of this study reveal a basic pattern of alteration of the hard and soft tissue profiles to surgical correction, but it can not safely be assumed that individual cases will conform strictly to this average pattern.

In reducing the prognathic state of the mandible, the necks of the condylar processes were severed from the rami of the mandible, and the mandible was moved posteriorly to a predetermined position. The skeletal analysis measurements made of the facial plane angle, the angle of convexity, and the Y-axis angle, are measurements which express the relative position of the chin of the mandible to the cranium. As the mandible assumed a more posterior relationship to the cranium after the surgical procedure, the facial plane angle, and the angle of convexity decreased in all cases, while the Y-axis angle increased in all cases.

The skeletal analysis measurements made of the ANB angle and the AB to the facial plane angle, express the relative position of the denture bases to one another, and to the facial plane. As the mandible was repositioned posteriorly, the denture bases assumed a more normal relationship to one another. As the denture bases assumed a more normal relationship to one another, the ANB angle, and the AB to the facial plane angle decreased in all cases.

The mandibular plane angle, which was measured in the skeletal analysis, is an expression of the relationship of the lower border of the mandible to the Frankfort Horizontal plane. The mandibular plane angle increased in fourteen of the sixteen cases investigated after surgery. This fact may be attributed to a "rocking up" of the gonial angle of the mandible, as the body of the mandible was repositioned posteriorly, along with a decrease of the overbite of the anterior teeth. The two cases in which there was a decrease in the mandibular plane angle, were cases where there was no "rocking up" of the gonial angle of the mandible, but only a decrease of the overbite and overjet of the anterior teeth.

The range of change and the average change of the measurements of the skeletal analysis were recorded in the section on findings. However, Wylie[25] has stated in regard to ranges and averages, " It must be emphaiszed that these values provide only a general sort of information and do not warrant any particular conclusion."

Scattergrams were used to graphically illustrate the relationship between the posterior displacement of pogonion, and the change in angulation of the various measurements of the skeletal analysis. If the two changes being compared on the scattergram were highly correlated to one another, the dots on the scattergram would be arranged to approximate a straight line. The lower the correlation between the two changes, the more these dots would deviate in arrangement from a straight line.

The coefficients of correlation (r),of the posterior displacement of pogonion and the changes in angulation of the various measurements of the skeletal analysis, were calculated. Varying degrees of correlation were exhibited. The change in the facial plane angle ($r= 0.68$)

the ANB angle (r= 0.67), and the AB to the facial plane angle (r= 0.64), exhibited the highest degrees of correlation. The change in the Y-axis angle (r= 0.53), the angle of convexity (r= 0.50), and the mandibular plane angle (r= 0.39), exhibited decreasing degrees of correlation.

These varying degrees of correlation may be attributed to the manner in which the mandible was repositioned posteriorly. The mandible was not displaced posteriorly in only one plane of space. In some cases the mandible was tipped upward as it was displaced posteriorly, while in other cases it was tipped very little. Also, the amount of posterior displacement of the mandible varied greatly in the cases of this sample. The lack of a high degree of consistency in the manner in which the mandible was repositioned posteriorly, predisposed these varying correlations.

Since the sample size of this investigation was relatively small, the main purpose for calculating the various coefficients of correlation, was not to assess a greater or lesser degree of consistency to any of them, but rather to say that one coefficient was larger than another, and list them accordingly.

In regard to scattergrams and coefficients of correlation, Thurow[26] has stated, " Actually, the original scattergram is frequently more meaningful than the coefficient, in spite of the fact that it is easier to obtain. The safest procedure, especially when many readers will not be professional statisticians, is to present the scattergrams with the coefficient, as was done by Wylie in his evaluation of Tweed's treatment."

In the improvement of the relationship of the mandible to the cranium, there was a concomitant improvement of the soft tissue profile of the face. The least amount of change of the soft tissue profile occurred in the upper lip and maxillary sulcus of the upper lip. However, the greatest amount of variation in response of the soft tissue profile, occurred in the upper lip and maxillary sulcus of the upper lip. The maxillary sulcus contour of the upper lip, in the majority of cases (12 cases), became more obtusely angulated. There was a minimal posterior displacement of the upper lip and maxillary sulcus, and a minimal downward displacement of the upper lip.

The greatest amount of change of the soft tissue profile, occurred in the lower lip, the mandibular sulcus of the lower lip, and the soft tissue chin. Along with the greatest amount of change, the lower lip, the mandibular sulcus of the lower lip, and the soft tissue chin exhibited the least amount of variation in response to surgery. The lower lip, mandibular sulcus of the lower lip, and the soft tissue chin were displaced posteriorly in all cases. There was a downward displacement of the lower lip and the soft tissue chin in the majority of cases (12 cases). The mandibular sulcus contour of the lower lip became more acutely angulated in the majority of cases (12 cases). As one would expect, the posterior displacement of the soft tissue chin followed closely that of the bony chin.

The total facial concavity was decreased in all cases, and the amount of reduction of the total facial concavity followed closely the distance which the mandible was repositioned posteriorly.

Since this paper was the first attempt to evaluate, with cephalometric measurements, the soft tissue profile changes occurring in the subcondylar osteotomy surgical procedure, or any other surgical procedure for the correction of mandibular prognathism, no comparison of these findings with any other similar findings was possible.

It appears reasonable to assume that with furthur cephalometric investigation of all the various aspects of the surgical correction of mandibular prognathism, a more objective diagnosis and prognosis of a case about to undergo surgical correction will be able to be made.

This study was limited to the net changes of the hard and soft tissue profiles occurring immediately after the surgical correction, and no investigation of the stability of these changes was made. Cephalometric headplates of the patients in this sample, a number of years after the surgical procedure, were not available. Future studies on the stability of these surgically corrected mandibular prognathism cases would be very useful.

SUMMARY AND CONCLUSIONS

The purpose of this study was to investigate, with cephalometric measurements, the net hard and soft tissue profile changes occurring after the surgical correction of mandibular prognathism, by the subcondylar osteotomy procedure. In addition, it was the purpose of this study to demonstrate the need for future investigation of all facets of surgical correction of mandibular prognathism , on a cephalometric measurement basis. Pre-operative and post-operative lateral cephalometric headplates of sixteen adult individuals, who underwent the subcondylar osteotomy surgical procedure, were evaluated from the standpoint of the net changes of various cephalometric measurements of the skeletal and soft tissue analyses.

The conclusions indicated from this study are as follows:

1. The facial concavity, in regard to the relationship of the hard and soft tissue chin to the upper face, was decreased by this surgical procedure, and facial esthetics was improved.

2. The mandible was repositioned posteriorly in all cases, and the lower denture base assumed a more normal relationship to the upper denture base.

3. The changes in angulation of the skeletal analysis measurements, showed varying degrees of correlation to the posterior displacement of the chin (pogonion). In decreasing degree of correlation, these relationships assumed the following order: (1) the facial plane angle,

(2) the ANB angle, (3) the AB to the facial plane angle, (4) the Y-axis angle, (5) the angle of convexity, (6) and the mandibular plane angle.

4. The soft tissue contour of the upper lip, the maxillary sulcus of the upper lip, the lower lip, the mandibular sulcus of the lower lip, and the soft tissue chin, were altered by the surgical procedure.

5. The greatest variation in response and least amount of change, of the soft tissue profile to the surgical procedure, was exhibited by the upper lip and maxillary sulcus of the upper lip. There was a tendency for the upper lip to be slightly posteriorly displaced, and the maxillary sulcus contour of the upper lip to become more obtusely angulated after the surgical procedure.

6. The least amount of variation and greatest amount of change, of the soft tissue profile to the surgical procedure, was exhibited by the lower lip, the mandibular sulcus of the lower lip, and the soft tissue chin. The lower lip and the soft tissue chin were posteriorly displaced in all cases, with a tendency for a downward displacement of the lower lip and the soft tissue chin. There was also a tendency for the mandibular sulcus contour of the lower lip to become more acutely angulated.

7. The lower lip and the soft tissue chin, being posteriorly repositioned in all cases, assumed a better esthetic relationship to the rest of the soft tissue profile.

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