A STUDY OF HARD AND SOFT TISSUE FACIAL PROFILE BEFORE AND AFTER ORTHOGNATHIC SURGERY

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INTRODUCTION

More than 90% of patients seek orthodontic services for esthetic reasons[1]; and most clinicians recognize that it is generally the unesthetic appearance of malaligned teeth and/or jaws that ultimately motivates patients to seek professional help.[2] The awareness of personal beauty, as in the past, continues to profoundly affect the attitudes, behavior, personalities, and life styles of patients.[2] Like the artist who transposes forms, and the sculptor whose creations result from visions, the orthodontist, too, must through an artistic evaluation of the head, face and teeth, be able to comprehend, imagine and visualize. The face is a complex blending of lines, angles, planes, forms, shapes, sizes and positions of bones and teeth that gives each individual his own appearance.[6]

Orthodontics is one of the few professions that daily deals with patients looking for dental and facial improvements.[3-10,33]

The orthodontist may have to include orthognathic surgery in the treatment plan to correct imbalance of discrepancies in sizes of bones to obtain that improvement.

It can be seen from the literature that since Camper in 1792, linear and angular measurements of facial profile have been a frequently discussed topic. A short time after Camper's treatise, Retzius, a Swedish anatomist, made a classification for human races differentiating:

1) orthognatic (straight jaw) from 2) prognathic (prominent jaw). Angle in 1907 wrote: "It is the best balance, the best harmony, the best proportions of the mouth in its relations to the other features requires that there shall be the full complement of teeth, and that each tooth shall be made to occupy its normal position-normal occlusion."

It is the orthodontist's responsibility to know what is an unbalanced face and when it can be improved, rather than arbitrarily assuming that with orthognathic surgery, favorable change in patient's profile will result.

Even though the clinical examination accompanied by conventional orthodontic records is the most complete way to study patients' profiles, usually we make judgements from their lateral cephalograms. It is the purpose of this study to analyze in retrospective view, the hard-soft tissue changes in patients from the orthodontic department of the Oregon Health Sciences University, who have had orthognathic surgery, not only in a quantitative way, but also in a subjective manner to see if they have indeed experienced an improvement in their profiles.

METHODS AND MATERIALS

This study compares preoperative and postoperative lateral head films from orthognathic surgery patients to determine hard and soft tissue changes. The identical anatomical hard and soft tissue landmarks were identified on both cephalograms. The change, as a result of treatment and surgery, was measured from standard reference lines in the horizontal and vertical plane.

The subjects for this investigation were obtained from the records of the orthodontic department of the Oregon Health Sciences University. The patient material was comprised of nine men and 11 women, aged 15-0 to 40-3 years with a mean age of 23-2 years; having facial, skeletal and/or dental discrepancies. These all required pre-surgical orthodontic treatment.

All patients had been examined by staff orthodontists to determine the relative location and degree of deformity. Before surgical correction, leveling of the curve of spee, expansion or contraction of the dental arches, correction of incisal axis inclination, alignment of displaced teeth, extractions, were performed in an effort to obtain the most stable occlusion preoperatively.

Optimum quality cephalograms were necessary for this study with the following requirements: 1) Preoperative and postoperative radiographs taken with the Broadbent[11,15] cephalometer; 2) All lateral

head films were taken by the same experienced technician; 3) All the films had good hard and soft tissue image quality; 4) The preoperative head films were taken before any treatment, and the postoperative were taken after active orthodontic treatment as appliances can influence in lip position [39,40] ; 5) At the moment of exposure, all patients were in centric occlusion and with their lips in repose [19,24] ; 6) All soft tissue changes resulting from different stages of healing and recovery were minimized by taking the postoperative film no sooner than six months following surgery.

The use of the same cephalometer for both cephalograms resulted in a uniform image magnification. Absolute values of hard-soft tissue changes were used; therefore, image magnification (8% in median plane) [15] had an insignificant effect on accuracy. In tracing the headplates, if bilateral structures appeared as two shadows, the average point or plane between them was drawn.

Preoperative and postoperative cephalograms were traced for every patient. On the preoperative tracing, the Sella Turcica-Nasion-Pogonion angle and Frankfort horizontal were constructed for reference lines in the horizontal and vertical plane respectively.[8,9,12] All additional landmarks (appendix A, Fig.1 & 2) were then established for both, preoperative and postoperative tracings. Using a rule moved at right angles to this reference line, the postoperative tracing was then superimposed onto the preoperative tracing using the anterior cranial base [13] registered on nasion, and the two reference lines were transferred.[8] All

points were measured and listed the linear distances of each cephalometric point from the stable horizontal and vertical reference lines. The net movement of each point was then determined, with a positive value given to anterior or superior displacements, and a negative value to posterior and inferior changes. (Dept. of Ortho-Radiology Program).

The data collection was as follows: first an acetate tracing paper, was secured over the preoperative cephalogram; the sella-nasion-pogonion angle and frankfort horizontal were established; all landmarks were identified and marked with a sharp instrument. Acetate tracing paper was secured over the postoperative cephalogram and all landmarks were established (superimposed on sella-nasion of the preoperative tracing). All the cephalometric points on both (pre and post-operative tracings) were measured and it was obtained the linear distance of each landmark, of both tracings from the horizontal and vertical references planes; then the net change in each point was calculated. To determine the "landmark location error" 16 pairs of cephalograms were taken from the same study. They were traced as previously described and the standard error of the measurement was calculated by the following formula: S.E.Meas. $= \sqrt{\frac{\Sigma d^2}{2N}}$, where "d" is the difference between duplicate measurements and "N" is the number of subjects in the sample. This S.E.Meas. has been well utilized and validated by Bjork,[4] Lundstrom,[30] Weislander and Buck[51] and many others. Also it was calculated the mean and standard deviation for each of the anatomical landmarks.

Since the data obtained in the investigation is ordinal scale, a Wilcoxon matched-pairs signed-rank test was used to test the null hypothesis (no change) and the alternative hypothesis (change). Because the null hypothesis or the alternative, doesn't tell us if the change was desirable, a percentage of the positives and negative changes were calculated, based on the rank given to the patients in the post-treatment cephalograms.

The evaluation of the soft tissue changes was evaluated by the following scores: A for excellent, B for very good, C for good, D for poor and E very poor profile . The board evaluating included one student of orthodontics and four orthodontics. The evaluation was purely subjective and was repeated two weeks later by a blind test. Then a number value was given to the patients according to their evaluations, giving a positive or negative if they improved or got worse respectively (e.g., from C to A would be +2; from B to D would be -2).

REVIEW OF THE LITERATURE

In 1849 Hullihen[1] wrote the first surgical report describing correction of mandibular prognathism. After him, Blair[1] in 1898 presented another approach for correction of skeletal class III; a short time after, in 1910 Babcock[1], 1912 Harsha[1], 1925 Limberg[1], were among those to describe orthodontic treatment before surgery; followed then by Kostecka[1] in 1934, Schaeffer[1] in 1941, Dingman[1] in 1944, Moose[1] in 1945, Kazanjian[1] in 1951, Reiter[1] in 1951, Caldwell and Letterman[1] in 1954, and Smith and Robinson[1] in 1954.

The first method of studying the facial profile on normalateralis radiographs was developed by Burstone[9] in 1958.

In 1950, Riedel[40], had a board of 72 orthodontists evaluate esthetically the soft tissue tracings of 28 persons, of whom 25 had normal or an orthodontically corrected occlusion. The purposes of the investigation were to obtain 1) an opinion of what constitutes "Good" or "Poor" profile; 2) an analysis of the underlying skeletal and dental pattern of selected "good" or "poor"profile outlines; and 3) apply these findings to orthodontic therapy. His conclusions to his three objectives were: 1) there is a remarkably uniform opinion of what is good or poor soft tissue profile; 2) common differences between individual profiles judged "Good" or "Poor" were found in dental and skeletal patterns; and 3) he concluded that the more convex the profile, the more upright must be the incisors to produce good facial balance.

Elsasser[16] in 1951 designed a simple instrument to study the dento facial morphology of orthodontic patients. This was one of the first assessments to correlate the orthodontic cephalometric skeletal analysis with the integumental profile. He directly measured nasion, subnasion, tip of the upper and lower incisors and pogonion soft tissue, at right angles to frankfort horizontal. They called this instrument the "Facial orthometer".

In 1957 Riedel[41] studied the hard and soft tissue profile of 30 Seattle seafair princesses. He had a brief history and oral examination, photos (frontal, profile and artistics positions), lateral headfilms and tracings of the same. He concluded that the skeletal pattern of the princesses were similar to other previous studies; more variation existed in the dental pattern in comparison to previous studies; the chin, lower and upper lip were found to be in the same plane in one half of the sample; and that the public's concept of beauty is in good agreement with standards established by orthodontists on the basis of normal occlusion.

In 1958 Burstone[9] developed a method of studying the integumental profile in lateral cephalograms. He took his sample from the Herron institute of art in Indianapolis, including more than 100 adults with acceptable young faces. He concluded saying that the soft tissue veneer covering the teeth and bone varies so greatly the study of the dento-skeletal pattern may be inadequate in evaluating facial disharmony.

Bowker and Meredith[7] in 1959 studied the integumental profile of the face in childhood in a quantitative way. The sample consisted of 26 girls and 22 boys, studied between two and 14 years of age. They

used Nasion-Pogonion hard tissue line as a reference for the soft tissue measurements. They divided their study by sex and age, and obtained a mean, standard deviation and correlation for the different anatomical landmarks in the horizontal and vertical vectors.

Utilizing lateral head plates, Burstone[10] in 1959 studied 37 adolescents (11 males and 26 females), and 40 young adults (25 females and 15 males). He measured in the horizontal and vertical planes, from the skeletal to the integumental landmarks. He collected all the linear measurements and calculated the mean, standard deviation, standard error of the mean and "t" tested between males and females. His conclusions were: 1) malocclusions showed considerable variation in the integumental profile from the mean standard; 2) there were sex differences, i.e., the areas inferior to the nose were generally horizontally greater in the soft tissue of the males; 3) and with maturation the total facial contour tended to be flatter.

In 1959 Subtelny[48] studied the profile soft tissue change in 30 subjects from three months to 18 years of age. He also used pronasale, subnasale, superior and inferior labrale, and pogonion soft tissue. He used basion-nasion pogonion (hard tissue), and made a projection of nasion to the soft tissue using the angle with pogonion soft tissue. His conclusions were as follows: 1) integumental and skeletal profile assumed a more forward relationship to the cranium; 2) the bony facial profile tended to become less convex with age, but the total soft tissue profile (including the nose) was found to increase in convexity with progression in growth; and 3) also demonstrated was the continuous growth of the nose downward and forward from one to 18 years of age.

In 1959 Wylie[55] discussed the influence of the lower incisor in esthetics and treatment planning, and concluded that the orthodontist should have these objectives: 1) to establish the best possible functioning unit considering teeth, supporting tissues, muscles and structures of the joint; 2) to establish the best possible appearance, not only in repose but in animation as well.

Also in 1958, Neger[35] concluded that change in the soft tissue profile does not necessarily accompany extensive dentition changes, so we cannot rely entirely on a dento skeletal analysis for accurate information concerning the soft tissue profile changes which can occur during orthodontic treatment.

In 1960 Salzmann[44] discussed the importance of including skeletal, dental and soft tissue profile factors in the cephalometric analysis for treatment planning. However, he recognized that certain skeletal angular criteria, soft tissue tonicity and muscle posture influence the soft tissue profile.

Bloom[6] in 1960 studied 60 orthodontically treated patients to see the influence of the dento-skeletal framework in the soft tissue profile. He concluded that the maxillary incisor movement causes change in the superior sulcus, upper and lower lip; and that mandibular incisors changes have influence on the inferior sulcus and lower lip.

In 1961 Subtelny[49] continued his study from 1959 adding to his conclusions that growth in the soft tissue profile seemed to be emphasized in the nose, lips and chin area, and that lip was closely correlated to the underlying dental and alveolar structures. This is important to the orthodontist due to the fact that he is capable of modifying the dento alveolar area, thus influencing the profile.

Knowles[27] in 1965 found, in patients that had surgical procedures for skeletal class III, and improvement in the lower third of the face, especially in the lower lip and chin areas.

In 1966 Charles J. Burstone[11] considered the lip posture and its roll in orthodontic analysis. He studied 32 boys and girls aged 13 to 15 years, and developed a method of obtaining a relaxed position for the lips at the moment of obtaining a lateral head film. His conclusions were: 1) the technique for obtaining relaxed position of the lips was reproducible; and 2) facial disharmonies may be observed in the absence of dento skeletal discrepancies. These disharmonies could be associated with either inadequacies or redundances of lip length.

In 1966 Merrifield[31] studied the soft-hard tissue profile in 120 roetgenograms (80 from Tweed's files, and 40 from his own file). His conclusions were: 1) the proportions of the lower face have a narrow range; 2) the "z" angle (frankfort horizontal and the line passing from pogonion soft tissue to the most prominent lip) eliminated the vagueness of "eye judgement"; 3) the chin thickness should be equal to or slightly greater than the upper lip thickness; and 4) the upper lip should be tangent to the line (from pogonion soft tissue), and the lower lip should be slightly behind this profile line.

In 1967 Aaronson Sandord[1] published the first paper that made an attempt to evaluate, with cephalometric measurements the soft tissue profile changes occurring in patients that had orthognathic surgery for the correction of mandibular prognathism. The study included 16 adults (11 females and 5 males), with pre and post-treatment cephalograms. He founded a decrease in the facial plane angle, angle of convexity, ANB

angle; and increase in the Y axix angle and mandibular plane angle. He also found that subnasale did not show change; the superior labial sulcus moved posteriorly in nine cases, one moved anteriorly and six did not have posterior displacement. Labrale superior moved back an average of 1.9 mm in 14 cases (one had anterior movement and one did not change). For labrale inferior all cases showed a posterior movement, with an average of 7.0 mm observed. The inferior labial sulcus had posterior displacement in all cases, with an average of 9.4 mm, and menton had posterior movement also in all cases; the subnasal angle decreased in all cases. Maxillary sulcus contour angle remained the same in one case, increased in 12 and decreased in three cases; and finally the mandibular sulcus contour remained the same in two cases, decreased in 12 and increased in two cases. Summarizing, patients with class III skeletal malocclusions had an improvement in their profile with the orthognathic surgery.

Fromm, Brynolf, Lundberg and Max[20] studied in 1970, the facial profile, before and after orthognathic surgery for skeletal class III malocclusion in 26 males and 26 females. The age range was 21 to 34 years; and compared them with a control group of 30 males and 30 females, aged from 21 to 26 years of age. They had a panel of 120 nurses, that examined the lateral cephalograms (before and after treatment). They ranked the patients' profiles from -1 to +6. About 10% of the individual voters, voted negatively (no change or worsening of the appearance); the rest showed an average in the middle of the scale in a positive way.

In 1970 McNeill, Proffit and White[33], presented a paper with the purpose of presenting a method for surgical orthodontic treatment planning. They concluded as many others have, that the soft tissue profile analysis should be included in the overall analysis in order to reduce the possibility of misdiagnosis and post-treatment surprises.

Bjork, Eliasson and Wictorin[5] studied in 1971 the hard-soft tissue changes in the short term and after a prolonged period in two groups. The first one had eight males and 14 females aged from 17 to 34 years with recent orthognathic surgery for skeletal class III; and the second had the surgery between 1955 to 1960 including 10 patients. They also made a measurement error study, having 0.63 mm for upper lip, 0.62 mm for lower lip and 0.43 mm for the chin. The results were: 1) the largest soft tissue changes were in the chin and the lower lip area; 2) the upper lip contour moved posteriorly about 2 mm in spite of no positional change of the upper central incisors.

In 1971 Cox and Van der Linden[13] studied the facial harmony in 241 female and 186 male young adult students. They studied the silhouette photographs (underexposure technique) to avoid other aspects that may affect the judgement when normal lateral photographs are taken. They concluded that a number of faces with good facial harmony were found to be associated with malocclusions. They also traced all the lateral films of the sample and concluded that in both sexes persons with poor facial balance have more convex faces.

Robinson, Speidel, Isaacson and Worm[42] in 1972 published a study that was done in 10 patients (seven females and three males) that were treated

by orthognathic surgery for mandibular prognathism. They utilized sella-nasion-pogonion angle for the pre and post-treatment cephalograms, and measured the differences from vertical and horizontal planes. They founded a 1:1 ratio for pogonion hard tissue to pogonion soft tissue.

Foster[18] in 1973, made a study to determine whether some group of people concur or have differences in preference for different profiles with respect to age and sex. He traced the soft tissue silhouette of an 18 year old caucasian girl and changed the original profile in the lips area, giving the lips a more full appearance. The results of the study were: 1) diversified groups in the study did seem to share a common esthetic standard for posture of the lips; 2) all groups were consistent in assigning fuller lips for younger ages and 3) for adult males all groups except orthodontics, preferred lips located behind the mean values for the esthetic and Holdaway lines.

Bell and Dann III[3] made in 1973 a retrospective study of 25 orthognathic surgery patients. All patients had maxillary ostectomies, nine had mandibular supapical ostectomies and eight had anterior sliding genioplasties. He concluded that all patients had a minimal bony relapse in an average follow-up of 25.6 months; the ANB mean difference was reduced from 6.1° to 2.8° and improvement in profile was achieved in all patients.

In 1974 Linnes, Steinhauser and Switzerland[29], performed 41 surgical procedures in 35 patients. They studied the hard-soft tissue profile, before and after the surgical procedure and found:

PROCEDURE	# of Cases	Points	Ratio
Mandibular set back	8	po-$\underline{pos}$	1:1
		LI-$\underline{\bar{1}}$	3:4
		Ls-$\bar{1}$	20% of movement
Total Mandibular Advance	9	Gn-Gns	1:1
		LI-$\underline{Gn}$	2:3
		LI-$\bar{1}$	62% of movement
Maxillary Advance	3	Hard-Soft	3:2
Mandibular Alveolar set back		Li-$\bar{1}$	3:4 (same as mandibular set back)
Maxillary Alveolar set back	7	Soft-Hard	1:2
Mandibular Alveolar Advance	2	LI-$\bar{1}$	60% of $\bar{1}$ movement
Bimaxillary Alveolar set back		Max. Soft-Hard	1:2
		Mand. Soft-Hard	3:4

Vertical dimensions: Soft tissue moved 80% of the hard tissue movement; as the facial height was reduced, the lips became fuller, and when increased they became thinner.

Garland and Lynn[21] in 1974 studied 24 patients (17 females and seven males), that had orthognathic surgery, to observe the soft tissue change with surgical treatment. They used the sella-nasion-pogonion angle in the pretreatment cephalogram and made a new sella-nasion plane duplicating the sella nasion-pogonion angle of the pretreatment lateral x-ray. The findings were: 1) a 1:0.9 ratio for hard-soft tissue pogonion point (different than Robinson, Speidel, Isaacson and Worms); 2) a 0.8:1 ratio for interior labial sulcus to pogonion hard tissue; 3) $\bar{1}$ had less posterior movement than pogonion, 0.6:1 ratio respectively; 4) even though that was only a

mandibular procedure they observed a 0.2:1 ratio of the upper lip to pogonion hard tissue movement; and 5) the lower lip was more prominent in relation to its sulcus, than the upper lip.

Midtgard, Blork and Linder-Aroson[34] studied in 1974 the reproducibility of fifteen landmarks and the error of measurement of the cephalometric cranial base. The sample used included 25 children that had two consecutive roetgenograms during the same examination period. They concluded that there are three types of errors in cephalometric measurement studies: 1) differences between two films of the same individual; 2) differences caused by variation of the positioning of the landmarks; and 3) errors in the reading process.

Wisth and Boe[52] in 1975 made a study of the reliability of cephalometric soft tissue measurements. The sample for the study comprised 30 children aged from 11 to 13 years of age, with class I occlusion and competent lips, and 30 others, with class II division I malocclusion with incompetent lips. All patients had two lateral cephalograms with an interval, between the two, of three weeks. The results showed that soft tissue variables generally displayed the same degree of error of method as corresponding hard tissue variables when evaluated from double recordings on the same film, with exception of: 1) upper face height hard tissue and upper face height soft tissue; and 2) lower face height hard tissue and lower face height soft tissue. Also, they concluded that the error of method was increased in children with incompetent lips; and they recommended some caution must be taken when orthodontists utilize soft tissue points on the most movable parts of the profile, especially in the vertical vector.

Also in 1975, Wisth[53] studied the soft tissue profiles of 16 women with mandibular protusion, and compared them with a "normal" group, before and after surgical correction; doing the evaluation in lateral cephalograms. The results before treatment in his study were: 1) the total profile convexity (nasion-pronasale-pogonion soft tissue) was less in the protusion group; 2) the upper lip angle (subnasale-superior labial sulcus-labrale superior) was similar in both groups, as was the depth of the upper lip; 3) the length of the upper lip was significantly shorter in the protusion group; 4) the lower lip angle (labrale inferior- B point- pogonion soft tissue) was more obtuse in the protusion group, however the length was similar in both groups; 5) the position of both lips was evaluated to the esthetic line and the lower lip was positioned similarly in both groups, while the upper was more posteriorly positioned in the protusion group. The results after treatment, were significantly different in two mean values: 1) the upper lip was still positioned more distally in the protusion group; and 2) the upper lip was thicker than the lower lip.

Dann III, Fonseca and Bell[14] in 1976 made a retrospective study of eight cases that had maxillary advancement. The records included a pre and post-treatment lateral cephalogram. They studied the lip position relative to frankfort horizontal; finding a decrease in the nasiolabial angle in relation to the anterior movement of the maxilla; as well as a decrease in lip thickness.

In 1976 Schendel, Eisenfeld, Bell and Epker[45] evaluated the stability and soft tissue osseous relations associated with superior repositioning

of the maxilla by total maxillary osteotomy or combined anterior and posterior maxillary osteotomies, in 30 patients. They concluded that 14 months post-operatively the patients had excellent skeletal stability; that the reduction in the lower face height and the amount of maxillary incisor exposure resulted in improved facial balance.

Ross[43] in 1977 studied 30 patients (10 boys and 20 girls) who were diagnosed as having class II division I malocclusion, and who had received orthodontic treatment. Hard soft tissue changes were measured and correlated, and his conclusion was that the degree of correction between changes in the soft tissue profile and changes in the skeletal profile during treatment varied.

McDonnell, McNeill and West[32] in 1977 selected 15 patients from a pool of 29 surgical orthodontic patients who received advancement of the mandibular symphisis, and concluded that for purposes of prediction in treatment planning, a ratio of 4:3 is recommended for surgical horizontal advancements of the symphisis versus the net horizontal change in the soft tissue chin point.

In 1977 Freihofer and Petresevic[19] studied 38 patients who had been treated by a mandibular advancement procedure. 75% of the patients were satisfied with the results, with no complaints; 20% (8 patients) were satisfied with some complaints such as: Hypo-anesthesia of the lower lip or clicking of the temporo mandibular joint, and only two patients would decline such an operation now. In the eyes of the examiner optimal results were obtained in 18 cases (47%); good results in 11 cases (29%); satisfactory in 8 cases and bad in one case. The occlusion was identical, in

26 patients, as it presented immediately after surgery (two years before). In all cases the vitality reaction of the teeth returned the third and sixth month after the operation.

Hillesund, Fjeld and Zachirson[22] in 1978 studied the reproducibility of the soft tissue profile attempting to obtain the most correct record of lip position and morphology in clinical practice. They recorded 35 children with more than 8 mm of overjet and 32 with normal overjet, twice, within three week intervals, and concluded that having a relaxed position of the lips was much more accurate than a closed position. They also concluded that technical equipment, procedure, operator interpretation and facial expression, influence in the reproducibility of the soft tissue landmarks.

In 1978 Burstone, Randal, Legan, Murphy and Norton[12] developed a cephalometric analysis for orthognathic patients, based on the landmarks that can be altered by various surgical procedures; but, they mention that it would be a mistake to treat the patients to skeletal standards, and not take the soft tissue into consideration, due to the fact that soft tissues can and do mask the underlaying bone and teeth; therefore one must compensate for this variation.

Kajikawa[26] in 1979 studied 11 males and 22 females that had orthognathic surgery for the correction of skeletal class III malocclusion, aged between 14 to 26 years of age; and compared them with a control group of 15 females aged between 18 and 19 years of age. They used the Steiner line[27], holdaway line[5] and the esthetic line[28], as reference planes in the pre and post-treatment cephalograms. He concluded that pogonion, menton and B points in hard tissue are followed by their

respective points in the soft tissue in a ratio close to 1:1; the major changes were in the lower third of the facial profile; and there were greater changes in the horizontal vector. After surgery the soft tissue points were in a better position with Steiner, Holdaway and the esthetic lines.

Legan and Burstone[28] in 1980, published a study of soft tissue analysis for orthognathic surgery patients. They studied 40 patients (20 males and 20 females), all adults aged from 20 to 30 years of age. They calculated the mean and standard deviation for six measurements of facial form and seven of lip form and position. They concluded that treatment using hard tissue cephalometric standard only, may not lead to the desired improvement in facial form, and therefore soft tissue analysis becomes paramount in treatment planning for orthognathic patients.

Dongieux and Sassouni[15] in 1980 studied the influence of vertical and horizontal mandibular position in relation to the total soft tissue profile, and their conclusions were: 1) the profile frontal view induced confusion in the judges' opinion; 2) the profile soft tissue view was the most reliable in assessing mandibular position; 3) the most pleasing type was class I; and 4) the vertical and horizontal position of the mandible does influence the opinion of the observers regarding the appearance of the profile.

In 1980 Worms, Speidel, Bevis and Waite[54] discussed in their paper, the stability and esthetic results of orthognathic surgery. They concluded and discussed the importance of incorporating an adequate soft tissue analysis in the diagnosis of orthognathic patients, if not included it would lead to many post-treatment disappointments.

In 1981 Radney and Jacobs[38] studied 10 patients from the oral and maxillofacial surgery department of Baylor College of Dentistry, that had maxillary intrusion and found: 1) that the nasolabial angle changed in response to the direction and amount of the intrusion; 2) in the upper lip found that labrale superior, superior labial sulcus and subnasale changed by 0.70, 0.30, and 0.30 mm respectively with the incisal edge of the upper incisor; 3) the soft tissue chin, inferior labial sulcus and pogonion soft tissue, responded to posterior maxillary intrusion by autorotating on the same arc as the bony chin on a 1:1 ratio and 4) the nasal tip (pronasale) moved superiorly slightly with maxillary intrusion and protraction.

In 1982 Fields, Vann and Vig[17] studied the reliability of a visual assessment of facial profile in 40 children (20 aged 8 years ∓ 5 months and 20 aged 12 years ∓ 5 months). The board consisted of 20 orthodontists, 20 pedodontists and 20 dental students. They concluded that the soft tissue outline from radiographs, with or without supplementary photographs, do not provide enough information to reliably assess the underlying skeletal pattern in children of 8 and 12 years of age. The assessment was less reliable at 8 than at 12 years of age.

Reed Holdaway[24] in 1983 wrote that the analysis of hard tissue alone is an incomplete analysis of the patient, because the hard tissue is covered by the soft tissue, which is different in each individual. He gave means and ranges for soft tissue linear and angular measurements as follows:

1) Soft tissue angle: 91 ∓ 7 degrees

2) Nasal prominence (measured from frankfort horizontal to labrale superior): 14 - 24 mm

3) Superior sulcus depth: 1 to 4 mm ($\bar{x}$: 3 mm)

4) Soft tissue subnasale: 3 - 7 mm ($\bar{x}$: 5 mm)

5) Upper lip thickness (measured from alveolar crest to labrale superior) : $\bar{x}$: 13 mm

6) H angle (angle of *H line to nasion pogonion soft tissue) : 10°

7) Lower lip to *H line: ideal of 0 to 0.5 mm anteriorly

8) Soft tissue chin thickness with a range of 10-12 mm

He also gave means for skeletal profile convexity, upper lip strain, and inferior sulcus to H line. He concluded that surgery is indicated mainly in cases of extreme vertical problems and those that need changes in the chin area.

Quast, Biggerstaff and Haley[37], studied the short and long term changes in the hard-soft tissue from pre and post-treatment cephalograms of 18 patients and founded: 1) in the horizontal plane that pogonion, Gnathion, Menton, B point and 1 hard tissue, moved anteriorly between 4-6 mm and Pogonion, Gnathion, Menton and inferior labial sulcus moved between 3.5 and 4.5 mm; 2) in the vertical plane, Pogonion, Gnathion, Menton, B point hard tissue moved inferiorly between 2.6 and 3.2 mm and pogonion, gnathion, menton and inferior labial sulcus moved between 3.2 and 3.8 mm. They also founded a high correlation at 0.5 confidence level, between: 1) Menton hard and menton soft tissue (0.827); 2) Gnathion hard and soft tissue (0.930); 3) Pogonion hard and soft tissue (0.968); 4) B point and Inferior labial sulcus (0.922). They also presented a table with the hard-soft tissue ratios as follows:

* Line from labrale superior to gnation soft tissue.

*Descriptive comments and soft-tissue to hard-tissue change ratios for orthognathic surgical procedures as presented in the orthodontic and oral surgery literature. * Quast, D.; Biggerstaff, R.; Haley, J.: Am. J. Orthod. 84:29, 1983.

Procedure	Soft-Tissue to Hard-Tissue Change
1. Total mandibular setback	(1) Horizontal soft-tissue pogonion: 0.9/1 mm setback pogonion (2) Horizontal inferior labial sulcus: 0.9/1 mm setback pt. B : 0.9-1.0/1 mm setback lower incisor (3) Horizontal lower lip: 0.6-0.7/1 mm setback pogonion (4) Horizontal upper lip: 0.2/1 mm setback pogonion
2. Mandibular anterior alveolar setback	(1) Horizontal lower vermilion border: 0.75/1 mm lower incisor setback
3. Total mandibular advancement	(1) Horizontal labrale inferius: 0.85/1 mm advancement, lower incisor (2) Horizontal inferior labial sulcus: 1/1 point B advancement (3) Horizontal soft-tissue pogonion: 1/1 pogonion advancement
4. Mandibular alveolar advancement	(1) Horizontal lower lip: 0.6/1 mm advancement, lower incisor
5. Total mandibular advancement	(1) Horizontal lower lip: 0.667/1 mm advancement, lower incisor (2) Horizontal soft-tissue pogonion: 1/1 pogonion advancement
6. Total maxillary advancement (LeForte I)	(1) Horizontal upper vermilion border: 0.5 $\pm$ 0.1/upper incisor advancement (2) Vertical upper vermilion border lengthens: 0.3 $\pm$ 0.15/ upper incisor advancement (3) Decrease nasolabial - 1.2° angle: 1.0 mm $\pm$ 0.26 (4) Horizontal pronasale: 2:7 advancement, upper incisor
7. Maxillary impaction (LeForte) without horizontal movement	(1) Vertical stomion: 0.4:1 mm upper incisor (2) Vertical labrale superius: 0.3:1 mm upper incisor (3) Vertical superior labial sulcus: 0.25/1 mm upper incisor (4) Vertical subnasale: 0.2/1 mm upper incisor (5) Vertical pronasale: 0.2/1 mm upper incisor
8. Maxillary impaction (LeForte I) and move posteriorly	(1) Horizontal labrale superius: 0.67/1 mm retraction, upper incisor (2) Horizontal superior labial sulcus: 0.33/1 mm retraction, upper incisor (3) Horizontal subnasale: 0.33/1 mm retraction, upper incisor (4) Vertical landmark changes same as maxillary impaction only
9. Bimaxillary alveolar setback	(1) Horizontal labrale inferius: 0.75/1 mm lower incisor (2) Horizontal labrale superius: 0.50/1 mm upper incisor
10. Vertical dimension reduction	(1) Vertical soft tissue (from soft-tissue pogonion to menton): 0.8/1 mm hard tissue
11. Maxillary alveolar setback	(1) Horizontal labrale inferius: 0.44/1 mm retraction, upper incisor (2) Horizontal superior labial sulcus: 0.6/1 mm, retraction, upper incisor (3) Horizontal labrale superius: 0.66/1 mm retraction, upper incisor

Discussion and Findings

In the past ten years tremendous advances have occurred in orthognathic surgery. Many new procedures have been developed and many of the older procedures have been further refined. The good working relationship between orthodontists, restorative dentists, and oral surgeons has significantly improved treatment planning and ultimate results.

For orthognathic patients an awareness of integumental extension and contour is an essential element of case analysis[28,33,44]. The present study is basically static in nature, and functional investigation of facial mimicry, movements of the head and, not least, the teeth would result in a better assessment of the results of surgery from the esthetic point of view[53,10].

Considerations for orthognathic surgery usually fall into five categories: functional, esthetic, stability, treatment time and cost of treatment. The treatment plan must be designed to correct functional and esthetic deformities, i.e., cases with skeletal open bites, skeletal class II or class III malocclusions, etc.; and in cases where pretreatment esthetics are good or optimal, the surgical procedure should be designed to provide optimal functional relationships without altering the esthetics (careful planning must be done so as not to worsen the facial esthetics).

Frequently one of the primary concerns the patient may have will involve facial esthetics, so in cases of musculoskeletal deformities, adequate esthetics correction without surgery is especially impossible when orthodontically treating a nongrowing individual. By careful patient assessment (particularly the clinical evaluation) the oral surgeon and the

orthodontist as well should plan to optimize function and esthetics; also the orthognathic team should analyze the other three basic considerations to provide the best service to the patient (stability, treatment time and cost of treatment).

The present study permitted the identification of several variables that can adversely affect a study of soft tissue change, among them: 1) small sample size; 2) the use of retrospective data; 3) variation in lip position when cephalograms were taken; and 4) inability to describe and predict changes (or the mimicry of them) in the frontal view of the patient.

Statistical analysis

I Radiographic examination

The results of the radiographic examination including soft and hard tissue are shown in appendix D and E.

The mean standard error of the measurement was 0.57 mm. Glabella showed the largest S.E.meas. of 1.19 mm and pronasale the smallest with 0.27 mm in the vertical plane. The mean S.E.meas. in the vertical vector was 0.73 mm. In the horizontal plane subnasale and superior labial sulcus showed the smallest measurement error, of 0.28 mm. Inferior labial sulcus showed the largest with 0.51 mm, and the mean S.E.meas. in the horizontal vector was 0.41 mm.

For the group of patients that had mandibular advancement, inferior labial sulcus soft tissue and pogonion hard tissue had the largest mean change with 2.82 mm and 4.1 mm respectively, in the horizontal plane

(relative to Na-Pog.). In the vertical plane superior labial sulcus showed a mean change of -2.35 mm and the lower central incisor incisal edge moved an average of 2.70 mm.

In the double procedure group, in the horizontal plane, inferior labial sulcus showed a mean change of 6.50 mm and pogonion of 8.2 mm. In the vertical pogonion soft tissue had a mean change of 4.0 mm and B point changed by 5.90 mm.

For the genioplasty patient the soft tissue point with the highest change respective to Na-Pog. plane was pogonion soft tissue with 7.6 mm. Pogonion hard tissue demonstrated a change of 7.6 mm, having a 1:1 ratio of hard-soft tissue change. In the vertical plane glabella had a 3.7 mm change and B point had 8.3 mm of change. In this patient the change in glabella is considered as an error of location, since the surgery does not affect this area of the face.

In the maxillary impaction group, horizontally, labrale superior had a mean change of 4.52 mm and superior incisor incisal edge changed -2.43 mm. In the vertical component pogonion soft tissue showed a mean change of 4.64 mm and B point a change of 6.5 mm.

Finally for the mandibular setback group pogonion soft tissue had a mean change of 3.5 mm in the horizontal plane, and B point had a -5.2 mm change. In the vertical vector inferior labial sulcus had a mean change of 3.84 mm and B point one of 4.27 mm, resulting in a hard to soft tissue ratio of 1.1:1.

II Esthetic assessment

The results of the esthetic evaluation are shown in appendix C and F.

Each judge made an evaluation of the 20 patients, before and after surgery (40 profiles) twice. For judge A, in his first and second evaluation 16 of 20 (80%) had an improvement with surgery; 1 of 20 (5%) had a negative change in the first evaluation, but none was worse in his second assessment; and 3 of 20 (15%) had no change in the first evaluation, while 4 of 20 (20%) remained unchanged in the second. For judge B, 14 of 20 (70%) had an improvement in the first evaluation and 16 of 20 (80%) in the second; 1 of 20 (5%) had negative change in the first assessment and 2 of 20 (10%) remained equal in the first and second evaluation respectively. For Judge C, 12 of 20 (60%) and 15 of 20 (75%) had an improvement in the first and second evaluation respectively; 5 of 20 (25%) had negative change in the first and second assessment; and 3 of 20 (15%) remained the same in the first evaluation while none did so in the second time. For Judge D, 16 of 20 (80%) and 14 of 20 (70%) improved with the orthognathic surgery the first and second time respectively; 1 of 20 (5%) got worse in both occasions; and 3 of 20 (15%) remained the same in the first evaluation while 5 of 20 (25%) did so in the second assessment. Finally, for Judge E, 12 of 20 (60%) demonstrated improvement in the first evaluation and 13 of 20 (65%) did so in the second; 2 out of 20 (10%) and 3 of 20 (15%) became worse in the first and second time respectively; and 6 of 20 (30%) remained the same in the first assessment while 4 of 20 (20%) remained unchanged in the second.

It can be noticed from this, that the majority of the patients improve their facial profile with the orthognathic surgery (particularly the ones that had an unacceptable profile to start with). Those that have an acceptable profile remain the same or get worse with the surgery. As a conclusion from the results, those patients that have good profiles may be better to finish them with compromised results without affecting function, rather than obtain worse results in esthetics trying to improve the occlusion. "Nobody dies of malocclusion."

A correlation of all judges, between the first and second evaluation was also performed to assess their consistency in evaluating the profiles. For judge A the correlation was 0.79, for judge B was 0.64, for judge C was 0.86, for judge D was 0.82 and for judge E was 0.89, showing all a high correlation that can be translated as good "Judge consistency".

Finally a "Z test" was done to test the null hypothesis in both occasions (the first and second evaluation) and also a combination of both. The test showed to be highly significant at the 0.05 level, showing -6.40, -5.84 in the first and second evaluation respectively, and -6.99 in the combination of both assessment. So the null hypothesis is rejected (no change) accepting the alternative hypothesis which means that the patients did change with the surgery (refer to esthetic assessment to see the % of improvement by judges).

SUMMARY AND CONCLUSION

The material for this investigation comprised nine men and 11 women aged 15-0 to 40-3 years with a mean age of 23-2 years. All patients were selected from the files of the orthodontic department of the O.S.H.U., and all had facial, skeletal and/or dental discrepancies. All had orthodontic examinations, record, an orthodontic treatment before and after orthognathic surgery in an attempt to improve function and/or esthetics.

The study was done only using lateral cephalograms to obtain the change of the hard and soft tissue landmarks in the vertical and horizontal vectors.

A wilcoxon matched pairs signed rank test was utilized to test the null and alternative hypothesis. The conclusions from the study were: 1) The orthodontist and oral surgeon must evaluate each patient individually due to the great individual variability in the soft-hard tissue response to orthognathic surgery. 2) The analysis of the soft tissue is important for the diagnosis and treatment planning of orthognathic patients. 3) The results confirm the assumption that profiles esthetically acceptable before surgery cannot be improved as considerably as the bad ones. They may even get worse. 4) Configuration and position of the lips is an important consideration in the soft tissue analysis. Those that have an interlabial gap (due to dental protusion and overjet) improve drastically. The change is due to the orthodontic treatment (which moves the incisors posteriorly, thereby changing the position of the lip) in one jaw, and the surgery in the other one, which results in closure of the interlabial gap.

5) The reproducibility of the different hard and soft tissue landmarks, were consistently good in the horizontal and vertical planes. 6) Greater changes were noticeable in the sagittal or horizontal vector. 7) As much as possible it is better to avoid orthognathic surgery in cases that have good facial esthetics to start with. 8) A "Z test" showed a significant change of the profile between the before and after treatment in the lateral headplate's view. The "Z test" did not show the amount or direction of change, but a panel of judges indicated a positive change in the majority of patients. 9) All judges showed a good consistency as evidenced by a high correlation between their own first and second evaluations.

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APPENDIX A

Definition and location of landmarks utilized in the investigation:

I-hard tissue points:

1) Nasion (Na): The most anterior point of the nasofrontal suture on the midsagital plane.

2) A point (A): The deepest point on the curvature of the maxilla between the anterior nasal spine and the maxillary dental alveolus.

3) Maxillary central incisor ($\underline{1}$): The maxillary central incisor's incisal edge.

4) Mandibular central incisor ($\overline{1}$): The mandibular central incisor's incisal edge.

5) B Point (B): The deepest point on the curve of the mandible between pogonion and dental alveolus.

6) Pogonion (Pg): The most anterior point on the hard tissue mandible.

7) Orbitale (Or): The lowest point of the bony orbit.

DERIVED POINTS

8) Sella Turcica (S): Center of bony contour of sella turcica.

9) Porion (Po): The top of the ear rods.

II - Soft tissue points:

10) Glabella (G): The most prominent point in the midsagital plane of the forehead.

11) Pronasale (Pn): The most anterior point on the nose profile.

12) Subnasale (Sn): The most post-superior point on the nasolabial curvature.

13) Superior Labial Sulcus (SLS): The point of greatest concavity in the midline of the maxillary lip between subnasale and labrale superior.

14) Labrale Superior (LS): The most anterior point on the convexity of the upper lip as measured from a perpendicular to frankfort horizontal.

15) Labrale Inferior (LI): The most anterior point on the convexity of the lower lip as measured from a perpendicular to frankfort horizontal.

16) Inferior Labial Sulcus (ILS): The point of greatest concavity in the midline of the mandibular lip between labrale inferior and soft tissue pogonion.

17) Soft tissue pogonion (PgS): The most anterior point on the soft tissue chin outline as determined by a perpendicular line to frankfort horizontal.

Planes:

1) Sella Turcica- Nasion (S-Na): The line connecting the sella-turcica point with Nasion point.

2) Nasion-Pogonion (Na-Pg): The line connecting Nasion point with Pogonion point.

3) Frankfort Horizontal: The line connecting Porion with orbitale point.

FIGURE 1

FIGURE 1

Hard Tissue Landmarks

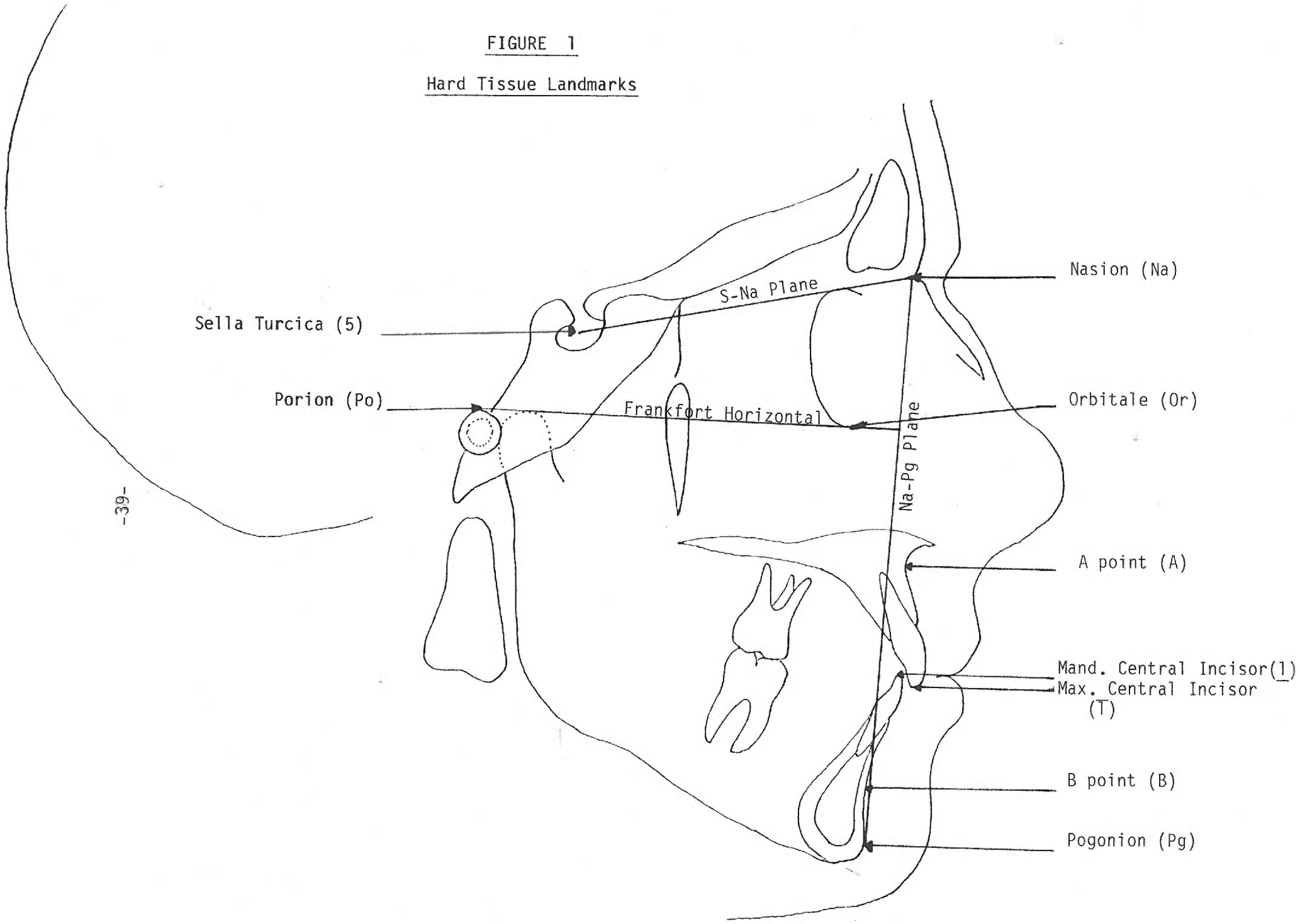
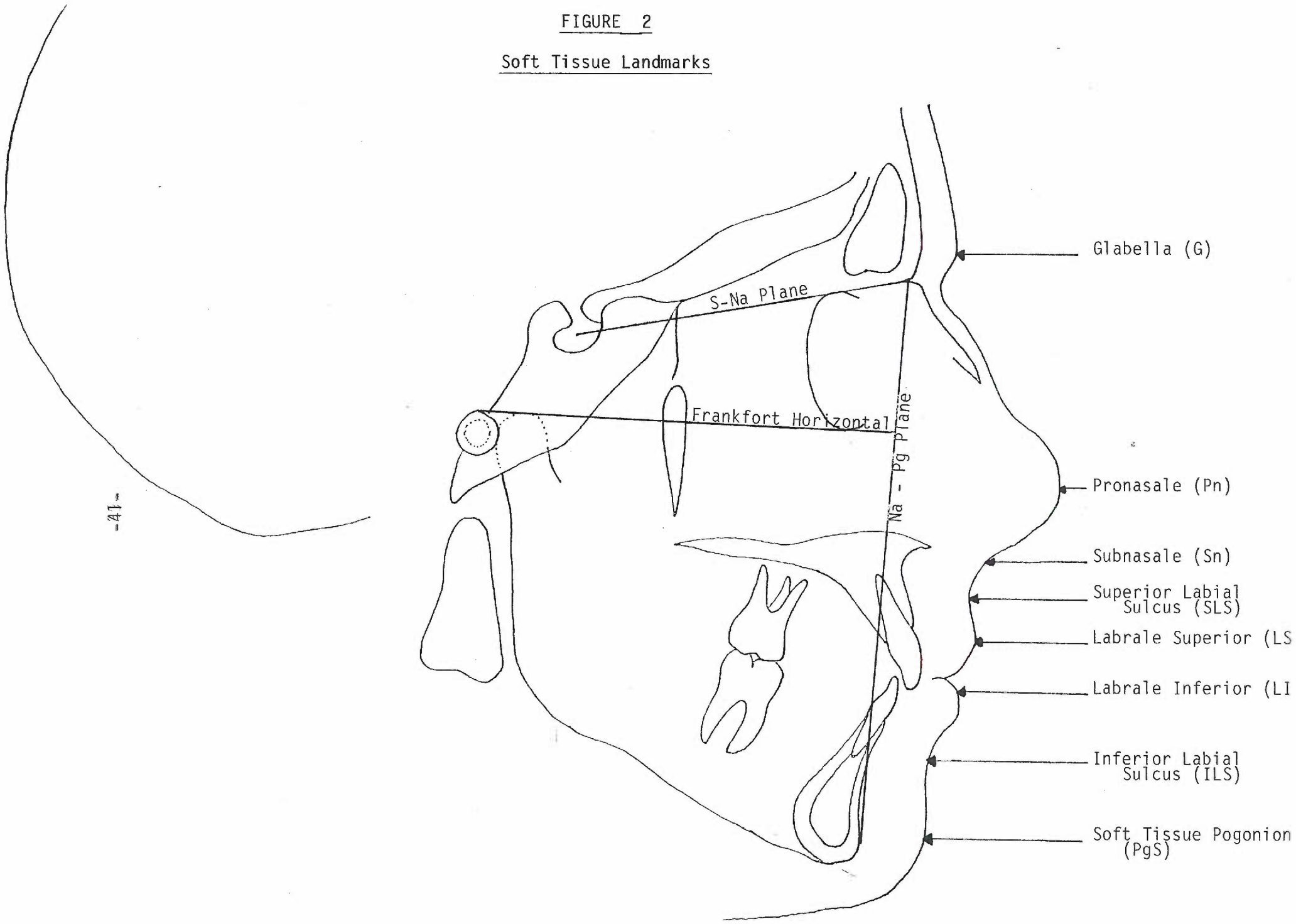


FIGURE 2

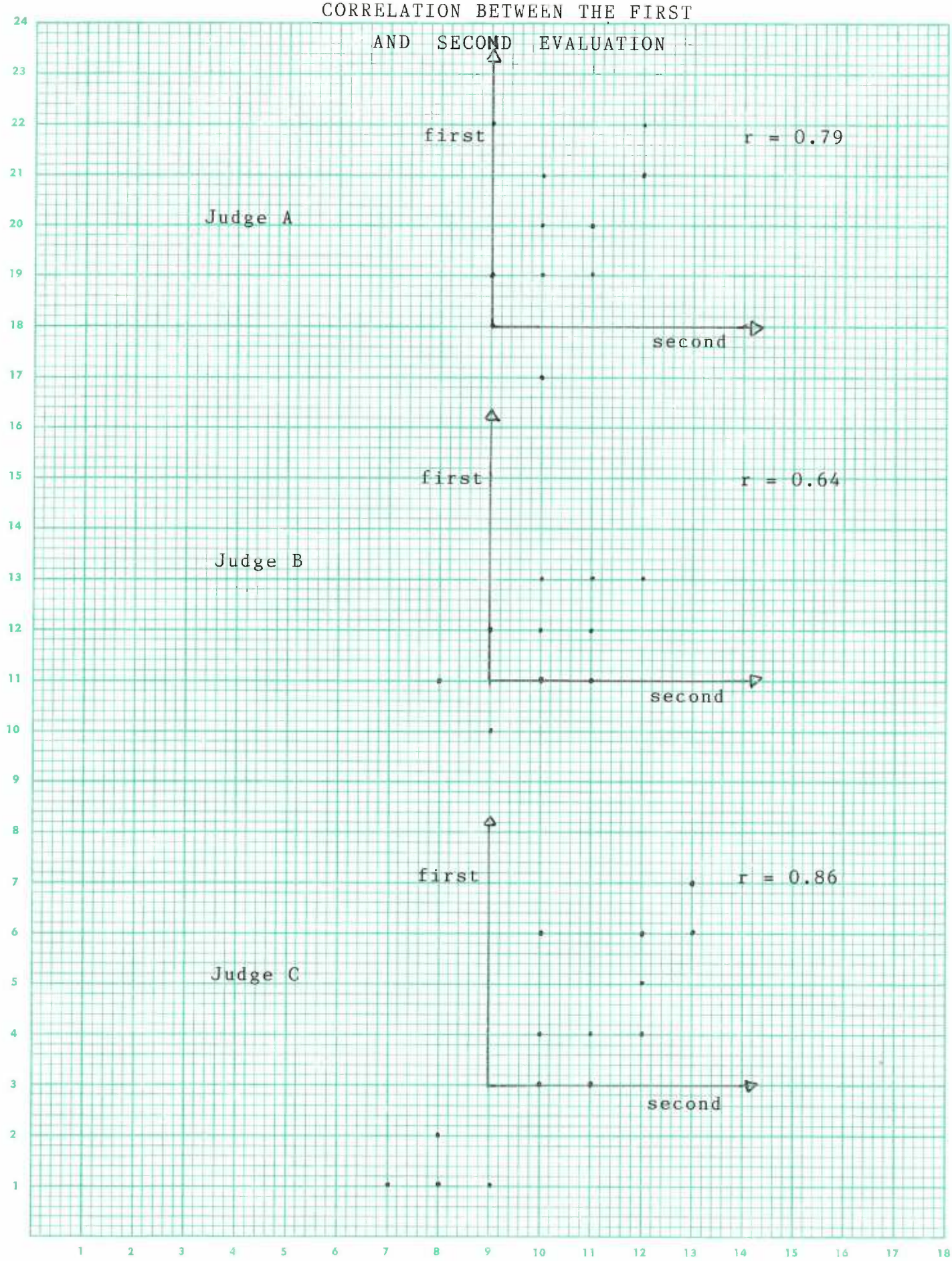
FIGURE 2

Soft Tissue Landmarks



GRAPH 1

CORRELATION BETWEEN THE FIRST AND SECOND EVALUATION



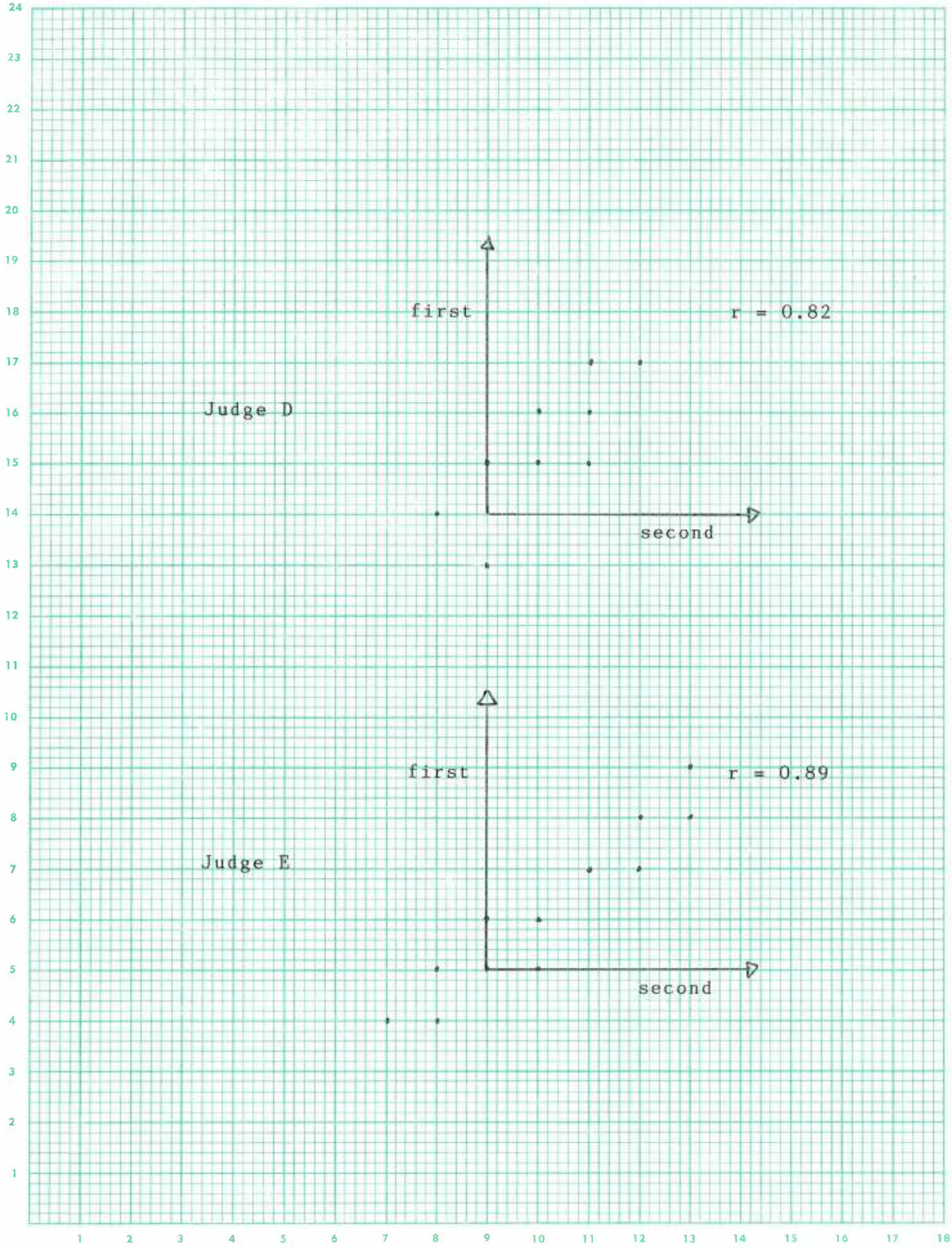

Judge D
first
second
r = 0.82
Judge E
first
second
r = 0.89

TABLE 1

TABLE 1

Percentage of patients with profile improvement

Number of patients with lack of profile improvement

	Percentage of Improvement		Number with Lack of Improvement	
Judge	1st Evaluation	2nd Evaluation	1st Evaluation	2nd Evaluation
A	80	80	1	0
B	70	80	1	2
C	60	75	5	5
D	80	70	1	1
E	60	65	2	3

N = 20

TABLES 2 - 7

TABLE 2

Maxillary Impaction

Relative to Na-Pog.	$\bar{X}$ of Soft tissue changes	$\bar{X}$ of Hard tissue changes	
G	+ 1.46	A	- 0.60
Pn	+ 0.60	$\underline{1}$	- 2.43
Sn	- 0.73	$\overline{1}$	- 1.30
SLS	- 0.83	B	- 2.26
LS	- 1.60	Po	- 1.16
LI	- 1.56		
ILS	- 0.93		
PoS	- 0.90		
Relative to Frankfort			
G	- 0.43	A	+ 6.20
Pn	+ 2.16	$\underline{1}$	+ 3.60
Sn	- 1.10	$\overline{1}$	+ 0.10
SLS	- 0.50	B	+ 6.10
LS	- 2.10	Po	- 0.30
LI	+ 2.26		
ILS	+ 1.63		
PoS	+ 0.08		

TABLE 3

Double Procedure

Relative to Na-Pog.	$\bar{X}$ of Soft tissue changes	$\bar{X}$ of Hard tissue changes	
G	+ 0.00	A	- 0.55
Pn	+ 0.00	$\underline{1}$	- 4.65
Sn	- 1.75	$\overline{1}$	+ 3.60
SLS	- 1.25	B	+ 5.55
LS	- 3.65	Po	+ 7.30
LI	- 0.25		
ILS	+ 6.50		
PoS	+ 6.10		
Relative to Frankfort			
G	- 1.00	A	+ 3.00
Pn	+ 1.30	$\underline{1}$	+ 3.45
Sn	+ 2.25	$\overline{1}$	+ 3.80
SLS	+ 0.90	B	+ 4.45
LS	- 0.90	Po	+ 1.70
LI	+12.35		
ILS	+ 3.00		
PoS	+ 4.00		

TABLE 4

Mandibular Setback

Relative to Na-Pog.	$\bar{X}$ of Soft tissue changes	$\bar{X}$ of Hard tissue changes	
G	- 0.66	A	+ 0.73
Pn	+ 0.74	$\underline{1}$	+ 1.22
Sn	+ 0.17	$\overline{1}$	- 3.51
SLS	- 0.13	B	- 5.23
LS	- 0.64	Po	- 4.60
LI	- 2.87		
ILS	- 5.31		
PoS	- 4.56		
Relative to Frankfort			
G	- 0.96	A	- 0.70
Pn	- 0.86	$\underline{1}$	+ 0.52
Sn	- 0.24	$\overline{1}$	+ 1.94
SLS	- 0.17	B	+ 4.27
LS	+ 1.29	Po	+ 1.69
LI	- 0.70		
ILS	+ 1.17		
PoS	+ 1.60		

TABLE 5

Mandibular Advance

Relative to Na-Pog.	$\bar{X}$ of Soft tissue changes	$\bar{X}$ of Hard tissue changes	
G	+ 0.17	A	- 0.39
Pn	+ 0.19	$\underline{1}$	- 4.44
Sn	- 1.54	$\overline{1}$	1.94
SLS	- 1.66	B	2.39
LI	- 0.20	Po	4.10
ILS	+ 2.83		
PoS			
Relative to Frankfort			
G	+ 0.69	A	- 2.35
Pn	- 1.03	$\underline{1}$	- 1.35
Sn	- 1.49	$\overline{1}$	- 4.40
SLS	- 2.36	B	- 1.93
LS	- 1.42	Po	- 3.95
LI	+ 0.70		
ILS	- 1.99		
PoS	- 1.30		

TABLE 6

Genioplasty

Relative to Na-Pog.	$\bar{X}$ of Soft tissue changes	$\bar{X}$ of Hard tissue changes	
G	+ 0.40	A	+ 1.80
Pn	+ 2.50	$\underline{1}$	- 2.10
Sn	+ 3.30	$\overline{1}$	+ 2.20
SLS	+ 7.20	B	+ 1.10
LS	+ 2.00	Po	+ 7.60
LI	- 5.00		
ILS	+ 4.80		
PoS	+ 7.60		
Relative to Frankfort			
G	+ 3.70	A	+ 3.00
Pn	+ 3.20	$\underline{1}$	+ 0.70
Sn	+ 3.30	$\overline{1}$	+ 2.60
SLS	+ 0.90	B	+ 8.30
LS	+ 2.50	Po	- 2.00
LI	+ 3.10		
ILS	+ 1.50		
PoS	- 2.50		

TABLE 7

Relative to Na-Pog.	S.E.Meas. for Soft tissue landmarks
G	0.38
Pn	0.37
Sn	0.28
SLS	0.28
LS	0.36
LI	0.77
ILS	0.51
PoS	0.34
Relative to Frankfort	
G	1.19
Pn	0.27
Sn	0.62
SLS	0.48
LS	0.56
LI	0.71
ILS	0.94
PoS	1.06

S.E.Meas. horizontal plane = 0.41 mm
S.E.Meas. vertical plane = 0.73 mm

Overall S.E.Meas. ($\overline{X}$) = 0.57 mm

FIGURES 3-6

Figure 3

Patient # 1

Before surgery

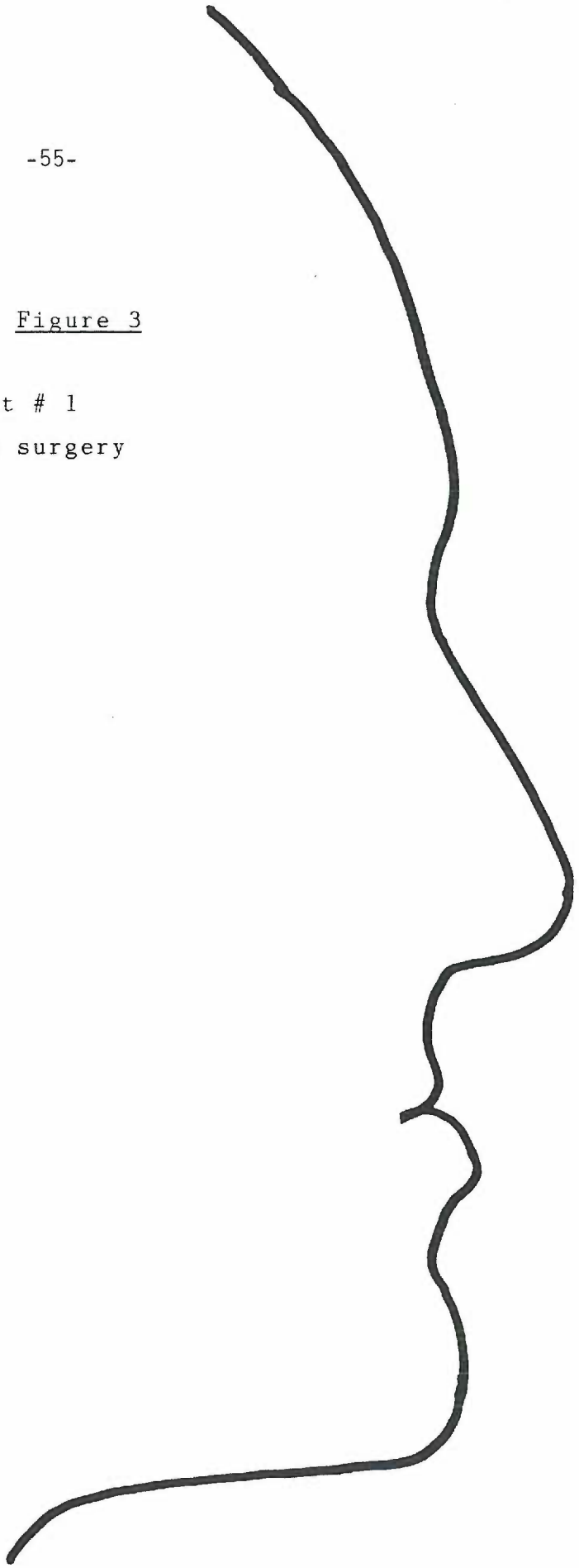


Figure 4

Patient # 1

After surgery

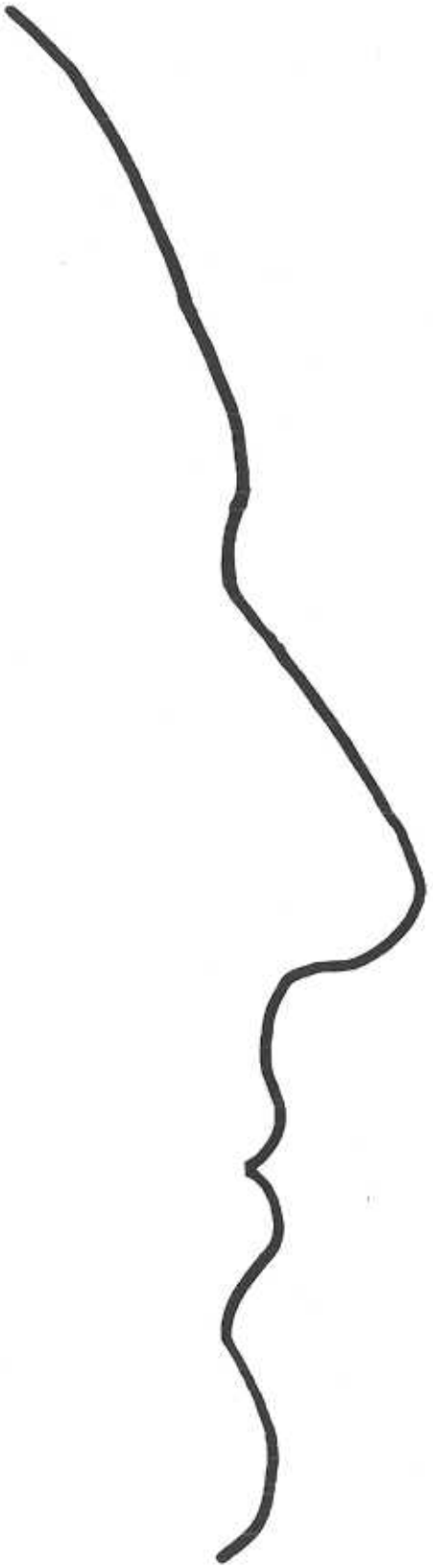


Figure 5

Patient # 2

Before surgery

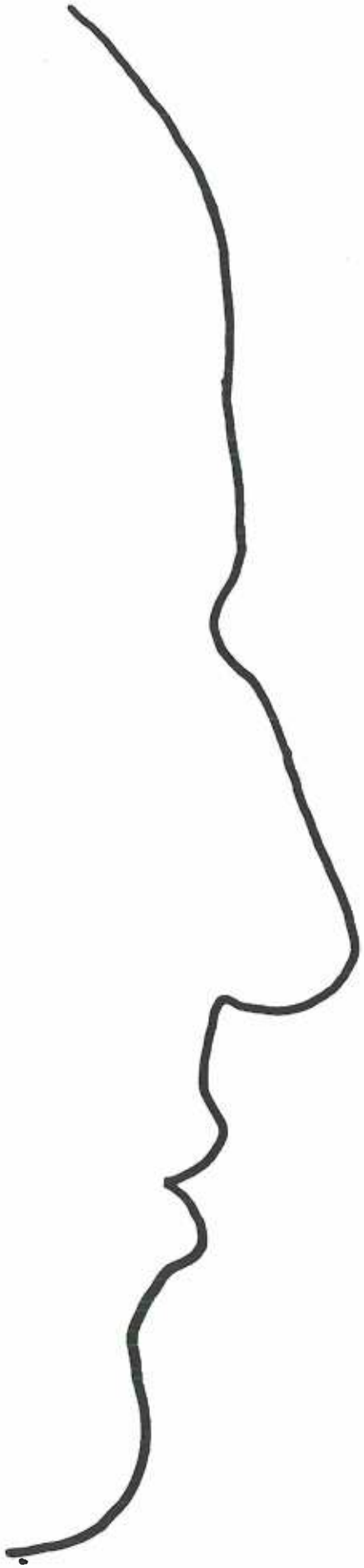


Figure 6

Patient # 2

After surgery