



THE UNIVERSITY OF
SYDNEY

COPYRIGHT AND USE OF THIS THESIS

This thesis must be used in accordance with the provisions of the Copyright Act 1968.

Reproduction of material protected by copyright may be an infringement of copyright and copyright owners may be entitled to take legal action against persons who infringe their copyright.

Section 51 (2) of the Copyright Act permits an authorized officer of a university library or archives to provide a copy (by communication or otherwise) of an unpublished thesis kept in the library or archives, to a person who satisfies the authorized officer that he or she requires the reproduction for the purposes of research or study.

The Copyright Act grants the creator of a work a number of moral rights, specifically the right of attribution, the right against false attribution and the right of integrity.

You may infringe the author's moral rights if you:

- fail to acknowledge the author of this thesis if you quote sections from the work
- attribute this thesis to another author
- subject this thesis to derogatory treatment which may prejudice the author's reputation

For further information contact the University's Copyright Service.

sydney.edu.au/copyright

DIAGNOSIS AND TREATMENT PLANNING OF MAXILLARY
RETROGNATHISM AMONG ADULT CLEFT LIP AND PALATE
PATIENTS INDICATED FOR MAXILLARY OSTEOTOMY.

UNIVERSITY OF SYDNEY

DENTAL DEPARTMENT

Joseph Kwan Sai-Kit
D.M.D. (University of the Philippines)

A thesis submitted in partial
requirement for the degree of
Master of Dental Science

Department of Preventive Dentistry,
Faculty of Dentistry
University of Sydney

1977

ACKNOWLEDGEMENTS

Grateful appreciation is extended to my supervisor, Mr. K. Godfrey (Associate Professor in the Department of Preventive Dentistry, University of Sydney), for his advices, patient guidance and assistance; Dr. J.E. DeB Norman and Professor G. Stacey, for their expert opinions, as well as allowing me access and use of some of their patient records. I feel very privileged to be able to observe and in a way participate in the 'Plastic Surgery Team', with Dr. D. Dey, Dr. A. Pelley and Mr. E. Godfrey. I am grateful also to Mr. P. Ward, Miss B. Bischoff and Mr. B. Van Luyn, of the Photographic Department, for their help in the practical aspects of this presentation. Last but not the least, my special thanks to my wife, Elizabeth, for her patient support and understanding and the typing of this thesis.

October, 1977
Sydney.

Joseph Kwan Sai-Kit
D.M.D.

INTRODUCTION

Facial deformities, particularly maxillary retrognathism or mid-face deficiency, is a growth problem among cleft lip and palate patients. Although it usually manifests itself in a minimal degree, or sometimes even unnoticeable, but through the process of growth and development, some of them do result in gross facial deformity after adolescence. Coupled with the unpleasant scar, which results from surgical closure of the lip, the young adult cleft patients become mentally, emotionally and socially handicapped.

In spite of the fact that a lot of research has been done regarding contributing factors to the growth problem of the mid-face region, as well as improvement through the years of the rehabilitation techniques, there are still some few cleft patients who grow up with severe maxillary deformity, where only surgical correction can restore skeletal balance, occlusal function and esthetic harmony.

The aim of this thesis is to report the design of a systematic method which can be used in orthodontic diagnosis and treatment planning of maxillary retrognathism among adult cleft lip and palate patients who are indicated for maxillary surgery. Through careful quantitative and

qualitative assessment of each patient, the cleft palate team , which consists mainly of the oral surgeon, plastic surgeon and orthodontist, will be able to execute a precise surgical approach for esthetic and functional rehabilitation of these patients.

The diagnostic method presented can later be used for the assessment and evaluation of short and long-term studies of the patients who have undergone maxillary surgery. Furthermore, this method should be able to lend itself in the assessment and treatment planning of other cranio-facial dysostoses (like Crouzon's disease or Apert's syndrome), as well as true mandibular prognathism.

In order to have a better understanding and cooperation by the orthodontists with the rest of the cleft palate team on the possible maxillary surgical approach, the last section of the literature review is on maxillary osteotomies, which in many instances, are indicated for adult cleft lip and palate patients with maxillary deformity.

CONTENTS

	<u>PAGE</u>
PART I . <u>LITERATURE REVIEW</u>	1-124
1. Cleft Lip and Palate .	1-15
1.1. Classification	1-4
1.2. Development of the Palate	5-11
1.3. Mechanism of Cleft Formation	12-15
2. Etiology of Maxillary Retrognathism Among Cleft Lip and Palate Patients	16-41
2.1. Introduction	16-17
2.2. Inherent Deficiency of Tissue Among Cleft Lip and Palate Patients	18-19
2.3. A Deficiency of Growth Potential of the Tissue Among Cleft Lip and Palate Patients	20-21
2.4. The Nefarious Effect of Surgery	22-34
2.5. Malalignment of the Structures During Growth	35-40
2.6. Summary	41
3. Morphology of Adult Repaired Cleft Lip and Palate Patients	42-57
3.1. Introduction	42
3.2. Facial Height	43
3.3. Cranial Base	44-45
3.4. Zygomatic Area	46
3.5. The Maxilla	47-48
3.6. The Mandible	49-51
3.7. The Nose	52-54
3.8. The Profile	55-56
3.9. Summary	57
4. Diagnosis and Treatment Planning for Surgical Correction of Maxillary Retrognathism Among Cleft Lip and Palate Patients	58-86
4.1. Introduction	58-60
4.2. Clinical Assessment	61-64
4.3. Photographic Assessment	65-67

	<u>PAGE</u>
4.4. Cephalometric Analysis	68-78
4.5. Model Study and Model Surgery	79-82
4.6. Profile Evaluation and Prediction	83-85
4.7. Summary	86
5. Treatment of Maxillary Retrognathism Among Cleft Lip and Palate Patients	87-124
5.1. Introduction	87-88
5.2. Pre-surgical Orthodontic Treatment	89-90
5.3. Indications and Contra-indications for Maxillary Osteotomy Among Cleft Lip and Palate Patients with Maxillary Retrognathism	91-93
5.4. Maxillary Osteotomy for Adult Cleft Lip and Palate Patients with Maxillary Retrognathism	94-113
5.5. Relapse after Maxillary Osteotomy in the Correction of Maxillary Retrognathism Among Adult Cleft Lip and Palate Patients	114-121
5.6. Soft Tissue Changes in Relation to Movement of Hard Structure in Maxillary Osteotomy	122-123
5.7. Summary	124
PART II . <u>PRESENTATION OF THE METHOD TO FORM A QUANTITATIVE ASSESSMENT FOR THE DIAGNOSIS AND TREATMENT PLANNING OF MAXILLARY RETROGNATHISM AMONG ADULT CLEFT LIP AND PALATE PATIENTS INDICATED FOR MAXILLARY OSTEOTOMY</u>	125-142
1. Introduction	125
2. Cephalometric Assessment	126-136
2.1. Bolton Standard Analysis	126-131
2.2. Sassouni's Archial Analysis	132-136
3. Model Study	137-139
3.1. Introduction	137
3.2. Method for Model Surgery	137-139

	<u>PAGE</u>
4. Profile Assessment	140-141
4.1. Introduction	140
4.2. Method for Profile Prediction	140-141
5. Summary	142
PART III. <u>PRESENTATION AND 'PROGRESS EVALUATION'</u> <u>OF SEVEN CASES USING THIS METHOD FOR</u> <u>DIAGNOSIS AND TREATMENT PLANNING OF</u> <u>MAXILLARY RETROGNATHISM AMONG ADULT</u> <u>CLEFT LIP AND PALATE PATIENTS INDICAT-</u> <u>ED FOR MAXILLARY OSTEOTOMY</u>	143-205
Case 1	143-151
Case 2	152-160
Case 3	161-169
Case 4	170-178
Case 5	179-187
Case 6	188-196
Case 7	197-205
PART IV . <u>DISCUSSION</u>	206-217
1. Comparison Between the Suggested Treatment Approach Based on Assessment made in This Study and the Surgeon's Decision	209-211
2. Nasal Height	211
3. Changes in S-N-A Angle and Facial Convexity (N-A-P), Before and After Surgery	211-213
4. Comparison Between Findings from Bolton Standard Analysis and Sassouni Archial Analysis	213-214
5. Planes Used to Locate Center "O" in Sassouni Archial Analysis	214-215
6. Ratio of Soft Tissue Changes to Bony Movement	215-216
7. Maxillary Osteotomy	216-217
PART V . <u>SUMMARY</u>	218

PAGE

PART VI. CONCLUSION

219

BIBLIOGRAPHY

220-241

PART I

LITERATURE REVIEW

1. CLEFT LIP AND PALATE

1.1. Classification

There are various systems for classifying cleft lip and palate cases. To facilitate discussion, the following is a brief review of some methods of classification.

Up to about fifteen to twenty years ago, the most popular systems were those of Veau (1934)²³¹ and Davis and Ritchie (1922)⁴⁴.

Veau (1934)²³¹ described four types of cleft :

Group I : Cleft of the soft palate only.

Group II : Cleft of the hard and soft palate to the incisive foramen.

Group III : Complete unilateral cleft of the soft and hard palate, and the lip and alveolar ridge on one side.

Group IV : Complete bilateral cleft of the soft and hard palate, and the lip and alveolar ridge on both sides.

Davis and Ritchie (1922)⁴⁴, who based their system on the location of the cleft relative to the alveolar process, used three major headings with some sub-divisions under each.

Group 1 : Pre-alveolar Cleft - Lip cleft only with sub-division for unilateral, median and bilateral.

Group 2 : Post-alveolar Cleft - Degrees of involvement of the soft and hard palates could be specified, up to the alveolar ridge (submucous cleft could also be included).

Group 3 : Alveolar Cleft - Complete cleft of the palate, alveolar ridge and lip with sub-division for unilateral, median and bilateral.

Pruzansky (1950)¹⁷⁵ described a large series of newborns with clefts and he stressed the need for an anatomically accurate means for describing clefts of the lip and palate in the newborn child. He proposed a classification with only three major headings.

- (1) Cleft of the lip,
- (2) Cleft of the lip and cleft palate, and
- (3) Cleft of the palate.

He considered a separate specification of alveolar cleft unnecessary because of the constant relationship of the lip and alveolar cleft.

In 1958, Kernahan and Stark (1958)¹⁰² proposed a new classification for cleft lip and palate with a morphological concept based on embryological patterns. In their classification, the terms 'primary' and 'secondary' palate are frequently used.

'Primary' palate in embryological sense means the premaxillary, triangular median anterior portion of the palate and lip proper.

'Secondary' palate involves the hard and soft palate. The incisive foramen with a bilateral fissure entering the interproximal space between maxillary lateral inci-

sor and canine is the junction between the primary and secondary palate.

This new classification is presented as follows :

(I) Cleft of primary palate only.

(1) Unilateral (right or left)

- (a) Complete
- (b) Incomplete

(2) Median

- (a) Complete (premaxilla absent)
- (b) Incomplete (premaxilla rudimentary)

(3) Bilateral

- (a) Complete
- (b) Incomplete

(II) Cleft of secondary palate only.

(1) Complete

(2) Incomplete

(3) Submucous

(III) Cleft of primary and secondary palate.

(1) Unilateral (right or left)

- (a) Complete
- (b) Incomplete

(2) Median

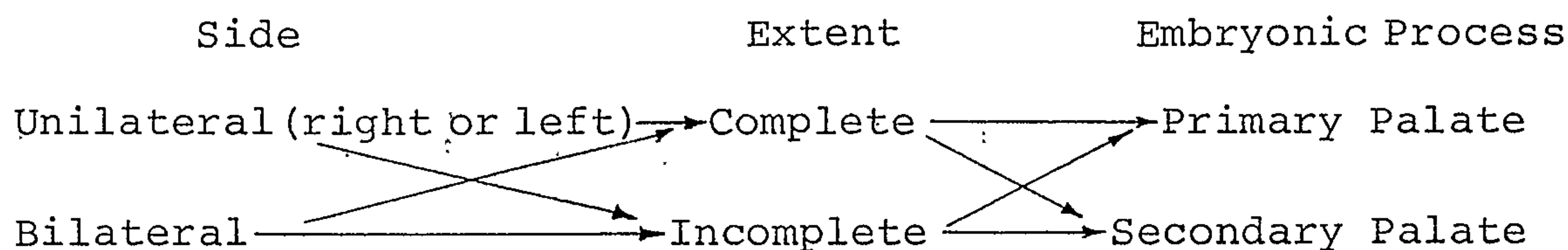
- (a) Complete
- (b) Incomplete

(3) Bilateral

- (a) Complete
- (b) Incomplete

Since median clefts are classified under rare

clefts of the face (Fogh-Andersen, 1968⁵⁸; Matthews, 1971¹⁴⁰), Godfrey (1976)⁷⁴ Sydney University presented a similar and yet slightly simpler diagrammatic presentation of Kernahan and Stark classification. The following is his contribution :



Godfrey (1973)⁷³ commented, "...this classification although useful, is not adequate to catalogue the varieties of these conditions."

At the time of Kernahan and Stark's publication, the Nomenclature Committee of American Association for Cleft Palate Rehabilitation (now American Cleft Palate Association) was working on the same problem and presented in 1962 another classification similar to Kernahan and Stark's classification. (Harkins et al, 1962)⁸³.

The American Cleft Palate Association's and Kernahan and Stark's classifications probably represent the more satisfactory systems today. Nonetheless, a standardized and universally accepted classification of cleft lip and palate does not as yet exist.

1.2. Development of the Palate

1.2.1. Primary Palate.

The center of the developing facial structure is initially formed by an ectodermal depression known as stomodeum as shown in Fig. 1 (Lungman, 1969)¹²³.

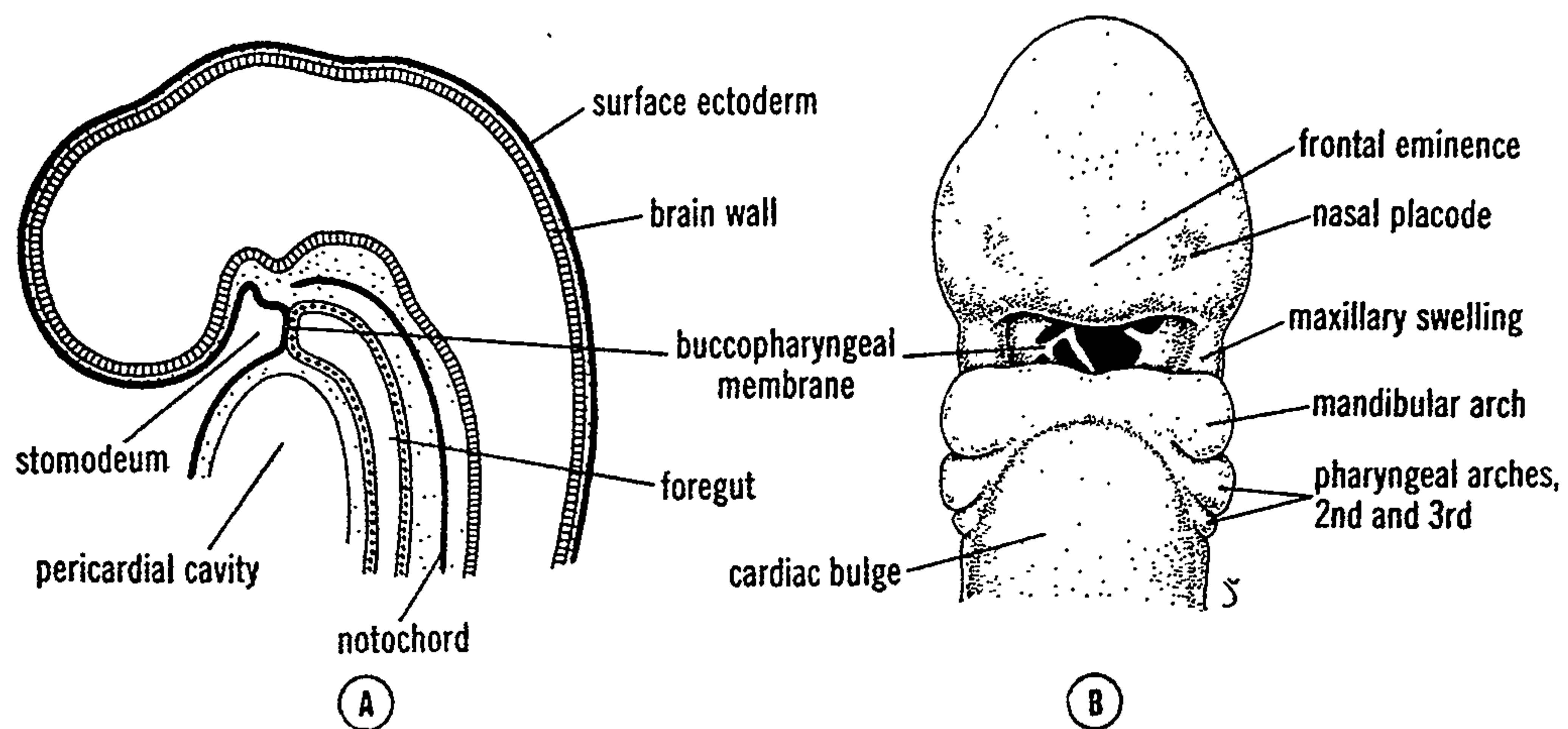


Fig. 1.

- A. Sagittal section through the cephalic end of an embryo of approximately 25 days.
 - B. Frontal view of a slightly older embryo.
- (Lungman 1969).

By the time the embryo is about 4-1/2 week old, the stomodeum is surrounded by a series of elevations form-

ed by proliferation of the mesenchyme. Above the depression is the frontal eminence (forebrain), the first (mandibular) arch below, separating it from pericardium and maxillary processes at the sides. On each side of the frontal prominence, just above the stomodeum is a local thickening of the surface ectoderms, the nasal placode or the nasal pit or olfactory pit.

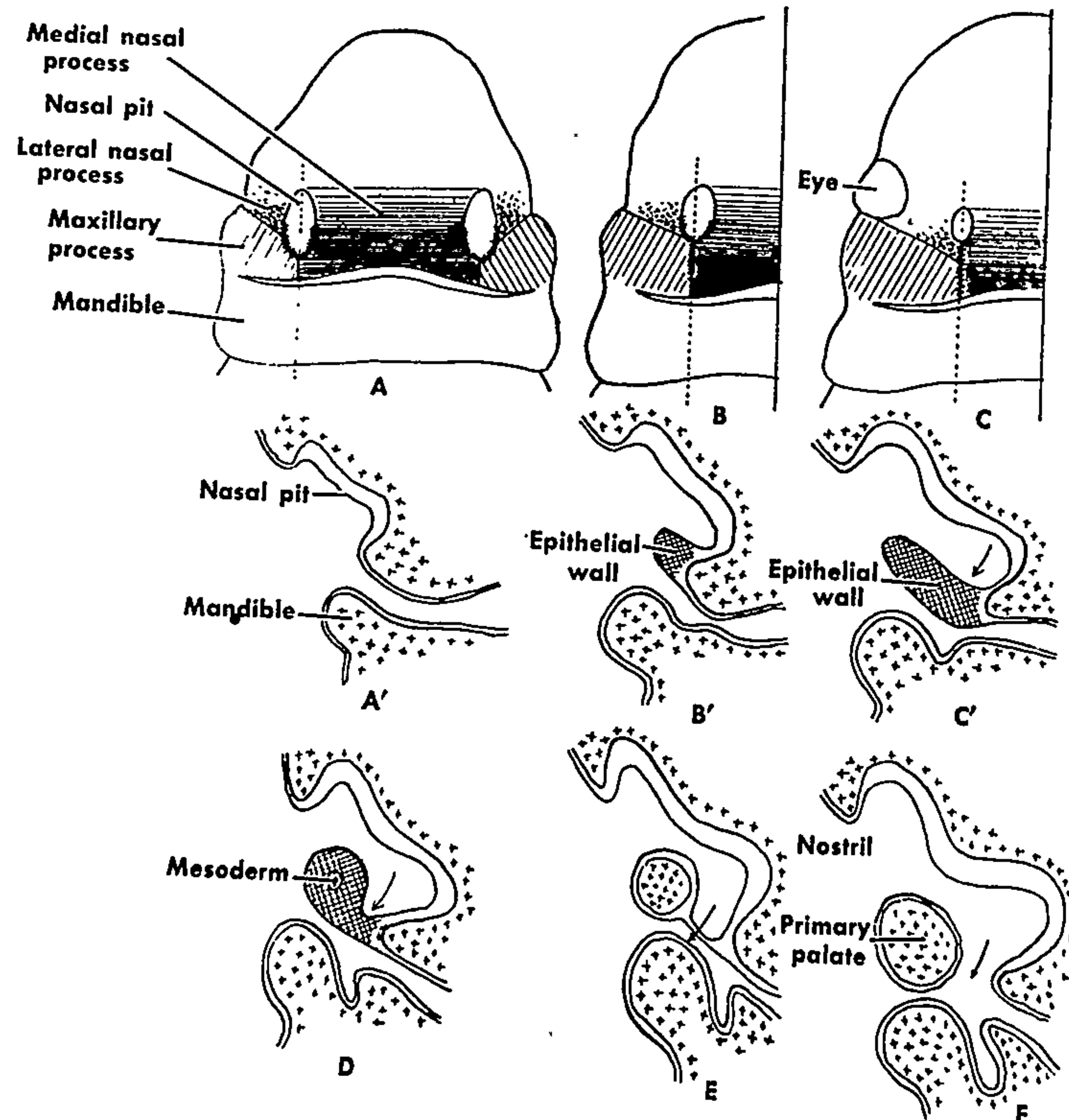
Primary palate is formed at about the fifth and sixth week of the intra-uterine life. The following is a summary of the developing sequences: (Sicher, 1966²⁰⁸; Avery, 1972⁶)

(1) Elevation of the border of the nasal pit along the inferior (caudal) half. Now the nasal pit is formed by (a) medial nasal process, (b) lateral nasal process and (c) the maxillary process (Fig. 2).

(2) The inferior margins of the nasal pit grow towards each other until they touch and unite. This union of lateral and medial borders of the lower portion of the nasal pit is epithelial in nature as shown in Fig. 2, B and C.

(3) Through proliferation of mesoderm (Fig. 2 D), it invades the epithelial lamina and makes this union permanent.

(4) At the blind end of the sac that is formed from the nasal pit, the epithelium is thinned out by growth of adjacent parts and is not replaced by mesoderm (Fig. 2-E). The resulting nasobuccal membrane separates the primitive oral cavity



Different stages in the development of the primary palate
(Sicher 1966).

Fig. 2.

from the nasal sac.

(5) When this membrane ruptures (Fig. 2 F), the nasal sac becomes the olfactory duct leading from the nostril to the opening into the oral cavity, the primary choana. The horizontal bar of tissue is the primary palate.

From the primary palate will develop the following structures :

- (1) the upper lip or prolabium,
- (2) the gnatho-gingival component within which develop the premaxillary portion of the upper jaw carrying the incisor teeth, and
- (3) the palatal component or primary medial palatal process. This medial palatal primordium is continuous with the most rostral portion of the nasal septum.

The term primary palate has had a rather widespread use among clinicians partly because Kernahan and Stark (1958)¹⁰² use this term in their system of classification of cleft lip and palate. Patten (1971)¹⁶⁸ and Lungman (1969)¹²³ disagree with the use of this term for they believe that the prolabium and premaxillary portion of the upper jaw are not palatal structures. Furthermore, Patten also criticized the use of the term 'prepalate' which is used by the classification from Nomenclature Committee of the American Cleft Palate Association (Harkins, 1962)⁸³, for he thinks it is illogical to call this segment the prepa-

late, when only one of its three components is the median anterior portion of the palate. He prefers to use the term 'intermaxillary' segment to substitute the term primary palate or prepalate.

1.2.2. Secondary Palate.

The secondary palate, which is destined to separate the oral and nasal cavities is formed by union of the two palatine processes or palatal shelves. During the seventh week of intra-uterine life, the maxillary processes proliferate medially. When the palatine processes first develop, the tongue lies between them, and they are directed downward so that their margins lie along the floor of the mouth on each side of the root of the tongue as shown in Fig. 3 (Sicher, 1966)²⁰⁸.

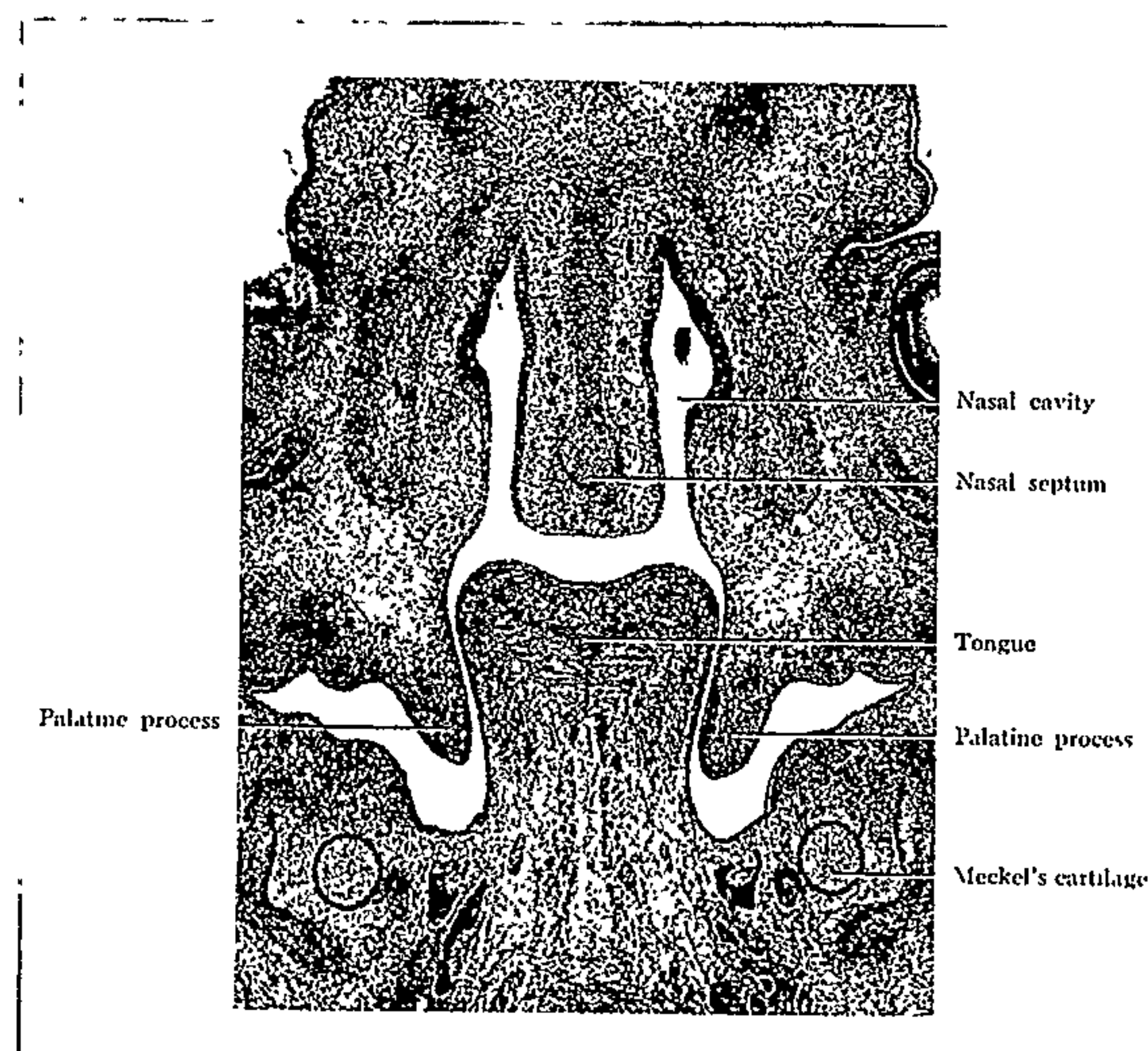


Fig. 3.

The tongue is high and narrow between the vertical palatine processes. (Sicher 1966)

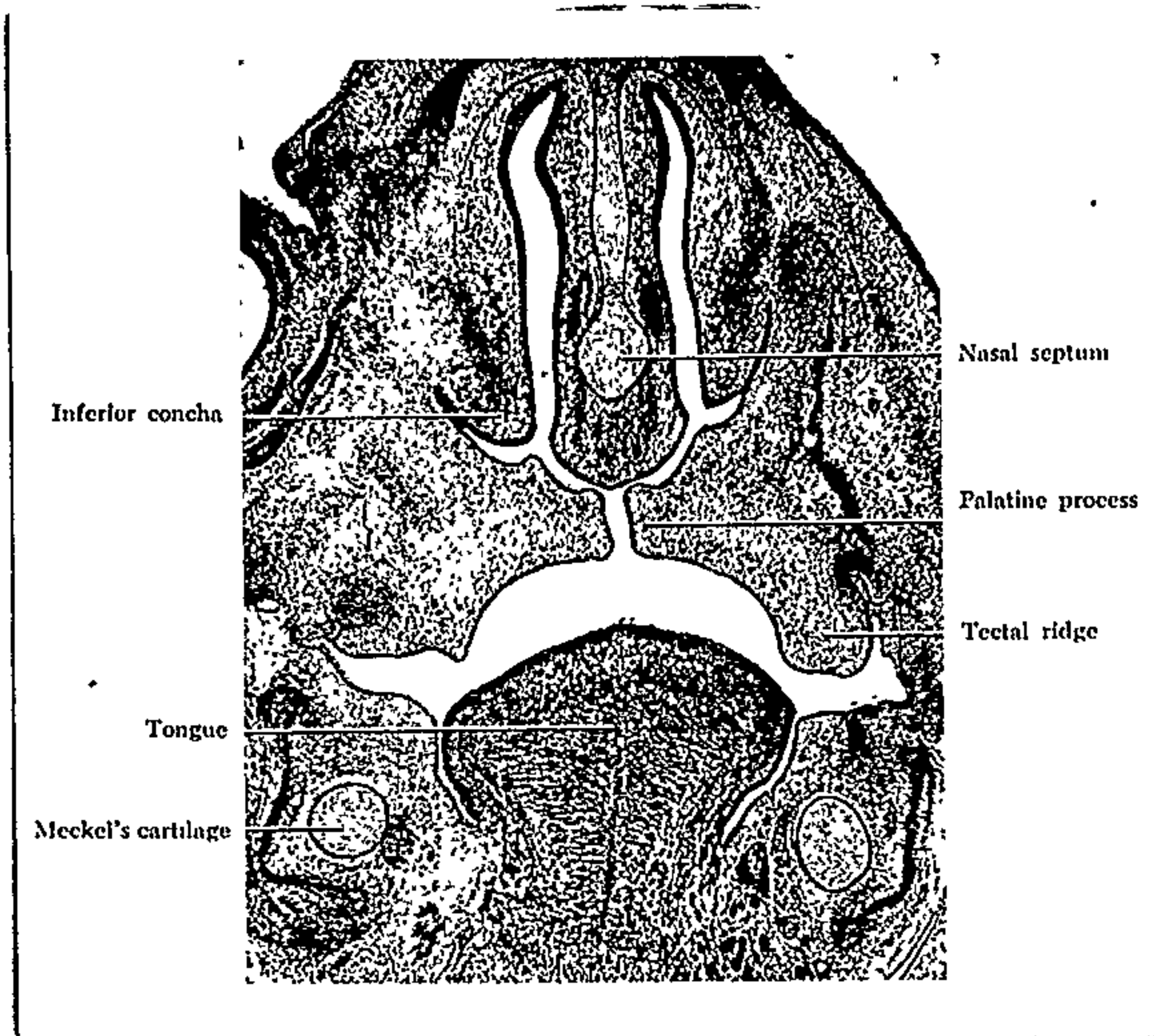


Fig. 4. The tongue has dropped and the palatine processes have fused each other and with the assumed a horizontal position. (Sicher 1966).

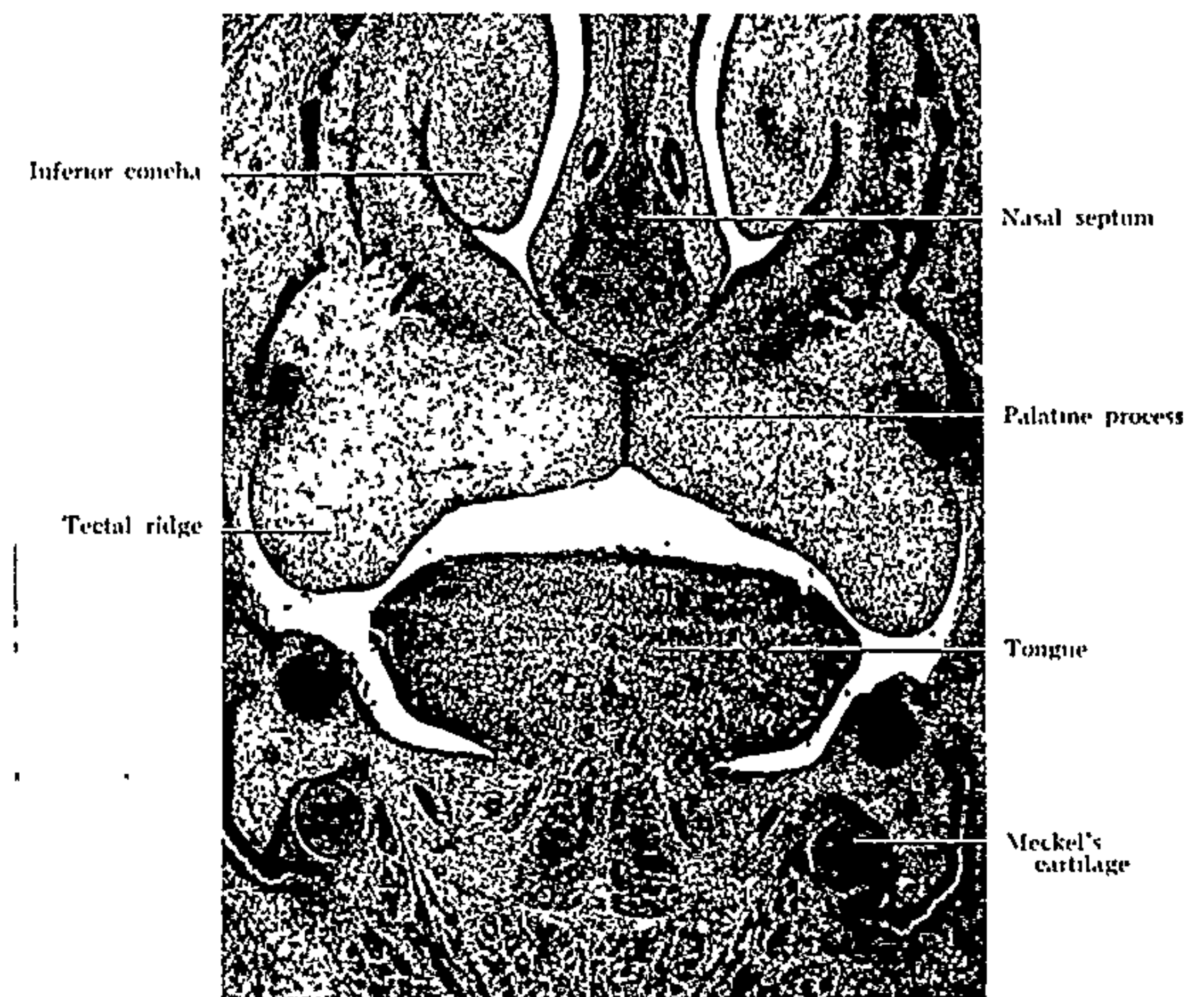


Fig. 5. The palatine processes have fused each other and with the nasal septum. (Sicher 1966).

As development progresses, the position of the tongue is shifted downward and the margins of the palatine processes are free to swing upward and toward the midline. This change in relation between the tongue and the palatine processes is crucial for the completion of the palate as shown in Figs. 4 and 5.

There is still unsatisfactory answer as to what is the prime mover in the change of relations. Zeiler et al (1964)²³⁸ in their animal experiment suggested that this change of relationship was related to 'shelf-force' which is the result of differential growth between maxilla and mandible. This in turn allows the tongue to drop.

Fulton (1957)⁶⁵, Kraus et al (1966)¹¹⁶ and Patten (1971)¹⁶⁸ generally agreed that the withdrawal of tongue from between the palatine processes occur towards

the end of the eighth week. Once the tongue drops down, the palatine processes move up and soon make contact. Thereafter fusion progresses from the rostral part toward the uvula. The anterior portions of the palatine processes are also united with the nasal septum. In the anterior region the hard palate develops. In the posterior region, in which the soft palate and uvula develop, there is no attachment to the nasal septum.

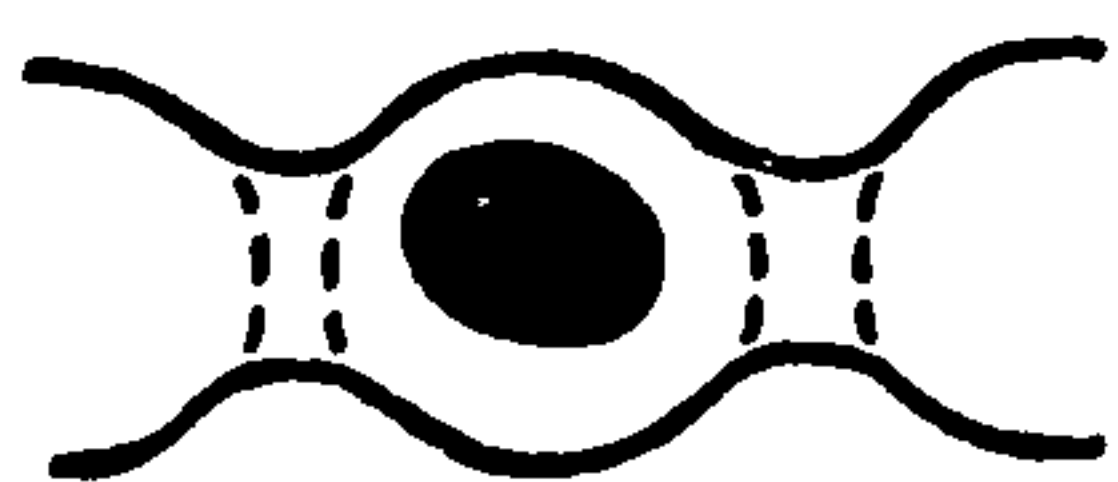
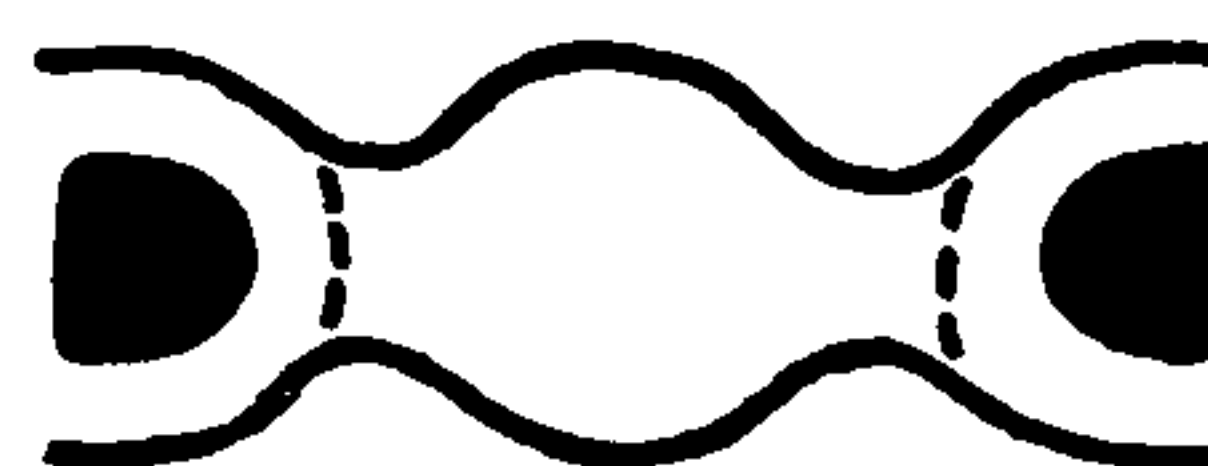
Burdi (1968)²⁷ and Fraser (1967)⁶¹ suggests that lengthening of the soft palate and formation of the uvula is brought about by merging rather than by fusion.

1.3. Mechanism of Cleft Formation

There is a general agreement that cleft of the lip and palate is the result of mal-union of the naso-medial process and maxillary process of the nasal fin in the former and the right and left palatine processes (palatal shelves) in the latter. Based on the 'mesodermal penetration' concept, Fogh-Anderson (1942)⁵⁷, Tondury (1961)²²⁸ and Stark (1954)²¹⁶ proposed that cleft is the result of the separate mesodermal masses which fail to meet and fuse, as a result of which the overlying epithelium is stretched until it is so attenuated that it gives way. Where small amount of mesoderm have met and fused, bridges called Simonart's bands, persist.

Stark (1954)²¹⁶ illustrated his concept of mesenchymal penetration in the development of primary palate as shown in Fig. 6. An epithelial wall exists initially as the anlage of the upper lip, premaxilla and upper incisor teeth. Three mesodermal volumes are located in it, one in the middle area and two laterally. These grow and fuse, forming the normal upper lip, premaxilla and four upper incisor teeth. If one volume of mesoderm is absent, the epithelial wall will rupture and a cleft will occur in that area. The following are the various combinations in cleft formation:

(1) The absence of a lateral volume will result in a uni-

**NORMAL****UNILATERAL HL****BILATERAL HL****MEDIAN CLEFT**

Stark's concept in the development of primary palate and cleft formation. (Stark 1954).

Fig. 6.

lateral cleft lip (Fig. 6 B).

(2) The absence of the two lateral volumes will cause a bilateral cleft lip to occur (Fig. 6 C).

(3) The absence of the median volume will result in a median cleft of the lip, a rare anomaly (Fig. 6 D).

Stark (1954)²¹⁶ suggested that failure in the primary palate occurs between the fourth and seventh week after conception.

Fraser (1968)⁶² discussed several possible mechanisms on the formation of cleft of the secondary palate :

(1) Delayed shelf movement due to decreased palatal shelf force.

(2) Increased tongue resistance.

(3) Lack of downward movement of the tongue from between the shelves.

(4) An abnormally narrow palatal shelf.

(5) Abnormal head width.

(6) Failure of processes fusion.

(7) Post closure reopening.

In one study, Kraus et al (1966)¹¹⁶ showed that nine out of ten fetuses with cleft had horizontally placed palatal processes. In another study, Latham (1967)¹²⁴ observed that most of the cleft palate fetuses in his collection had horizontal processes. These two studies showed that the movement of the palate per se is not critical; rather it is the timing of the palatal movement. Smiley (1972)²¹⁴ stated that delayed movement and delayed contact could possibly upset the timing for programmed epithelial cell death or epithelial degeneration which could be critical to the timing of epithelial contact or adherence. Post-closure reopening may be due to presence of epithelial rests in the midline which may develop into cysts and rupture. Burke et al (1966)²⁸ as well as Scott (1955)²⁰⁵ have observed these

forming at a later stage of intra-uterine growth.

Failure of the secondary palate occurs between seventh-and-a-half and tenth week in-utero (Stark, 1968)²¹⁷. In spite of numerous theories on embryogenesis of cleft lip and palate, none is entirely satisfactory (Patten, 1971)¹⁶⁸. Authors generally agree on a basic fact in clefting which is due to a breakdown in the proliferation process of the embryonic mesenchyme. A thorough understanding of the process has not been achieved.

2. ETIOLOGY OF MAXILLARY RETROGNATHISM AMONG CLEFT LIP AND PALATE PATIENTS

2.1. Introduction

There is a high incidence of maxillary retrognathism among cleft lip and palate patients. Foster (1959)⁵⁹ examined 200 patients with repaired cleft lip and palate and reported that about 34% of the total patients had maxillary retrognathism. Levin (1963)¹²⁹ studied 847 cleft lip and palate patients and revealed that over half of them had some degree of deficiency in the middle third of the face. Walter (1960)²³², Leech (1958)¹²⁸ and Pognel (1960)¹⁷¹ did surveys of sections of the non-cleft population and they reported an incidence of 11.1%, 9% and 2.7% respectively.

Foster (1962)⁶⁰ and Ross (1970)¹⁸⁸ agreed that retrusion of middle face with inadequate antero-posterior growth of the maxilla was one of the major growth problems among cleft lip and palate population.

Narula and Ross (1970)¹⁵⁸, Shibisaki and Ross (1967)¹⁸⁷, Slaughter and Brodie (1949)²¹³ described this growth aberration as progressive and accumulative in nature.

Pruzansky (1973)¹⁷⁹ believed that ultimate mid-face retrusion or dish-in profile, being so common among cleft lip and palate patients, depends not only on adequate

growth of the maxilla, but also on the pattern of mandibular growth. A small mandible can mask mid-face under-development. Similarly, a large mandible can exaggerate the deformity.

Hagerty (1963)⁸² found that clefts of the soft and hard palate, which do not extend through the alveolar ridge are not usually associated with marked abnormalities of facial contour.

There is still controversy about the contributing factors responsible for the growth disturbance among cleft lip and palate patients. The factors which may contribute to growth discrepancy among cleft lip and palate patients will be discussed under the following headings :
(Converse, et al 1964)³⁸

- (1) Inherent deficiency of tissue among cleft lip and palate patients;
- (2) A deficiency of growth potential of the tissue;
- (3) The nefarious effect of surgery; and
- (4) Malalignment of the structures during growth.

2.2. Inherent Deficiency of Tissue Among Cleft Lip and Palate Patients

Different opinions are expressed as to whether the defect is purely a lack of fusion or whether there is an underdevelopment of maxillary process.

Avery and Devine (1959)⁷ and Stark (1954)²¹⁶, in their studies on embryogenesis of cleft lip and palate demonstrated that there is evidence of a mild or moderate embryonic deficiency of tissue in the maxillary complex.

Kraus and Ahern (1960)¹¹⁵ believed that there is normal or compensatory growth during the fetal period and that most of the deficiency is eliminated by birth in the majority of cases.

Coupe and Subtelny (1960)⁴² examined 127 unoperated subjects aged 3 years and under, and revealed that there is deficiency of hard palate tissue in three types of cleft involving the hard palate, i.e. the unilateral, bilateral and the posterior cleft palate, with the bilateral clefts exhibiting the greatest deficiency of the three.

Pruzansky (1955)¹⁷⁶, Slaughter and Brodie (1949)²¹³, and Subtelny (1961)²²³ believed that the severe distortion of the maxillary complex noted at birth is due to muscular imbalance. Latham and Burston (1964)¹²⁶ believed that it's due to disturbance in nasal septum growth. These authors re-

fuse to agree with the idea that the distortion of the maxillary complex is due to an intrinsic inadequacy.

Graber (1954)⁷⁹ in his study of a large sample of cleft lip and palate patients concluded that there was no intrinsic deficiency of tissue in infants with cleft lip and palate and that without surgery, these individuals would show little or no disturbance in growth.

Summing up, it is most probable that infants with cleft have reasonably normal mid-face development, but with occasional local deficiency of tissue immediately adjacent to the cleft.

2.3. A Deficiency of Growth Potential of the Tissue Among Cleft Lip and Palate Patients

The high incidence of maxillary retrognathism among cleft lip and palate population (see 2.1.) may be the result of diminished growth potential of the palate and nasal septum. It is logical to review some studies on growth among (a) non-operated cleft patients and (b) cleft lip and palate patients who have been operated on their lip alone.

Ortiz-Monasterio et al (1959)¹⁶⁵ in their cephalometric studies of 19 adults with non-operated cleft lip and palate indicated that forward growth of the maxilla is the same or greater than in normal cases. The slightly increased maxillary protrusion can be explained by lack of restraining action effected by the normal muscle continuity of the lip.

The other studies which came to similar conclusion were : Khoo Boo Chai (1971)¹⁰⁴, Graber (1949)⁷⁷, Innis (1962)⁹⁷ and Dahl (1970)⁴³.

There is abundant evidence that maxillary complex grows adequately when a child with cleft lip and palate does not have the palate repaired surgically.

Atherton (1967)⁵ in his study of facial bones in 15 skulls with unoperated cleft palate revealed that the bones on the cleft side achieved a remarkable degree

of development.

Hagerty and Hill (1963)⁸², Herfert (1963)⁹¹ and Mestre et al (1960)¹⁴⁷ studied cleft lip and palate cases who did not have the palate repaired surgically, revealed that the maxillary complex grows adequately.

Unoperated cases and cases with lip repaired alone are not so numerous nowadays because all clefts are usually repaired during early childhood in most parts of the world. Nevertheless, there seems to be a general agreement that these patients have a similar growth potential to normal non-cleft individuals.

2.4. The Nefarious Effect of Surgery

Surgical procedures which may have an effect on the growth of the maxilla are :

- (1) Surgical methods for cleft lip and palate closure.
- (2) Surgical recession of the premaxilla for bilateral complete cleft patients.
- (3) Timing of surgical procedures.
- (4) Primary bone grafting.
- (5) Periosteoplasty.

These will be discussed accordingly under the same headings.

2.4.1. Surgical Methods for Cleft Lip and Palate Closure.

It is universally accepted that it is necessary to correct cleft lip and palate defects by surgery at an early age. Slaughter and Brodie (1949)²¹³ enumerated the following reasons for surgical intervention:

- (1) The desirability of separating the nose and mouth cavities in order that the child might develop normal breathing habits.
- (2) The prevention of the return of food through the nose and the promotion of easier feeding.
- (3) The establishment of normal physiological function of the nose in order to assure normal development and to minimize mid-ear infection.

(4) Improvement of the appearance of the face.

During the early years of this century, Brophy (1923)²² stated that there was no deficiency of the tissue at birth and that the maxilla tended to separate as growth continued. He believed that the tongue forced the two segments apart and also that the lower jaw, bearing on the inclined plane of the upper jaw, aggravated this process. Brophy therefore praised early operations, performed as soon as possible after birth. He used wire and lead plate to pull the two halves of the upper jaw together and claimed that a normal palate would result. He believed that the deformity which developed shortly afterwards was only a temporary phenomenon and that later the maxilla and teeth grew normally.

In the middle of this century, some of the results from Brophy's technique appeared in the literature. Slaughter and Brodie (1949)²¹³ concluded that improper and repeated surgery can and does inhibit growth. They considered that the interference is directly proportional to the amount of injury and to the diminution of blood supply to the parts concerned.

Graber (1949)⁷⁸ reported a cephalometric study of 175 cleft palate patients and compared them with normal individual. He found that the cleft palate series as a whole had a deficiency pattern of maxillary growth and

that the patients treated surgically had the worst deformities.

Slaughter and Brodie (1949)²¹³ and Graber (1949)⁷⁸ agreed that for patients who had not been subjected to operation, growth had occurred almost normally.

Jolly (1954-55)¹⁰⁰ found that there is restriction of growth in the horizontal plane but not in the vertical direction. He did not believe that diminution of blood supply to the part concerned, as suggested by Slaughter and Brodie (1949)²¹³, to be true. He thought that a large proportion of the blood supply to the very cancellous bone in the upper jaw is never cut off. The mucosa covering the alveoli, the lateral wall of the nose and the lining of the maxillary sinus are not interfered with. The posterior and lateral walls of the maxilla remain untouched, leaving intact the infra-orbital and sphenopalatine arteries, and the posterior superior dental arteries which supply the upper alveolus. He continued that restriction of growth, although serious, can be minimized by performing the simpler and less traumatic types of operation.

Hotz (1973)⁹⁴ observed that unoperated cleft patients clearly show that growth potential of the maxilla kept pace with the mandible. Consequently, pseudo-prognathism, still so common today, has to be attributed to premature inadequate surgical methods.

Jolly (1954-55)¹⁰⁰ and Ross (1970)¹⁸⁸ believed that the growth arrest seems much more likely because of the fibrous tissue which result from the operation. Ross (1970)¹⁸⁸ maintained that there is always a continuum of scar tissue which joins the maxilla, the palatine bone, the pterygoid plate of the sphenoid as shown in Fig. 7, inhibiting the separation of these bones and thereby creating a condition which Ross (1970)¹⁸⁸ termed as maxillary ankylosis. He advised that great care should be practised to reduce scarring across the pterygoid-palatine-maxillary junction.

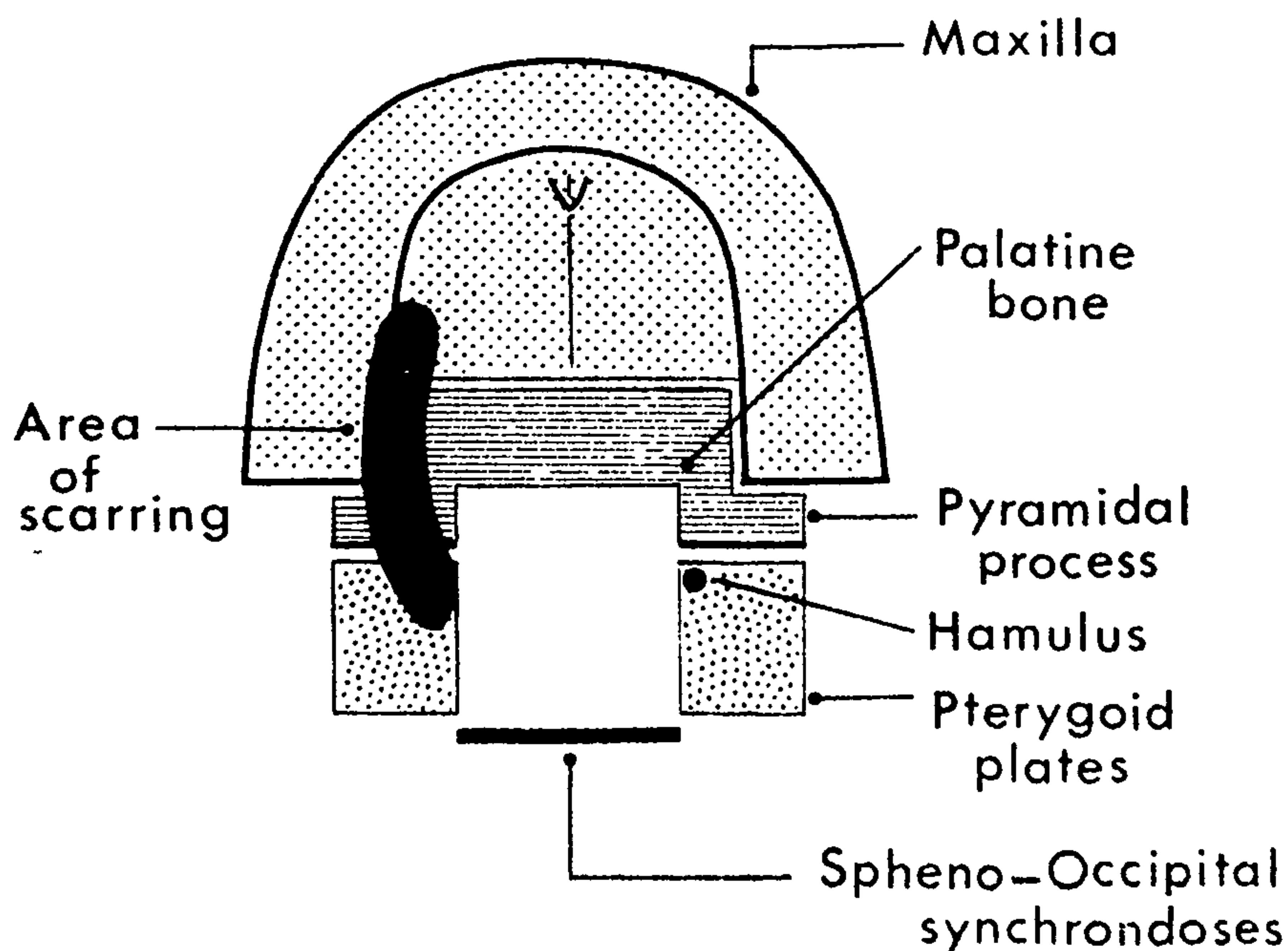


Fig. 7.

Diagrammatic representation of the continuum of scar tissue in a repaired cleft palate which unite the bones of the maxillary complex and pterygoid plates of the sphenoid bone, including a mild maxillary ankylosis. This is fibrous ankylosis, not the true bony type. (Ross 1970).

On the other hand, Pruzansky (1973)¹⁷⁹, Krogman et al (1975)¹²¹ point out that in some way, cleft lip and palate surgery could actually aid or facilitate and direct natural development processes through the re-establishment of more normal forces.

A series of animal experiments carried out by Searl and Biggs (1974)²⁰⁶, Kremenak, Huffman and Olin (1970)¹¹⁹ also support the hypothesis that growth and traumatic surgery are somewhat related.

Aduss (1971)⁴, in one of his growth studies of complete unilateral cleft and palate concluded that the current conservative surgical techniques, based on an understanding of facial growth have invalidated Graber's (1954)⁷⁹ conclusion, "...an indictment of early traumatic surgery which produce considerable facial deformity and functional inadequacy."

2.4.2. Surgical Recession of the Premaxilla Among the Bilateral Complete Cleft Patients.

When the premaxilla is too far anteriorly protruded among the bilateral complete cleft patients, some surgeons advocate surgical recession of the premaxilla (Monroe, 1959¹³⁵; 1970¹³⁶; Matthews, 1952¹³⁹; Friede and Pruzansky, 1972⁶⁴; Browne, 1949²⁶).

The advantages of premaxilla set-back among the bilateral complete cleft patients are : (Matthews, 1952)¹³⁹.

(1) It will help to prevent the maxillary processes from falling inwards and will avoid the creation of the ugly flared alae which so often result from the tension produced in reaching the anteverted premaxilla.

(2) The set-back operation frees the soft tissue element of the premaxilla. This will result in a naso+labial angle which may be sufficient as the child grows to render secondary elevation of the nose tip unnecessary.

(3) If secondary elevation of the nose tip is necessary, premaxilla set-back will certainly make secondary operation easier and perhaps more successful.

There are criticisms about surgical recession of the premaxilla in bilateral complete cleft palate cases (Bauer et al, 1959⁹; 1966¹⁰; Fara et al, 1965⁵³; Glover et al, 1961⁷²; Herfert, 1963⁹¹). Surgical recession will traumatize the nasal septum or vomer bone which is responsible for the forward and downward growth of the maxillary complex (Kremenak et al, 1969¹¹⁷; Latham, 1969¹²⁵; Kiunnsland, 1970¹¹⁰; Sarnat, 1969¹⁹⁶; 1970¹⁹⁴; 1973¹⁹⁵; Scott, 1953²⁰⁴). Furthermore, Latham et al (1975)¹²⁷ were able to show maxillary antero-posterior retardation of growth in all five dogs with surgically placed clefts and extirpation of the vomer within eight weeks.

On the other hand, Moss et al (1968)¹⁵⁴ and Stenstrom and Thilander (1970)²²⁰, demonstrate that the nasal

septal cartilage plays a secondary compensatory role rather than primary morphogenetic one. Bergland and Borchgrevink (1974)¹⁵ observed four rare cleft variants where there is complete disjunction between the nasal septum/vomer and the clinically normal secondary palate, and the occlusal development and facial growth appeared to have attained a final morphology and well within normal ranges of variation.

Browne (1949)²⁶ believes that the reason for the growth arrest in premaxilla set-back is due to excising the anterior part of the vomer instead of 'pre-vomerine' bone. In his view, the essential feature of a push-back operation is to keep the septal excision in front of the suture line between the vomer and the pre-vomerine bone. It is also necessary to free the soft tissues extensively from the premaxillary alveolar element to prevent the nose tip being dragged down as the premaxilla rotates back.

Our experience in premaxilla recession was not as good. Our two cases from Royal Alexandra Children's Hospital showed some sort of mid-face deficiency. This made us refrain from doing more of this type of operation. Moreover, pre-surgical orthopedics can be an alternative to surgical recession (McNeil, 1964)¹⁴⁴.

2.4.3. Timing of Surgical Procedures.

Slaughter and Brodie (1949)²¹³, Graber (1949)⁷⁸,

Jolly (1954-55)¹⁰⁰, pointed out that a large proportion of the maxillary growth occurs in the first five years of life. They advised the repair of the soft palate alone at the age of a few months, and the hard palate at four to five years old.

Hotz (1976)⁹⁵ advocates surgical closure of the lip in unilateral cleft on the fifth to sixth month after birth with similar reasons as those given by Slaughter and Brodie (1949)²¹³. Velar closure is performed at about eighteen months of age for the sake of speech development; hard palate closure is delayed until the sixth to eighth year.

Silla (1970)²⁰⁹ advocated individualized treatment. In cases which show a remarkable width of the maxilla in relation to the mandible, and in these cases neither teloradiography nor lateral view show evident disharmony of the middle third of the face, then all surgical treatment on the palate could be performed at the same time without danger of an accentuated transverse maxillary reduction. In unilateral cleft lip and palate with underdevelopment of the maxilla and the profile of the child is typically pseudo-progenic, then the surgical closure of the anterior palate is advised to be delayed as long as possible.

Ross (1970)¹⁸⁸ thought that from a theoretical

point of view, it would be preferable to postpone surgery until maxillary growth is almost complete, that is, until the age of twelve years or later. At four to six years of age, the child's maxilla has only achieved most of its transverse maxillary growth, not antero-posterior growth. Postponing palatal surgery, he thought, may create a number of additional difficulties particularly in the area of speech development. He suggested the use of atraumatic palatal surgery which could be performed at early age, yet would not interfere with mid-face development.

Robertson and Jolly (1974)¹⁸³ in their study, concluded that there is no significant difference in respect of occlusion or of profile in two groups of children age about fourteen years in which one group had their hard palate repaired at age of eleven months, while in the second group, it was carried out at five years of age.

It seems that it is not the timing of the surgical procedure but rather the nature of the surgery, the technique and the skill of the surgeon, which apparently play a more important role in the growth of the maxilla.

2.4.4. Primary Bone Grafting.

It is important that a distinction be made at the onset of this discussion between bone grafting as a primary procedure and its utilization as a secondary procedure following orthodontic expansion in the adult den-

tition. The present review is confined to bone grafting as a primary procedure among the cleft lip and palate patients.

Nordin and Johanson (1955)¹⁵⁹ and Schmid (1955)²⁰⁰, based on the concept of mesodermal deficiency (Stark, 1954)²¹⁶, originated bone grafting as a primary procedure among the cleft lip and palate patients.

Pruzansky (1964)¹⁷⁷ thought that this concept deserves critical examination for the following two reasons :

(1) He pointed out that Stark's conclusions were drawn from a study of six dead embryos, and the skull of a dead child was not necessarily the skull of a healthy growing child.

(2) There are many examples drawn from the post-natal development to support the contention that deficiencies can diminish with growth.

The aim of primary bone grafting in complete bilateral cleft infants as suggested by Stellmach (1959)²⁰² was to stabilize the mobile premaxilla which was not accessible to orthodontic treatment and otherwise worthless in respect of mastication.

The other purposes of primary bone grafting as suggested by various other authors are :

(1) Creation of new bone matrix for the eruption of teeth

in the cleft area (Johanson, 1966⁹⁹; Longacre, 1966¹³³).

(2) The under padding of the alar base (Coerd, 1970)³⁵.

(3) Stabilization of the lateral tooth-bearing segment and obstruction of maxillary compression (Kriens, 1969¹²⁰).

(4) Normalising or even stimulation of maxillary growth (Longacre, 1966¹³³; Skoog, 1965²¹⁰).

Since then, favorable and unfavorable results about bone grafting appeared in the literature.

Rosenstein (1975)¹⁸⁵ evaluated a group of his patients about ten years of age with orthodontic and early bone grafting procedures, reported that there is no growth alteration in the posterior/anterior dimension. The maxilla, at least to the age observed (6-9 years old) does not appear to have been diminished in growth.

Schmid et al (1974)²⁰¹ advocated bone grafting in selected cases. They utilized primary bone grafting in wide clefts and refrained from performing it in cases of compression between palatine processes.

Nordin et al (1974)¹⁶⁰ reported 39 cases of complete unilateral cleft and 14 bilateral cleft, both with primary and early bone grafting, and observed that 80% of the former and 50% of the latter had an acceptable appearance. Moreover, speech assessment was good and superior to that of non-bone-grafted group of patients.

Kling (1964,¹¹¹; 1966¹¹²) found a striking in-

crease of lateral crossbite (88% increase) and mandibular pseudo-prognathism (58% increase).

Stenstrom and Thilander (1963)²¹⁹ could demonstrate a disturbance in maxillary growth after bone-grafting in animal experiment.

Jolly and Robertson (1972)¹⁰¹ recorded that one-half of all cases with primary bone grafting showed some incisal retrusion with dorsal position of the anterior nasal spine.

Ross (1970)¹⁸⁸ described bone grafting as a procedure which aids the orthodontic placement of teeth and provides greater maxillary stability. He pointed out that bone grafting should have no effect in long term maxillary growth, since the graft is placed in an area where growth does not usually occur. He believed that the critical variable may be the surgical procedure used in repairing the palate, not the placement of bone grafting.

There seems to be a growing consensus that early bone graft is not favorable. But this has to be confirmed by larger numbers of longitudinal studies on maxillary growth subsequent to primary bone grafting.

2.4.5. Periostoplasty.

Instead of bone grafting, Skoog (1965)²¹¹ recommended a periosteal flap to produce adequate amount of new bone over the cleft through a procedure termed peri-

osteoplasty.

The principle of periosteoplasty procedure involves the establishment of periosteal continuity across the cleft utilizing local flaps from the bordering maxillary segment.

Later, the technique was further developed to include the use of oxidized regenerated cellulose (Surgicel) to obtain a large volume of bone to bridge the cleft (Skoog, 1967)²¹².

This technique was proven successful by a number of authors and has been observed in some of our cleft patients in United Dental Hospital, Sydney.

This surgical technique in periosteoplasty was originated and modified in 1965 and 1967, respectively. There is no long term result available as yet with regards to growth. Hellquist (1971⁸⁸; 1973⁸⁹) commented that the results from this technique have been very promising and there is no clinical evidence of retarded growth of that part of the maxilla which was temporarily denuded of periosteum.

2.5. Malalignment of the Structures During Growth

Pre- , Post-surgical orthopaedic and orthodontic treatment are the two long term treatment that may contribute to the growth of the maxilla through alignment of the alveolar segments and teeth among cleft lip and palate patients.

2.5.1. Pre-, Post-surgical Orthopaedics.

McNeil (1956¹⁴²; 1964¹⁴⁴) first advocated treatment by appliances to control the dental arch in early infancy. His aims were:

- (1) To control the position of cleft segment;
- (2) To stimulate bone deposition at the medial extremity of the lesser segment of the alveolar process and palatal shelf of the lesser segment directed towards bridging the clefts; and
- (3) To assist in establishing normal function of sucking, chewing and so making use of the forceful stimuli which these functions provide per medium of his appliance, to the palato-alveolar bone mass.

Hotz (1973)⁹³ regarded early maxillary orthopaedic treatment (pre- and post-surgical orthopaedics) as a series of intermaxillary procedures with the following objectives :

- (1) Normalize functions like feeding, tongue posture and swallowing by providing temporary obturation.

(2) Attempts to guide physiological growth under normalized condition.

(3) Avoid inhibiting effect of primary surgery on maxillary development by creating or maintaining regular intermaxillary relationship.

So her primary objective of early orthopaedics is not to facilitate surgery but to take advantage of the intrinsic developmental potentialities. In her later preliminary report, she concluded that pre- and post-operative orthopaedic care results in good arch alignment and good occlusion in the early mixed dentition (Hotz, 1976)⁹⁵.

Huddart (1967)⁹⁶ suggested that the appliance may minimize the lateral growth of the maxillary arch, in turn, improve the ratio between the amount of tissue present and the area of the cleft to be closed.

Robertson (1971)¹⁸² demonstrated that the use of the appliance restrained the forward growth of pre-maxillary segment while the maxillary element continues to move forward thus reducing anterior cleft width. He stressed that the changes produced are limited in their nature and extent and also that cautious use of orthopaedic treatment might be beneficial.

Pruzansky (1964)¹⁷⁷ claimed that his longitudinal record gives ample evidence that spontaneous improvement over the longer term does occur without resorting to pre-

surgical orthopaedics manipulation. However, he does suggest that pre-surgical orthopaedics may have real value in encouraging medial repositioning of the maxillary halves which are occasionally widely displaced in clefts of the secondary palate. Perhaps, he added, the most unsatisfactory feature of early orthopaedics is that sufficient evidence of its ultimate efficacy has not been obtained.

Rosenstein (1964)¹⁸⁴ stressed that the delay in the age at lip repair, which this treatment necessitated, and the associated parental anxiety were real disadvantages.

Ross (1970)¹⁸⁸ presented three reasons why he cannot accept the fact that early orthopaedics stimulate growth :

(1) It is difficult to understand how infant orthopaedics can alter growth, since they appear to merely tip the maxillary segment slightly.

(2) The benefits that are obtained seem to be limited to the lateral or width dimension of the maxilla, and this is prevention of a relatively minor problem. Antero-posterior growth is the major problem and is probably not affected by infant orthopaedics.

(3) These procedures are carried out at an inappropriate time. Growth problems are insignificant before palatal surgery and thereafter gradually increase in severity to become worse in adolescence.

He concluded that infant orthopaedics are essentially irrelevant to the long term facial growth of the child with a cleft lip and palate.

Another long term study by Graf-Pinthus and Bettex (1975)⁸¹ also concluded that pre-surgical orthopaedic treatment does not seem to offer a consistent or exciting solution to the orthodontic problem but secondary rehabilitation procedures in older patients is almost always unnecessary.

Godfrey (1977)⁷⁵ favors selective use of pre-surgical orthopaedics especially among bilateral complete cleft cases. His purposes of pre-surgical orthopaedics are:

- (1) To apply positional control or active remolding forces to the segments of the cleft alveolus.
- (2) Provide some redirection of functional stress and separation of the tongue from direct influence in the central nasal region and in preventing further separation of the palatal shelves.

In summary, pre-surgical orthopaedics certainly contribute to some extent to the surgical repair of the lip and palate in spite of the fact that its contribution to the growth of the maxilla is doubtful.

2.5.2. Orthodontic Treatment.

The presence of teeth is essential for the existence of alveolar bone and the position and direction of

eruption of teeth influences the size and shape of the oral cavity and foundation for the soft tissue of the infra-orbital part of the face, lip and nose (Quinn, 1973)¹⁸⁰.

By influencing maxillary arch form and attaining overbite in the buccal and labial segment, orthodontic treatment secures the functional unity of the maxilla and mandible which is the best assurance of harmonious growth (Hotz, 1970)⁹².

Coccaro (1969)³³ concluded in his study that as a result of early orthodontic treatment procedures, favorable growth is apparent in malpositioned palatal segments that are initially constricted and impacted.

On the other hand, Ross (1967)¹⁸⁷ disagreed that there is significant growth change resulting from early orthodontic treatment. He concluded in his study that most children with unilateral cleft lip and palate, orthodontic treatment prior to the permanent dentition had no appreciable effect on facial growth pattern.

Early correction of maxillary deformities also bring about significant change in the form of the mandible. This hypothesis was proven to be true by Harvold through a series of animal experiments (1960^{85,86}; 1970³⁰; 1973³¹).

It seems that orthodontic treatment per se is not capable of stimulating growth. Instead, orthodontic

treatment affects growth by achieving a more normal oral and nasal functions and by removing any detrimental factors which are responsible for growth arrest.

2.6. Summary

It is hard to conclude which of the above discussed cleft lip and palate procedures/strategies diminish or stimulate growth of the maxilla. Based on the reports I have gathered here, it seems most authors favor atraumatic cleft lip and palate closure surgery, orthodontic treatment and selective pre-surgical orthopaedics. The other procedures have both favorable and unfavorable reports which are not yet conclusive due to lack of long term longitudinal studies. It takes an extremely long time, 18-20 years, before the result of a primary method can finally be judged. Hotz (1970)⁹² stated , "Every case requires many years of observation since result can be accepted as valid only when growth has ceased. So to gather enough material at a cleft palate clinic may take 5 to 10 years, another 15 to 20 years must be allowed for longitudinal studies. This means that a total of 20 to 30 years may be required to reach conclusive result."

3. MORPHOLOGY OF ADULT REPAIRED CLEFT LIP AND PALATE PATIENTS

3.1. Introduction

To perform the diagnosis and treatment planning of secondary surgical correction for cleft lip and palate patients, it is pertinent to be familiar with their morphologic pattern especially among young adults since this correction is preferably done after active growth becomes static. The reasons for this will be mentioned in 5.5.5. of this review.

It is said that when the cleft is limited to the soft and hard palate, the other parts of the maxilla usually develop within normal limits. Similarly, when the cleft occurs in the lip alone, or in the lip and alveolar process, the effect on the development of the jaw and dentition is very limited. It is the unilateral and bilateral clefts that present the morphologic problem among the cleft adults (Harvold, 1954)⁸⁴. So this review will include more reports on the adult morphologic pattern of the operated unilateral and bilateral adult clefts.

3.2. Facial Height

Graber (1954)⁷⁹ in his study reported that upper facial height (N-ANS) has a wide range among cleft patients. It ranged from a low of 40% of the total facial height to a high of 51% with a mean of 45%. This was compared with a mean of 43.95% for the normal individual.

A later study by Farkas and Lindsay (1972)⁵⁵ reported a similar result, i.e. there is almost no difference in the upper facial height between cleft and non-cleft group.

The lower facial height (ANS-Me) was reported to be significantly higher among the cleft patients (Farkas and Lindsay, 1972)⁵⁵. Graber (1954)⁷⁹ reported that the maxillary height was deficient and the occlusal clearance (free-way space) was excessive. Harvold (1968)⁸⁷, Oblak (1975)¹⁶¹ reasoned that increased lower facial height and steep mandibular plane angle may relate to mandibular posturing from enforced mouth breathing by nasal obstruction (See 3.6.).

Summing up the findings of Graber (1954)⁷⁹, Chapman (1966)²⁹, Ross and Johnston (1972)¹⁹⁰, Farkas and Lindsay (1972⁵⁵; 1973⁵⁶) and Mowbray (1977)¹⁵⁵, they all reported that cleft population usually demonstrate an increase in their total facial height and the increase is often found in the lower third of the face.

3.3. Cranial Base

The cranial base is of particular interest because its morphology may influence the facial structures due to its close proximity. Authors like Gilley (1947)⁶⁷, Graber (1949)⁷⁸, and Ross (1965)¹⁸⁶, observed in their studies that the deformities of cleft are localized in the area of the maxilla which lies below the anterior nasal spine and nasal cavity.

On the other hand, as early as 1928, Wardill²³³ stated that cleft may be associated with 'widespread' structural changes in other parts of the skull and, perhaps even further 'afield'.

Moss (1956)¹⁵² also found that there is marked kyphosis (abnormally increased convexity) of the sphenoid bone associated with clefts.

Ross (1965)¹⁸⁶ and Wepner and Hollmann (1975)²³⁴, both reported a shorter S-N (linear measurement) between cleft and non-cleft children and the differences were found to be 3.5 mm. and 2.5 mm., respectively. The cranial angle (B-S-N) again was found to be smaller between cleft and non-cleft population, and the differences were found to be less by 1.2° and 1° , respectively in both studies.

Furthermore, Ross (1965)¹⁸⁶ concluded in his study the following :

(1) The cranial base is smaller in children with cleft

than in normals. This is probably due to the smaller size of the children and is not a reflection of abnormalities in the cranial base.

(2) The component parts of the cranial base of the cleft children are equally proportional to those of non-cleft children.

(3) The spatial relationships between the components of the cranial base are essentially the same in cleft and non-cleft children.

Other studies like Borden (1953)²⁰, Subtelney (1955)²²² and McNeil (1962)¹⁴³, also found that the anterior cranial base length did not differ much between cleft and normal groups.

In summary, the cranial base does not significantly differ much in size and shape among most of the cleft and non-cleft population.

Wepner and Hollmann (1975)²³⁴ remarked that in spite of the slight shortening of the anterior cranial base, it has no more than a negligible effect on the facial structures.

3.4. Zygomatic Area

There are only few studies on the zygomatic area of the adult cleft lip and palate patients. Nevertheless, these studies mostly revealed that zygomatic area is not much affected among the adult cleft population.

Wepner and Hollmann (1975)²³⁴, Nakamura et al (1972)¹⁵⁷, Aduss and Pruzansky (1967)³, and Harvold (1954)⁸⁴, reported that the bizygomatic distance of cleft patients fell within normal range. Harvold (1954)⁸⁴ concluded in his study that the zygomatic bone is normal inspite of the severe malformation in the maxilla and palatine bone. Moreover, the maxillary sinuses were found to develop normally in a lateral direction. This study was done on a group of twenty-one children, age from three to fourteen years with complete unilateral cleft.

Both the operated and non-operated cleft infants and children were found to have a slightly larger nasal cavity, bony nasopharynx width and bizygomatic maxillary distance, when compared with the control group (Coup and Subtelny, 1960)⁴².

Between both sexes in the adult cleft population, Farkas and Lindsay (1973)⁵⁶ found that the bizygomatic diameter was slightly shorter on both male and female patients in comparison with the control, but only in the male was the difference significant.

3.5. The Maxilla

There is no doubt that the maxilla of the cleft patient is always affected to a certain degree (Bishara and Iverson, 1974¹⁷; Coccaro and Pruzansky, 1965³⁴; Chapman, 1966²⁹; Mowbray, 1977¹⁵⁵). The ultimate facial deformity depends mostly on how much the growth of the maxilla is inhibited.

The growth arrest problem of the maxilla is a localized defect, mainly in the alveolar and palatal process of the lateral part of the maxilla, and also in the mid-section; that is, in the nasal septum and pre-maxilla (Harvold, 1954)⁸⁴.

Graber (1954)⁷⁹ and Ross and Johnston (1972)¹⁹⁰, noted that the growth of the maxilla is possibly deficient in three dimensions, i.e. vertical, antero-posterior and in width.

Evaluation by Wepner and Hollmann (1973)²³⁴ revealed that an average reduction of the S-N-A angle of 3.8° in cleft individual age ten to fourteen years, and 4.3° in adult cleft patients. This included both complete unilateral and bilateral cleft cases. As well, they revealed that Point A of adult cleft patients is displaced dorsally by no more than 1.6 mm. relative to the facial axis (N-Pog). However, relative to the N-S plane, the dorsal displacement amounts to 4.6 mm. The slight dis-

placement of Point A relative to facial axis is accounted for by the dorsal displacement of the chin in cleft subjects (review in 3.6.).

The latest cephalometric finding by Mowbray (1977)¹⁵⁵ revealed similar result, i.e. the maxilla is retruded by 4.4° among children with surgically repaired unilateral complete cleft lip and palate.

The factors that may contribute to the growth of the maxilla were reviewed in section 2.1. They are:

- (1) Inherent deficiency of tissue among cleft lip and palate patients;
- (2) A deficiency of growth potential of the tissue;
- (3) The nefarious effect of surgery; and
- (4) Malalignment of the structures during growth.

3.6. The Mandible

Due to an increase in total facial height and usually a steeper mandibular angle (Gilley, 1947⁶⁸; Harvold, 1960⁸⁶), it is interesting to go through some studies on the general morphology of the mandible among the cleft lip and palate patients.

In the middle of this century, Graber (1949⁷⁶; 1949⁷⁷; 1954⁷⁹) carried out three studies on the skeletal morphology of the cleft lip and palate population. In his first two studies, he concluded that the mandible appeared normal. In his third and larger study, he reported that there is a definite mandibular underdevelopment. Other later studies that support this conclusion are : Ponterio (1952)¹⁷²; Snodgrass (1954)²¹⁵; Tong (1960)²²⁹; Levin (1963)¹²⁹; and Deuseckle and Kalter (1962)⁴⁶.

Studies by Swanson (1955)²²⁴, Borden (1957)²¹ and Kim (1958)¹⁰⁷, found that the size and form of the mandible among the cleft population is almost identical with the non-cleft population.

Sadowsky, Aduss and Pruzansky (1973)¹⁹³ found that the mandible of the cleft group was not as protrusive as the non-cleft control group, although the patterns of growth for both groups were the same. Their findings were also observed by other authors like Wepner and Holl-

mann (1975)²³⁴, Nakamura et al (1972)¹⁵⁷ and Cocco and Pruzansky (1965)³⁴.

Wepner and Hollmann (1975)²³⁴ in their study of 54 cleft patients, 10 to 14 years of age, found the facial angle (S-N-Pog) to be 1.6° smaller than in the non-cleft group of comparable age. Mowbray (1977)¹⁵⁵, in a small group (15) of 12 year old unilateral cleft lip and palate patients, found that both the soft tissue and hard tissue profile of the mandible (S-N-Pog) decreased in the cleft group by 5.0° and 4.8° , respectively.

As early as 1960, Harvold^{85,86} observed that mandibular morphology in cleft palate cases differed in certain basic characteristics from unaffected children. He hypothesized that this change in mandibular shape was due to the lowered postural position of the mandible under the condition of maxillary deformities. His later animal experiments supported his hypothesis (1970³⁰; 1973³¹).

The lowered position of the mandible may be the result of mouth breathing (Oblak, 1975)¹⁶¹. He believes that a great majority of unilateral complete cleft cases with combined surgical closure of the cleft in the lip and cleft in the alveolar ridge at the same intervention, have their respiratory pathway closed also. This pathway was established through the cleft nasal floor and alveolar ridge after birth, so from the first surgical intervention

on, the child is forced to breathe through the mouth.

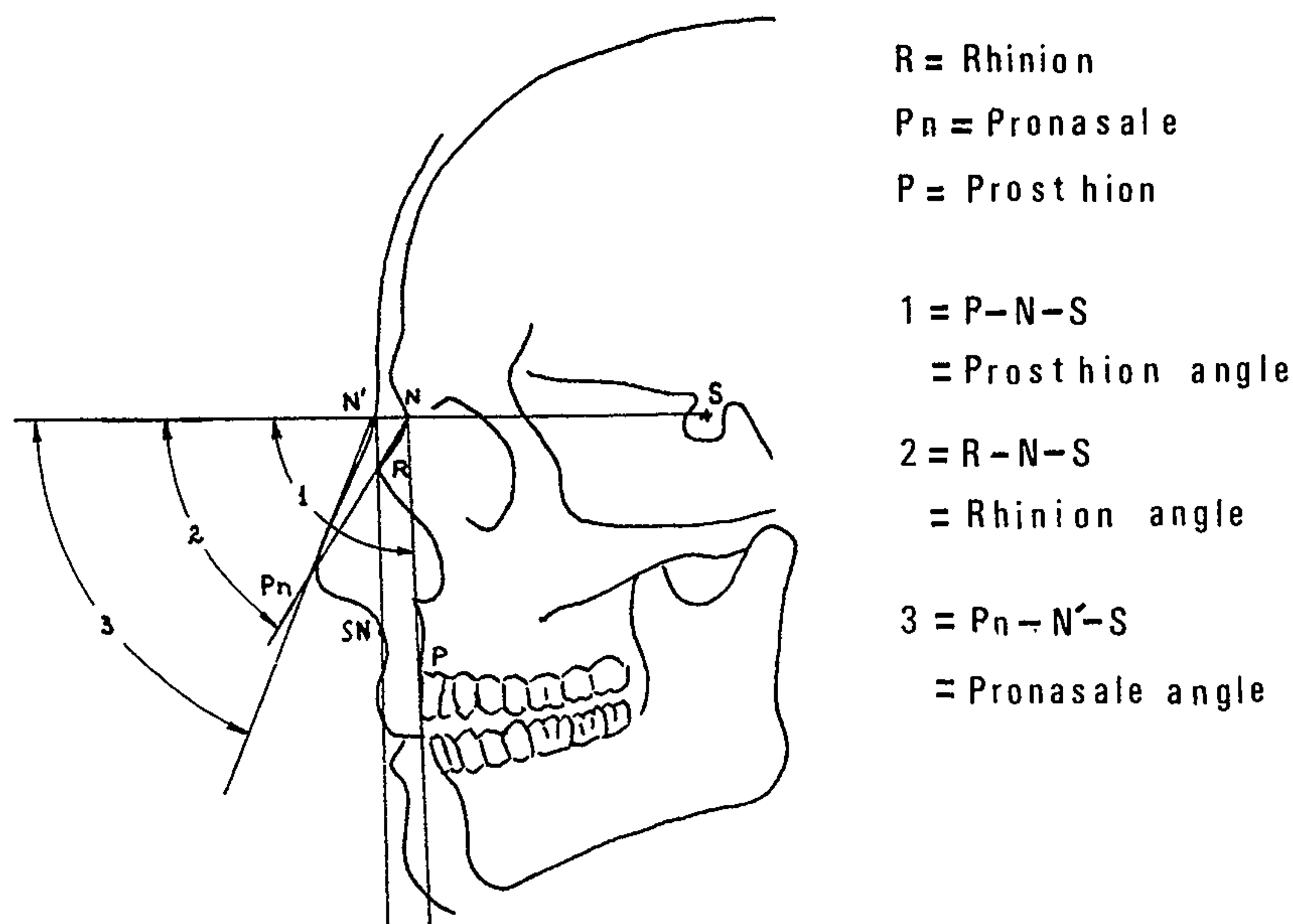
In summary, the change in mandibular morphology is likely a part of morphologic adaptation and nature's compensation for the maxillary deformities.

3.7. The Nose

Being influenced by the maxillary deformities, the nose height and width are somewhat affected, inspite of the fact that the growth potential of the nose in both population is similar (Sadowsky et al, 1973¹⁹³; Wepner and Hollmann, 1975²³⁴; Farkas and Lindsay, 1973⁵⁶).

In the unilateral cleft patients, Sadowsky et al (1973)¹⁹³ observed that the nose showed progressive anterior projection with time. However, this was less than the unaffected control population with a relative backward and downward position of the nose and an overall flattened facial profile. In short, the nose is less prominent in patients with clefts and, with growth, the nose projects forward to a lesser degree. The pubertal and post-pubertal nasal growth spurt observed in the cleft sample is similar to that for non-cleft population and is part of the rationale for delaying rhinoplastic procedures until the late teens.

Wepner and Hollmann (1975)²³⁴ used R-N-S angle (Rhinion angle, $\angle 2$) and Pn-N'-S angle (Pronasale angle, $\angle 3$), as shown in Fig. 8, to evaluate the bony and soft tissue profile of the nose. The rhinion angle of adult cleft subjects is 5.3° larger than in normals (clefts, 65.7° vs. non-clefts, 60.4°). The increased rhinion angle in the cleft population is objective evidence for the dorsal



Cephalometric evaluation of nasal profile. (Wepner and Hollmann 1975)

Fig. 8.

flattening of the bony nasal profile associated with cleft lips and palate. The pronasale angle of adult operated cleft patients is 8.6° larger than normal (cleft, 73.7° vs. non-cleft, 65.1°). This is indicative of a more pronounced flattening of the nasal soft tissue profile among cleft and normal population.

The nasal defects among cleft lip and palate patients which call for rhinoplasty (as part of the secondary rehabilitative programme) are: (Bala, 1970)⁸

- (1) Defect in floor of nostril.
- (2) Lateral spread of the nose.

(3) Deviation of septum.

(4) Deflection of nose to the affected side in unilateral cases.

(5) Depression of tip of the nose.

In summary, it seems that cleft patients have similar nasal growth as the non-cleft population, but the profile of the nose is slightly flattened. Moreover, nasal asymmetry is common among unilateral complete cleft patients.

3.8. The Profile

The profile, in fact, is the cumulative effect of the size and location of the cranial base, the zygomatic bones, the maxilla, the mandible, the nose and the soft tissue profile. As previously reviewed, one generally finds an increase in total facial height, retrusion of the maxilla, and slightly downward and backward position of the nose, and therefore a longer, less convex, or even concave profile is usually seen among the cleft lip and palate patients.

The unesthetic profile sometimes noted among the cleft population is not only due to skeletal problems but may be due to soft tissue defects and in fact, in many instances, it is the result of both of them (Ross and Johnston, 1972)¹⁹⁰.

The following factors may contribute to a defective soft tissue profile : (Ross and Johnston, 1972)¹⁹⁰

- (1) A short columella among bilateral clefts - it does not only depress the tip of the nose but also tends to eliminate the angle between columella and lip (naso-labial angle).
- (2) A thin repaired upper lip.
- (3) A moderately thick and protrusive lower lip.
- (4) Thick soft tissue chin which is common among the cleft individuals.

With growth, skeletal convexity of the profile

reduces at a more rapid rate among the cleft patients than in the non-cleft population, so that at eighteen years of age, the cleft patient usually has a more concave profile than the non-cleft subjects.

Friede and Pruzansky (1972)⁶⁴ suggested that the pre-operative degree of premaxillary protrusion (in complete bilateral clefts) to be an indicator of subsequent deviation of facial profile. Unfortunately, it is still not yet possible to predict accurately, at an early age, the extent of profile changes. Sometimes, the facial profile deformities won't be apparent until after pubertal growth is over (Ross and Johnston, 1972)¹⁹⁰. Occasionally, the deformities are so severe that the patient requires maxillary surgery as part of their secondary rehabilitative programme (I.5.).

As a whole, the facial profile of the cleft group is slightly less convex when compared with the non-cleft group, but the deviation is not much inspite of the fact that there are some basic morphologic differences (reviewed earlier in this section).

3.9. Summary

From numerous morphologic studies of adult cleft lip and palate patients mentioned earlier, it seems that there are not many cases with severe mid-face deformities. The facial deformities among the clefts are usually slight and, many a time, almost unnoticeable. That is why Sadowsky et al (1973)¹⁹³, in their soft tissue profile study on cleft and non-cleft groups stated, "Although these differences are statistically significant, they are not of sufficient magnitude to differentiate the clefts from the range that constitute the norm."

4. DIAGNOSIS AND TREATMENT PLANNING FOR SURGICAL CORRECTION OF MAXILLARY RETROGNATHISM AMONG CLEFT LIP AND PALATE PATIENTS

4.1. Introduction

Diagnosis and treatment planning for surgical correction of maxillary retrognathism and hypoplasia among cleft lip and palate patients requires the cooperative efforts of the orthodontist, oral surgeon and maxillo-facial surgeon.

The contribution of the orthodontist in the assessment of dento-facial morphology and malocclusion are:

(Mills, 1965)¹⁴⁸

- (1) To correlate clinical findings.
- (2) To do the cephalometric analysis.
- (3) To evaluate the dental casts.
- (4) To arrive at an analytical diagnosis and basic approach to treatment.
- (5) To predict treatment results.
- (6) To document and anticipate changes after surgery.

Obwegeser (1969¹⁶³; 1971¹⁶⁴) stated that the objective of the diagnosis and treatment planning of a maxillo-facial surgery is to locate the site of disharmony, either the maxilla, or the mandible or both. His golden rule is to operate at the site of deformity. In patient with cleft, of course, this means that maxilla is usually selected as the operative site. Occlusal relationship is his basic guide

and therefore, the goals which the operation seeks to achieve are :

- (1) Masticatory function and favorable intermaxillary and/or interalveolar relationship.
- (2) Facial esthetics in ideal conditions.

These two objectives usually go together, i.e. generally, a satisfactory functional result almost always bring about the conditions for the best esthetic rehabilitation.

The common procedures for diagnosis and treatment planning of maxillary retrognathism are : (Obwegeser, 1969¹⁶³; 1971¹⁶⁴; MacIntosh, 1970¹³⁴; Kufner, 1971¹²²; Lines et al, 1974¹³¹; Gans and Kallal, 1975⁶⁶; Epker, 1975⁵¹)

- (1) Clinical assessment;
- (2) Cephalometric analysis;
- (3) Photograph appraisal;
- (4) Model surgery;
- (5) Profile evaluation;
- (6) Full mouth radiograph and panoramic radiographs examination;
- (7) Intra-oral examination and occlusal study; and
- (8) Total health evaluation including emotional and psychological state.

The patient's past medical, dental and orthodontic records are important. As well, a good communication

with the cleft lip and palate patient is essential because the true desire of the patient may influence the treatment approach (Pedersen, 1975¹⁶⁹).

Further literature review will emphasize more on the following topics:

- (1) Clinical assessment;
- (2) Photographic assessment;
- (3) Cephalometric analysis;
- (4) Model study; and
- (5) Profile evaluation.

4.2. Clinical Assessment

There are four conditions that may result in apparent mandibular prognathism and they are : (Obwegeser, 1967)¹⁶²

(1) Normal maxilla with either the body or the dental alveolar process or both lying too far posteriorly.

(2) Small Maxilla.

(3) Overdeveloped lower jaw.

(4) The alveolar process of the mandible lies too far anteriorly.

Some clinical manifestations of maxillary retrognathism as described by various authors are : (Knowles, 1969¹¹³; Bala, 1970⁸; Epker et al, 1975⁵¹; Gans and Kallah, 1975⁶⁶)

(1) The maxilla is posterior to the mandible.

(2) Flatness and depression of the middle third of the face especially in the upper lip and nasolabial area.

(3) The mandibular anterior teeth are crowded, lingually inclined and with Class III malocclusion.

(4) Among some cleft patients, the typical retrusive appearance of the middle third of the face is further accentuated by a large and everted lower lip. Abbe flap operation can improve the situation but the profile cannot really be restored to normality, if the underlying bony structures are out of balance. Such bony disproportion

may be the result of either some excess of mandibular size, or a smallness of the maxilla because of deficiency of tissue by virtue of cleft palate condition or may be due to a combination of both of these factors in varying degrees.

(5) Occasionally, there is lateral depression of the nose and depression of the tip of the nose.

Pedersen (1975)¹⁶⁹, apart from other examinations, like intra-oral, intra-nasal examination etc., uses eight questions to guide his clinical assessment of the face of cleft lip and palate patients.

(1) Is the profile strikingly prognathic in appearance?

(2) Is the patient's clinical condition maxillary retrognathic versus mandibular prognathic, or do both conditions co-exist?

(3) Is the nasal profile pleasing?

(4) Does a short columella displace the tip of the nose?

(5) Is a labial seal present at rest?

(6) Is the labial seal present by a "whistle defect" or achieved inspite of a deficient superior lip by a compensatory lower lip activity?

(7) Is a labio-mental crease present, absent or accentuated?

(8) Does an abundance of soft tissue contribute to the relative mandibular protrusion:

Another method for clinical assessment suggested by Epker et al (1975)⁵¹, is to evaluate full face and pro-

file of the patient by sequential masking to different areas of the face with a small piece of cardboard to form a qualitative evaluation of the face of the patient.

In full face evaluation, using masking procedure, he examines the inter-pupillary distance, inter-orbital distance, the malar eminences, the nose and its relationship to the middle part of the face, the lips and their relationship to the teeth, the alar base, columella, prolabium and labio-mental fold, the symmetry of the horizontal and vertical relation of the face. In case of right and left asymmetry, direct measurements are necessary.

With similar procedures, the profile evaluation includes the relation of the supra-orbital shape of the forehead, the nasal bridge, entire nose to the aforementioned structures, the entire middle third of the face, the lower third of the face and its relation to middle third and soft tissue chin to the lip and to the nose.

The sequential masking examination focuses critical observation on one or two facial features at a time, and on their relation to one another and to the entire face. When the entire face is viewed, the relative relationship of different facial structures are frequently misleading.

In fact, Epker et al (1975)⁵¹ claimed that their primary criteria for diagnosis and treatment planning based

more on the clinical patient evaluation than on other procedures.

The patient's complaint is of value also in the course of diagnosis and treatment planning because the patient is generally as aware of the point of greatest abnormality in a general sense, as is the examiner (MacIntosh, 1970)¹³⁴.

Summing up, through careful examination of each part of the face (full face and profile), observing the relative relationship of different facial structures and identifying some of the clinical manifestations of maxillary retrognathism among cleft lip and palate patients, one should be able to formulate a reasonably accurate description of the location and magnitude of the facial deformities.

4.3. Photographic Assessment

4.3.1. Types of Photographs for Surgical Orthodontic Diagnosis and Treatment Planning.

Essential photographs for pre-operative planning are the front and profile view, intra-oral and occlusal prints (Obwegeser, 1971)¹⁶⁴.

A more systematic approach in photography for surgical orthodontic diagnosis and treatment planning is the one suggested by Ackerman and Proffit (1975)¹. They recommended six different views to capture the aspects of facial appearance already reviewed during the initial examination of the patient. The frontal and lateral views should be taken in standardized position using a head holder with the patient's visual axis parallel to the floor. The six different views are :

(1) and (2): Frontal and lateral facial photographs taken when the teeth are in maximum intercuspitation.

(3) and (4): Frontal and lateral facial photographs taken when the mandible is in rest position and the lip in repose.

(5) A silhouette photograph with the teeth in intercuspital position and the lips closed.

(6) A three quarter view smiling photograph.

Another technique in photography to help in surgical orthodontic diagnosis and treatment planning is the physioprint (Sassouni, 1974)¹⁹⁹. The purpose of physioprint is to obtain an accurate three dimensional pic-

ture of the face. To do this, two mirrors are placed behind the patient's head and angulated with the mid-sagittal plane of the patient's face, allowing only chin and neck to be included in the picture. Two ear rods hold patient's head so that the Frankfort horizontal plane is parallel to the ground. With the head positioned in this manner, the picture is taken with grid superimposed, permitting the observation of facial symmetry.

4.3.2. Role of Photography.

Facial and intra-oral photographs are used to corroborate clinical and cephalometric evidence of the patient's profile, upper lip, size and shape of the nose and soft tissue chin (Graber, 1967)⁸⁰.

Epker et al (1972)⁵⁰ used photographs to supplement clinical examination and enable one to identify details not realized in the clinical examination.

Sassouni (1974)¹⁹⁹ in his book said that the photograph is absolutely critical for documentation.

There are several anatomical characteristics that present in the photographs of normal individuals (Mathews and Broadbent, 1957)¹⁴¹. Deviation from these can help in diagnosis and treatment planning of surgical correction among cleft lip and palate patients with facial deformities.

(1) The nose profile is usually parallel with the long axis of the ear.

(2) The nasal tip is generally a pyramid with the lateral nostril borders pointing upward meet at the tip on the skin surface.

(3) A degree of central fullness with projection of the upper lip forward the lower lip is normal. The reverse of this is found in the 'bull dog' appearance of some cleft lip patients with a tight upper lip.

Aside from comparing in the photographs some anatomical characteristics that present among normal individuals, the lower portion of the photograph can be cut horizontally at the level of lip commissure and this will allow for posterior positioning of the mandible and will immediately reveal the difference between maxillary retrusion and mandibular prognathism. Retro-positioning of the mandible in patient with maxillary retrusion results in a marked retrogenia and an unacceptable profile (Gans and Kallal, 1975)⁶⁶.

In summary, photographs are important for documentation, for identifying details, for reviewing the facial appearance following the initial examination and last but not the least is to help in diagnosis.

4.4. Cephalometric Analysis

4.4.1. The Role of Cephalometrics.

The cephalometric radiograph , if properly evaluated, is a key diagnostic and planning aid in surgical correction of maxillary deformities. It contains vital information which reveals, (i) The inter-relationship of the facial bones, and (ii) The ratio of the soft tissue to the facial skeleton (Obwegeser, 1971)¹⁶⁴.

Cephalometric analysis in surgical and orthodontic diagnosis does the role of disclosing the location and extent of skeletal deformities (Lines et al, 1974)¹³¹. The data (i.e. linear measurements and angular measurements) obtained from cephalometric analysis serves as guideline for a quantitative assessment. For diagnostic purpose, the quantitative data has the following functions: (Khouw et al, 1970)¹⁰⁵

- (1) To help in determining the nature and degree of deformities.
- (2) To help in selection of treatment approach in order to improve facial esthetics.

Among the clefts the study of their cephalometric radiographs enables a more precise analysis of the bony deformities and aids in determination of operative procedure. Furthermore, the cephalogram permits longitudinal growth studies of the abnormalities as well as comparing the re-

sult after surgery (Converse et al, 1964)³⁸.

More specifically, the role of cephalometrics in total maxillary osteotomy for cleft palate rehabilitation are (Pedersen et al, 1975)¹⁶⁹:

- (1) To deny or confirm borderline clinical impression, i.e. to detect if the deformities are more on the maxilla or mandible.
- (2) To aid in the projection of results and assess immediate and long term success or failure.

Aside from study of antero-posterior relationship in the cephalograms, Epker et al (1975)⁵¹ stated that more attention should be paid to :

- (1) Right to left or full face deformities about which, in fact, the patients are generally much more concerned.
- (2) Anterior vertical facial proportions.

Different authors agree that cephalometric analysis should neither be over-emphasized nor de-emphasized in maxillary surgery planning. Treatment judgement based primarily on cephalometric analysis may be misleading and inappropriate which will be discussed later under section 4.3.3. Cephalometric analysis should serve not as an absolute guide, but rather as an aid to the clinical judgement (Converse et al, 1964³⁸; Obwegeser, 1971¹⁶⁴; Epker et al, 1975⁵¹; Pedersen et al, 1975¹⁶⁹).

In summary, cephalometric analysis is an indis-

pensable tool in diagnosis and treatment planning for surgical correction of maxillary retrognathism among clefts. However, it has to be used in conjunction with other means like clinical examination, study of dental casts, photographic examination, etc., in order to yield accurate information for diagnosis and treatment approach.

4.4.2. Methods of Cephalometric Analyses.

The recognition of maxillary skeletal deficiency or mid-face retrusion is particularly difficult when using traditional cephalometric alone (Gans and Kallal, 1975)⁶⁶. Also, a cleft patient with a retruded maxilla can have a concave, or straight, or even convex profile (Grabner, 1967)⁸⁰. At the same time, three types of profile are accepted as standard of normals. These profiles of human face have been classified as : (i) straight forward, (ii) straight backward, and (iii) average (Schwarz, 1951²⁰³; Kirchner, 1961¹⁰⁹).

Using angular and linear measurements, six major relationships can be evaluated in cephalometric analysis, and they are : (Khouw et al , 1970)¹⁰⁵

- (1) Maxilla to cranium (S-N-A)
- (2) Mandible to cranium (S-N-B)
- (3) Maxilla to mandible (A-N-B)
- (4) Maxillary teeth to maxilla (1 to N-A in degrees; 1 to N-A in mm.)

(5) Mandibular teeth to mandible ($\bar{I}$ to N-B in degrees; $\bar{I}$ to N-B in mm.)

(6) Anterior facial height (N-ANS, ANS-Gn and N-Gn)

Levin (1963)¹²⁹ considered a deficiency of the maxilla is present when the S-N-B angle is larger than S-N-A angle among cleft population. Gans and Kallal (1975)⁶⁶ considered a patient with maxillary retrognathism when his S-N-A is decreased, S-N-B may be normal and A-N-B is decreased.

To assess antero-posterior dysplasia of the maxilla and mandible, Wylie's (1947)²³⁶ method involves measuring the projection of sella (s), the pterygo-maxillary fissure (Ptm), the maxillary first molar, and the anterior nasal spine (A-N-S) to the Frankfort or visual plane. The proportional relationships of these measurements, according to Wylie's standard, are then compared to discover the relative size of each component of the facial structures. To assess vertical dysplasia, Wylie et al (1952)²³⁷ suggested to use two transparencies for rapid evaluation of facial dysplasia in vertical plane.

In cephalometric analysis of surgical treatment of malformation of the face, Converse (1954)³⁷ used Margolis' data as his reference. Margolis showed that the angle formed by the intersection of the cranial base (S-N) and facial plane (N-Pog), average approximately 75 degrees.

in a well balanced face, (1947)¹³⁷.

To decide the facial structure of an individual, Gonzalez-Ulloa (1969)¹³⁸ used Frankfort line (inferior orbital margin to the upper margin of the external auditory canal) and a perpendicular line from nasion as his axial reference in cephalometric diagnosis. These two lines are good axial references :

- (1) to quantify the architecture of the face;
- (2) to quantify the relationship of a "beautiful" face to these axial lines;
- (3) to quantify the relationship of a defective face to these same lines, thereby making possible an assessment of the problem posed by each segment;
- (4) to serve as orientating guide lines in the correction of the defective segments; and
- (5) to assess the accuracy of surgery.

In soft tissue analysis, Epker (1972)⁵⁰ used similar reference lines as Gonzalez-Ulloa (1969)¹³⁸ to relate the upper part of the face to the chin. He has found these to be helpful to correct the patient's profile and the existing malocclusion simultaneously. To determine the balance between chin, lip and nose, the facial line and Merrifield's 'Z' angle are used. Obwegeser (1971)¹⁶⁴ used the position of the forehead as a fixed reference point to plan and measure the antero-posterior movement

of individual facial bone during surgery. However, he did not mention which of the anatomical landmark as his fixed reference point nor did he describe his cephalometric method.

To evaluate the mid-face deficiency of cleft lip and palate patient, Levin (1963)¹²⁹ used Coben's (1955)³² analysis, which emphasized the use of linear measurement expressed as percentage or proportion of cranial base (Ba-N) and total facial height (N-Me) for facial depth and facial height evaluation. Frankfort horizontal plane is used as the plane of reference or orientation.

Other cephalometric analysis used in diagnosis and treatment planning of maxillo-facial surgery are:

(1) Moorrees' Mesh Diagram (1962)¹⁵⁰: The coordinate system was first utilized by D'Arcy Thompson (1942)²²⁷ for his studies of growth and form. This method was applied by Moorrees for the analysis of standardized head radiographs. The mesh diagram is a regularly spaced grid projected over the facial area. The spacing is determined by the size of the individual patient's cranial base. Deviation from normal proportionality are then expressed graphically by distortion of the grid as it fits over the patient's actual cephalometric landmark.

(2) Sassouni's Archial Analysis (1955)¹⁹⁷: The basis of the construction of the archial analysis is an anterior

arc that represents the line of reference which permits the evaluation of the maxillary and mandibular relationships. The details of this method will be discussed later in Part II, 2.2.2.

(3) Bolton Standard Analysis (1975)²³: Bolton standards are a series of average Caucasian male and female individual cases that have optimal facial and dental development growth. Five thousand youngsters with more than twenty-two thousand recordings are used to make up Bolton standards. Presentation of Bolton standards are in lateral and frontal cephalometric transparent templates which cover the age range from one to eighteen years of age. The clinical usage of the Bolton standard is to compare individual patients to the standard for diagnostic assessment in orthodontic treatment, oral surgery, and maxillo-facial surgery.

In summary, the respective angular measurements, linear measurements, reference lines, templates, etc., all serve as a guide for the clinician in diagnosis and treatment planning of maxillary surgery for facial deformities.

4.4.3. Reference Lines for Orientation.

Sella-nasion (S-N), the Frankfort horizontal plane (F.H.) and the basic cranial plane, basion-nasion (Ba-N), have been chosen as appropriate lines for cepha-

lometric orientation (Ricketts, 1976)¹⁸¹.

Traditionally, most orthodontic authors use sella-nasion and Frankfort horizontal plane as reference lines for their analysis (Tweed, 1946²³⁰; Margolis, 1947¹³⁷; Downs, 1952,⁴⁹; Steiner, 1953²¹⁸; Moorrees, 1962¹⁵⁰; Ricketts, 1976¹⁸¹).

Sella-nasion plane is defined as the plane from point sella, located by inspection in the center of sella turcica and point nasion, located at the suture junction of the frontal bone with the nasal bone (Graber, 1967)⁸⁰.

Frankfort horizontal plane is defined as the plane from the point porion, located at the superior border of the external auditory meatus, and the orbitale, located at the inferior border of the orbital rim (Graber, 1967)⁸⁰.

The average Frankfort plane in the population does represent a horizontal to the earth's surface (Ricketts, 1976)¹⁸¹. However, there is no certainty that the cranial base can escape malformation in individuals who have deviation from ideal proportion elsewhere, such as cleft deformities or malocclusion. It is reasonable to presume that the greater the malocclusion severity, the greater is the chance that there will be deviation in the cranial base as well as in the jaw and the teeth (Ackerman and Proffit, 1975)². In fact, Moss (1956)¹⁵²

found that there is higher incidence of cranial base deformities, eg. dysostosis of sphenoidale, among cleft population than the average group.

Due to the unreliability of the cranial base among cleft patients, it is preferable to use an external type of reference which is not related to the skeleton at all, eg. the patient's visual axis. Bjerin (1957)¹⁸ pointed out that each individual tends to orient his head in space so that it returns to a reproducible position when he looks at an object infinitely far away or at the horizon. This is the natural head position, and Broca (1862)²⁵ defined it as the position when a man is standing and when his visual axis is horizontal.

Clinically, natural head position was obtained by Moorrees and Kean (1958)¹⁴⁹. It was obtained when the head of the patient was at ease and unsupported and the eyes looking into their own image in a mirror 170 cm. in front, having the same level as the pupils of the patient's eyes. This position (natural head position) was found to be remarkably constant at different time of observation. They concluded that when the cephalograms of patients in natural head position are obtained, the true horizontal (a line drawn perpendicular to the image of the plumb line) is preferable to the intra-cranial lines, such as Frankfort horizontal and sella-nasion line. So it is ad-

vantageous for patients with severe deformities, to use the true horizontal obtained from natural head position, as the reference line in their cephalometric analysis (Ackerman and Proffit, 1975)².

Khouw et al (1970)¹⁰⁵, MacIntosh (1970)¹³⁴, Epker et al (1972)⁵⁰, were aware of the fact that skeletal deformities can result in misleading cephalometric analysis.

When correlation of clinical findings and cephalometric analysis suggests an abnormal S-N plane or Frankfort horizontal plane, Epker et al (1972)⁵⁰ rely on the plane that correlates best with clinical impression.

Khouw et al (1970)¹⁰⁵ use intra-cranial reference lines such as S-N and true horizontal at the same time while doing their surgical cephalometric analysis. The true horizontal provides a check for possible deviation in the orientation of S-N. If S-N is oriented poorly, a correction should be made.

In summary, among cleft lip and palate patients, particularly those with maxillary retrognathism, there is a likelihood that they have cranial-skeletal deformities which make traditional reference lines of orientation misleading in cephalometric analysis. Visual axis provides part of the answer for proper orientation, but extreme care and experience is necessary to obtain an accurate reprodu-

cible natural head position (Ackerman and Profit, 1975)².

So, in doing cephalometric analysis for cleft lip and palate patients with maxillary retrognathism indicated for maxillary surgery, it is not reliable to use traditional reference lines of orientation (eg. S-Na, F-H plane, Ba-Na) as they do not always provide results that agree with the clinical qualitative assessment. This is true at least with the group of cleft patients involved in this study. Visual axis can be used for line of reference but there is no known skeletal analysis as yet in the literature that relates this reference line to the underlying skeleton. It is because of these difficulties that one is lead to search for another or combined cephalometric analysis that can give a more consistent and reliable results comparable to the clinical evaluation.

4.5. Model Study and Model Surgery

The roles of model study and model surgery in maxillary osteotomy are :

- (1) To reveal the resulting occlusion by such surgical movement. The required forward positioning of the maxillary segment on the model will reveal the required orthodontic correction necessary to secure a stable functional result before or after surgery (Gans and Kallal, 1975)⁶⁶.
- (2) To visualize and measure the exact amount of movement during surgery for desired correction (Kiehn et al, 1968)¹⁰⁶.
- (3) To evaluate and to determine which jaw will correct the existing functional and esthetic deformities in the simplest and most effective manner (Epker et al, 1972)⁵⁰.
- (4) To disclose the finer points of a functional occlusion and determine the limits of correction (MacIntosh, 1970)¹³⁴.
- (5) To appraise the possible relationships of tooth bearing arches after surgery (Obwegeser, 1969)¹⁶³.

The basic principles in model surgery are :

- (1) To create the best possible occlusal relationship with acceptable facial esthetics.
- (2) To attack the problem at the point of greatest deformities (MacIntosh, 1970¹³⁴; Obwegeser, 1971¹⁶⁴).

Obwegeser (1971)¹⁶⁴ required three sets of study casts for planning maxillary surgery : one stone set to

record the pre-operative occlusion and the jaw relationship; two plaster sets to be used for model operation. He uses a special articulator so that it permits the movement of any part of the upper and lower models in any direction to determine the required correction.

Lines (1974)¹³¹ suggested the following procedures for model surgery :

- (1) Plaster casts are mounted on a type of articulator (Obwegeser type) that allows the dental segment to be cut and repositioned while the bases maintain their relationship.
- (2) The casts are marked with the facial midline, and measuring marks are placed at either side of the surgical site.
- (3) A model surgery procedure is then performed on the mounted casts to determine the direction and extent of movement of teeth and supporting structures necessary to obtain the best post-operative occlusion.
- (4) The amount of repositioning necessary in the model surgery casts is measured; it will be used later in an attempt to determine the facial profile that will result from the proposed surgical treatment.

Pedersen et al (1975)¹⁶⁹ advocate a slightly different model surgery procedure for cleft lip and palate patients for maxillary osteotomy:

- (1) The maxillary model is divided along the line of cleft.
- (2) The two segments are mounted against the mandibular model in the most ideal relationship which also include certain amount for over-correction.
- (3) Measurements of maxillary alterations are made in the three spatial planes.
- (4) The projected advancement of the maxilla is transferred to the cephalometric tracing, and anticipated soft tissue changes are outlined.

There are several points that one should pay attention to during model surgery:

- (1) The best interdigitation does not always produce the best profile. Occasionally, one must compromise to attain an acceptable result in occlusion and profile (Lines and Steinhauser, 1974)¹³¹.
- (2) Dental casts, used alone, are insufficient for the diagnosis and treatment planning of dento-facial disharmonies, because casts only demonstrate occlusal relationship of teeth. Models, in particular the upper, do not accurately represent jaw anatomy beyond alveolar level. Measurements made on the base portion cannot be expected to represent accurately changes in anatomy effected at the time of surgery (Khouw et al, 1970¹⁰⁵; MacIntosh, 1970¹³⁴).
- (3) Accurate vertical measurements are as important as

those in horizontal plane. Patient's vertical dimension should be maintained throughout the model surgery (MacIntosh, 1970)¹³⁴.

(4) Over-correction is necessary in order to prevent relapse. It should be over-corrected by a margin of at least 25% (Lines and Steinhauser, 1974)¹³¹.

In summing up, the guiding principles to do model surgery is to achieve the best possible occlusion after surgical correction of skeletal discrepancy. It helps to visualize the possible occlusal relations after surgical correction in three dimensions.

4.6. Profile Evaluation and Prediction

In doing the profile prediction for maxillary osteotomy, the changed vertical measurement and the projected horizontal bony advancement of the maxilla from model surgery are transferred to the cephalometric tracing (Pedersen et al, 1975)¹⁶⁹. To predict the soft tissue changes, Epker et al (1972)⁵⁰ use 1:1 soft tissue to bony change ratio, i.e. 1 cm. soft tissue change correspond to 1 cm. hard tissue movement. Therefore, the post-operative result can be visualized by repositioning cut-out of the jaw segments (from duplicate cephalometric tracing) on the original cephalometric tracing.

McNeil et al (1972)¹⁴⁵ described the following procedures for profile prediction :

- (1) The diagnostic cephalometric film is traced.
- (2) A second sheet of tracing paper is placed over the original diagnostic cephalometric tracing.
- (3) The hard and soft tissues not to be moved or altered during treatment are traced onto the overlay.
- (4) Marks locating the cusp tips and apices of teeth and bony landmarks of structure to be repositioned are placed on the overlay from the original tracing.
- (5) Measurement from the surgery cast of teeth and hard tissues to be moved are then used to locate and place new marks on the overlay, using the first marks as reference. The teeth and hard tissue structures that are to be moved

or altered are then traced in the new position.

(6) Using King's data (1970)¹⁰⁸, which stated that orthodontic tooth movement of maxillary anterior teeth, the upper lip followed in a 2:1 ratio, one can then predict the soft tissue profile after maxillary surgery.

Bell et al (1977)¹⁴, in their cephalometric profile prediction of surgical correction of long face syndrome follow these procedures :

(1) Trace all of the maxillary and mandibular teeth and bony landmarks and the enveloping soft tissue profile on acetate tracing film.

(2) Simulated maxillo-mandibular and soft tissue changes in this radiograph closely parallel the changes associated with superior repositioning of the maxilla by surgical means. To simulate the dento-skeletal facial profile changes, the maxillary and mandibular teeth and bone are traced with different colored pencils onto a second piece of overlaid acetate tracing film.

(3) The cut out film template of the maxilla and mandible are now moved the amount and direction necessary to achieve the desired esthetic result and to simulate the planned maxillary movement.

(4) On the basis of anticipated changes in the soft tissue associated with antero-posterior and vertical movement of the dento-osseous segments, a new soft tissue profile . . .

serves as the basis for simulating additional profile changes by genioplasty or rhinoplasty. .

There is no uniformity on how the soft tissue will change with respect to bony movement during surgery. Different authors suggest different ratios of change. I suppose it is reasonable to believe that it is difficult to obtain an accurate measurable plan as to where and to what extent correction has to be achieved. This is the area where the surgeon's judgement, experience and intuition come to play.

Profile prediction only gives an approximate idea of what the profile will look like after the planned bony movement. To have a stable and desirable profile and occlusion, what Obwegeser (1969)¹⁶³ advised seems most appropriate : "For profile consideration, when the maxilla is moved forward, I strive to create a Class II occlusion, thus slightly over-correcting the occlusion."

4.7. Summary

To run a diagnosis and treatment planning for surgical correction of facial deformity among adult cleft lip and palate patients, it is necessary to go through the clinical, photographic and cephalometric assessment, model study and profile evaluation thoroughly. The patient's complaints and desires have to be taken into account as well. Furthermore, just as in any ordinary type of comprehensive dental examination, the patient's past medical, dental and orthodontic history are equally important. All the information so gathered are significant in the final diagnosis and selection of treatment approach.

Last of all, esthetics is an art and is very subjective. No one can provide a canon of beauty (Gonzalez-Ulloa, 1969)¹³⁸. Hence, the treatment planning for facial deformity among adult cleft lip and palate patients is also greatly influenced by the surgeon's experience, imagination and intuition.

5. TREATMENT OF MAXILLARY RETROGNATHISM AMONG CLEFT LIP AND PALATE PATIENTS

5.1. Introduction

Before the feasibility of basic surgical correction of skeletal deformities among cleft lip and palate patients, the treatments were usually limited to prosthetic restoration, onlay bone graft, buccal inlay, supplementary soft tissue operation or orthodontic treatment (Rowe, 1954¹⁹¹; Kettle, 1954¹⁰³; Desprez et al, 1968⁴⁵; Obwegeser, 1969¹⁶³; Lewin et al, 1971¹³⁰). Nowadays, rehabilitation programs for correction of facial deformities among cleft lip and palate patients can be one or two or even three of the following types of treatment :

- (1) Orthodontic treatment and/or,
- (2) Surgical treatment (soft tissue and/or skeletal correction) and/or,
- (3) Prosthetic treatment.

It is not the intention of this review to cover all types of rehabilitation procedures, but rather to review the fundamental reconstructive surgery to correct the basic skeletal and occlusal discrepancies such as indicated by Rowe (1954)¹⁹¹ : "...placing back into normal position those bony structures which are out of balance."

In many cases of cleft lip and palate patients with severe problems in the maxillo-facial morphology,

generally, only combined surgical and orthodontic treatment can lead to an acceptable appearance during the second phase of the rehabilitation program (Stockli, 1973)²²¹. Thus, the surgeon and the orthodontist have to acquire a good knowledge of each other's work if true partnership is to be achieved.

5.2. Pre-surgical Orthodontic Treatment

Some authors advocate pre-surgical orthodontic treatment to facilitate and guide the occlusal correction during surgery (Stockli, 1973²²¹; Lines et al, 1974¹³¹; Poulton, 1976¹⁷⁴; Worms et al, 1976²³⁵).

The purposes of pre-surgical orthodontic treatment are :

- (1) To align teeth according to model surgery (Stockli, 1973)²²¹.
- (2) To resolve crowding and to level severe occlusal curve (Poulton, 1976)¹⁷⁴.
- (3) To reduce or remove dental compensation. (A term used by Worms et al²³⁵ to describe the tendency of teeth, especially the anterior, to overcome skeletal base disproportion). The best surgical repositioning of the jaw is possible only when all dental compensation is removed.

Obwegeser (1971)¹⁶⁴ emphasized that pre-surgical orthodontic treatment should be limited to alignment of the axis of the teeth with the axis of the alveolar process. He discouraged any attempt to create an overjet for the following reasons:

- (1) The patients show insufficient improvement of outward appearance.
- (2) The teeth or alveolar process will be inclined too far anteriorly, in cases where the pre-treatment condition was

an anterior crossbite or Angle Class III.

(3) The periodontal tissues are jeopardized.

(4) Subsequent surgical correction of the profile is rendered more difficult. He advocated post-surgical orthodontic treatment and he regarded pre-operative orthodontic treatment to be rarely necessary.

In conclusion, pre-surgical orthodontic treatment should be limited to :

(1) Alignment of crowded teeth;

(2) To achieve proper axial inclination of the teeth to the alveolar process; and

(3) To level the severe occlusal curve (Curve of Spee).

All these can help the placement of the maxilla after its mobilization and establishment of a stable occlusion to prevent relapse (Kufner, 1971)¹²².

5.3. Indications and Contra-indications for Maxillary Osteotomy Among Cleft Lip and Palate Patients with Maxillary Retrognathism

Maxillary osteotomy is indicated where there are:

- (1) Maxillary hypoplasia (Obwegeser, 1967¹⁶²; Lewin et al, 1971¹³⁰).
- (2) Severe malocclusion (Class III pseudo-prognathism) (Obwegeser, 1967¹⁶²; Lewin et al, 1971¹³⁰).
- (3) Flatness of the median part of the mid-face (Friehofer, 1975)⁶³.
- (4) In-built gross bony deformities among adult cleft lip and palate patients (Dey, 1970)⁴⁷.

Total maxillary osteotomy is a surgical measure ideally suited for the late management of cleft lip and palate deformity. This relatively simple but tedious procedure make possible the correction of skeletal and occlusal disharmonies with immediate improvement of nasal-labial-mental configuration (Pedersen et al, 1975)¹⁶⁹.

On the other hand, Obwegeser (1969)¹⁶³ categorized the following as indications for maxillary osteotomy among patients with maxillary retrognathism :

- (1) Functional indication - the therapy is to improve mastication, speech or breathing.
- (2) Esthetic indication - the therapy is to improve the patient's outward appearance which is the main motivation for seeking therapy.

(3) Psychic indication - the therapy is to resolve patient's psychologic problem which may in fact be the result of unesthetic appearance, abnormalities of occlusion, mastication, speech or even breathing.

(4) Social indication - because of previously mentioned problems, one may not be able to cope with his private and/or public life.

Kufner (1971)¹²² named two contra-indications for maxillary osteotomy :

(1) Infection of the paranasal sinuses.

(2) Any deterioration of general or local resistance to infection.

The pre-operative health of the sinuses must be evaluated. Where there is no disease before operation, post-operative sinus health is usually maintained. When pre-operative chronic sinus disease is present, there is usually an increased sinus problem post-operatively. Resolution of chronic sinus disease in these patients via conservative and surgical means are incorporated into the overall treatment plan (Epker, 1975)⁵¹.

Stark (1968)²¹⁷ stressed that the anatomical feature of the patient's mouth should be evaluated before anesthesia is begun in palatoplasty. This should apply to maxillary surgery. Instead of the mouth, the nose is the area for intubation. In cases in which serious difficulties

may be anticipated, the patient should be intubated awake, before induction of anesthesia. Experience indicates that if nasal intubation is difficult at the commencement of the operation, oral intubation can be used. Once maxillary osteotomy is completed and bony mobilization obtained, nasal intubation is possible and can replace oral intubation (Overton, 1977)¹⁶⁷, thus avoiding possible need for tracheostomy.

In summary, where there is severe skeletal and occlusal discrepancy among cleft lip and palate patients, maxillary osteotomy is usually the treatment of choice to restore the functional and esthetic requirements.

Apart from usual medical contra-indications for surgery, sinus disease and nasal obstruction may pose some problem in maxillary osteotomy.

5.4. Maxillary Osteotomy for Adult Cleft Lip and Palate Patients with Maxillary Retrognathism

5.4.1. Introduction.

Maxillary osteotomies are performed along the classical lines of fracture described in 1904 by a Frenchman by the name of Le Fort. Because of the variation in the strength and fragility of various parts of the facial skeleton, fractures of the face usually follow a typical pattern (Gillies and Millard, 1957)⁷¹.

Bone sectioning is practised by different authors at various levels and along various lines, but in general, it follows the Le Fort lines.

The Le Fort classification as described by Dingman and Natvig (1964)⁴⁸ are :

(1) Le Fort Type I (Guerin) - occurs transversely through the maxilla above the level of the teeth. The fractured segments contain the alveolar process, portion of the wall of the maxillary sinuses, the palate, and the lower portion of the pterygoid process of the sphenoid bone as shown in Fig. 9 (black line).

(2) Le Fort Type II (Middle third) - is the fracture of the nasal bones and of the frontal process of the maxilla. The fracture line then pass laterally through the floor of the orbit, and near or through the zygomatic-maxillary fossa. This fracture, because of its general shape, has been termed the pyramidal fracture, as shown in Fig. 9



A. Front View.



B. Side View.

Fig. 9. Le Fort I (black), Le Fort II (blue), and Le Fort III (green) Fracture Lines.

(blue line).

(3) Le Fort Type III (Glabella + orbital floor + malar) - this fracture line usually occurs through the zygomatic-frontal, maxillo-frontal and nasal-frontal sutures, through the floor of the orbit, and through the ethmoid and sphenoid bones, with complete separation of all the structures of the middle facial skeleton from their attachment, as shown in Fig. 9 (green line).

Arbitrarily, Converse (1971)³⁹ divided osteotomy into two categories : (1) Extra-cranial osteotomy. (2) Combination of extra-cranial and intra-cranial osteotomy. It is however, beyond the scope of this review to deal on intra-cranial osteotomies.

5.4.2. Low Maxillary Advancement Osteotomy.

There are two types of low maxillary osteotomies (Converse, 1971)³⁹:

(1) Complete Transverse (Le Fort I) Osteotomy, in which the maxilla is transected backward to the pterygoid process.

(2) Segmental Maxillary Osteotomy, in which the posterior portion of the maxilla is left intact, the line of osteotomy traversing the hard palate at various selective sites.

Le Fort I osteotomy or complete transverse osteotomy transects the maxilla at the level of Le Fort I (Guerin) maxillary fracture, as shown in Fig. 10 (Obwegesser, 1971)¹⁶⁴.

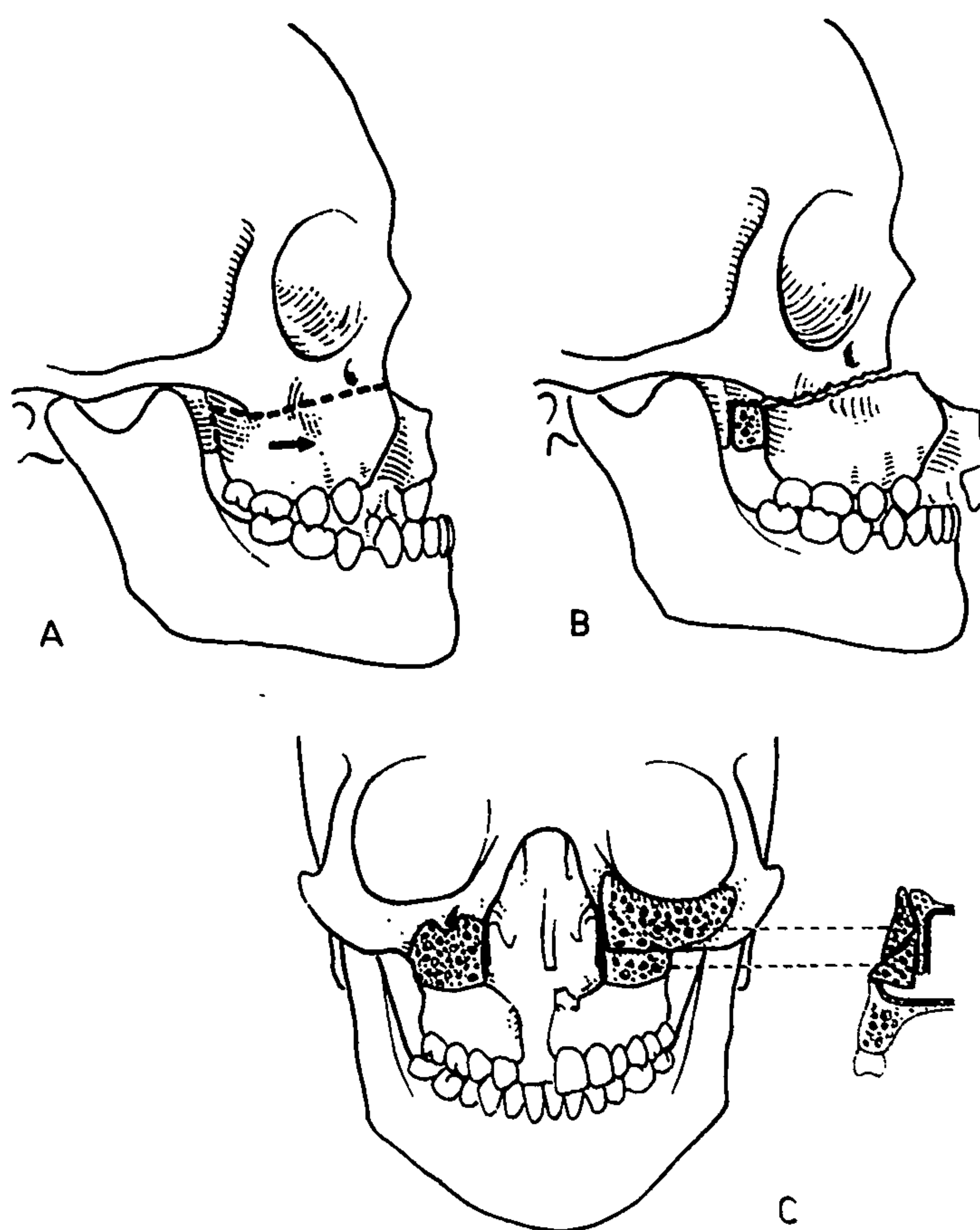


Fig. 10.

High Le Fort Type I Osteotomy for forward movement of maxilla. A. Path of bone cuts (dashed line). B. Repositioned maxilla with bone implant behind tuberosity to stabilize maxilla. C. Post-operative anterior view with bone implant around infra-orbital area. (Obwegeser 1971).

Onlay bone grafts may be placed over the line of section if it is desired to further improve the contour around the pyriform aperture (Fig. 10, C), although bone grafts are not necessary for the consolidation of the line of osteotomy. A piece of bone may be wedged into the pterygo-maxillary space to assist the forward projection, as shown in Fig. 10, B.

The new occlusal relationship between maxillary and mandibular teeth is maintained by inter-maxillary fixation. A supportive bandage is usually sufficient to ensure the stability of the mandible.

In segmental maxillary advancement osteotomy, the posterior portion of the hard palate and maxilla are not mobilized. The line of transection is placed anterior to the posterior border of the hard palate. Segmental maxillary osteotomy may be divided into two types :

(1) Retromolar Segmental Maxillary Osteotomy : The line of osteotomy is as shown in Fig. 11 (Converse et al, 1952)³⁶.

(2) The Premolar Segmental Maxillary Osteotomy : This transects the hard palate anteriorly to the molar teeth, generally through the bicuspid area, as shown in Fig. 12 (Converse et al, 1964)³⁸.

The advantages of these two techniques are :
(Converse, 1971)³⁹

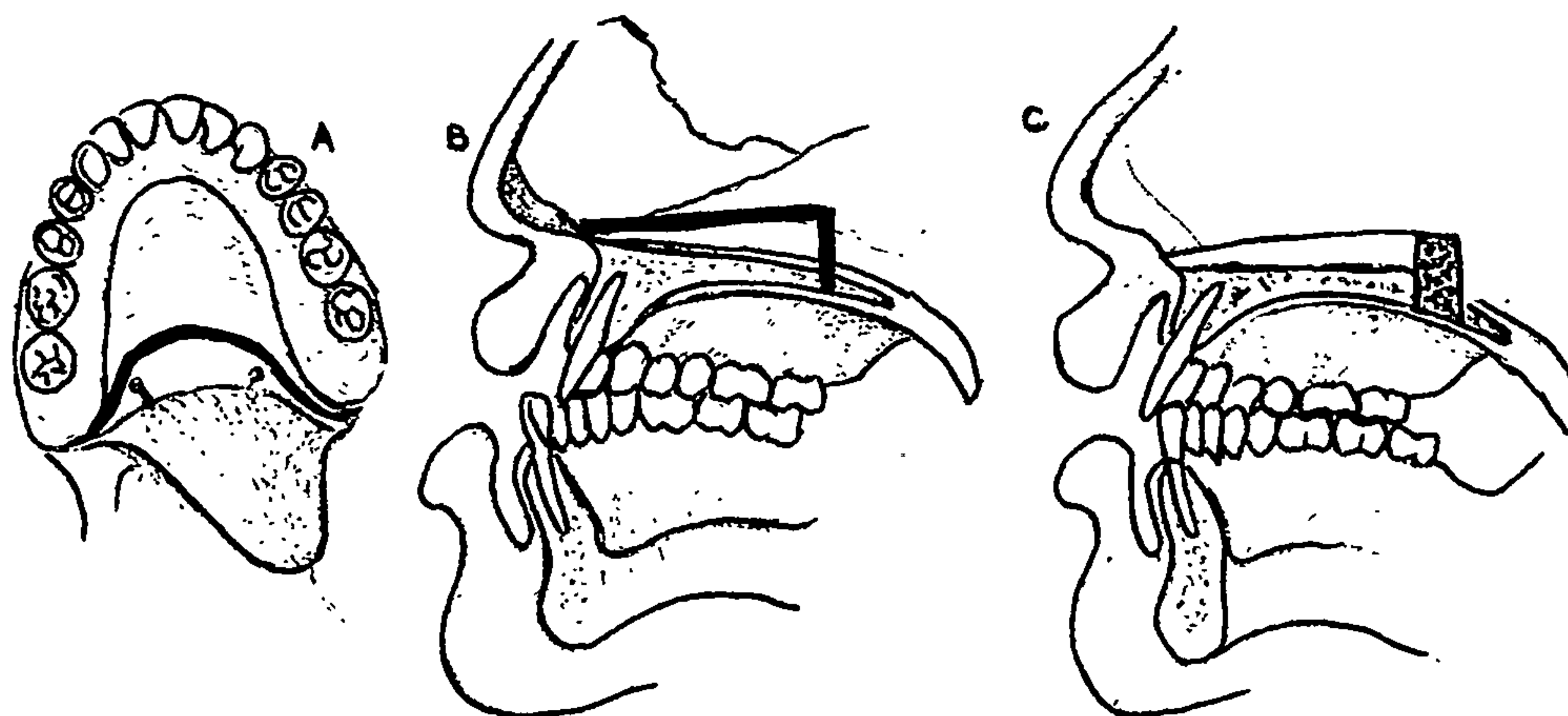


Fig. 11.

Retromolar segmental maxillary osteotomy : A. Exposure of the hard palate by elevation of the palatal mucoperiosteum. The line of osteotomy is indicated by the broken line. B. Sagittal view illustrating the incision at the junction of the septal cartilage and the vomer and the osteotomy through the hard palate and vomer. C. The maxillary segment has been advanced and bone grafts wedged into the palatal defect. (Converse et al, 1952)

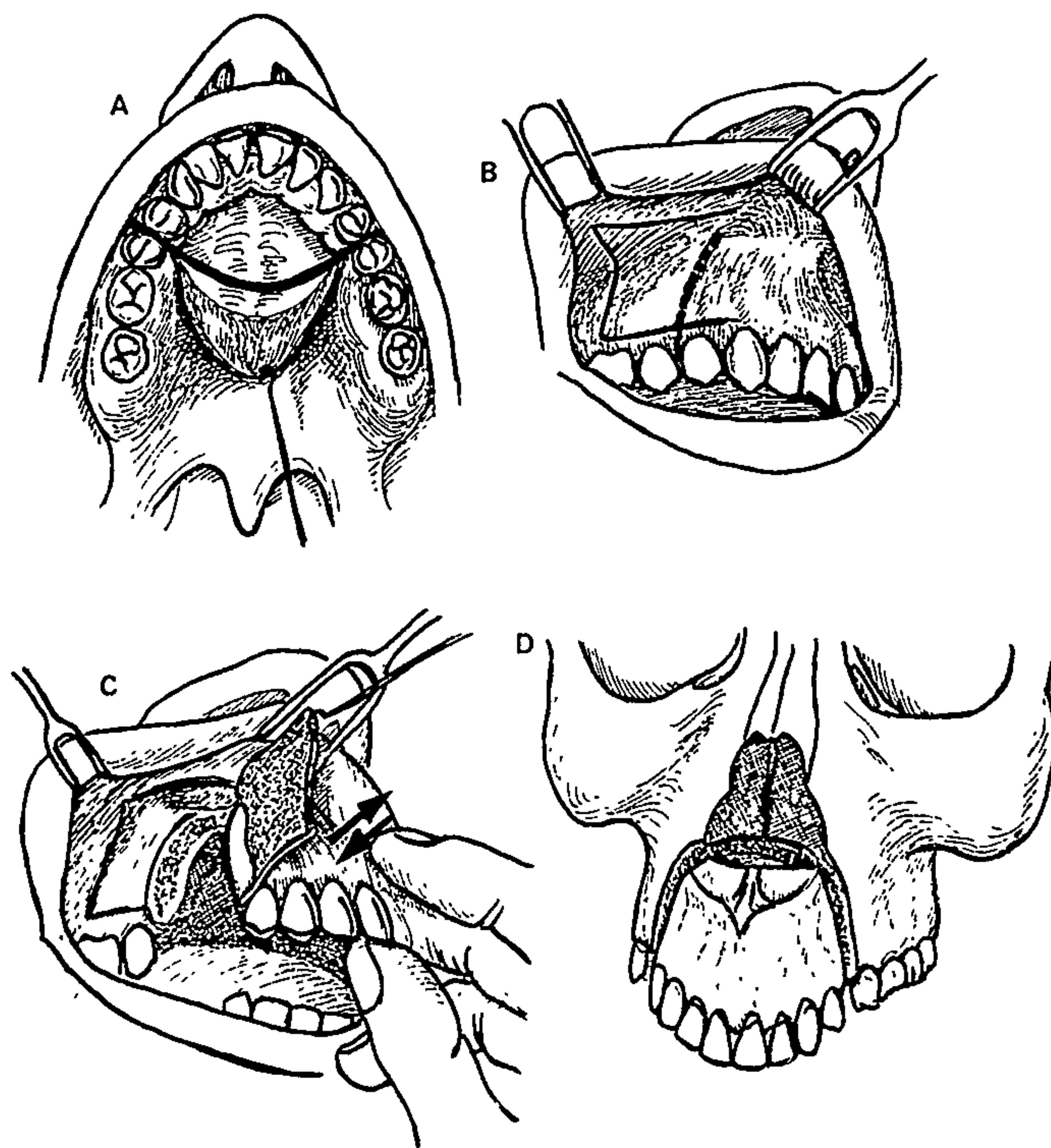


Fig. 12.

Premolar segmental maxillary osteotomy : A. Palatal flap raised. The transverse line of osteotomy is indicated. B. Anteriorly-based mucoperiosteal flap designed to cover the line of osteotomy and bone grafts after advancement. C. Forward, upward, downward or lateral displacement can be achieved, the maxillary segment remaining vascularized by the anterior mucoperiosteal flap. D. Outline of lines of osteotomy. (Converse et al, 1964).

(1) The posterior border of the hard palate and the attachment of the soft palate are undisturbed, thus the risk of shortening the soft palate and of resultant velo-pharyngeal incompetency are avoided, a complication which is apt to occur in the cleft palate patients.

(2) An additional advantage is offered by the posterior stable portion of the maxilla, in premolar segmental osteotomies, as bone grafts may be wedged between the posterior stable portion and the anterior mobile portion, thus diminishing the chance of a recurring retro-position of the anteriorly mobilized segment.

Inter-maxillary fixation is needed in retromolar segmental maxillary osteotomy while in premolar segmental maxillary osteotomy, inter-maxillary fixation is not necessary. The molar teeth provided anchorage for fixation appliances like arch wire and orthodontic bands.

Other minor segmental maxillary osteotomy advocated by Obwegeser (1971)¹⁶⁴ for surgical correction of maxillary deformities among cleft lip and palate patients are :

- (1) Corticotomy.
- (2) Unilateral rotation of small alveolar segment.
- (3) Rotation of bilateral alveolar segment.
- (4) Reduction of the broad maxillary arch.
- (5) Osteotomy for tilting the premaxilla.

(6) Repositioning and reinforcing of malposed premaxilla in bilateral clefts.

5.4.3. Le Fort II Osteotomy.

Gillies, in 1923⁶⁹, described the naso-maxillary skin graft inlay technique for the correction of the naso-maxillary hypoplasia of the syphilitic nose. This technique provided adequate contour restoration but obliged the patient to wear a permanent supporting prosthesis. In order to find a solution to the problem of naso-maxillary hypoplasia by providing elongation and an increase in size of the under-developed nose and also to correct the maxillary deformity, Le Fort II and pyramidal naso-orbito-maxillary osteotomy (modified Le Fort II) have been developed.

The basic line of Le Fort II osteotomy of Henderson et al (1973)⁹⁰ closely approximate that of the Le Fort II fracture pattern, as shown in Fig. 13.

It therefore results in the mobilization of the true maxilla and the nasal bone which can then be advanced, tilted or rotated. At the same time, the associated soft tissues and nasal skeleton can be displaced in a controlled manner.

Converse's pyramidal naso-orbito-maxillary osteotomy (1971)³⁹ is a modified Le Fort II osteotomy, as shown in Fig. 14. Henderson et al (1973)⁹⁰ commented that this approach is effective when the maxillary dentition is com-

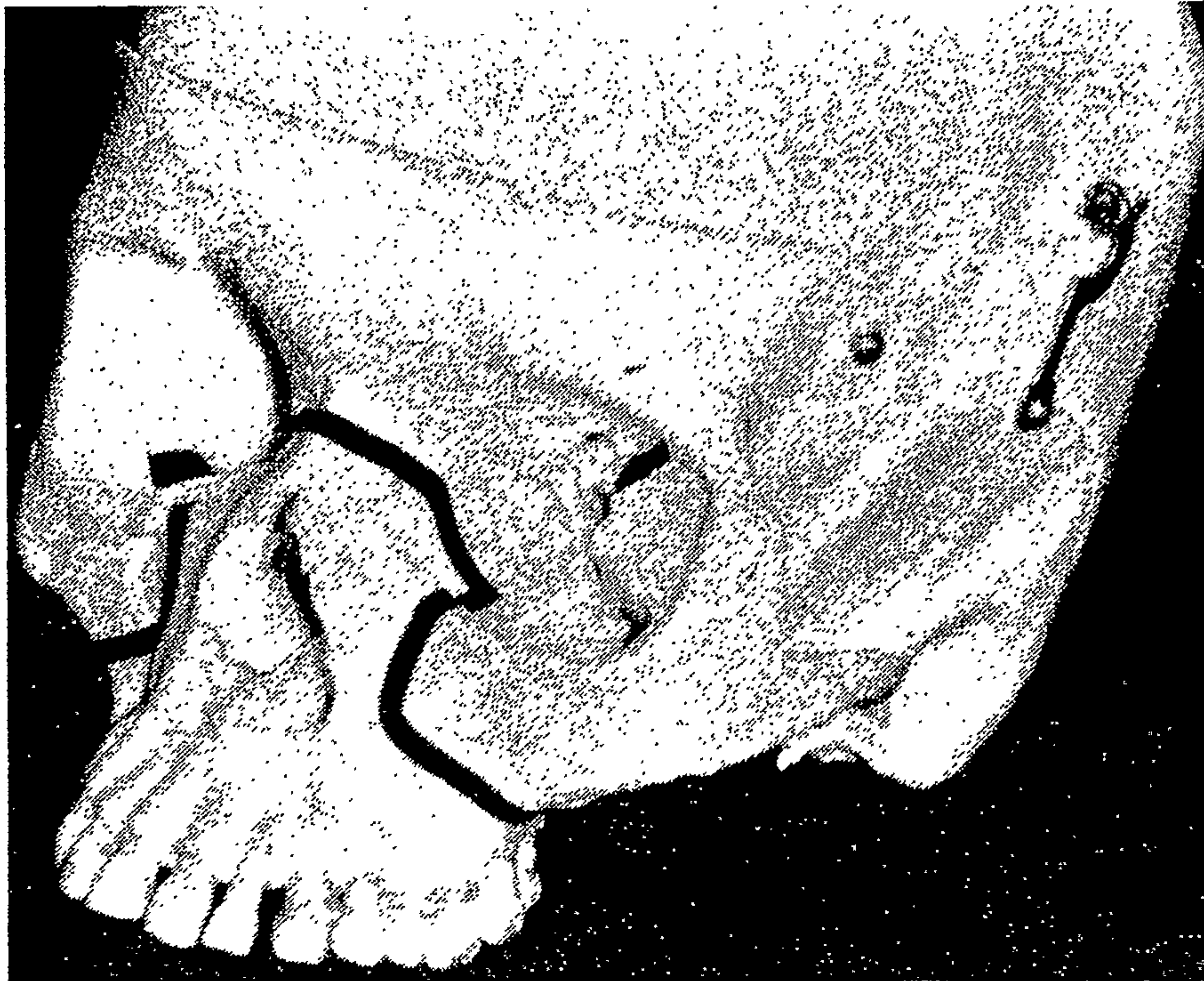


Fig. 13.

Basic line of Le Fort II osteotomy.
(Henderson et al, 1973).

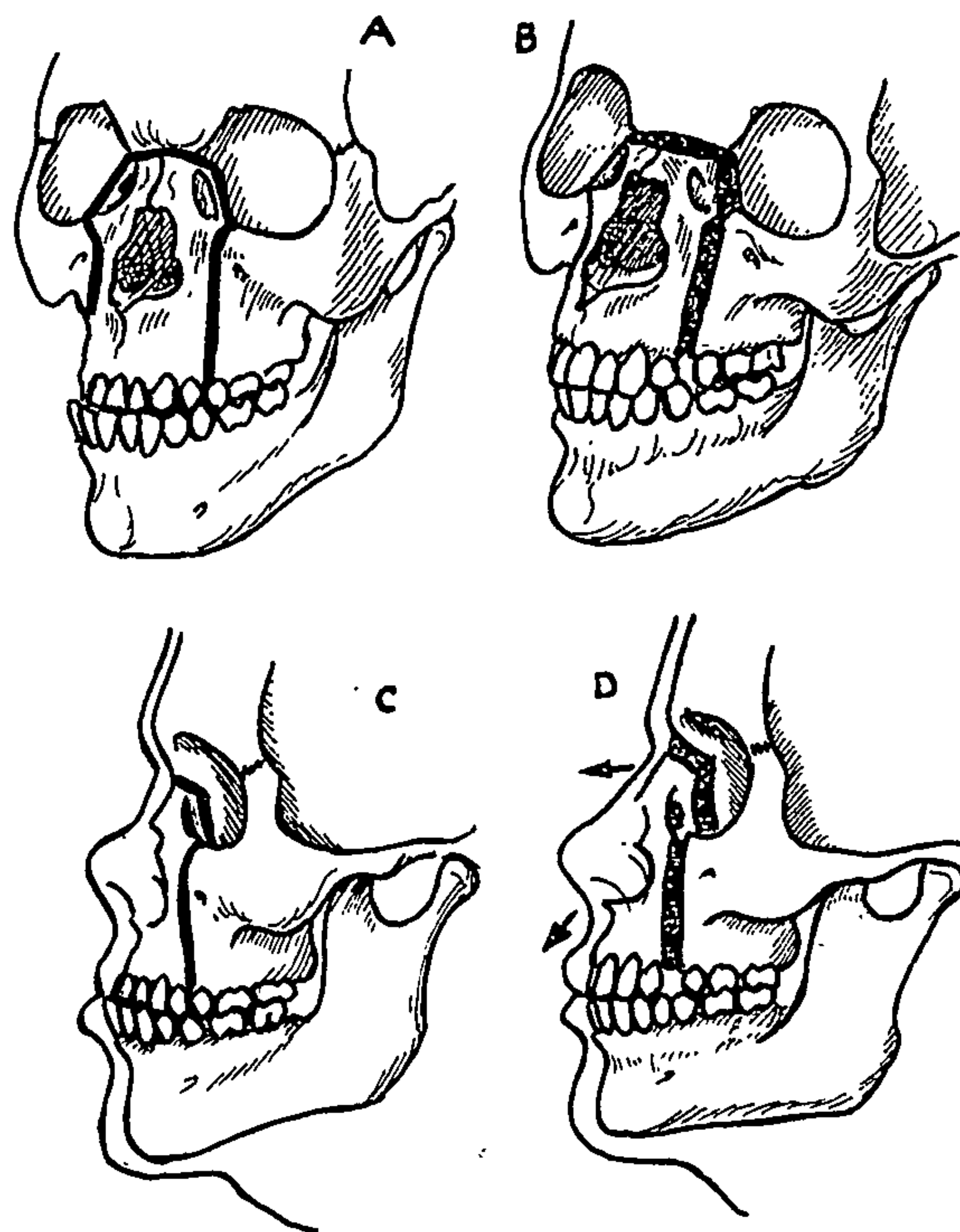


Fig. 14.

Elongation and forward displacement of the naso-maxillary complex by the naso-orbito-maxillary osteotomy (A, C) technique : After moving the central segment forward and downward (B,D) the bony gaps are filled with bone grafts and the position of the segment is maintained by orthodontic fixation. Note that the line of osteotomy serves the medial wall of the orbit posterior to the lachrymal fossa. (Converse et al, 1971).

plete. Cranio-maxillary extra-skeletal fixation is avoided, but the operation is impossible in cleft palate cases because of the position of the bony defect, and unsuitable for many patients whose dentition is inadequate for control of the premaxillary fragment. Planning is imprecise, and the operation is technically more difficult than the Le Fort II osteotomy.

The fixation of Converse's (1971)³⁹ pyramidal naso-orbito-maxillary osteotomy is to use the stable posterior portion of the maxilla which provide a strong abutment. The orthodontic bands on the molar teeth are stable posterior points of fixation. Fragments of cancellous bone are used to fill : (1) naso-frontal area; (2) medial portion of the orbit; (3) Maxillary sinus; and (4) hard palate and alveolar process. The upper portion of the bone graft is maintained by wire fixation at the naso-frontal area.

5.4.4. Le Fort III Osteotomy.

Because of the danger of fracture lines extending to the optic canal and intra-cranial penetration and complication, high maxillary osteotomy techniques have been developed only more recently than other mid-face osteotomies. Gillies and Harrison (1951)⁷⁰ reported a high maxillary (a modified Le Fort III) osteotomy in a patient with cranio-stenosis. Their line of fracture is as shown in Fig. 15.

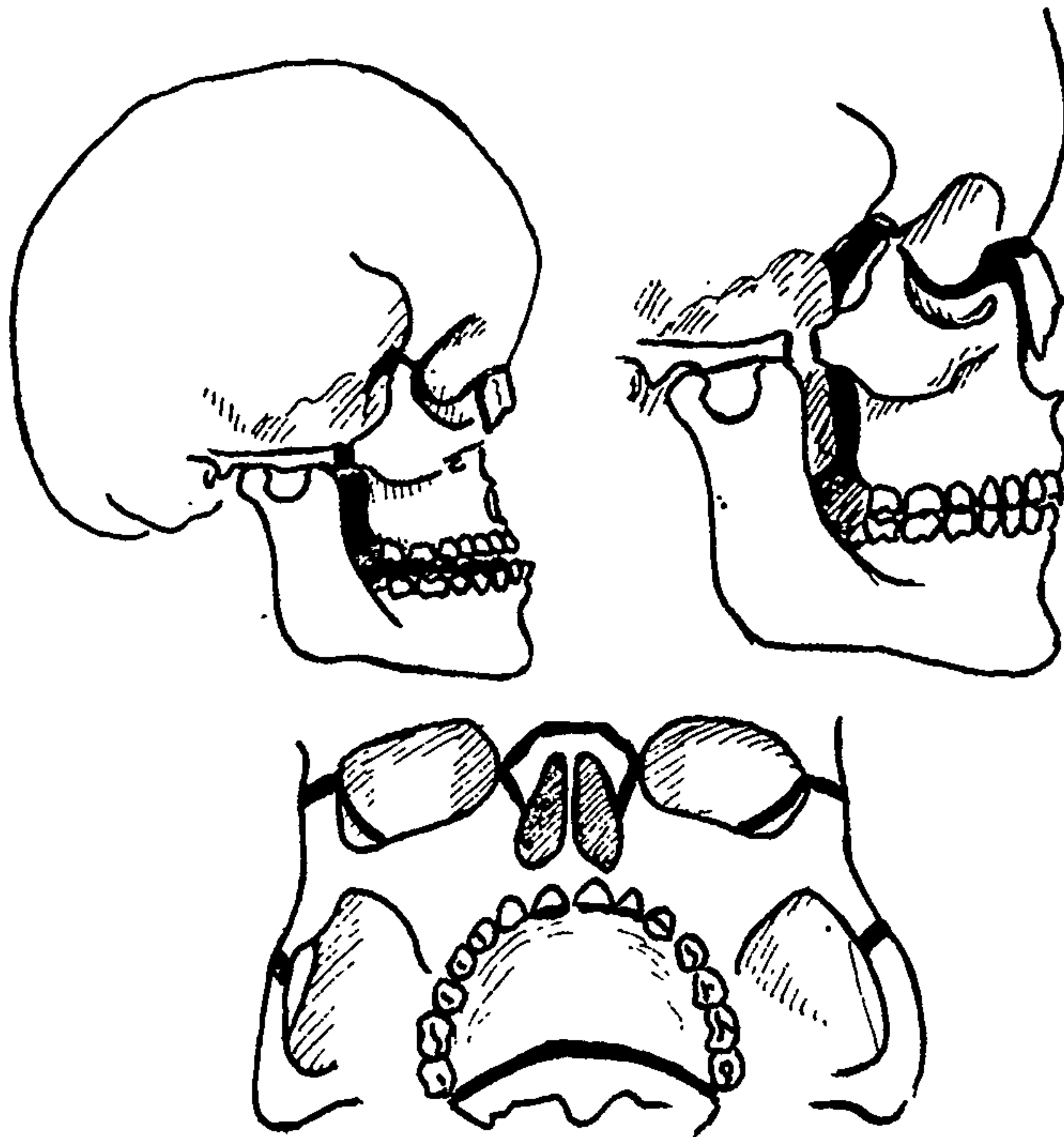


Fig. 15.

High maxillary osteotomy (redrawn after Gillies and Harrison) : (Upper left). Lines of osteotomy through the nasal bones, orbital floor, lateral wall of the orbit, zygomatic arch and pterygo-maxillary fossa. (Upper right). Position of the mid-facial area after advancement. (Lower). Outline of the osteotomy through the posterior portion of the hard palate. (Gillies and Harrison, 1951).

Although no bone grafting was done to facilitate the consolidation of the lines of osteotomy, a satisfactory result was reported. Fixation was done with inter-maxillary wiring. Forward retention was maintained by traction with one pound weight through a pulley and attached to the maxillary splint.

Gillies stated that the operation had been successful but that, because of the difficulty and risk, it was the last operation of this sort that he would ever have performed (Converse, 1971)³⁹.

Since then, very little appeared in the literature until the report of Tessier in 1967²²⁵, 1967²²⁶, and that of Murray and Swanson in 1968¹⁵⁶.

A number of major developments have made possible the recent success of cranio-facial and mid-face osteotomy (Converse, 1971)³⁹.

(1) The disclosure of the remarkable propensity of bone graft.

(2) The demonstration of the possibility of success despite contamination of bacteria of bone grafts and osteotomies through an intra-oral approach.

(3) Survival of teeth on fragments of bone detached from the surrounding bone when two conditions are met which favor their survival : the first is the presence of a thin layer of bone over the apex of the tooth, and the

second is sufficient soft tissue attachment to guarantee some blood supply.

(4) The advance in hypotensive anesthesia has proved beneficial in diminishing blood loss, increasing operative visibility and allowing an increase of operation time.

A considerable step forward was taken when Tessier (1967²²⁵; 1967²²⁶) reported a number of cases operated upon by a technique distinctive from that of Gillies (1951)⁷⁰, in that the line of osteotomy traversing the orbits reproduced the Le Fort III type line of fracture, as shown in Fig. 16.

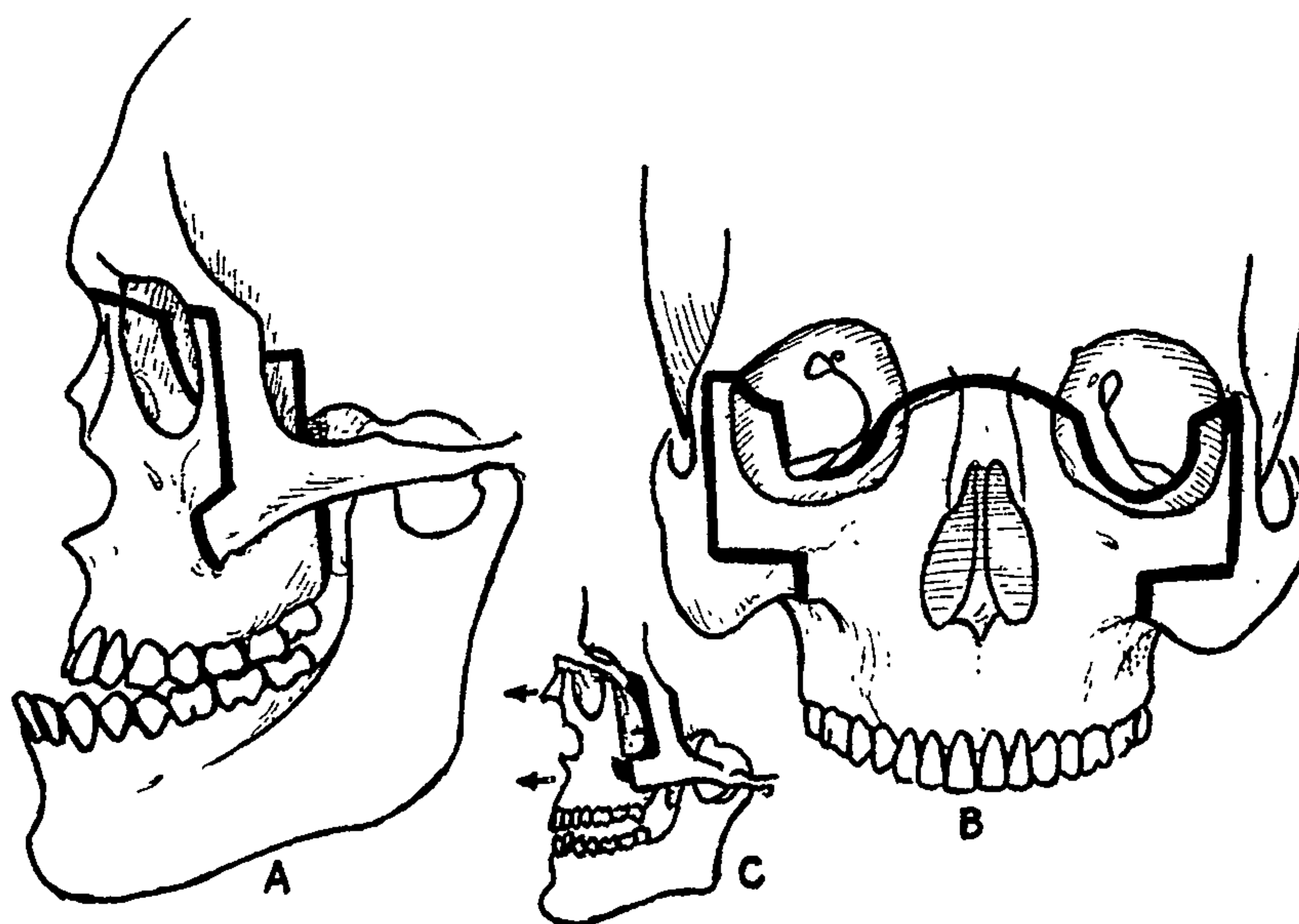


Fig. 16.

High maxillary osteotomy (after Tessier): A. Outlines of lines of osteotomy through the naso-frontal junction, the medial wall of the orbit, posterior to the lachrymal groove, through the zygoma and in the pterygo-maxillary fossa. B. In this drawing the line of osteotomy is shown to extend into the inferior orbital fissure. C. Position of the mid-facial area after surgical advancement. (Tessier, 1967).

The advantages of this type of osteotomy through zygoma are : (Converse, 1971)³⁹

(1) It provides a strong posterior buttress and strong support for bone graft which is inter-posed after the advancement of the mid-facial skeleton.

(2) Preservation of the attachments of the masseter muscles to zygoma.

Forward traction was maintained by means of cranially-fixed traction appliance and proper bone graft implantation.

Murray and Swanson (1968)¹⁵⁶ performed an osteotomy in a patient with cranio-stenosis, similar to that performed by Gillies et al (1951)⁷⁰. The line of osteotomy ran anterior to the lachrymal groove, sectioning the temporal process of the zygoma anterior to the zygomato-temporal suture line, as shown in Fig. 17.

Iliac bone grafts were placed over defects in the pterygo-palatine areas and in dead space left by the forward displacement of the mid-facial bony complex. Inter-maxillary traction was then exerted to promote forward displacement of the maxilla and further traction was obtained by means of a head-frame which exerted a forward traction on a Kingsley-type of appliance fixed to the teeth of the upper jaw.

Jabaley and Edgerton (1969)⁹⁸ reported an excellent

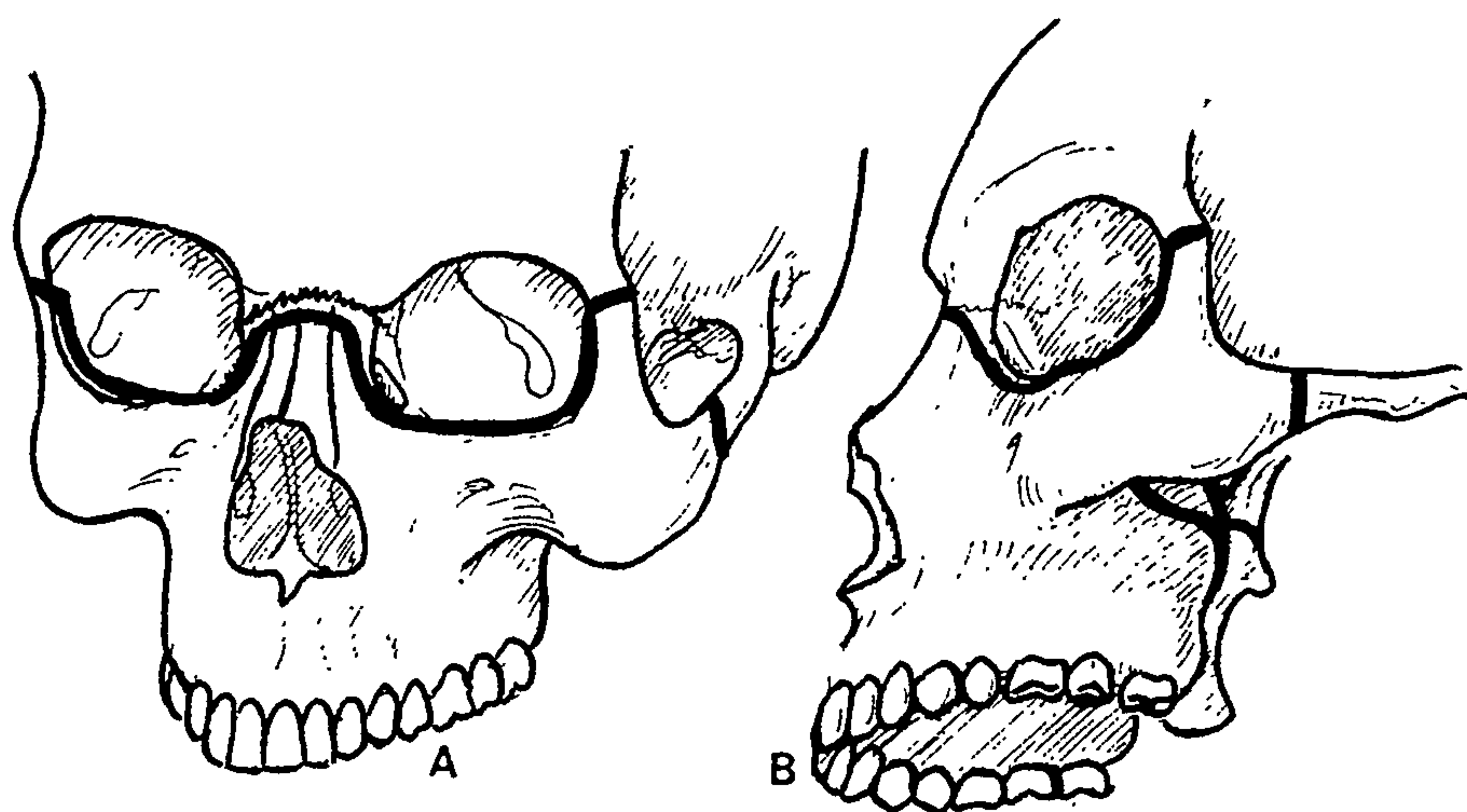


Fig. 17.

High maxillary osteotomy (after Murray and Swanson): A. Outline of the transverse osteotomy similar to that of Gillies. B. Illustrates the osteotomy through the posterior wall of the maxillary sinus and the pterygoid processes and the osteotomy through the zygomatic arch. (Murray and Swanson, 1968).

result in a patient with mid-facial deformity and the line of osteotomy is as shown in Fig. 18.

They performed an osteotomy similar to that of Tessier (1967²²⁵; 1967²²⁶), entering the inferior orbital fissure, then upward through the lateral orbital wall, to the fronto-zygomatic junction, differing however in the zygomatic area as the osteotomy was done through the zygomatic arch instead of the body of the zygoma. They separated the hard palate from the pterygoid process cutting

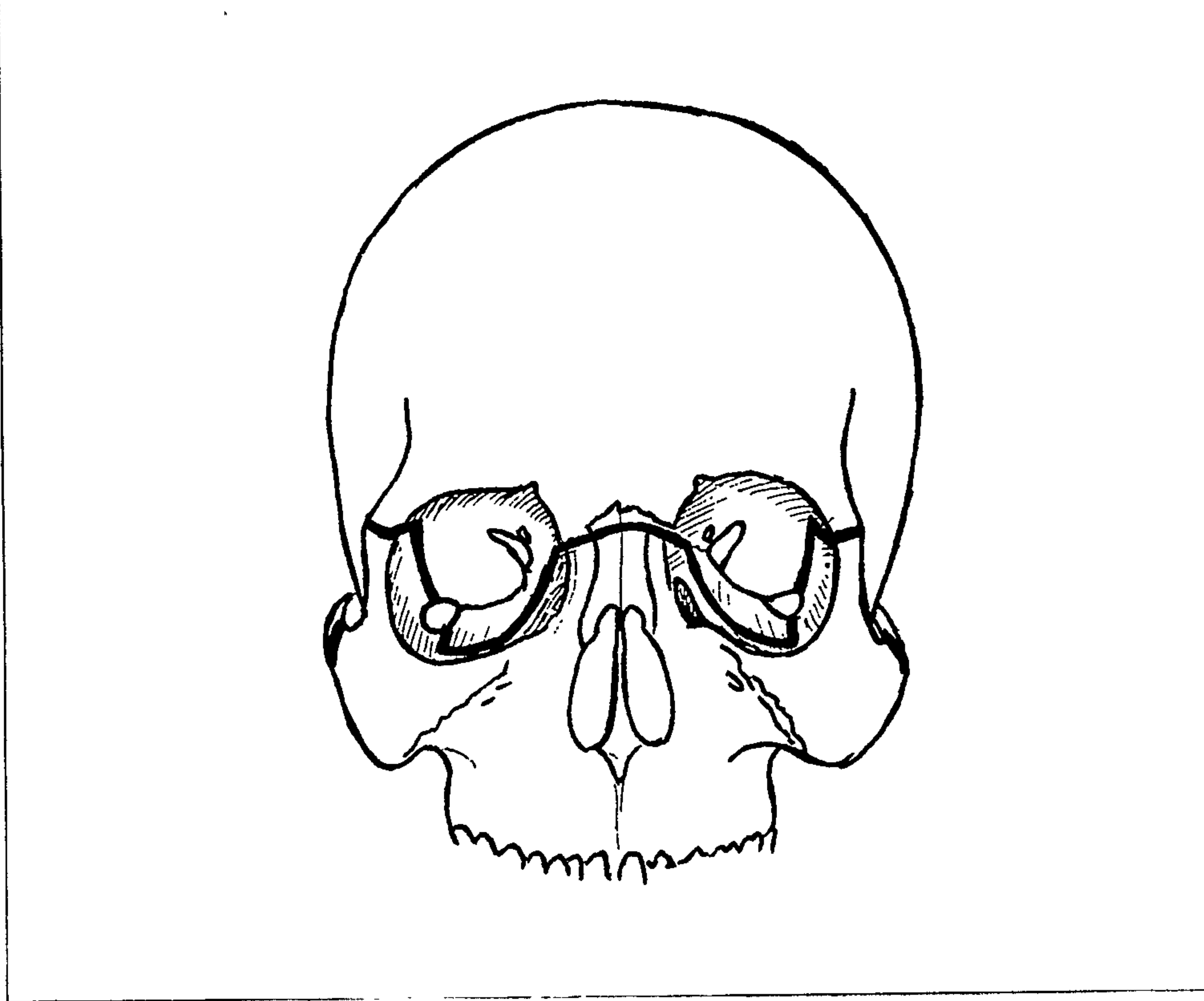


Fig. 18.

High maxillary osteotomy (after Jabaley and Edgerton): The nasal and orbital osteotomies are similar to those of Tessier. The zygomatic osteotomy extends through the zygomatic arch. (Jabaley and Edgerton, 1969).

through the posterior wall of the maxillary sinus lateral to the pterygoid processes.

Bone grafts were utilized to fill the interstices produced by the mid-facial advancement but not in the pterygo-maxillary area. Forward traction was maintained by transcutaneous wires placed through the lateral portion of the orbital rim and connected to an extension bar from a head-frame.

In some cases, an independent forward repositioning of the lower-half and the upper-half of the middle third of the facial skeleton must be performed. In the lower-half of the middle-third of the facial skeleton, the degree of forward movement is determined by occlusal necessity. The degree of movement of the upper-half is influenced mainly by esthetics. To achieve both goals simultaneously, Obwegeser (1969)¹⁶³ suggested both a Le Fort III and a Le Fort I osteotomy procedures in one operation, as shown in Fig. 19.

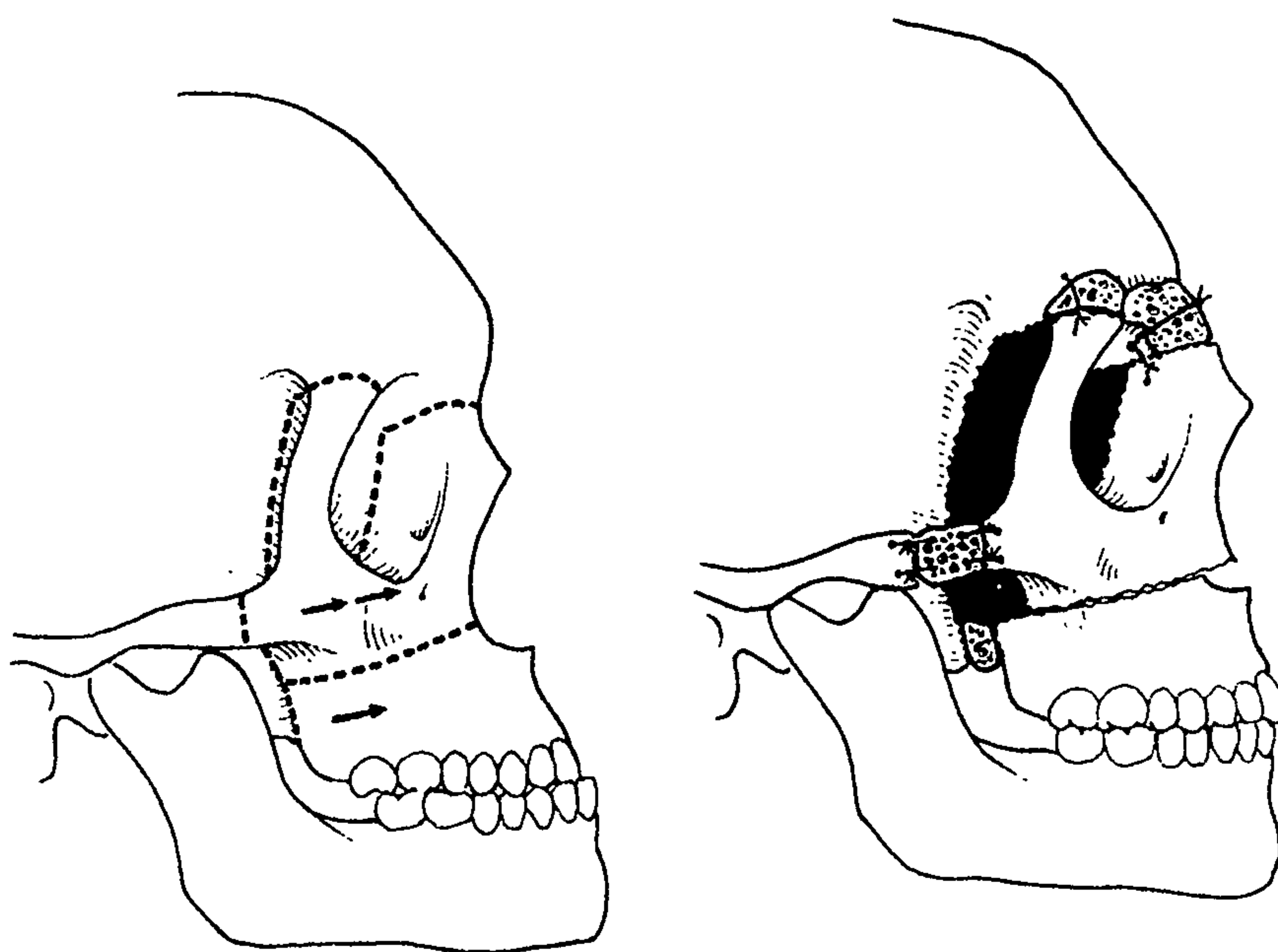


Fig. 19.

Combination of Le Fort I and Le Fort III maxillary osteotomy (after Obwegeser, 1969).

To ensure a firm bony union, important spaces between the moved and stable parts of the facial skeleton must be filled with bone. Bony steps, resulting from the movement of the skeletal parts are contoured with pieces of bones.

5.4.5. Conclusion.

There is no set pattern of the line osteotomy. The technique of osteotomy has to be adapted to the particular anomaly of the case and, as Epker (1975)⁵¹ stated, "... each deformity demands individual characterization and treatment considerations. In so doing, one must design an operation to fit the deformity and not to perform a standard operation."

Occasionally, mandibular osteotomy or ostectomy combined with maxillary surgery would have a place in the program of rehabilitation among cleft lip and palate patients (Knowles, 1969)¹¹³.

5.5. Relapse after Maxillary Osteotomy in the Correction of Maxillary Retrognathism Among Adult Cleft Lip and Palate Patients

5.5.1. Causes for Relapse.

As in orthodontic treatment, relapse is always a problem. Some of the possible causes for relapse after maxillary osteotomy are:

- (1) Insufficient period of immobilization (Kufner, 1971)¹²².
- (2) Insufficient immobilization technique (Conway et al, 1970)⁴¹.
- (3) Occlusal instability - relapse can be caused by insufficient occlusion for stabilization (Kufner, 1971)¹²².
- (4) Skin turgor - patients who have tight skin expect more relapse after the advancement of the mid-face (Epker, 1975)⁵¹.
- (5) Incomplete mobilization of fragment before repositioning. The prognosis for post-operative stability is excellent if good mobility is achieved during surgery (Epker, 1975)⁵¹. Obwegeser (1971)¹⁶⁴ required that the moved segments should be completely mobilized that a light finger pressure can displace the segment. Converse et al (1971)³⁹ stated that the moved segment should be 'rocked' loose.

Thus, the following points are taken into consideration to compensate or reduce the anticipated relapse.

5.5.2. Bone Graft.

A major contribution to prevent relapse in maxil-

lary osteotomy is the use of bone graft (Tessier, 1967^{225, 226}). These bone grafts were intended to prevent the advanced maxilla from receding and to ensure a firm, rapid union. Obwegeser (1971)¹⁶⁴ explained that defects between the margins of a repositioned segment and its host site do not always become filled by bone automatically. Soft tissue may fill in, and these contract, which may result in a dislocation. Therefore, the tendency for relapse is much less if the surgeon places bone along the path of the bone cut. This seems to ensure a better bony union.

Bone grafts are suggested to be placed in the following areas : (Epker et al, 1975)⁵¹

- (1) Pterygo-maxillary area.
- (2) Along the line of osteotomy on the lateral walls of the maxilla.
- (3) Other separations in the orbito-zygomatic area.

Posterior to the tuberosity, between the tuberosity and pterygoid process, is an empty space into which a piece of bone must be inserted. Failure to do so permits the scar tissue to contract and pull the maxilla backward (Obwegeser, 1971)¹⁶⁴.

Bell (1975)¹² stressed that the indications for the use of bone grafts are determined from pre-operative clinical and cephalometric studies, model analysis and clinical judgement. Bone grafts are indicated for the fol-

lowing bony movements :

- (1) Substantial advancement of the maxilla.
- (2) Widening of the maxilla.
- (3) Augmentation of the naso-labial, malar or infra-orbital area.
- (4) Increase in vertical height.
- (5) Residual bone clefts.

A covering of well-vascularized soft tissue is essential for the healing of fractures, line of osteotomy and bone grafts (Bell et al, 1975)¹³. Bone grafts are usually taken from the patient's own iliac bone (in the adult), or from one of his ribs (in children or adolescent). Bone taken from the patient himself (autograft) is far superior to bone supplied from other individuals (homograft), or from animal (xeno-graft). In bone grafting for jaw malformation, however, only a moderate amount of bone is required, and the patient's own bone gives the best chance of success (Converse, 1954)³⁷.

5.5.3. Period of Immobilization.

Sufficient period of immobilization allows bone healing and certainly contribute to prevention of relapse (Kufner, 1971)¹²². Definitely, this also depends on the osteogenic response of the patient. The following table is a summary of the period of time advocated by some surgeons for immobilization.

Table 1 . Summary of the Period of Immobilization Advocated by Different Authors.

Surgeon	Period of Immobilization	Surgeon	Period of Immobilization
Bala (1970) ^a	6 wks.	Hopkin (1975) ^h	6 wks.
Bell (1975) ^b	6-8 wks.	Kiehn et al (1968) ⁱ	4-6 wks.
Converse et al (1970) ^c	6 wks.	Murray & Swanson (1968) ^j	8 wks + 8 wks.w/ elastic
Dupont et al (1974) ^d	6-8 wks.	Obwegeser (1967) ^k	6 wks.
Edgerton et al (1969) ^e	10 wks. + 6 wks.w/elastic	Pedersen et al (1975) ^l	5-6 wks.
Epker et al (1975) ^f	6 wks.	Popescu (1974) ^m	55 days
Gillies (1950) ^g	5 wks.	Rowe (1954) ⁿ	3 mos.

(cont'd)

Table 1 . (cont'd)

- a. Bala, S. (1970). Maxillary osteotomy as a secondary cleft palate procedure. Trans. Congr. Int. Assoc. Oral Surg., p.32.
- b. Bell, W.H. (1975). Le Fort I osteotomy for correction of maxillary deformities. J. Oral Surg., 33:412.
- c. Converse, J.M., Horowitz, S.L., Valauri, A.J. and Montandon, D. (1970). The treatment of naso-maxillary hypoplasia. Plastic and Reconstr. Surg., 45: 527.
- d. Dupont, C., Ciaburro, H. and Prevost, Y. (1974). Simplifying the Le Fort I type of maxillary osteotomy. Plastic and Reconstr. Surg., 54:142.
- e. Edgerton, M.T. and Jabaley, M.E. (1969). Surgical correction of congenital mid-face retrusion in the presence of mandibular prognathism. Plastic Reconstr. Surg., 44:1.
- f. Epker, B.N. and Wolford, L.M. (1975). Middle-third facial osteotomies : their use in the correction of acquired and developmental dento-facial and cranio-facial deformities. J. Oral Sug., 33:491.
- g. Gillies, H. (1951). Operative correction by osteotomy of recessed malar maxillary compound in a case of oxycephaly. British J. of Plastic Surg., 3: 125.
- h. Hopkin, R. (1975). The use of a Le Fort I osteotomy as a surgical approach. British J. of Oral Surg., 13:27.
- i. Kiehn, C.L., Desprez, J.D. and Brown, F. (1968). Maxillary osteotomy for late correction of occlusion and appearance in cleft lip and palate patients. Plastic Reconstr. Surg., 42:1968.
- j. Murray, J.E. and Swanson, L.T. (1968). Mid-face osteotomy and advancement for craniosynostosis. Plastic Reconstr. Surg., 41:299.
- k. Obwegeser, H. (1967). Surgery as an adjunct to orthodontics in normal and cleft palate patients. Trans. of European Ortho. Socety, p.343.
- l. Pedersen, G. W. and Blako, D.M. (1975). Total maxillary osteotomy for cleft palate rehabilitation. Oral Surg., 39:669.
- m. Popescu, V.C. (1974). Advancement of the middle-third of the face without bone grafting in a case of Crouzon's disease. J. Max-fac. Surg., 2:219.
- n. Rowe, N.L. (1954). Secondary surgical procedures for the correction of deformity in the cleft lip and palate patients. British Socety for the Study of Ortho., 5:54.

In summary, most surgeons agree that six weeks' immobilization seem adequate.

5.5.4. Occlusal Stability.

A stable occlusion can help to prevent relapse. Good intercuspitation and vertical overbite will also help to counteract the scar contraction in the retromaxillary region (Friehofer, 1973)⁶³. Sometimes, careful selective grinding of the buccal cusps of the lower posterior teeth is indicated because the unfavorable inclines of the lower teeth can be a factor in encouraging relapse (Rowe, 1954) 191.

5.5.5. Age.

Obwegeser (1971)¹⁶⁴, Popescu (1974)¹⁷³ and Kogeman et al (1974)¹¹⁴, have the impression that there is a higher tendency for relapse in the younger patients than in those adult patients.

Two possible reasons have been offered to explain this impression : (Knowles, 1969¹¹³; Converse, 1975⁴⁰)

(1) Growth - It is advisable to delay any osteotomies until growth becomes static when one can assess definitely the degree of deformities.

(2) Insufficient immobilization - The permanent dentition is more suitable for retention of splint for immobilization purpose.

5.5.6. Overcorrection.

A limited amount of relapse does occur in almost every case of maxillary surgery. Overcorrection must be considered to obtain the desirable esthetic result (Epker, 1975⁵¹; Converse, 1975⁴⁰). This is particularly true in planning maxillary surgery for younger individuals (Friehofer, 1973)⁶³. The further growth of the mandible will finally create a profile line which is near to normal.

Lines and Steinhauser (1974)¹³¹ suggested that an overcorrection of at least 25 % is made to counteract the relapse tendency when planning maxillary advancement surgery for cleft lip and palate patients.

5.5.7. Proper Use of Immobilization Appliances.

There is a wide range of appliances for immobilization that are designed for different types of osteotomies, like inter-maxillary wires, direct bone wires, external fixation, (like head-frames and plaster of Paris headcap), cast splints, orthodontic bands, and labial rectangular wire, Kirschner wires, Oliver loop or arch bars, etc. These can be used singly or in combination to provide firm and rigid control of the moved segments during immobilization period (Rowe, 1954¹⁹¹; Kiehn et al, 1968¹⁰⁶; Conway, 1970⁴¹; Friehofer, 1973⁶³; Epker, 1975⁵¹).

5.5.8. Summary.

A complete and concise summary of Kufner (1971)
122 serves as our guide to prevent relapse :

- (1) Good planning of the operation;
- (2) Implantation of bone graft;
- (3) Thorough and effective fixation;
- (4) Deep bite occlusion; and
- (5) Sufficient long period of inter-maxillary immobilization.

5.6. Soft Tissue Changes in Relation to Movement of Hard Structure in Maxillary Osteotomy

There is very little in the literature on the soft tissue profile changes after maxillary surgery. In orthodontic tooth movement, King (1960)¹⁰⁸, Bloom (1961)¹⁹, and Rudee (1961)¹⁹², respectively, found that the distal movement of maxillary anterior teeth and the upper lip followed a 2:1, 1:0.85 and, 1:0.75 ratio.

Lines and Steinhauser (1974)¹³² found that after surgical posterior repositioning of the maxillary teeth, the ratio also approximate a 2:1 hard to soft tissue ratio.

Bell (1973)¹¹, in his study of 25 patients, found a highly significant correlation of 0.75 for movement of upper lip retraction with incisor retraction produced by anterior maxillary osteotomy. He suggested to use the figure 0.7 ± 0.1 for clinical use in predicting upper lip position after anterior maxillary osteotomy

In one study of three cleft lip and palate patient who had maxillary advancement, the ratio of soft to hard structure was nearly 2:3 (Lines and Steinhauser, 1974)¹³². With such a small number of cases, this may be only a preliminary indicator.

He listed the following problems in evaluating soft tissue changes among cleft lip and palate patients after maxillary advancement surgery :

(1) The presence of scar band in the upper lip which may affect the measurement.

(2) Difficulty in location of point A.

(3) Maxillary surgery sometimes requires removal of the anterior nasal spine which make the location of point A impossible.

At this time, there is no conclusive figure to guide us in predicting the soft tissue changes after maxillary advancement surgery among cleft lip and palate patients.

5.7. Summary

Whenever there is severe skeletal and occlusal discrepancy among adult cleft lip and palate patients with maxillary retrognathism, maxillary surgery is indicated. The technique of maxillary osteotomy has to be adapted to the particular anomaly of the case. Proper pre-surgical orthodontic treatment has been shown to be beneficial in the correction of the occlusal discrepancy during the surgery. Relapse and complications are expected and these can be minimized through good planning of the operation, implantation of bone graft, thorough and effective fixation, deep bite occlusion and sufficient long period of inter-maxillary immobilization.

PART II

PRESENTATION OF THE METHOD TO FORM A QUANTITATIVE
ASSESSMENT FOR THE DIAGNOSIS AND TREATMENT PLANNING
OF MAXILLARY RETROGNATHISM AMONG ADULT CLEFT LIP
AND PALATE PATIENTS INDICATED FOR MAXILLARY OSTEOTOMY .

1. INTRODUCTION

In order to form a quantitative assessment in this study, for the diagnosis and treatment planning for this group of cleft lip and palate patients with maxillary retrognathism indicated for maxillary surgery, we depend more on the information from (1) cephalometric assessment, (2) model study and, (3) profile evaluation and prediction.

In the cephalometric assessment, Sassouni's Archial Analysis is used for skeletal appraisal. This analysis does not depend solely on the use of the cranial base as its line of reference; the latter's unreliability, especially among this group of cleft patients with maxillary retrognathism, has been mentioned in the literature review (Section 4.4.3). Bolton Standard Analysis is used in conjunction with Sassouni Archial Analysis to evaluate each component of facial skeleton according to age-size standards and also the spatial relationship of the skeletal parts and soft tissue profile.

The qualitative assessment is actually the clinical and photographic evaluation. This, together with the quantitative assessment in this study enables the plastic surgeon, the oral surgeon and the orthodontist to make the final diagnosis and treatment planning for the patient.

2. CEPHALOMETRIC ASSESSMENT

The objectives of cephalometric assessment for surgical correction of facial deformities among cleft lip and palate patients is to have a critical appraisal of the cranio-facial skeletal make-up which includes : (1) the actual size of each skeletal component; (2) the relative position of each skeletal component; and (3) the location of the sites of facial skeletal deformities.

To do this, we use Bolton Standards (Broadbent et al, 1975)²⁴ and Sassouni Archial Analysis (Sassouni, 1955¹⁹⁷; 1974¹⁹⁹; 1975¹⁹⁸).

2.1. Bolton Standard Analysis

2.1.1. Definitions of Cephalometric Landmarks and Terms for Bolton Standard Analysis.

(1) Anterior Nasal Spine (A-N-S) : sharp median process formed by the forward prolongation of the two maxillae at the lower margin of the anterior aperture of the nose.

(2) Articulare (Ar) : intersection of the lateral radiographic image of the posterior border of the ramus with the base of the occipital bone. On the lateral cephalometric tracing, the point of intersection of the posterior border of the condyle of the mandible with the Bolton plane.

(3) Basion (Ba) : point where the median sagittal plane of the skull intersects the lowest point on the anterior margin of the foramen magnum.

(4) Bolton Plane : line joining the Bolton point and nasion on the lateral radiograph.

(5) Bolton Point (Bo) : point in space, about the center of the foramen magnum, that is located on the lateral cephalometric radiograph by the highest point in the profile image of the post-condylar notches of the occipital bone. Since the post-condylar notches are close to the median sagittal plane, their shadows generally register on the lateral film as a single image; also the posterior termination of the Bolton plane.

(6) Frankfort Plane (F.H.) : horizontal plane determined by the two poria and the left orbitale. It approximates closely the position in which the head is carried during life and is established on the lateral cephalometric radiograph by a line joining orbitale with porion, as indicated by the top of the ear rod of the cephalometer.

(7) Gnathion (Gn) : lowest, most anterior midline point in the symphysis of the mandible.

(8) Nasion (N) : craniometric point where the mid-sagittal plane intersects the most anterior point of the naso-frontal sutures; the anterior termination of the Bolton plane.

(9) Point R (Bolton registration point) : center of the Bolton cranial base; a point midway on a perpendicular erected from the Bolton plane to the center of the sella turcica(s).

(10) Subspinale (A) : point in the median sagittal plane where the lower front edge of the anterior nasal spine meets the front wall of the maxillary alveolar process.

(11) Posterior nasal spine (P-N-S) : process formed by the united projecting medial ends of the posterior border of the two palatine bones.

(12) Sella turcica (Turkish saddle) S : hypophyseal, or pituitary, fossa of the sphenoid bone, lodging the pituitary body. The landmark S is the center of the sella, as seen in the lateral radiograph and located by inspection.

(13) Bolton standard correlation : it is the interpretation of the cranio-facial components by comparing to the Bolton Standards (as described by Broadbent et al, 1975)²⁴.

(14) Cranial base, Bolton standard correlation (CB,BSC) : a given chronologic age value obtained by comparing the measurement of the cranial base (measured between the Bolton point (Bo) and nasion) to the Bolton Standards (as described by Broadbent et al, 1975)²⁴.

(15) Maxillary, Bolton standard correlation (Mx,BSC) : a given chronologic age value obtained by comparing the measurement of the maxilla (measured between posterior nasal spine to point A) to the Bolton Standards (as described by Broadbent et al, 1975)²⁴.

(16) Mandibular, Bolton standard correlation (Mn,BSC) : a given chronologic age value obtained by comparing the measurement of the effective length of the mandible (measured between Bolton articulare to gnathion) to the Bolton Standards (as described by Broadbent et al, 1975)²⁴.

2.1.2. Bolton Standards.

Bolton Standards are a series of average of Caucasian male and female individual cases that have optimal facial and dental developmental growth. The individuals who were to make the standards have been selected from the population of the Bolton study, which has a data base of more than 22,000 recordings or over 5,000 youngsters. The recordings are accumulated in a computer as longitudinal series.

The youngsters selected for the Bolton Standards all have : (1) excellent healthy history; (2) very good dentition; (3) normal developing occlusion (no orthodontic intervention); (4) long term longitudinal X-ray recordings and; (5) favorable comparison to an 'optimal' face. The optimum model, or 'mean face', was developed through a painstaking process of measurement and inspection of the multitude of originally collected data and updated over the years. From a model of this type, derived through laborious statistical averaging and careful morphologic comparison, the basis for selection of cases was developed.

Presentation of Bolton Standards is in lateral

and frontal cephalometric transparent templates which have the age range from one to eighteen years of age.

2.1.3. Suggested Method for Bolton Standard Analysis (Broadbent et al, 1975)²⁴.

(1) Superimpose the appropriate chronologic Bolton Standards on the tracing (or radiograph) and compare in Bolton relation (R point superimposed and Bolton planes parallel).

This procedure enables proper orientation of the Bolton Standard templates for later skeletal and soft tissue assessment.

(2) Next, assess the component skeletal parts individually with Bolton Standard that best approximates the skeletal area under appraisal and assign a BSC age to each (cranial base-CB, maxilla-Mx, mandible-Mn).

This procedure enables the clinician to visualize the relative size of each skeletal component of the face. Ideally, different skeletal components of the face should carry the same or, nearly the same Bolton Standard Correlation age.

(3) Make a coordinate appraisal of the total skeletal relationships, both morphologic and spatial, noting in particular the factors influencing the position of the dental arches.

This procedure enables the assessment of the relative position of each skeletal component and possibly to locate the site or sites of facial skeletal deformities.

(4) Finally, analyze the soft tissue morphology on a 'best fit' basis (starting with the forehead and nose) and relate it to the underlying skeletal components.

This procedure enables assessment of the integumental profile of the patient. The nose, both in height and outline, is important in the total profile of the patient and this can also be assessed by comparing with the Bolton Standards.

2.2. Sassouni's Archial Analysis (Sassouni, 1955¹⁹⁷; 1974¹⁹⁹; 1975¹⁹⁸)

It was pointed out in the literature review (4.4.3.), that use of different planes of orientation (either Frankfort horizontal, Cranial base (S-N) or visual axis etc.) lead to different quantitative results. Sometimes the results can be contradictory with qualitative results from clinical and photographic assessment. This happens more often when doing the cephalometric analysis for patients with facial deformities like cleft lip and palate patients (Moss, 1956)¹⁵².

In order to have satisfactory and reasonable cephalometric analysis which agrees with the clinical impression, we attempt to use Sassouni Archial Analysis. In this analysis, instead of using a single line or point of reference, four planes (supra-orbital, palatal, occlusal, mandibular) form the basis of the construction. These four planes are orientated in such a way that they tend to converge posteriorly to the profile. The point of convergence does vary both vertically and antero-posteriorly in each particular face. No one plane nor point in this construction is considered fixed. The advantage of the arc (as will be described in Part II, 2.2.2.), is to provide an anterior reference (the anterior arc), not being dependent on one fixed plane, but on the resultant of four. Being individual in construction, the arc affords a positive approach for

diagnostic analysis.

2.2.1. Definition of Cephalometric Landmarks and Terms for Sassouni Archial Analysis. (Sassouni, 1974)¹⁹⁹

- (1) Sella Turcica (S) : Hypophyseal or pituitary fossa of the sphenoid bone, lodging the pituitary body. The landmark 'S' is the center of sella.
- (2) Dorsum Sellae (SP) : Most posterior point on the internal contour of sella turcica.
- (3) Floor of Sella (Si) : Lowermost point on the internal contour of sella turcica.
- (4) Clinoidale (Cl) : Most superior point on the contour of the anterior clinoid.
- (5) Roof of the Orbit (Ro) : Uppermost point on the roof of the orbit.
- (6) Supra-orbitale (SOr) : Most anterior point of the intersection of the orbit and its lateral contour.
- (7) Supra-orbital Plane : Line drawn tangent to the most superior point on the roof of the orbit and the anterior clinoid.
- (8) Parallel to Supra-orbital Plane : Line drawn tangent to the lowest point of the contour of sella turcica (Si) and parallel to the supra-orbital plane.
- (9) Occlusal Plane : Constructed by joining A-N-S and P-N-S.
- (10) Mandibular Plane : Constructed by drawing a line

from menton to the lowest point of the ramus just posterior to the ante-gonial notch.

(11) Incisor Superius (Is) : Incisal tip of the crown of the most anterior anterior central incisor.

2.2.2. Methods Suggested in Sassouni Archial Analysis.
(Sassouni, 1974)¹⁹⁹ Fig. 20

(1) Draw: a) parallel to supra-orbital plane, b) occlusal plane, c) palatal plane, d) mandibular plane, and extend them posteriorly. The most frequent tendency for the planes is to converge posteriorly toward a common center (center 'O'). This center should be located as the center of an area of 15 mm. diameter (size of a dime), within which pass the planes. If any one plane is out of convergence to a degree where it cannot be covered by a dime in the location of the center 'O', that plane is not taken into account.

From center 'O', a series of arcs is drawn.

(2) The anterior arc from nasion. In comparison to this arc, A-N-S, Is and Pog are evaluated. In balanced profiles, these three points are situated in the arc. When all three are anterior or posterior to the arc, a second arc is drawn from A-N-S in order to evaluate the position of the upper incisor on the maxilla and the position of the chin in relation to maxilla.

(3) The posterior arc from Sp (dorsum sella) should pass through gonion (Go), and is indicative of the posterior

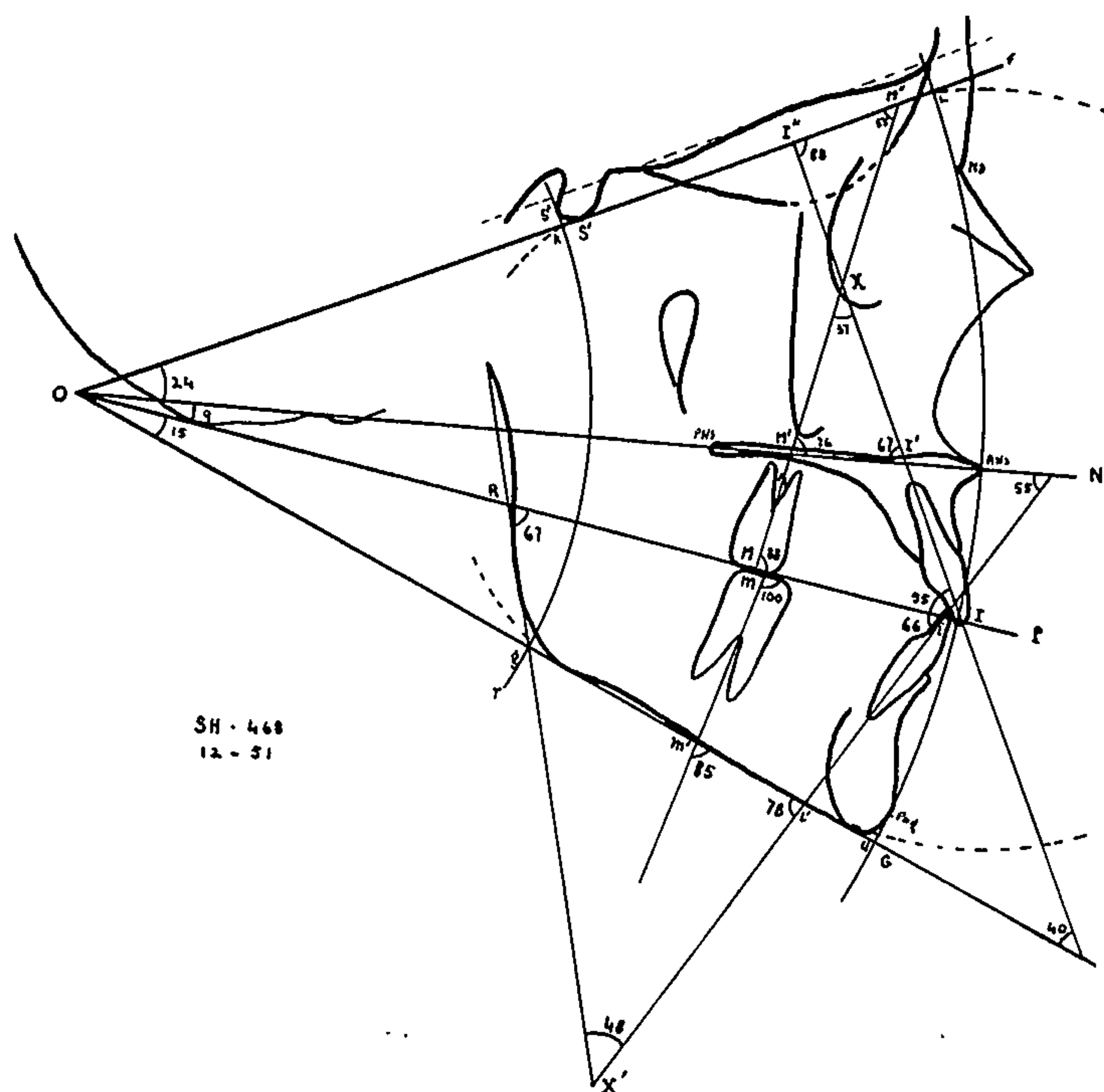


Fig. 20

A well-proportioned face in Sassouni Archial Analysis
(Sassouni, 1955).

position of the mandible.

(4) Anterior vertical : Put the point of compass on A-N-S and open the compass to supra-orbitale, then transfer this dimension by rotating the compass until it intersects the anterior arc at the level of menton. This distance from A-N-S, to supra-orbitale should be equal to [that from A-N-S, to supra-orbitale should be equal to that [from A-N-S] to menton at 4 years of age. At 12 years, the distance ANS-Me is approximately 5 mm. greater than A-N-S to supra-orbitale. In the adult male, the distance A-N-S to Me is 10 mm. larger than A-N-S to supra-orbitale.

(5) Posterior vertical : Put the point of compass on P-N-S and open to the point of intersection of the posterior arc with the parallel plane, then transfer this dimension by rotating the compass until it intersects the posterior arc at the level of gonion. The distance from P-N-S to the point of intersection of the posterior arc with the parallel plane (upper posterior facial height) should be equal to that from P-N-S to gonion (lowest posterior facial height).

3. MODEL STUDY

3.1. Introduction

The purpose of model study is to use the occlusion as the guide for surgery. There is a great chance that a good functional occlusion usually accompany an acceptable profile (Obwegeser, 1969)¹⁶³.

3.2. Method for Model Surgery

The procedures of model surgery are carried out as follows :

- (1) Take two upper and lower impressions, so as to have one stone set to record pre-operative occlusion and jaw relation, and the other plaster set for model surgery.
- (2) Put some vaseline on the base of the upper cast which is for model operation.
- (3) Mount the upper and lower casts to the articulator according to the patient's occlusal relationship.
- (4) Tighten the screw behind the articulator so as to fix and maintain the same vertical dimension throughout the model operation.
- (5) Draw two lines of 10 mm. apart, one on the upper plaster base of the articulator and the other line on the plaster base of the upper cast. Any change in distance between these two lines during model operation indicates change in vertical position of the maxilla.
- (6) Along both sides of the upper plaster base, mark some

vertical lines across the plaster base of the articulator and the upper model. The difference between corresponding vertical lines after model surgery indicates change in the horizontal position of the maxilla.

(7) Carefully separate the upper plaster cast from the plaster base of the articulator.

(8) With the amount of skeletal or occlusal discrepancy (as derived from cephalometric analysis) as reference, manipulate the upper cast by a) sectioning along the cleft or clefts in unilateral or bilateral condition and put the segments together again to achieve proper transversal maxillary dimension; b) by moving the cast forward and backward; c) by tilting the cast upward and downward in order to accomplish the following: i. correction of the skeletal discrepancy. ii. an acceptable occlusion. iii. maintaining the same vertical dimension.

In case of maxillary surgery, it is important to over-correct the maxilla forward an additional of 25% of the dimension which the maxilla is originally planned to move forward. This is the allowance for relapse.

(9) Mount the upper cast again to the plaster base of the articulator in the new position.

(10) Measure the differences of the horizontal and vertical lines after model surgery. These differences in different area show how the maxilla should move forward. The

amount of movement will be transferred to the cephalometric tracing again for profile prediction.

4. PROFILE ASSESSMENT

4.1. Introduction

The process of predicting the profile is an attempt to visualize the profile after surgery. If the predicted profile is not satisfactory, one has to start over the whole procedure again from cephalometric analysis or it may be necessary to do genioplasty or rhinoplasty for satisfactory result.

4.2. Method for Profile Prediction

The method we use to predict profile is as follows :

- (1) Trace the pre-surgical cephalometric radiograph of the patient on acetate tracing film.
- (2) Cut from the ceph-photo-transparency, the parts that are not going to be touched in the operation. These parts will be positioned to the corresponding position in the pre-surgical cephalometric tracing.
- (3) The parts that are going to be corrected will be related to the cephalometric tracing with corresponding vertical and horizontal movement from model surgery.
- (4) Evaluate the facial soft tissue profile with esthetic plane after repositioning the cutout of the jaw segments to the original cephalometric tracing.

The profile can also be evaluated directly from the Profile Prediction Tracing where all the changes (both

vertical and horizontal dimensions) from model surgery, are transferred to the original cephalometric tracing. The soft tissue profile simply follows the bony structures in a 1:1 ratio. An over-corrected convex profile should be expected from such prediction, although the actual soft tissue profile change may be less than the hard tissue change i.e. 1:0.75. (Bell et al, 1973)¹¹.

5. SUMMARY

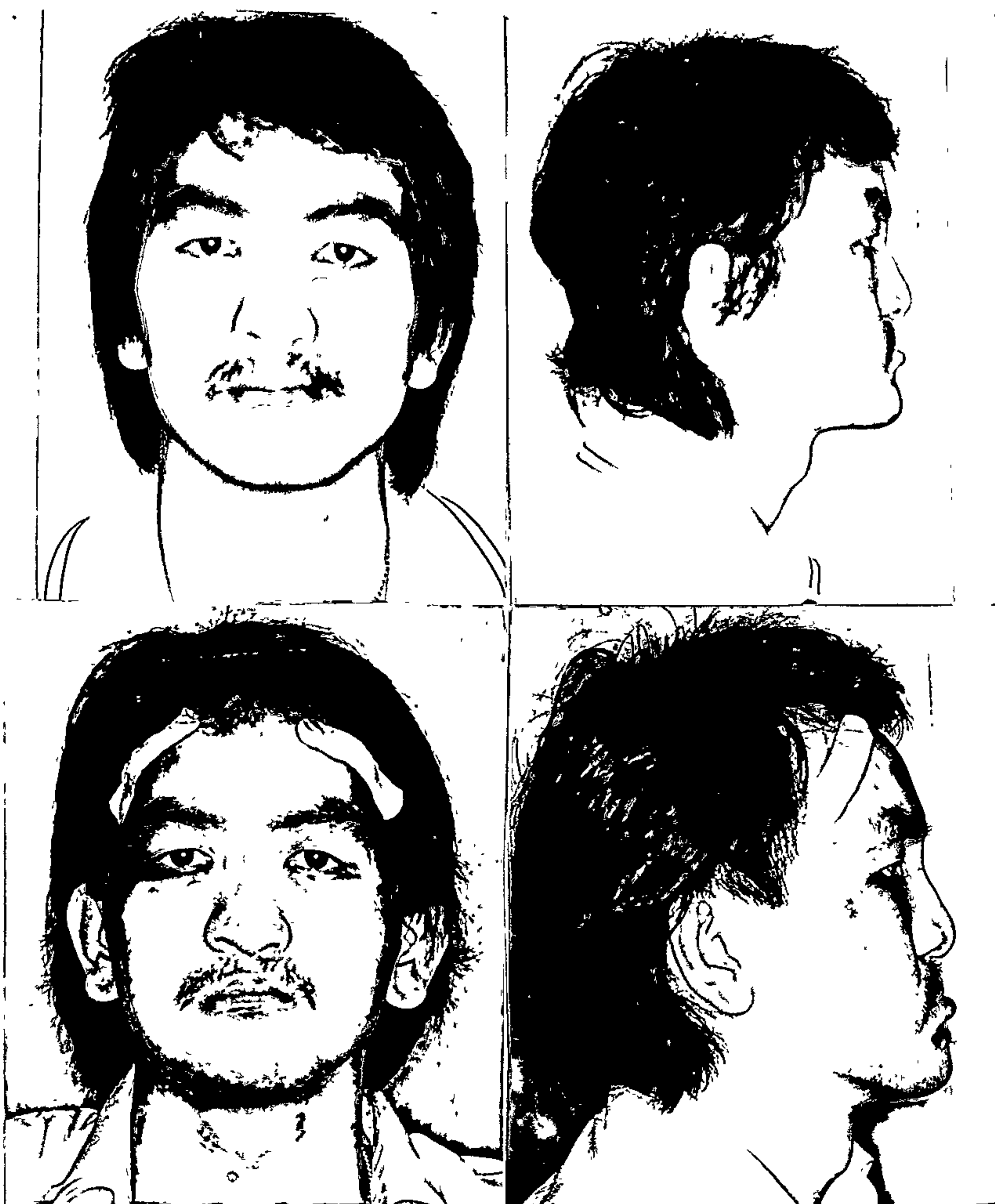
Having done the cephalometric analysis, model study and profile assessment of the patient, one can then present the quantitative data to the plastic surgeon and oral surgeon for further comments.

PART III

PRESENTATION AND 'PROGRESS EVALUATION' OF SEVEN CASES
USING THIS METHOD FOR DIAGNOSIS AND TREATMENT PLANNING
OF MAXILLARY RETROGNATHISM AMONG ADULT CLEFT LIP AND
PALATE PATIENTS INDICATED FOR MAXILLARY OSTEOTOMY.

CASE 1

LE FORT III MAXILLARY OSTEOTOMY



Before
Surgery

After
Surgery

Age : 24 years old.

Sex : Male

Original Condition : Unilateral Complete Left Cleft.

History : Repair of cleft palate at 20 months old.

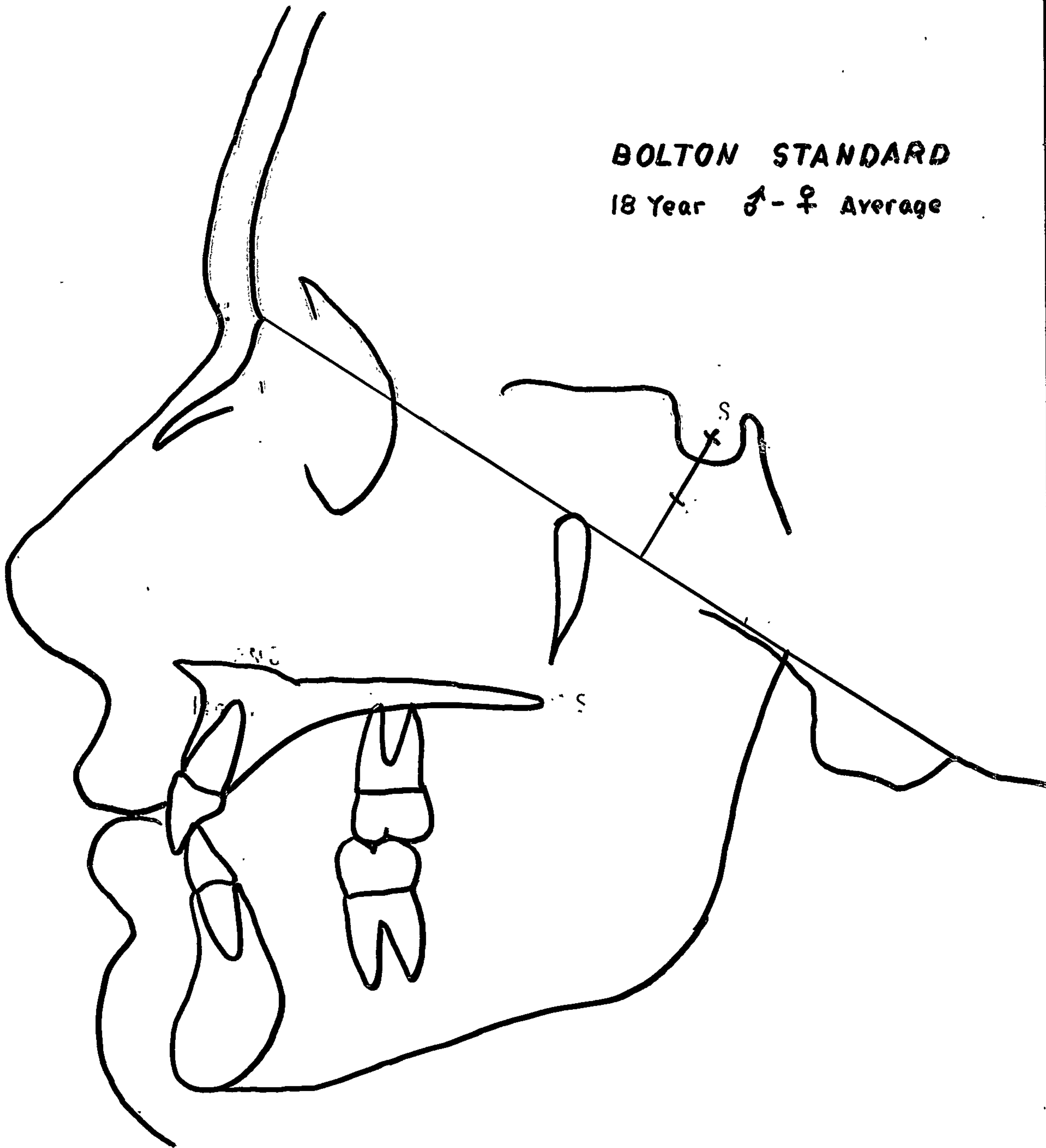
Repair of cleft lip at 10 years old.

No other significant medical findings.

No nasal problem.

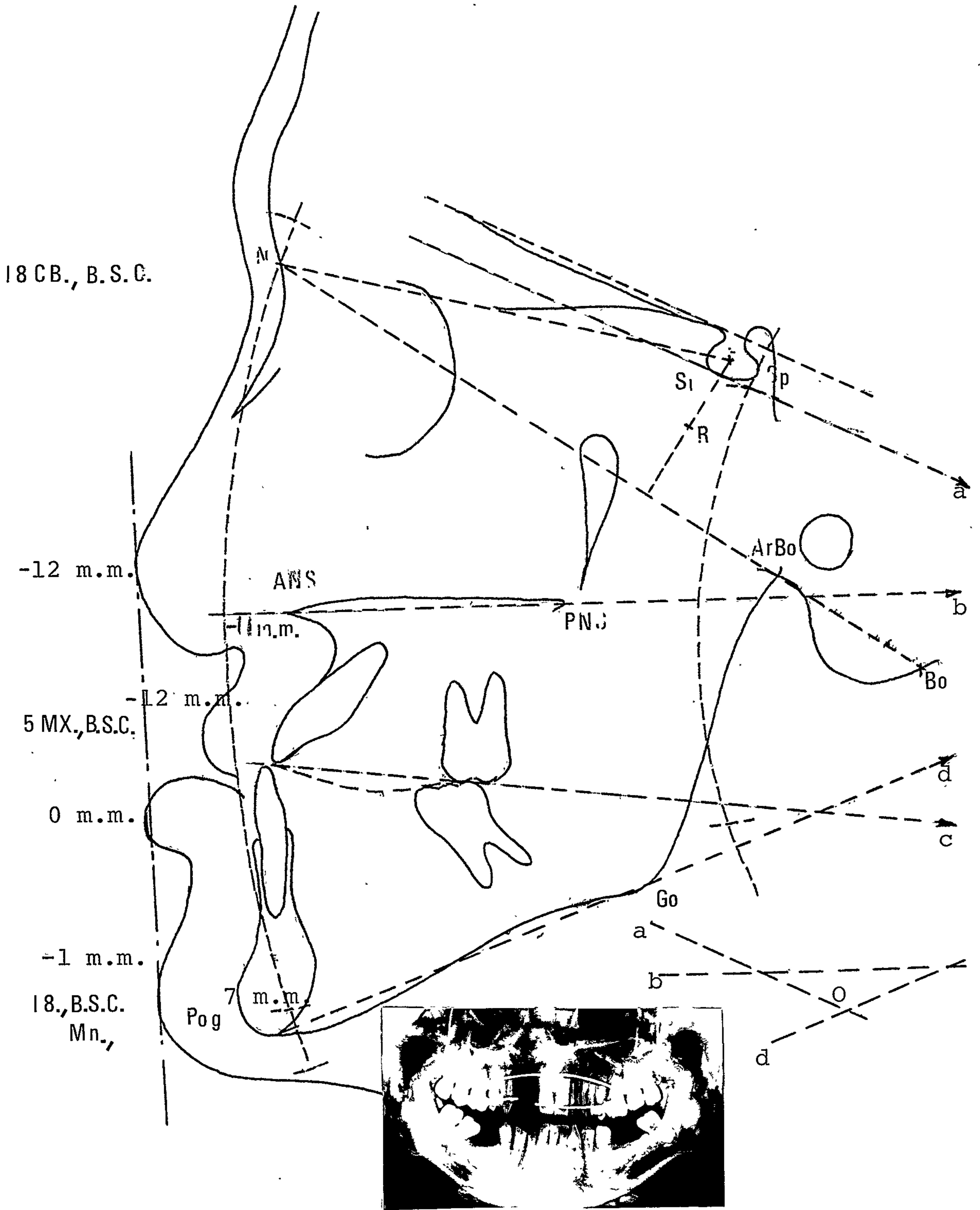
BOLTON STANDARD

18 Year ♂ - ♀ Average



CASE 1
DIAGNOSTIC TRACING

19-11-76



CASE I DISCUSSION

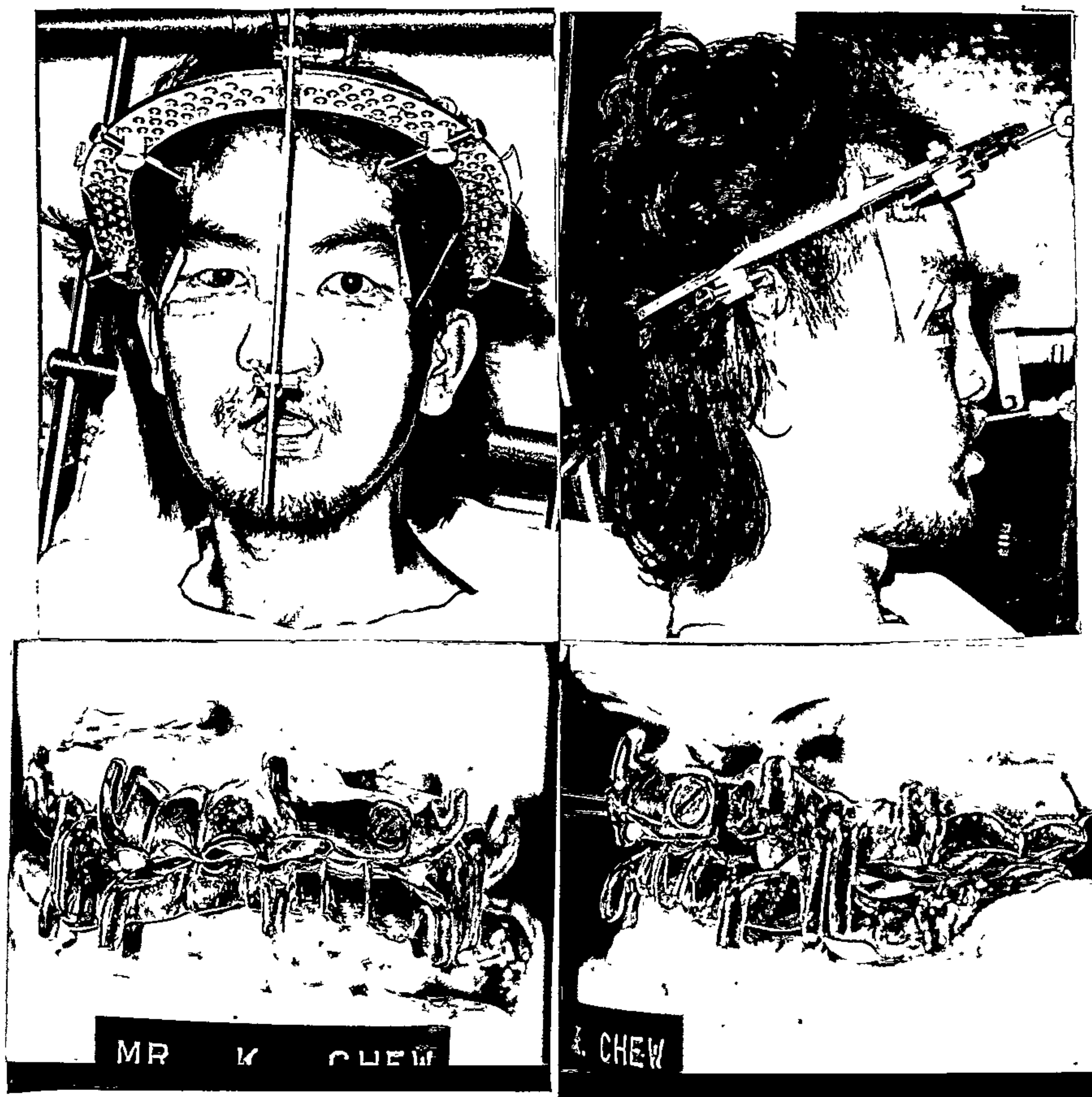
Diagnostic tracing shows that the cranial base and mandible are of normal size antero-posteriorly (18 CB., 18 Mn., B.S.C.) while the maxilla is very much under-developed (5 Mx., B.S.C.). In Sassouni Archial Analysis, mandibular pogonion is +7mm. in front of the anterior arc and maxillary A-N-S is -11 mm. behind the anterior arc. This indicates that maxillary complex is the major region of deformity. Bolton Standard template of 18 years confirms this finding. Moreover, the nasal tip and upper lip are both -12 mm. behind the Bolton Standard. Lower lip and soft tissue pogonion are normal when compared to Bolton Standard of 18 years.

In order to correct mid-face deficiency and nasal height, a high Le Fort I or a Le Fort II maxillary osteotomy is indicated in this case. The surgeon decided to do a Le Fort III maxillary osteotomy in this case. Model surgery indicated that a forward movement of maxillary complex of 10 mm. would provide a stable occlusion and correction of the skeletal discrepancy. The predicted profile (from cephalometric and photographic profile prediction) is satisfactory when compared to esthetic plane and Bolton Standard template of 18 years.

Post-operative changes can be evaluated with

Sassouni Archial Analysis, Bolton Standard, normal cephalometric analysis and model studies as shown in (1) pre- and post-surgical cephalometric assessment, and (2) model study assessment.

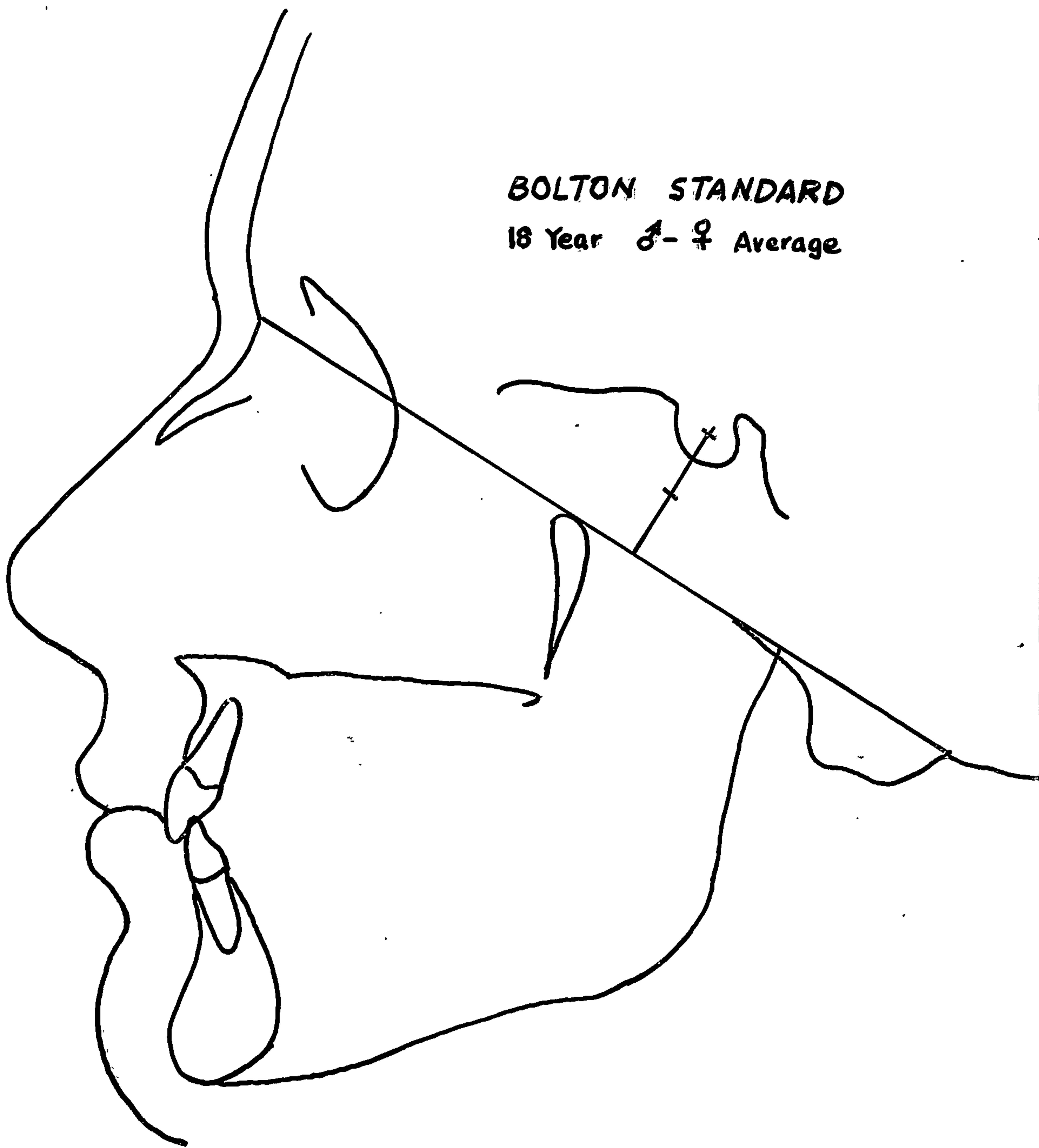
Intra-oral casted silver splint and head-frame were used for immobilization for 6 weeks, as shown :



Planes used to locate center "O" in Sassouni Archial Analysis were : (1) parallel to supra-orbital plane, (2) palatal palne and (3) mandibular plane.

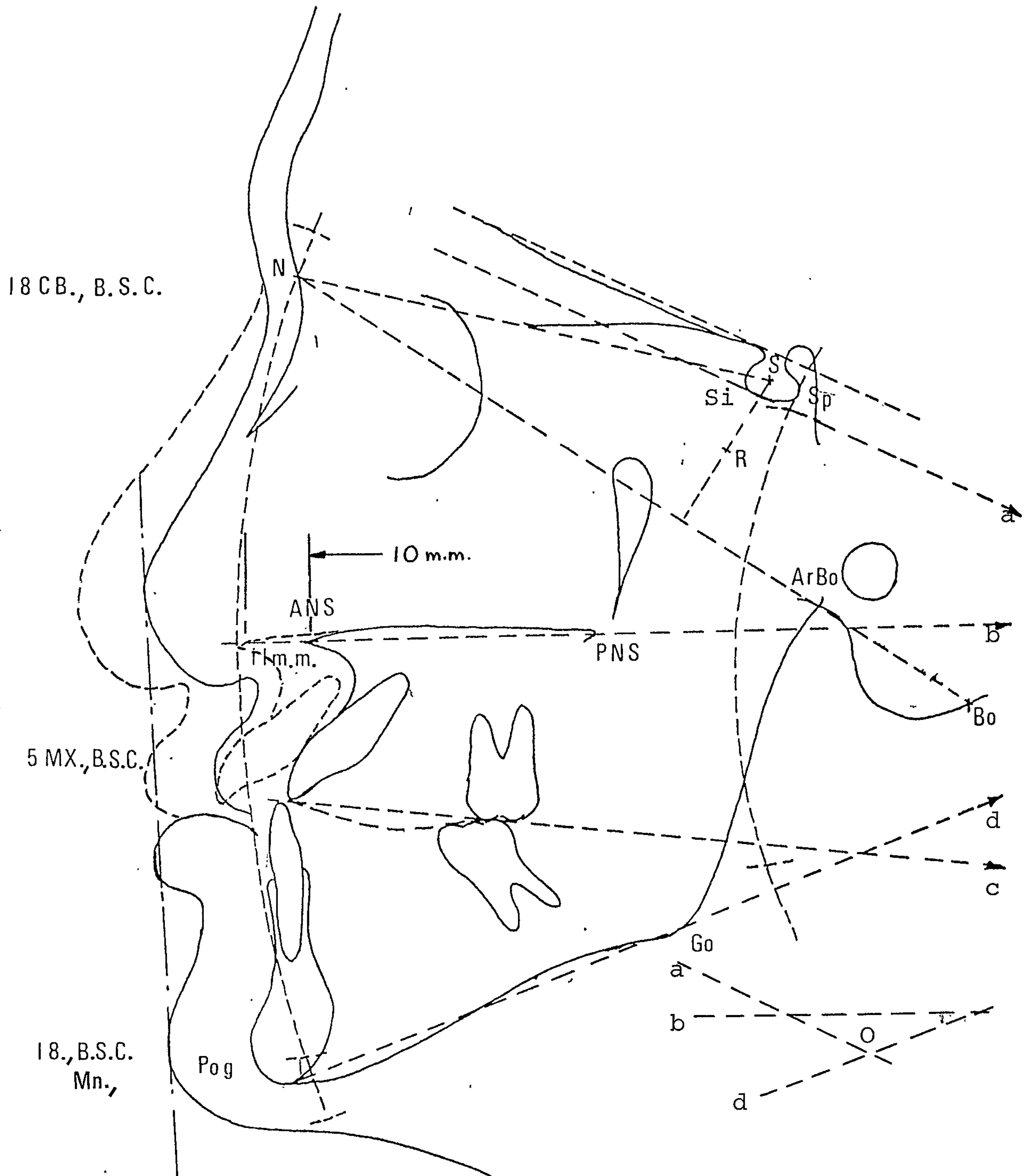
Radius of the anterior arc in Sassouni Archial Analysis was found to be 17.7 cm.

BOLTON STANDARD
18 Year ♂-♀ Average



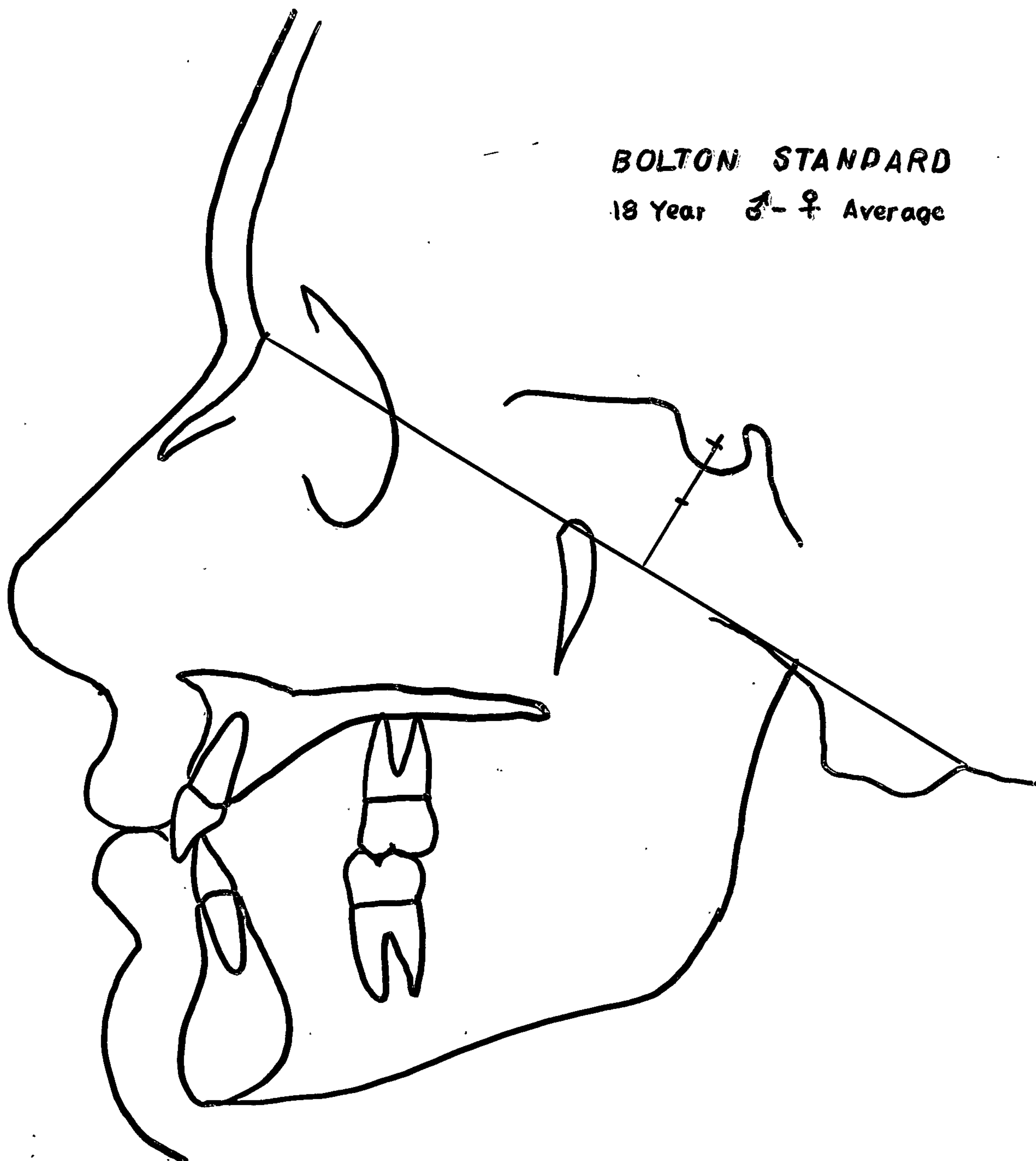
PROFILE PREDICTION TRACING

19-11-76



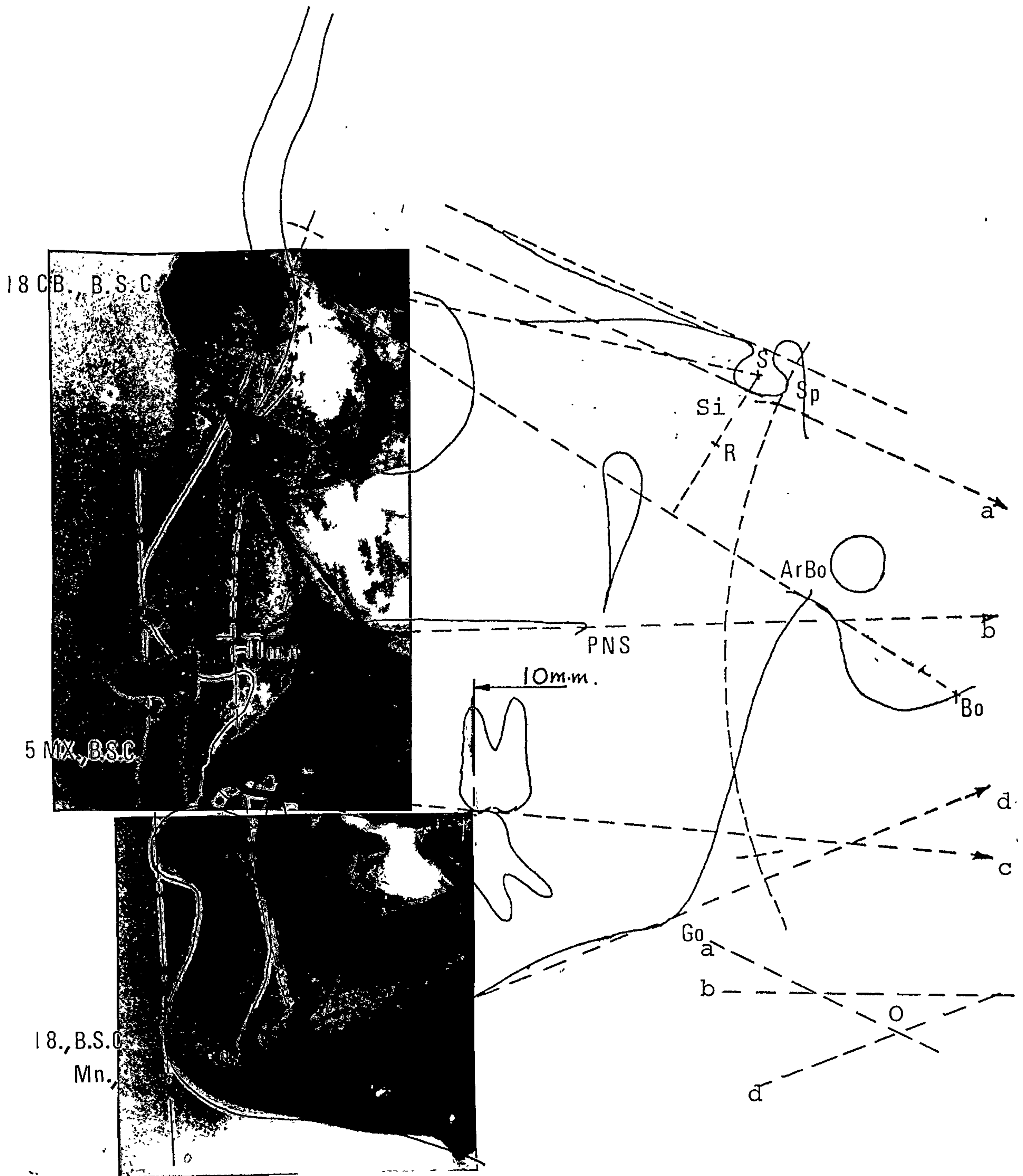
BOLTON STANDARD

18 Year ♂ - ♀ Average

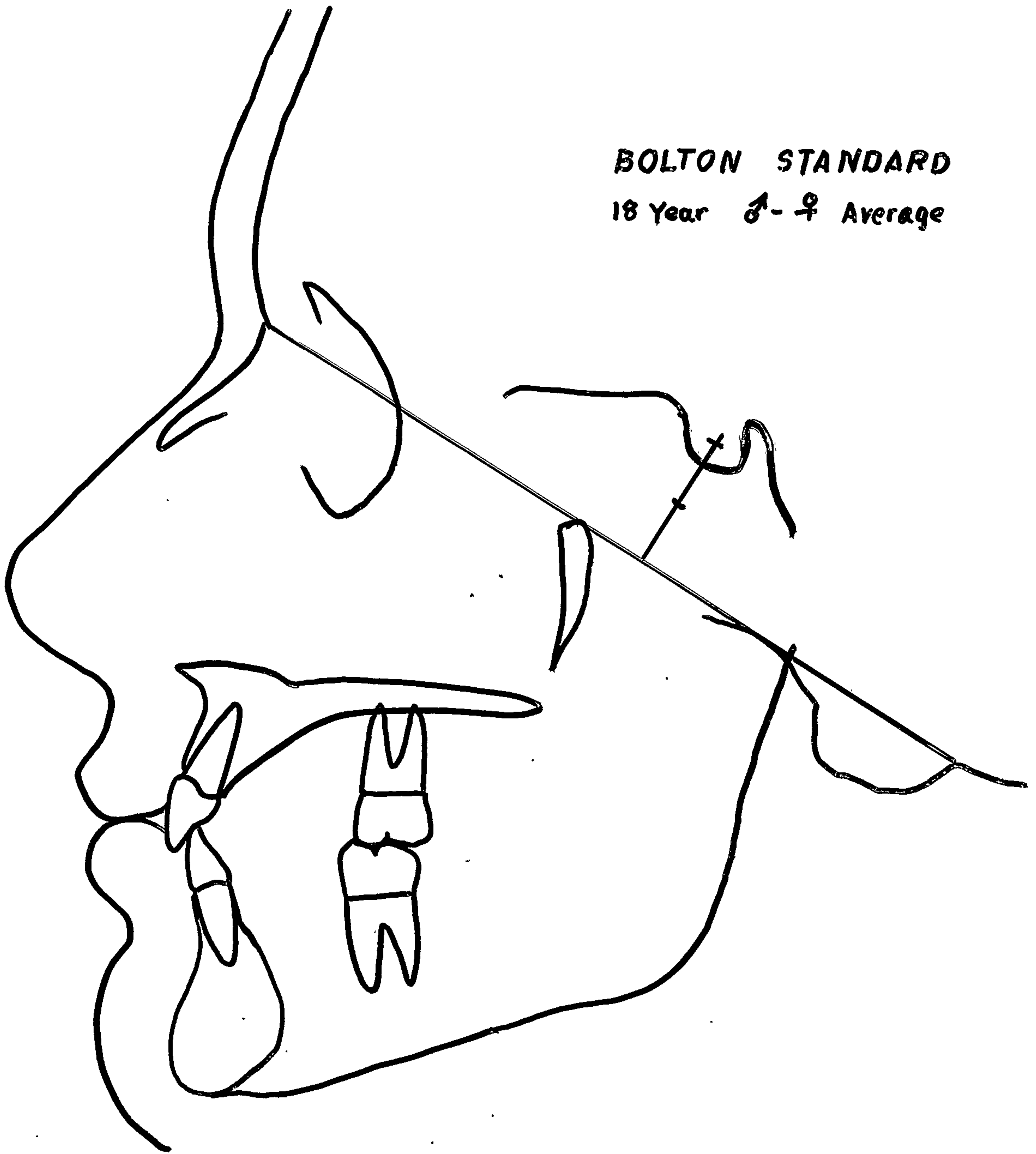


PHOTOGRAPHIC PROFILE PREDICTION

19-11-76



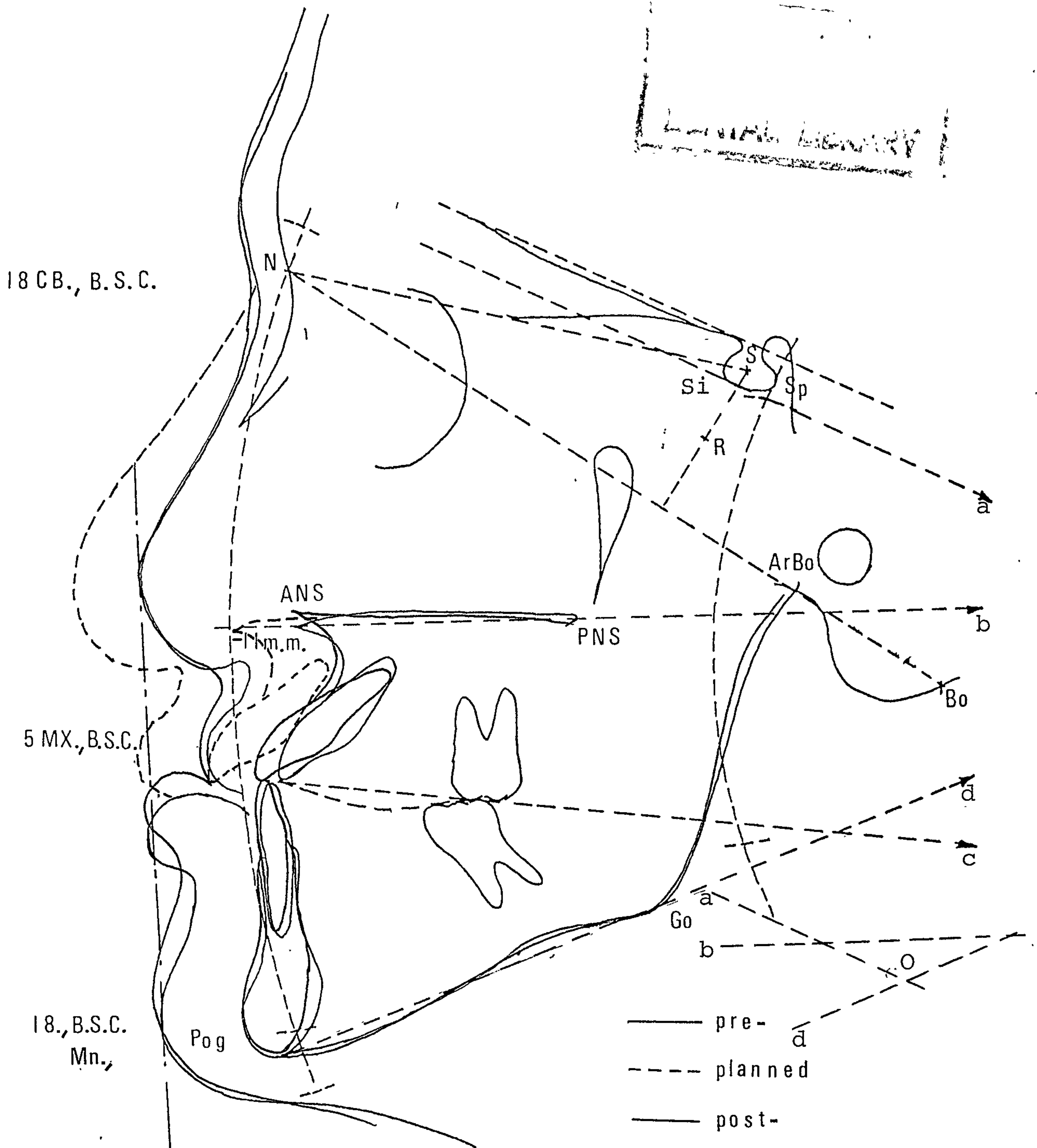
BOLTON STANDARD
18 Year ♂ - ♀ Average



PRE-and POST- SURGICAL CEPH. ASSESSMENT

19-11-76

15- 8-77



PRE-, PLANNED, AND POST-SURGICAL CEPHALOMETRIC ANALYSIS

		PRE-	PLANNED	POST-
SKELETAL ANALYSIS	S-N-A	70°	81°	71°
	S-N-B	80°	80°	81°
	A-N-B	-10°	1°	-10°
	Angle of convexity (N-A-P)	-25°	-2°	-24°
	Y axis to N-S	65°	65°	64°
	Mn. pl. to N-S	34°	34°	32°
DENTAL ANALYSIS	U1 to A-Pog.	5 mm.	8 mm.	7 mm.
	L1 to A-Pog.	6 mm.	-2 mm.	6 mm.
	L1 to Mn. pl.	72°	72°	75°
	U1 to L1	131°	131°	124°
	U1 to S-N	122°	122°	132°
SASSOUNI ARCHIAL ANALYSIS	A-N-S to Sassouni Anterior Arc	-11mm.	-1 mm.	-11 mm.
	U1 Tip to Sassouni Anterior Arc	-6 mm.	4 mm.	-3 mm.
	Pog. to Sassouni Anterior Arc	7 mm.	7 mm.	7 mm.
BOLTON STANDARD ANALYSIS	Nasal Height to Bolton Standard	-12mm.	-1 mm.	-12 mm.
	Upper Lip Height to Bolton Standard	-12mm.	-1 mm.	-10 mm.
	Lower Lip Height to Bolton Standard	0 mm.	0 mm.	0 mm.
	Soft tissue Pog. to Bolton Standard	-1 mm.	-1 mm.	0 mm.

CASE 1

MODEL STUDY ASSESSMENT

Pre-Surgery

Model Surgery

Post-Surgery



Front



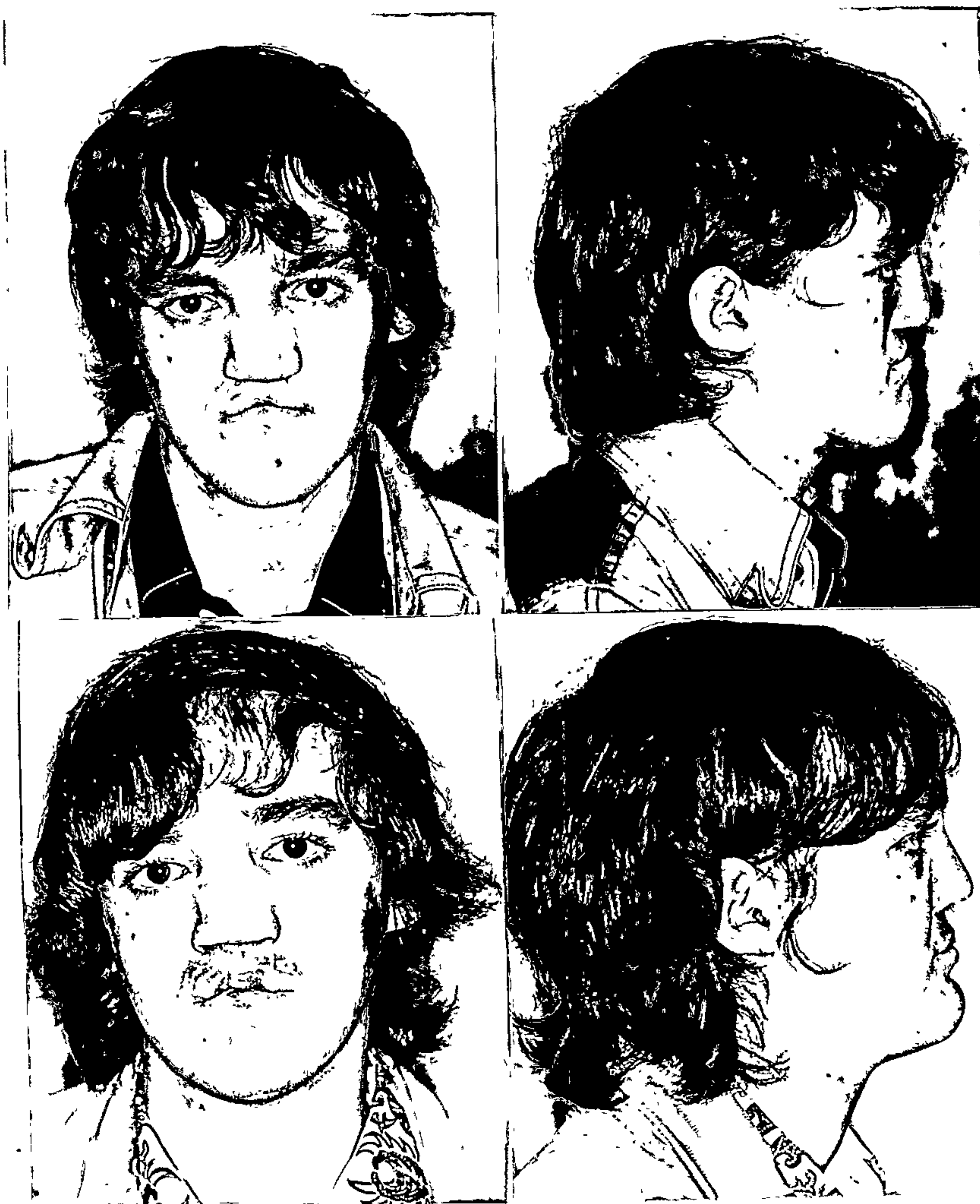
Right Side



Left Side

CASE 2

HIGH LE FORT I MAXILLARY OSTEOTOMY



Before
Surgery

After
Surgery

Age : 19 years old.

Sex : Male.

Original Condition : Bilateral Complete Cleft.

History : Repositioning of premaxilla and closure of
anterior palate at 2 months old.

Bilateral repair of lip at 4 months old.

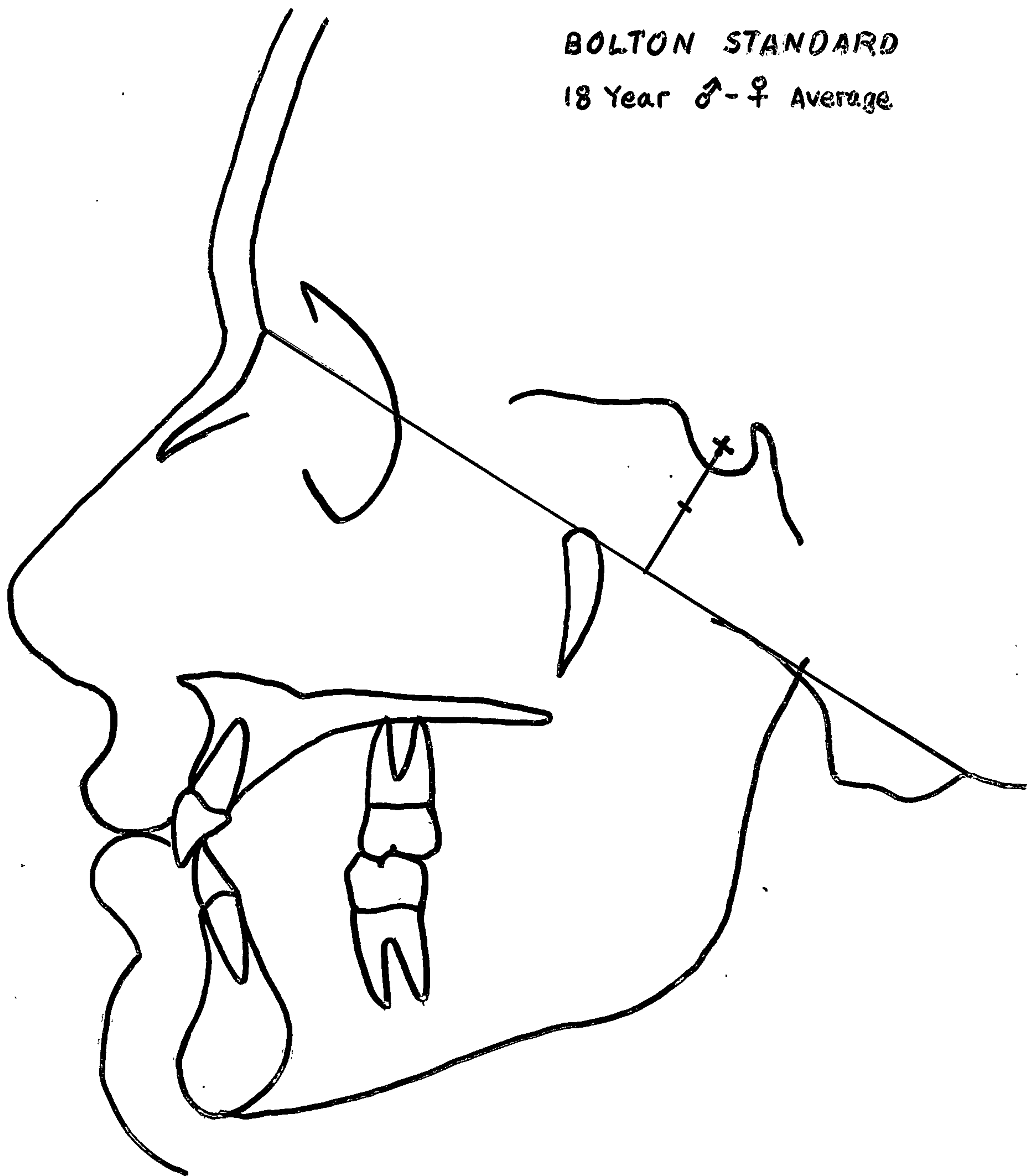
Repaired of palate at 1 year 8 months old.

No other significant medical findings.

No nasal problem.

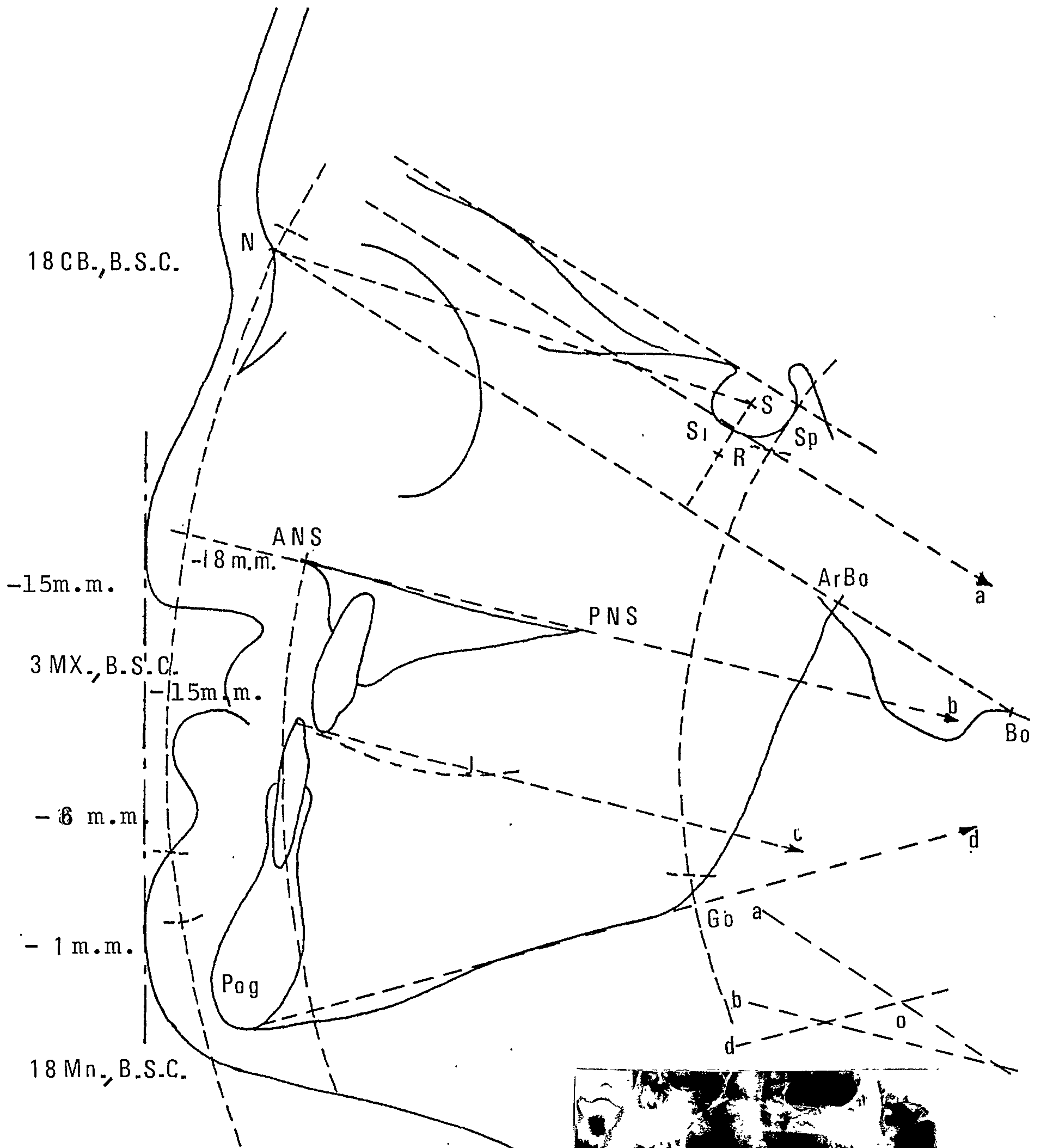
BOLTON STANDARD

18 Year ♂-♀ Average



CASE 2
DIAGNOSTIC TRACING

25 - 1 - 1977



CASE 2 DISCUSSION

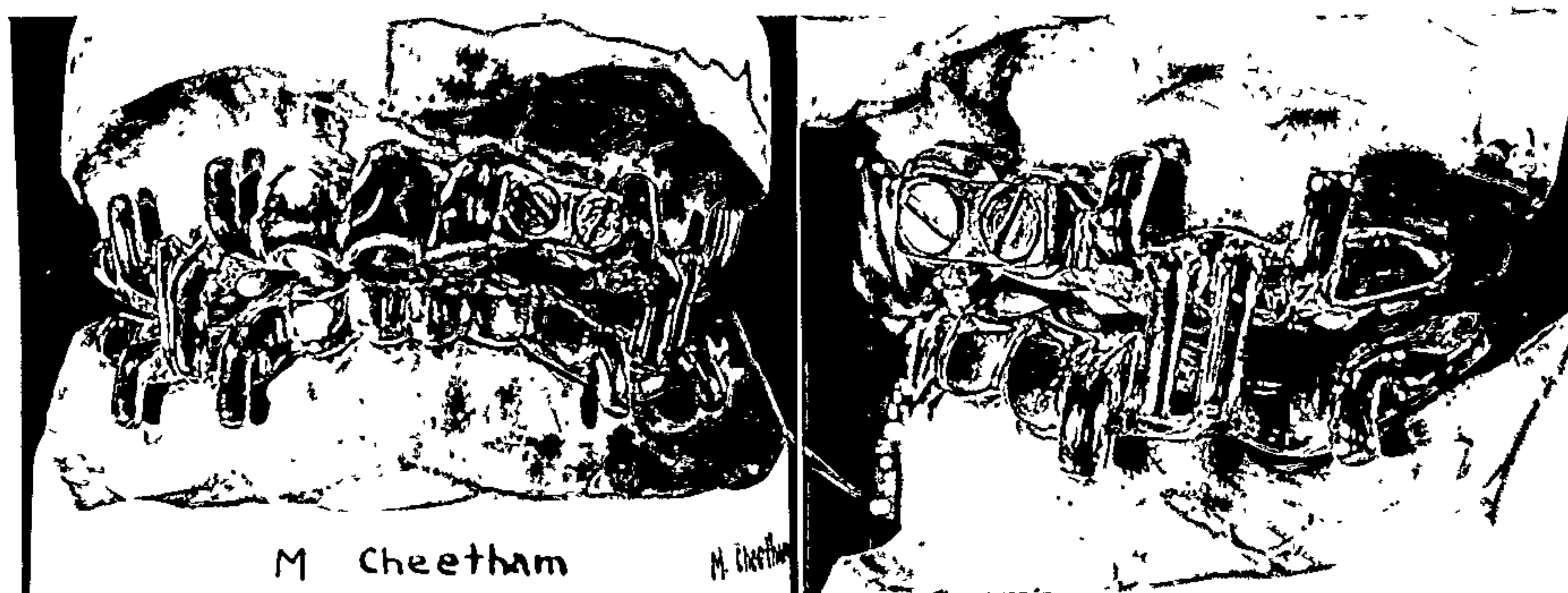
Diagnostic tracing shows that the cranial base and mandible are of normal size antero-posteriorly (18 CB., 18 Mn., B.S.C,) while the maxilla is very much under-developed (3 Mx., B.S.C.). In Sassouni Archial Analysis, both mandibular pogonion and maxillary A-N-S are behind the anterior arc (-3 mm. and -18 mm., respectively) indicating maxillary complex is the major region of deformity. Bolton Standard template of 18 years old confirms this finding. Moreover, the soft tissue nasal tip, upper lip, lower lip and soft tissue pogonion are -15 mm., -15 mm., -6 mm. and -2 mm., respectively.

In order to correct the under-developed maxillary complex and nasal height, high Le Fort I or Le Fort II maxillary osteotomy is indicated in this case. The surgeon decided to do a high Le Fort I maxillary osteotomy in this case. Model surgery indicated that a forward movement of 8 mm. and downward tilt of 2 mm. would provide a stable occlusion and correction of the skeletal discrepancy. The predicted profile (from cephalometric and photographic profile prediction) is satisfactory when compared to esthetic plane and Bolton Standard template of 18 years .

Post-operative changes can be evaluated with Sassouni Archial Analysis, Bolton Standards, normal cephalometric analysis and model studies, as shown in (1) pre-

and post-surgical cephalometric assessment, and (2) model study assessment.

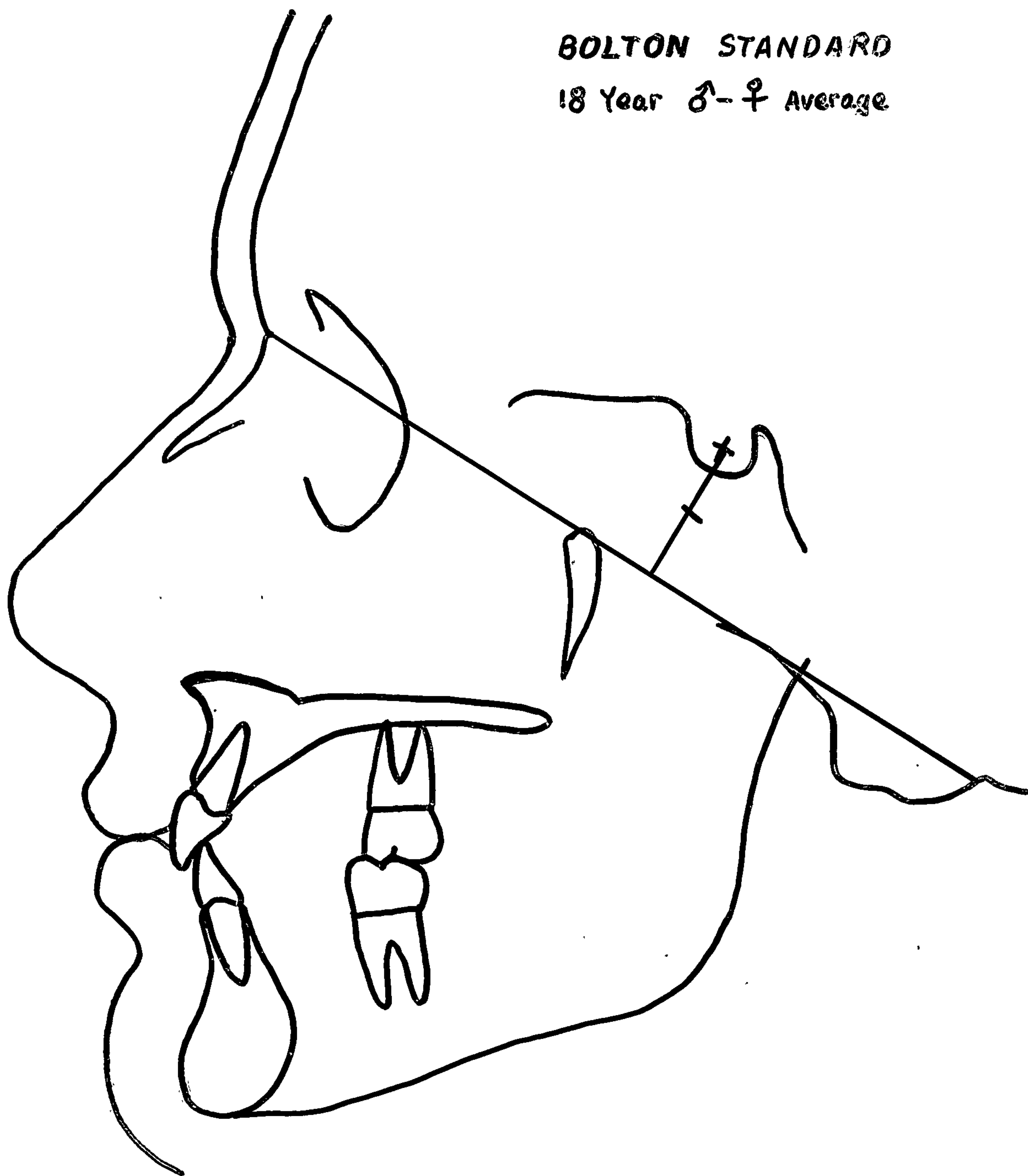
Upper and lower intra-oral silver splints were used for immobilization for 8 weeks, as shown :



Planes used to locate center "O" in Sassouni Archial Analysis were : (1) parallel to supra-orbital plane, (2) palatal plane and (3) mandibular plane.

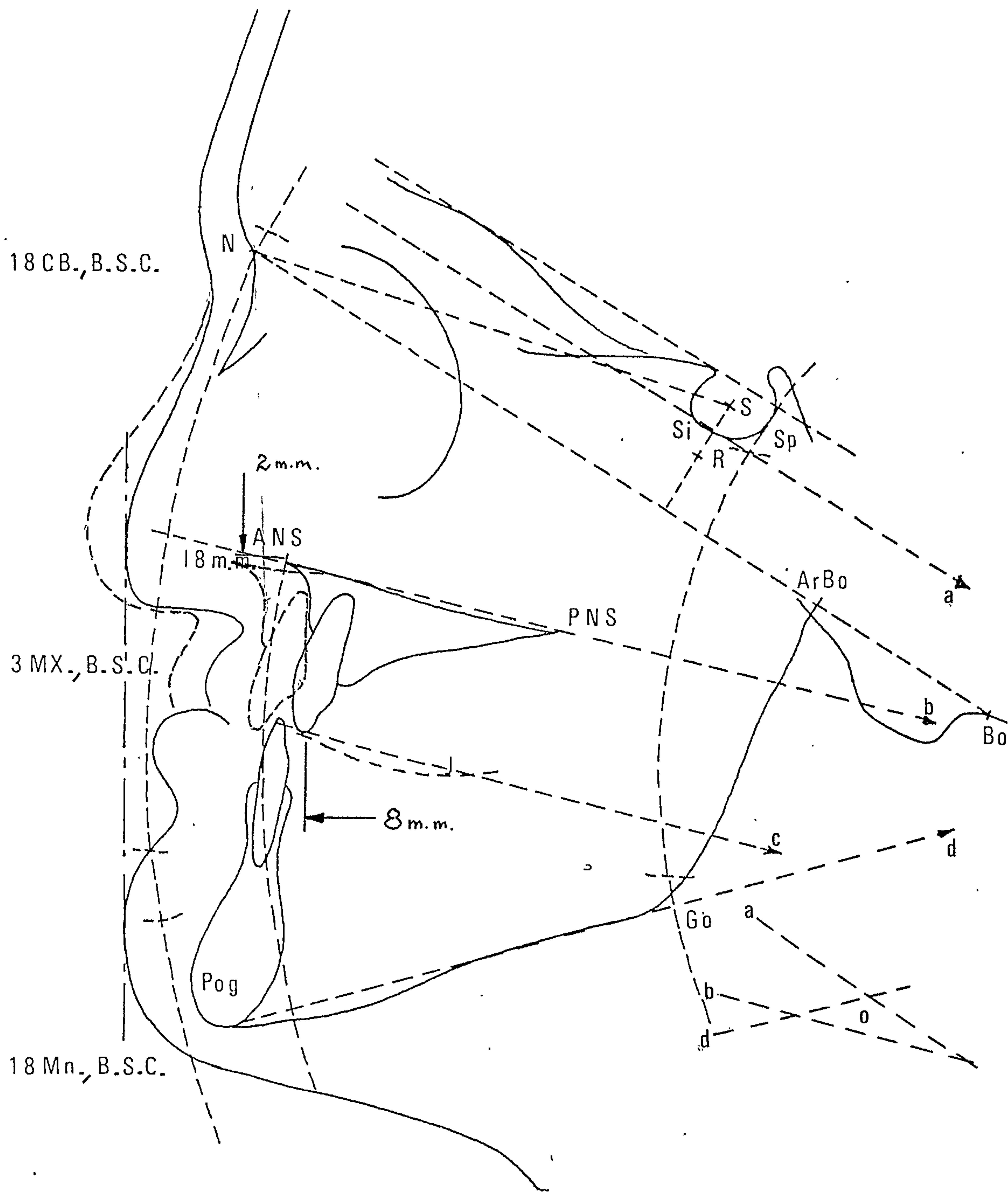
Radius of the anterior arc in Sassouni Archial Analysis was found to be 17 cm.

BOLTON STANDARD
18 Year ♂-♀ Average

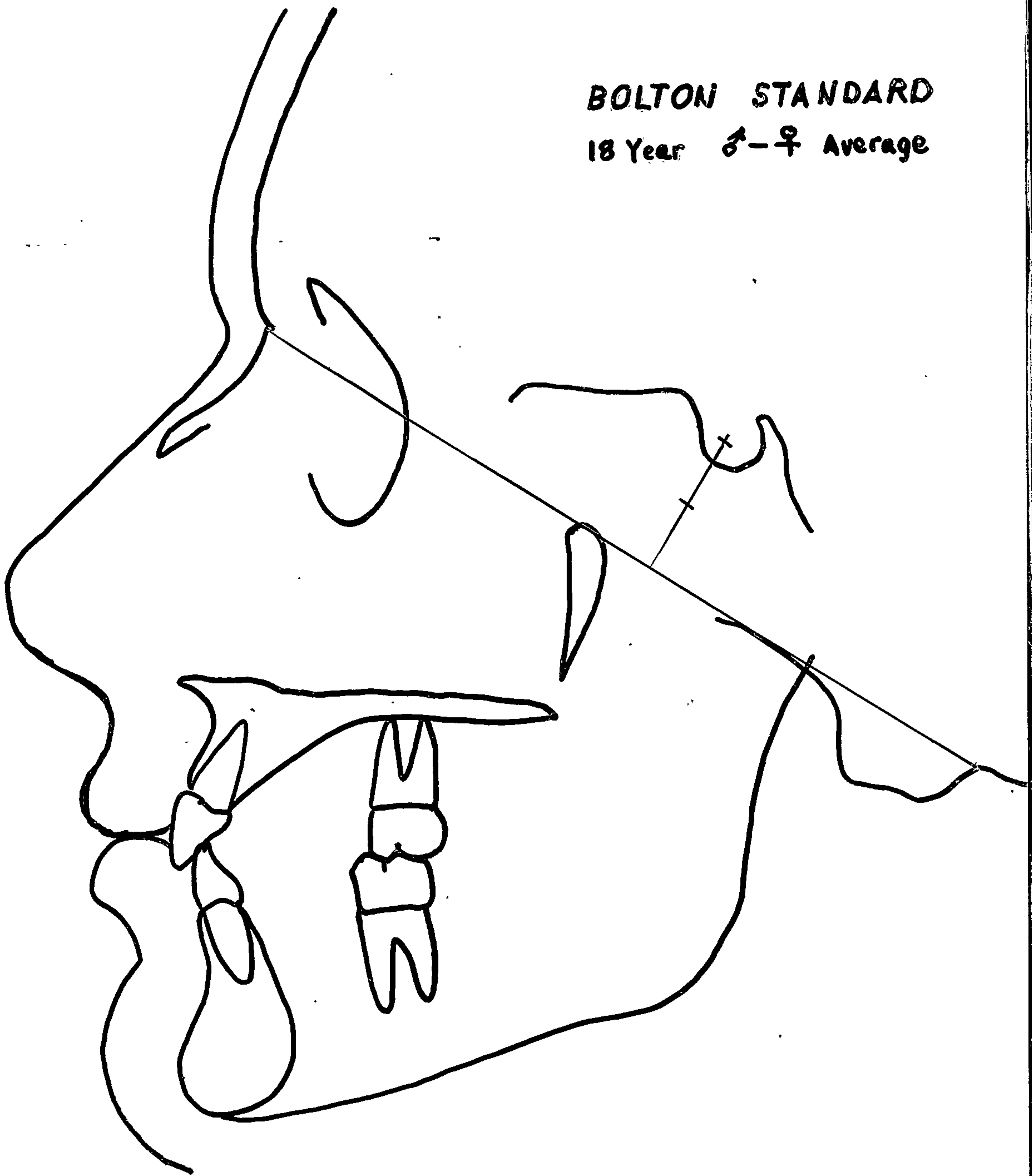


PROFILE PREDICTION TRACING

25-1-1977



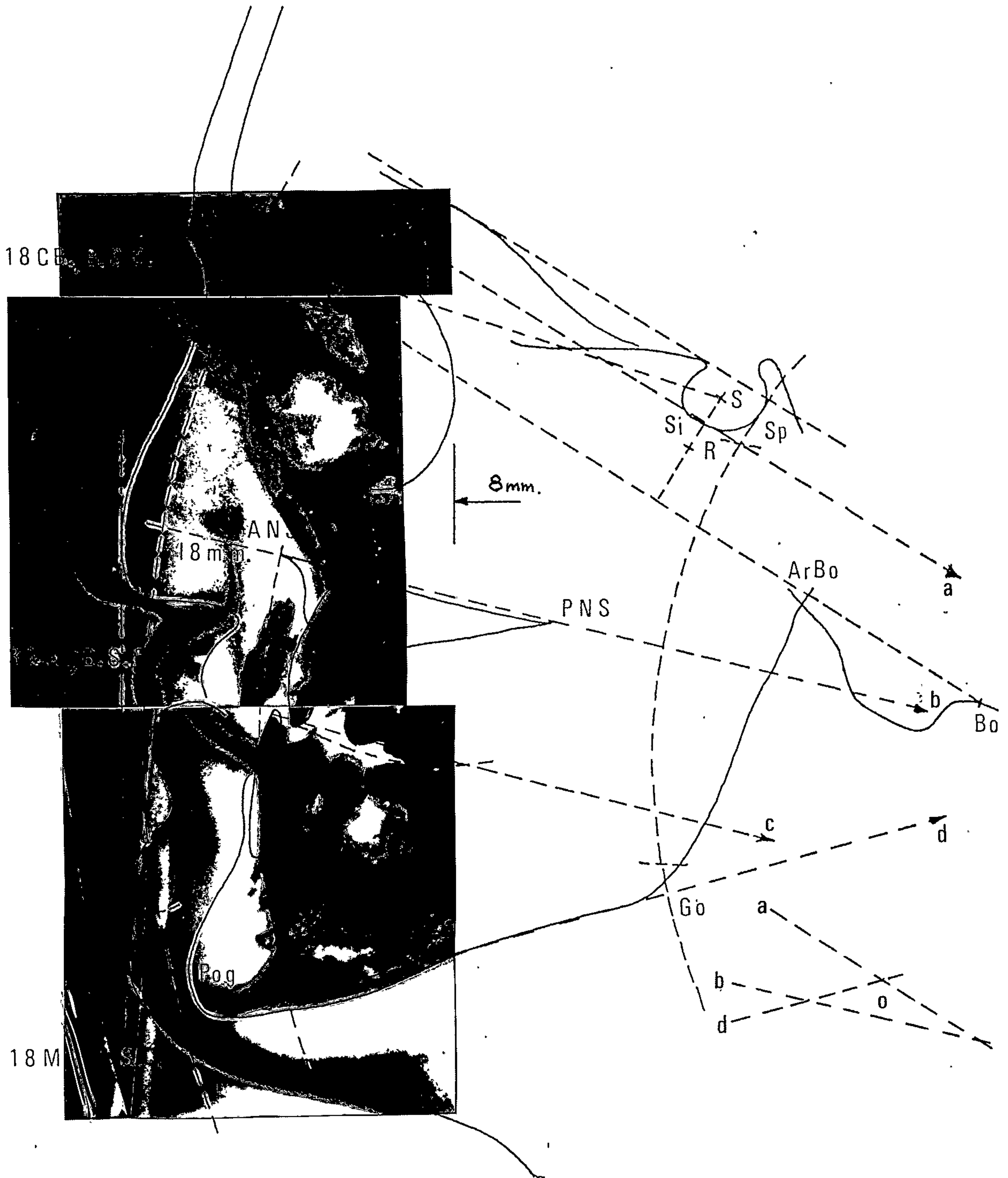
BOLTON STANDARD
18 Year ♂-♀ Average



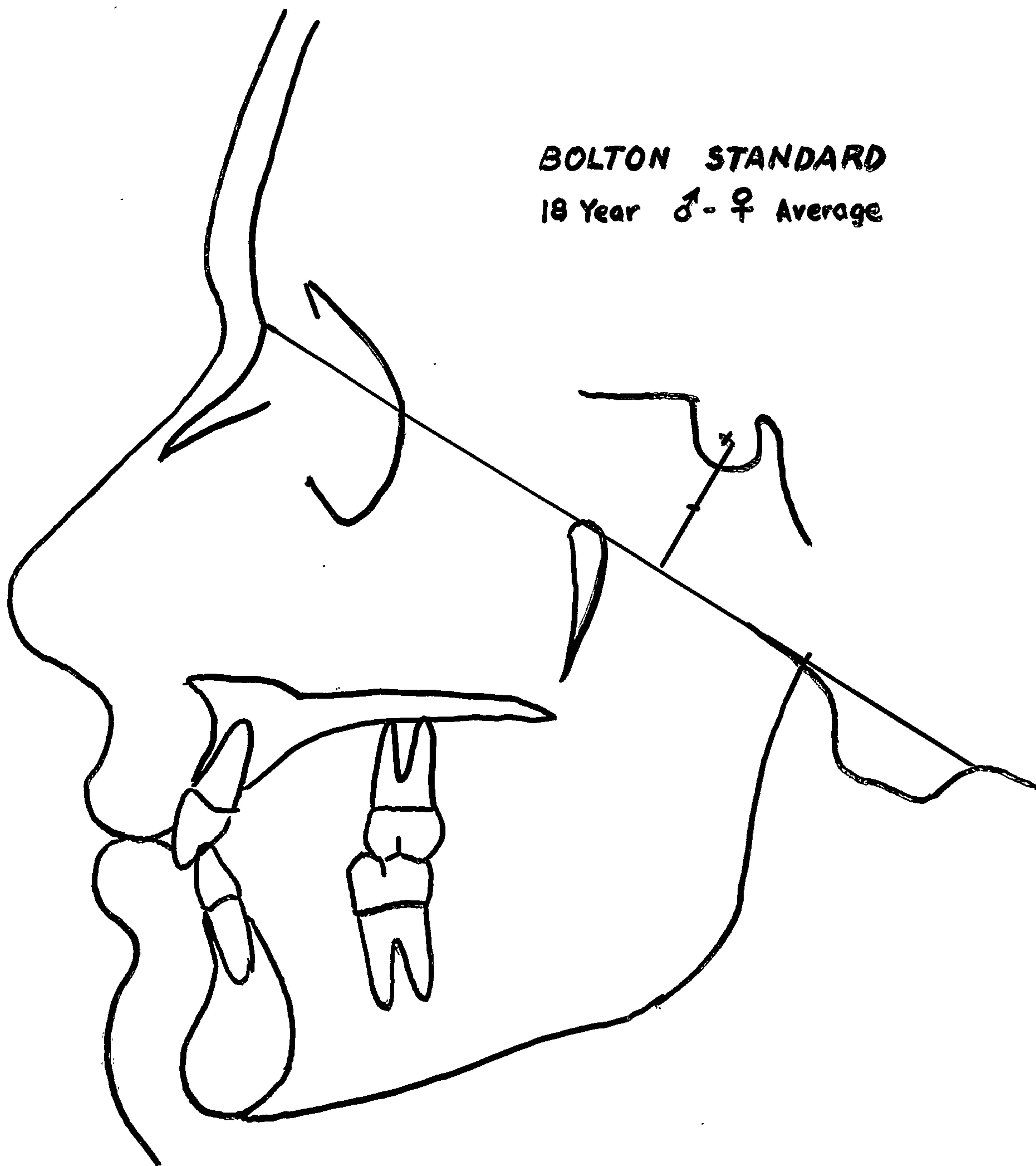
CASE 2

PHOTOGRAPHIC PROFILE PREDICTION

25 - 1 - 1977



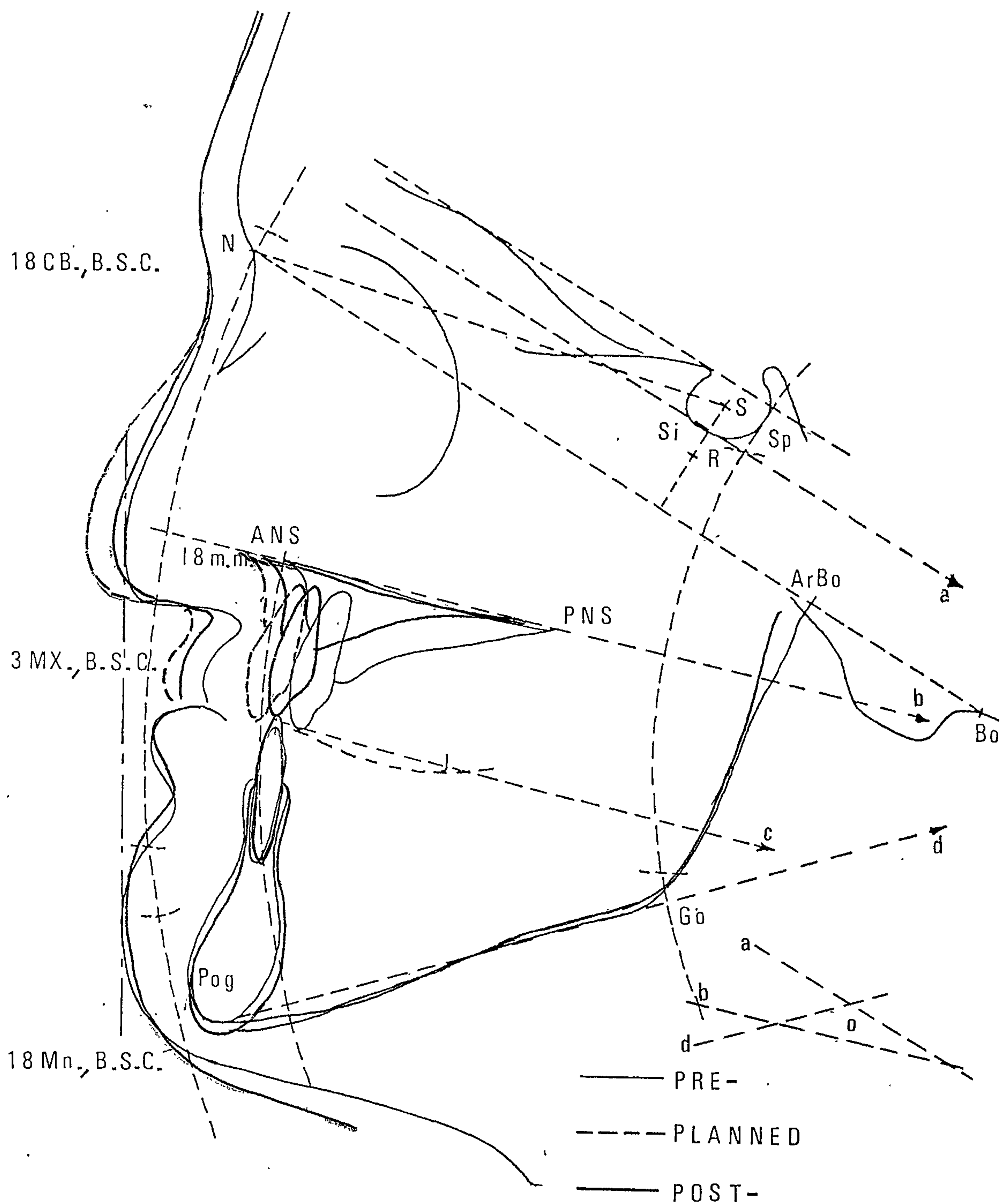
BOLTON STANDARD
18 Year ♂ - ♀ Average



PRE- and POST- SURGICAL CEPH. ASSESSMENT

25-1-1977

28-6-1977



PRE-, PLANNED, AND POST-SURGICAL CEPHALOMETRIC ANALYSIS

		PRE-	PLANNED	POST-
SKELETAL ANALYSIS	S-N-A	63°	71°	67°
	S-N-B	73°	73°	73°
	A-N-B	-10°	-2°	-6°
	Angle of convexity (N-A-P)	-28°	-13°	-20°
	Y axis to N-S	67°	67°	67°
	Mn. pl. to N-S	33°	33°	35°
DENTAL ANALYSIS	U1 to A-Pog.	-5 mm.	-2 mm.	-3 mm.
	L1 to A-Pog.	-1 mm.	-6 mm.	-4 mm.
	L1 to Mn. pl.	67°	67°	66°
	U1 to L1	170°	171°	170°
	U1 to S-N	90°	89°	90°
SASSOUNI ARCHIAL ANALYSIS	A-N-S to Sassouni Anterior Arc	-18 mm.	-10 mm.	-15 mm.
	U1 Tip to Sassouni Anterior Arc	-25 mm.	-17 mm.	-21 mm.
	Pog. to Sassouni Anterior Arc	-2 mm.	-2 mm.	-2 mm.
BOLTON STANDARD ANALYSIS	Nasal Height to Bolton Standard	-15mm.	-7 mm.	-12mm.
	Upper Lip Height to Bolton Standard	-15mm.	-7 mm.	-12mm.
	Lower Lip Height to Bolton Standard	-6 mm.	-6 mm.	-6 mm.
	Soft tissue Pog. to Bolton Standard	-1 mm.	-1 mm.	-1 mm.

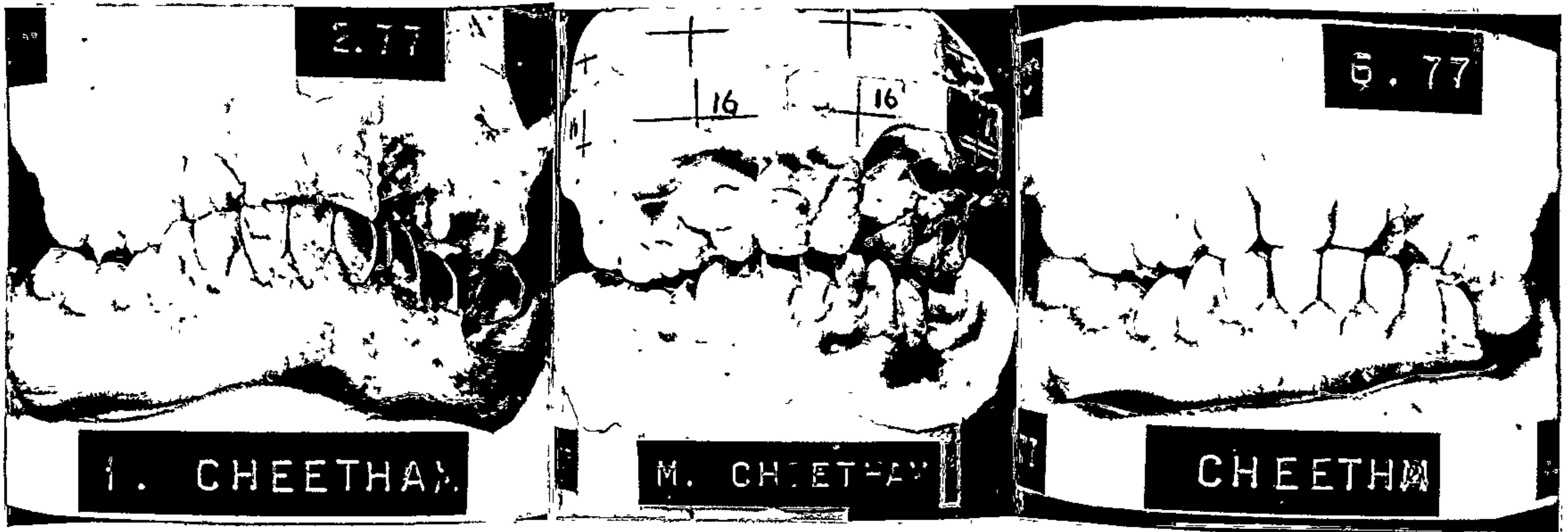
CASE 2

MODEL STUDY ASSESSMENT

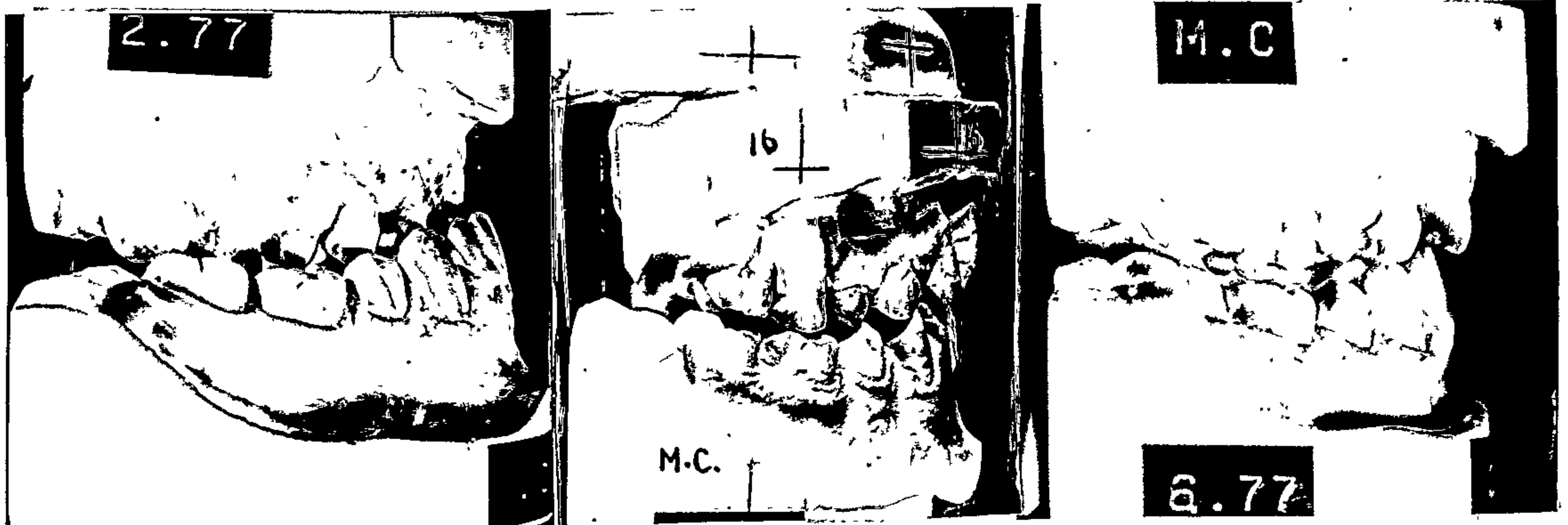
Pre-Surgery

Model Surgery

Post-Surgery



Front



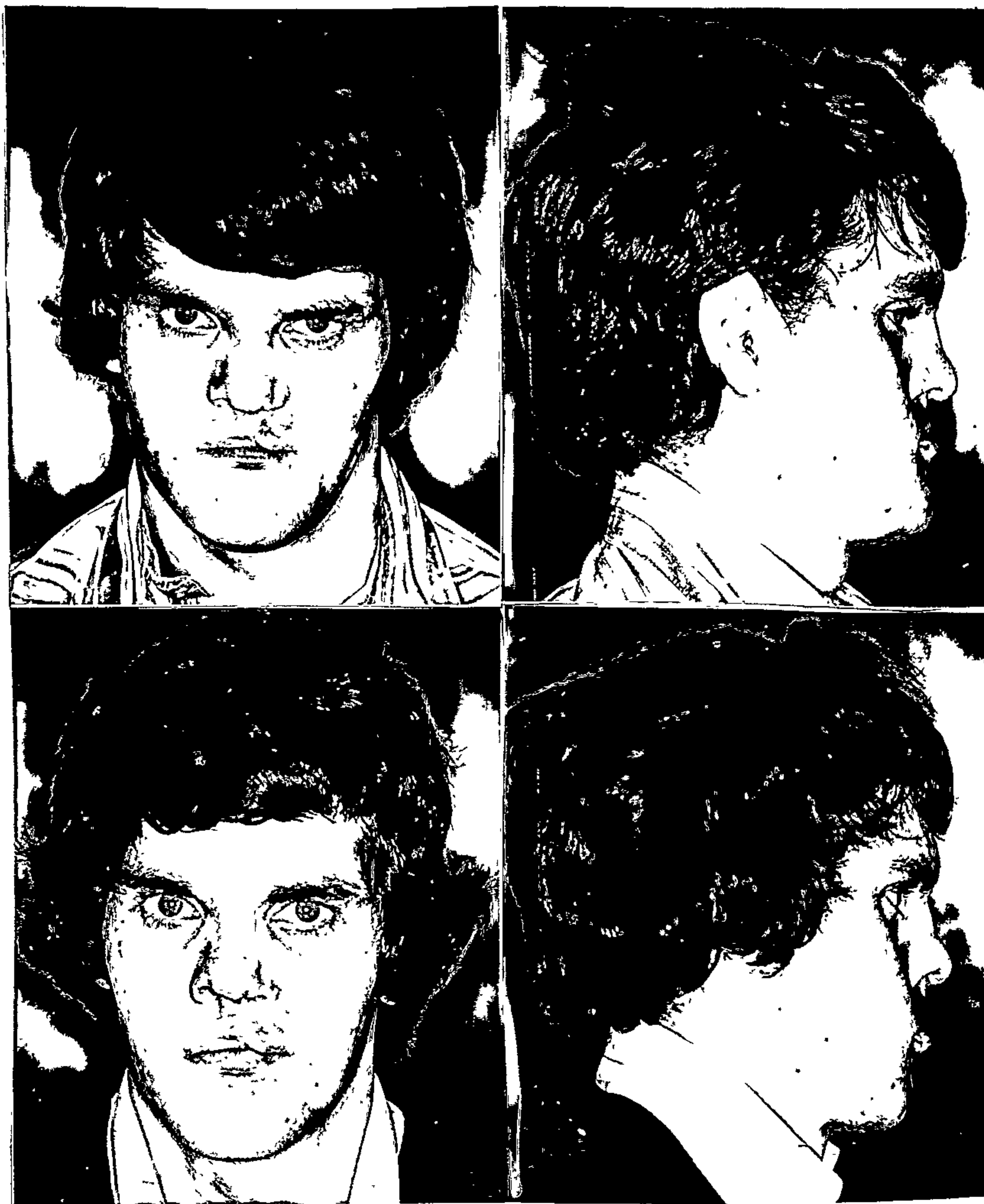
Right Side



Left Side

CASE 3

LE FORT I MAXILLARY OSTEOTOMY



Before
Surgery

After
Surgery

Age : 20 years old.

Sex : Male.

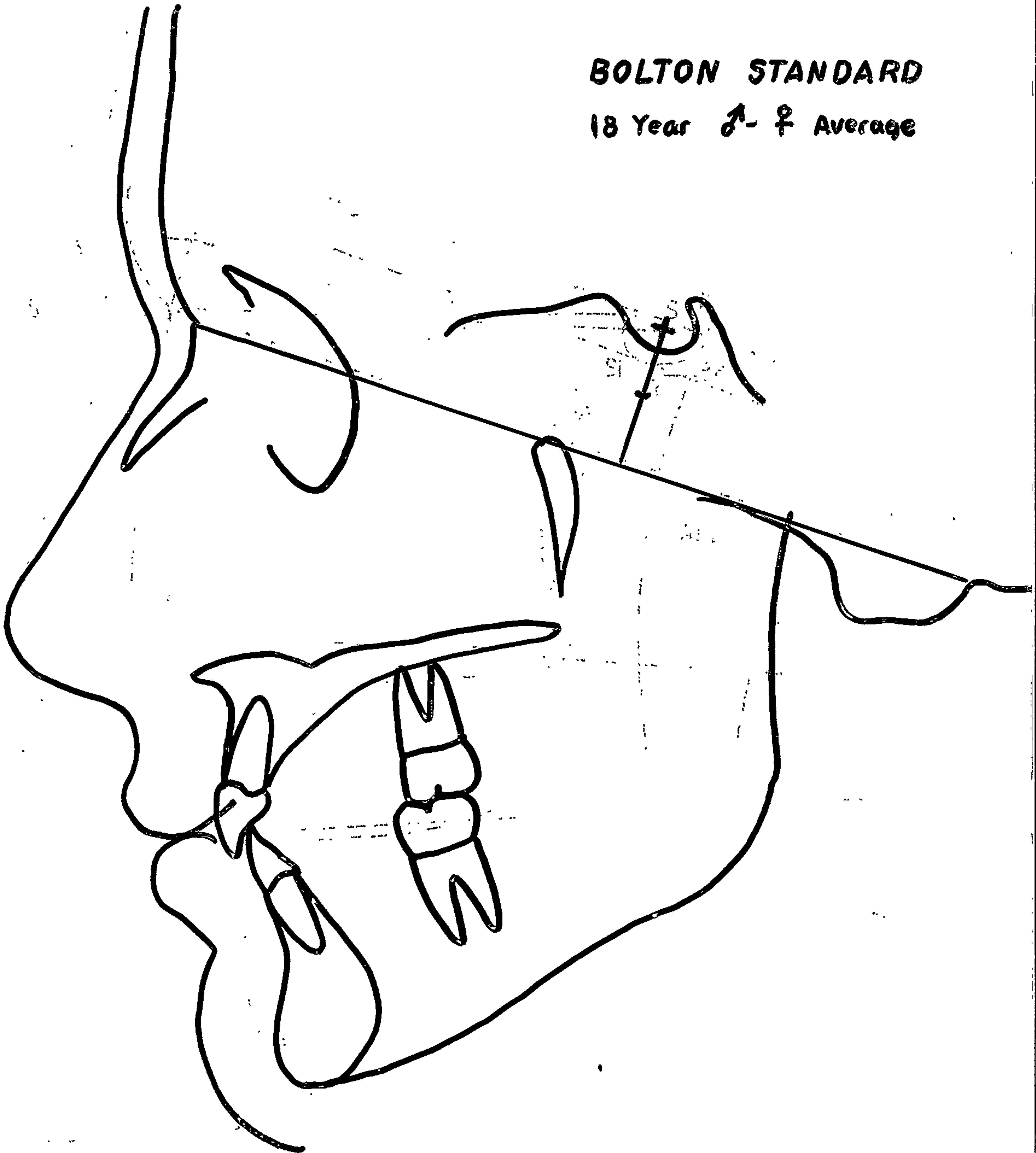
Original Condition : Unilateral Left Cleft of Primary
Palate (Lip and Alveolus)

History : Repaired of cleft lip at 6 weeks.

No other significant medical findings.

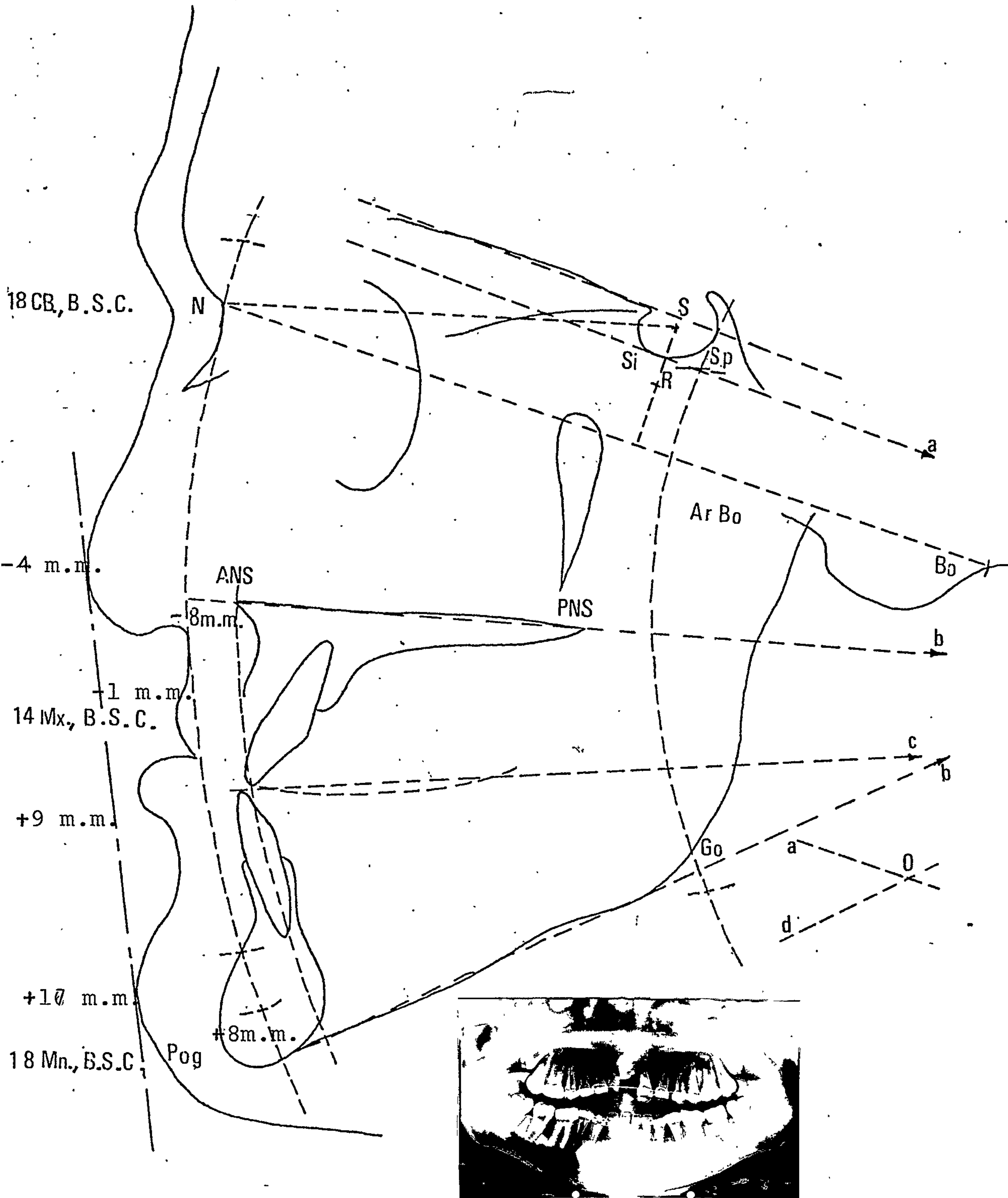
No nasal problem.

BOLTON STANDARD
18 Year ♂- ♀ Average



CASE 3
DIAGNOSTIC TRACING

15 - 4 - 77



CASE 3 DISCUSSION

Diagnostic tracing shows that the cranial base and mandible are of normal size antero-posteriorly (18 CB., 18 Mn., B.S.C.) while the maxilla is slightly under-developed (14 Mx., B.S.C.). With reference to Sassouni Archial Analysis, mandibular pogonion is +8 mm. in front of the anterior arc and maxillary A-N-S is -8 mm. behind the anterior arc. This indicates that both mandible and maxilla contribute to the facial deformity. In fact, Bolton Standard template reveals that the mandible is the major region of deformity. Soft tissue nasal height, upper lip, lower lip and soft tissue pogonion are -4 mm., -1 mm., +9 mm. and +17 mm., respectively, when compared to Bolton Standard of 18 years.

In order to correct the flatness of the mid-face region and prognathic appearance, a low Le Fort I maxillary osteotomy and mandibular set-back or genioplasty are indicated in this case. The surgeon agreed on this suggestion but preferred to delay mandibular surgery. Model surgery indicated a forward movement of 5 mm. may provide an acceptable occlusion and correct part of the skeletal discrepancy. The planned occlusion is not as good as the pre-surgery occlusion due to the wider maxillary trans-palatal width (compared to the lower) after bringing the maxilla forward.

Minor post-surgery orthodontic treatment is indicated in this case. The predicted profile (from cephalometric and photographic profile prediction) is satisfactory when related to esthetic plane and Bolton Standards.

Post-operative changes can be evaluated with Sassouni Archial Analysis, Bolton Standards, normal cephalometric analysis and model studies, as shown in (1) pre- and post-surgical cephalometric assessment, and (2) model study assessment.

Intra-oral splinting with orthodontic bands was used in this case, as shown :

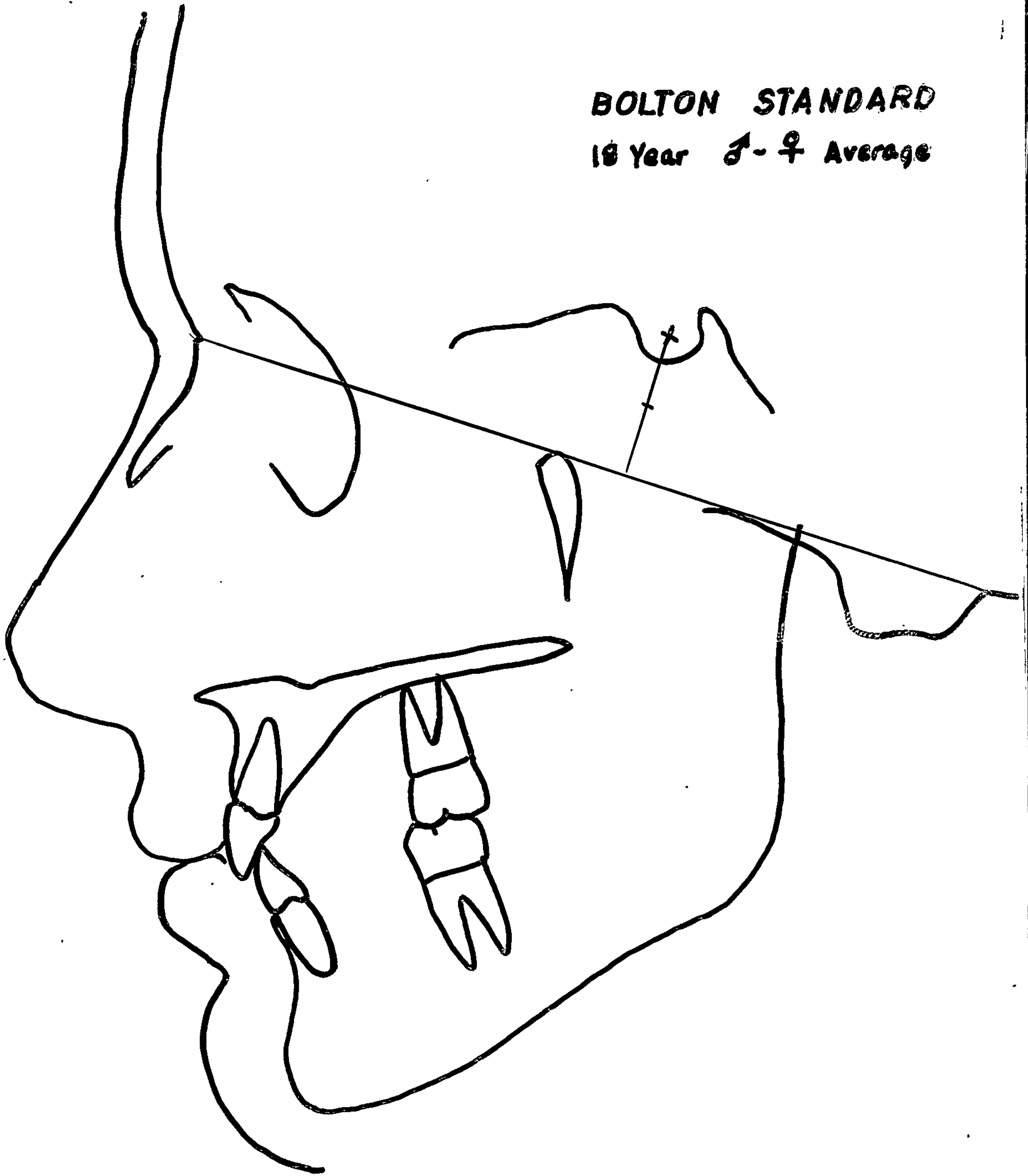


The lower heavy labial arch wire which is not yet in place in this photograph is similar to the upper one.

Planes used to locate center "O" in Sassouni Archial Analysis were : (1) parallel to supra-orbital plane, (2) palatal plane and (3) mandibular plane.

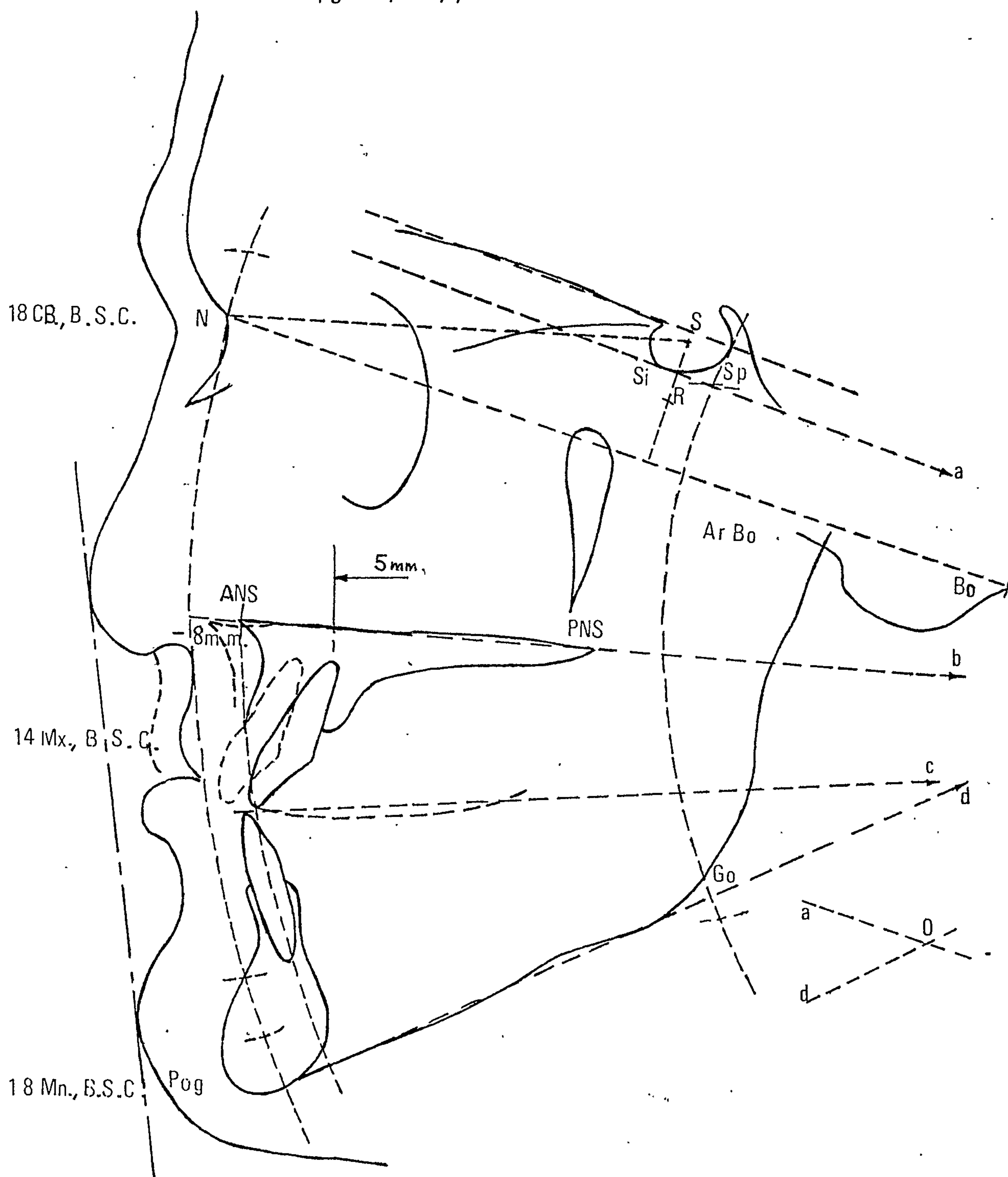
Radius of the anterior arc in Sassouni Archial Analysis was found to be 18.6 cm.

BOLTON STANDARD
18 Year ♂ - ♀ Average



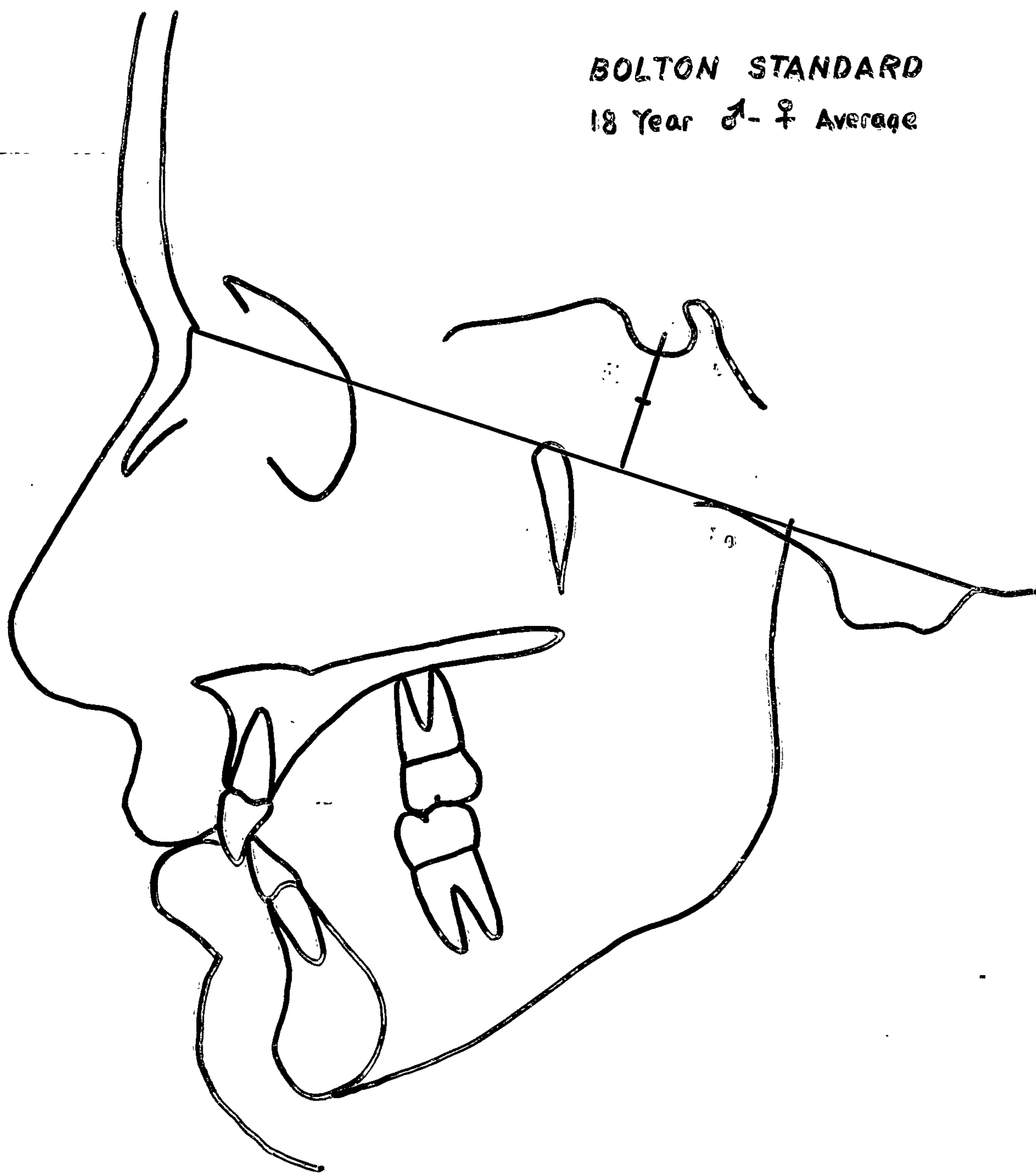
CASE 3
PROFILE PREDICTION TRACING

15 - 4 - 77



BOLTON STANDARD

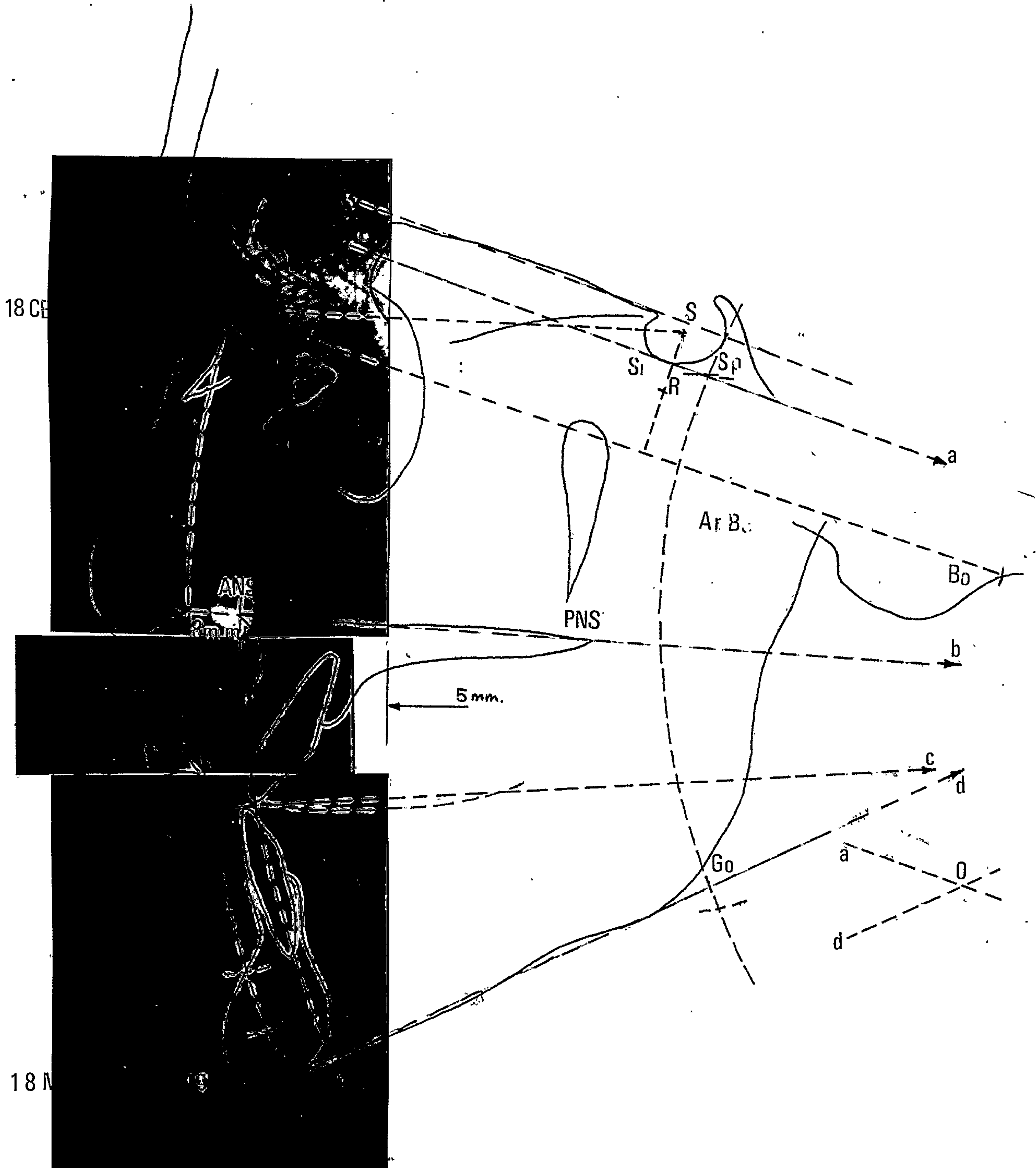
18 Year ♂ - ♀ Average



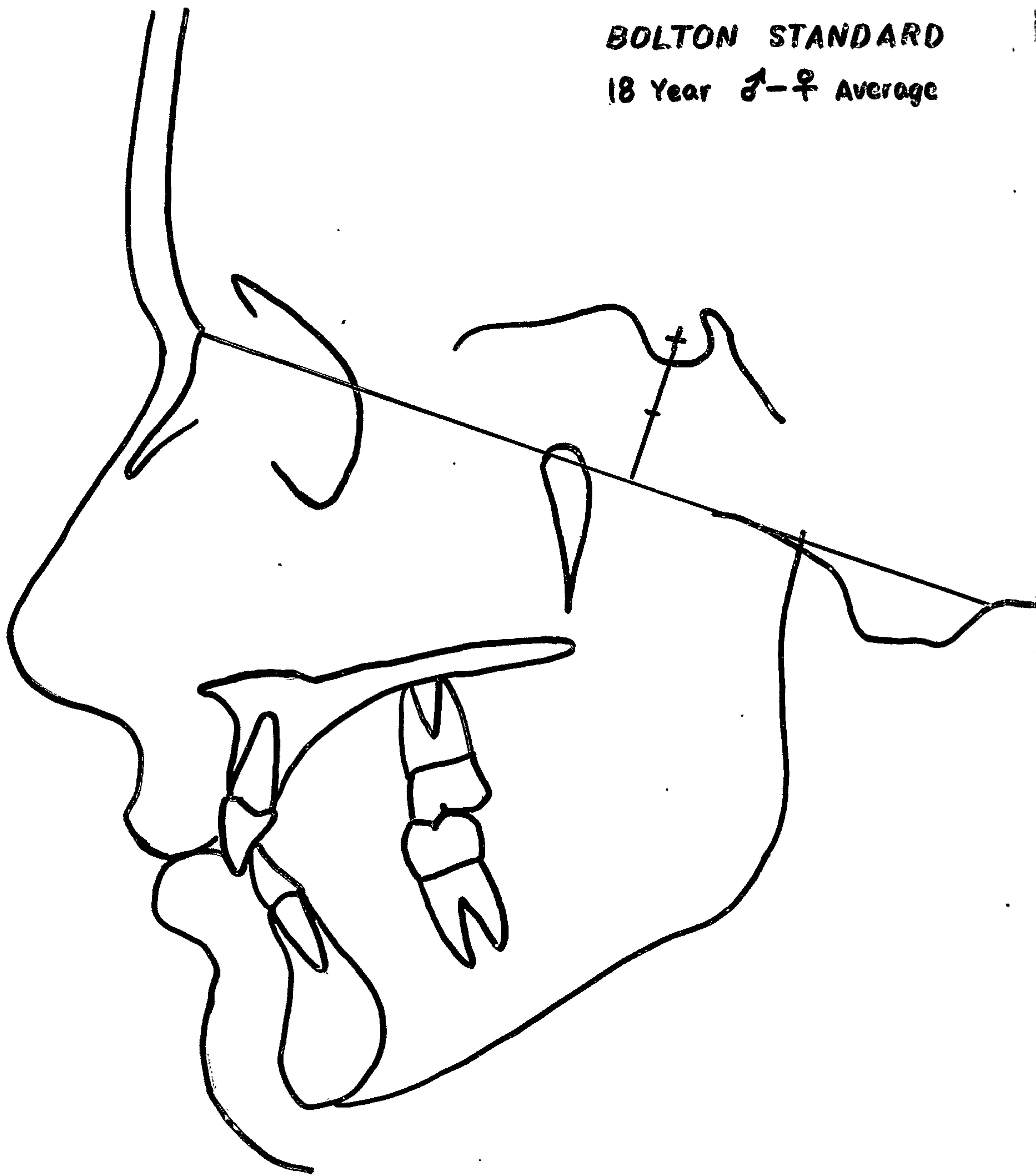
CASE 3

PHOTOGRAPHIC PROFILE PREDICTION

15 - 4 - 77



BOLTON STANDARD
18 Year ♂-♀ Average

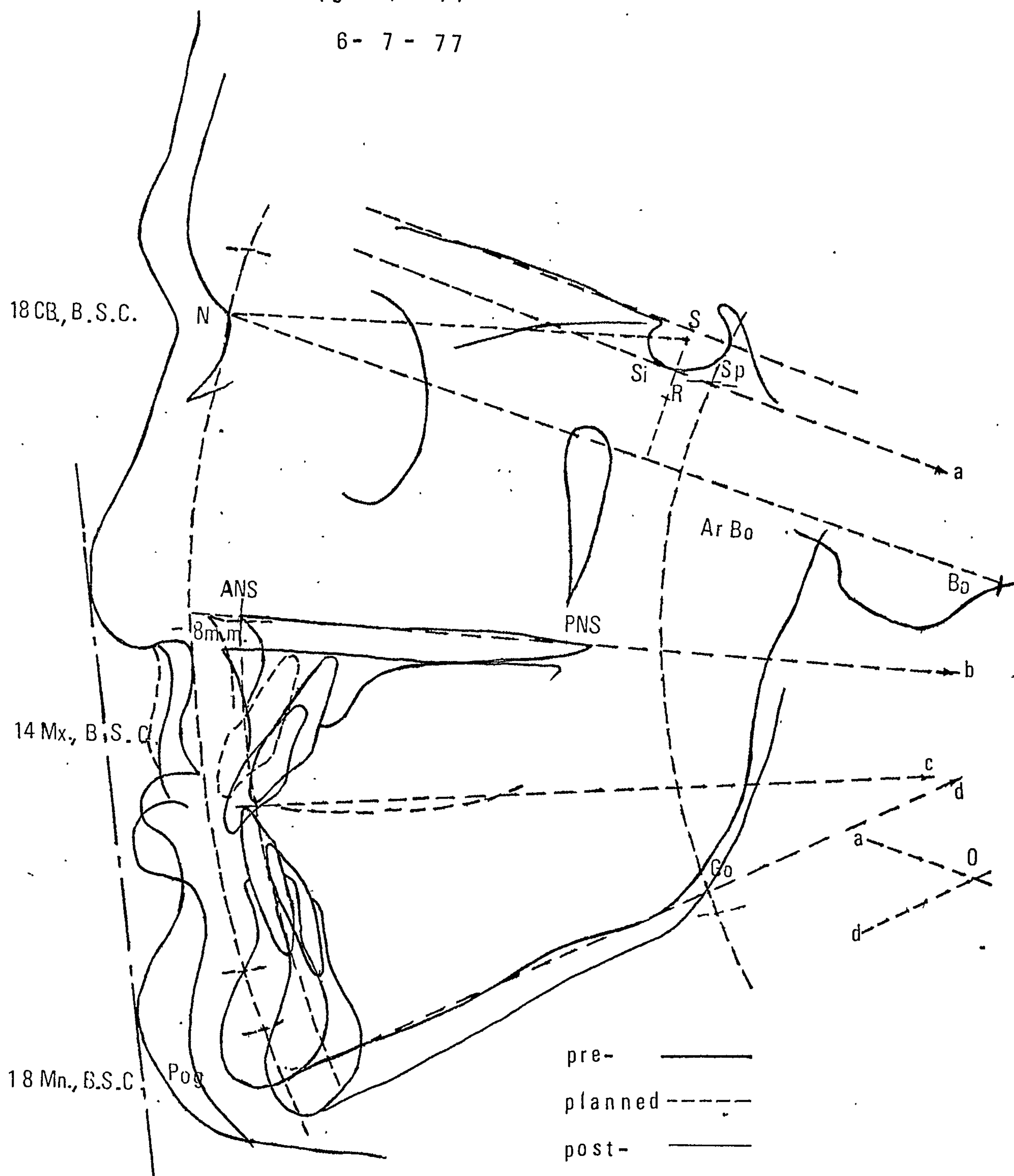


CASE 3

PRE- and POST- SURGICAL CEPH. ASSESSMENT

15 - 4 - 77

6 - 7 - 77



PRE-, PLANNED, AND POST-SURGICAL CEPHALOMETRIC ANALYSIS

		PRE-	PLANNED	POST-
SKELETAL ANALYSIS	S-N-A	81°	87°	85°
	S-N-B	84°	84°	81°
	A-N-B	-3°	+3°	4°
	Angle of convexity (N-A-P)	-13°	-3°	1°
	Y axis to N-S	62°	62°	65°
	Mn. pl. to N-S	27°	27°	31°
DENTAL ANALYSIS	U1 to A-Pog.	-2 mm.	2 mm.	4 mm.
	L1 to A-Pog.	1 mm.	-2 mm.	-2 mm.
	L1 to Mn. pl.	84°	84°	85°
	U1 to L1	132°	132°	130°
	U1 to S-N	117°	117°	115°
SASSOUNI ARCHIAL ANALYSIS	A-N-S to Sassouni Anterior Arc	-8 mm.	-3 mm.	-5 mm.
	U1 Tip to Sassouni Anterior Arc	-8 mm.	-3 mm.	-3 mm.
	Pog. to Sassouni Anterior Arc	8 mm.	8 mm.	3 mm.
BOLTON STANDARD ANALYSIS	Nasal Height to Bolton Standard	-4 mm.	-4 mm.	-4 mm.
	Upper Lip Height to Bolton Standard	-1 mm.	5 mm.	4 mm.
	Lower Lip Height to Bolton Standard	9 mm.	9 mm.	11 mm.
	Soft tissue Pog. to Bolton Standard	16 mm.	16 mm.	12 mm.

CASE 3

MODEL STUDY ASSESSMENT

Pre-Surgery

Model Surgery

Post-Surgery



Front



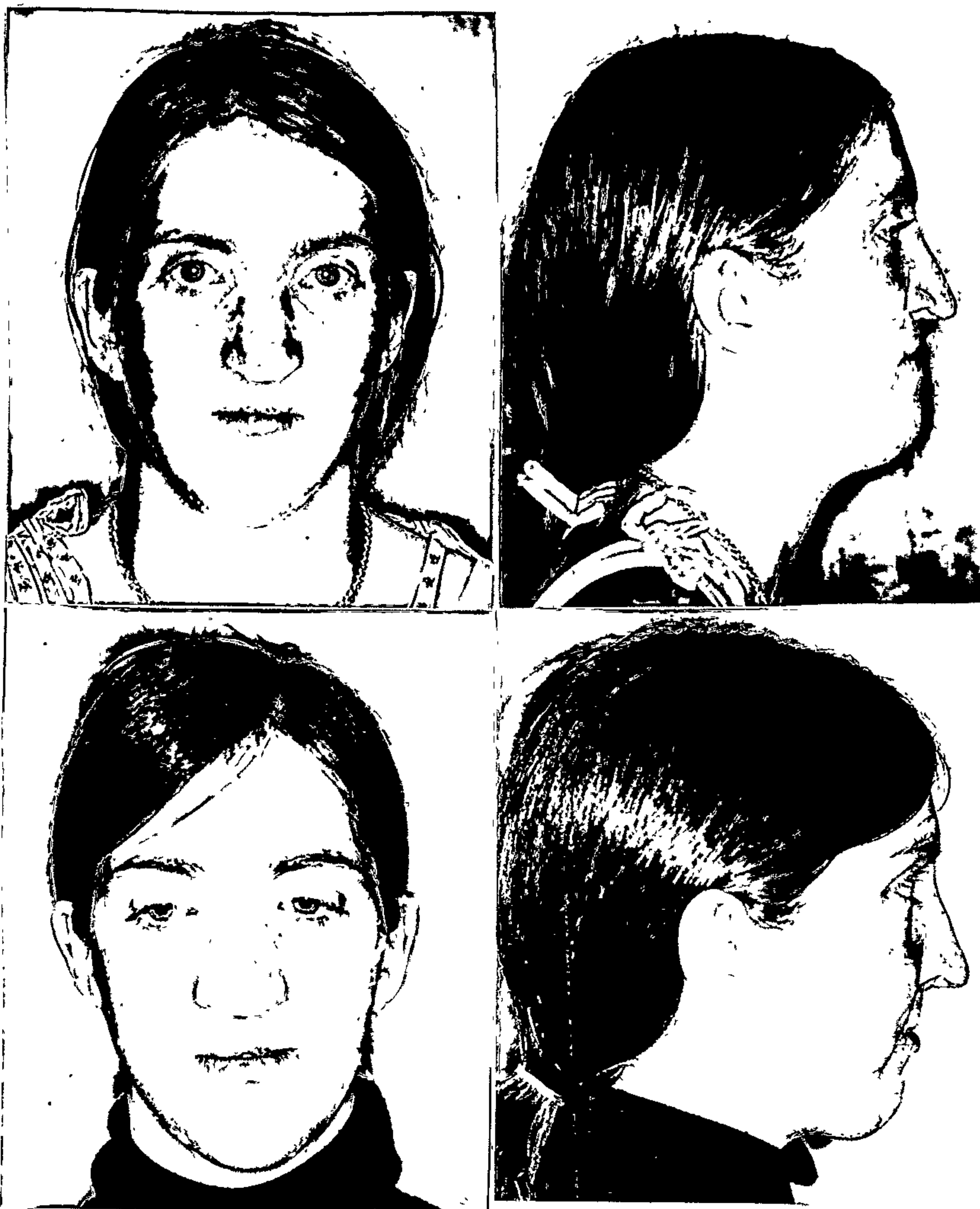
Right Side



Left Side

CASE . 4

HIGH LE FORT I MAXILLARY OSTEOTOMY



Age : 16 years old.

Sex : Female.

Original Condition : Bilateral Complete Cleft.

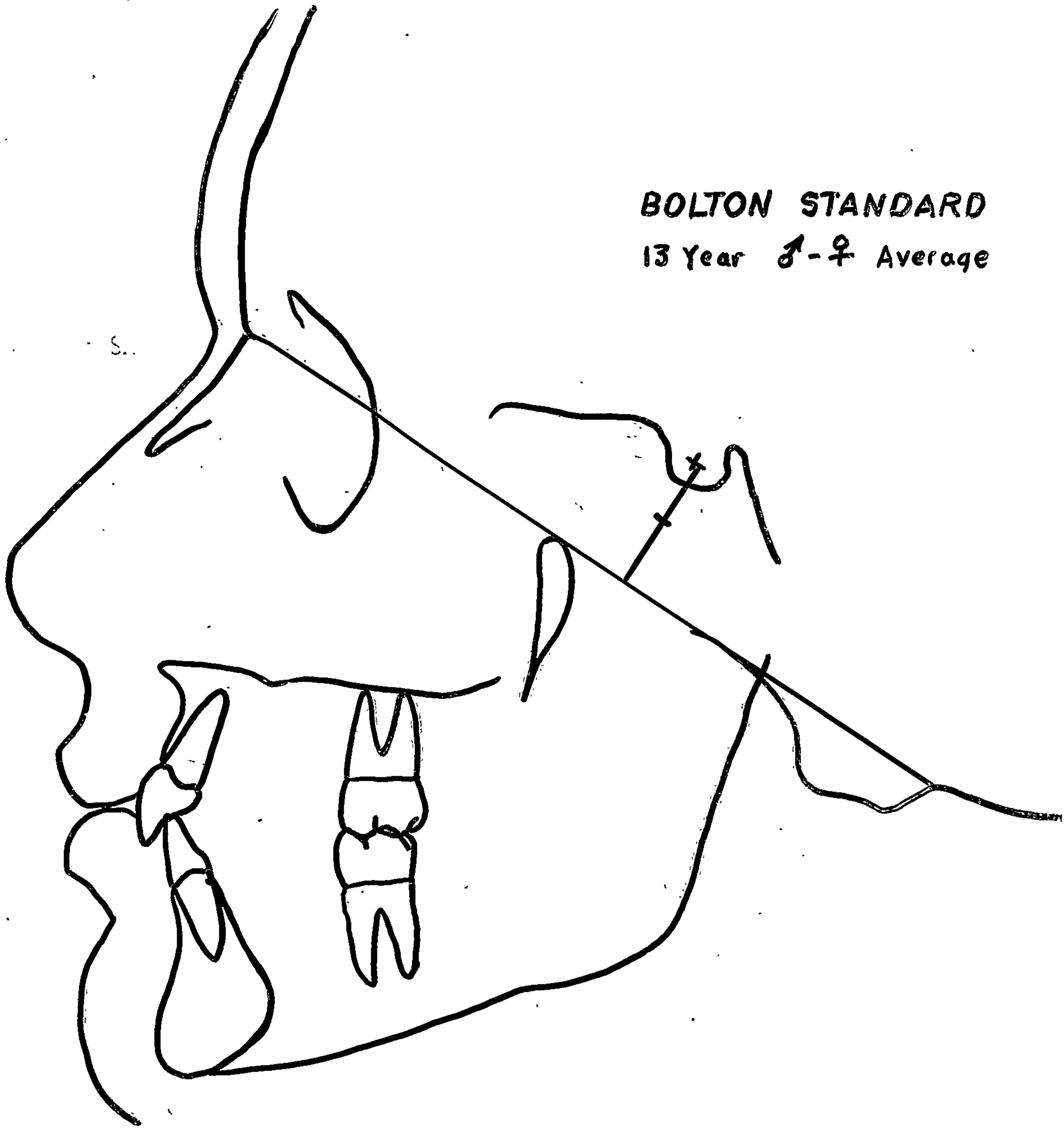
History : Repair of cleft right lip at 12 months old.

Repair of cleft left lip at 14 months old.

Repair of cleft palate at 2 years old.

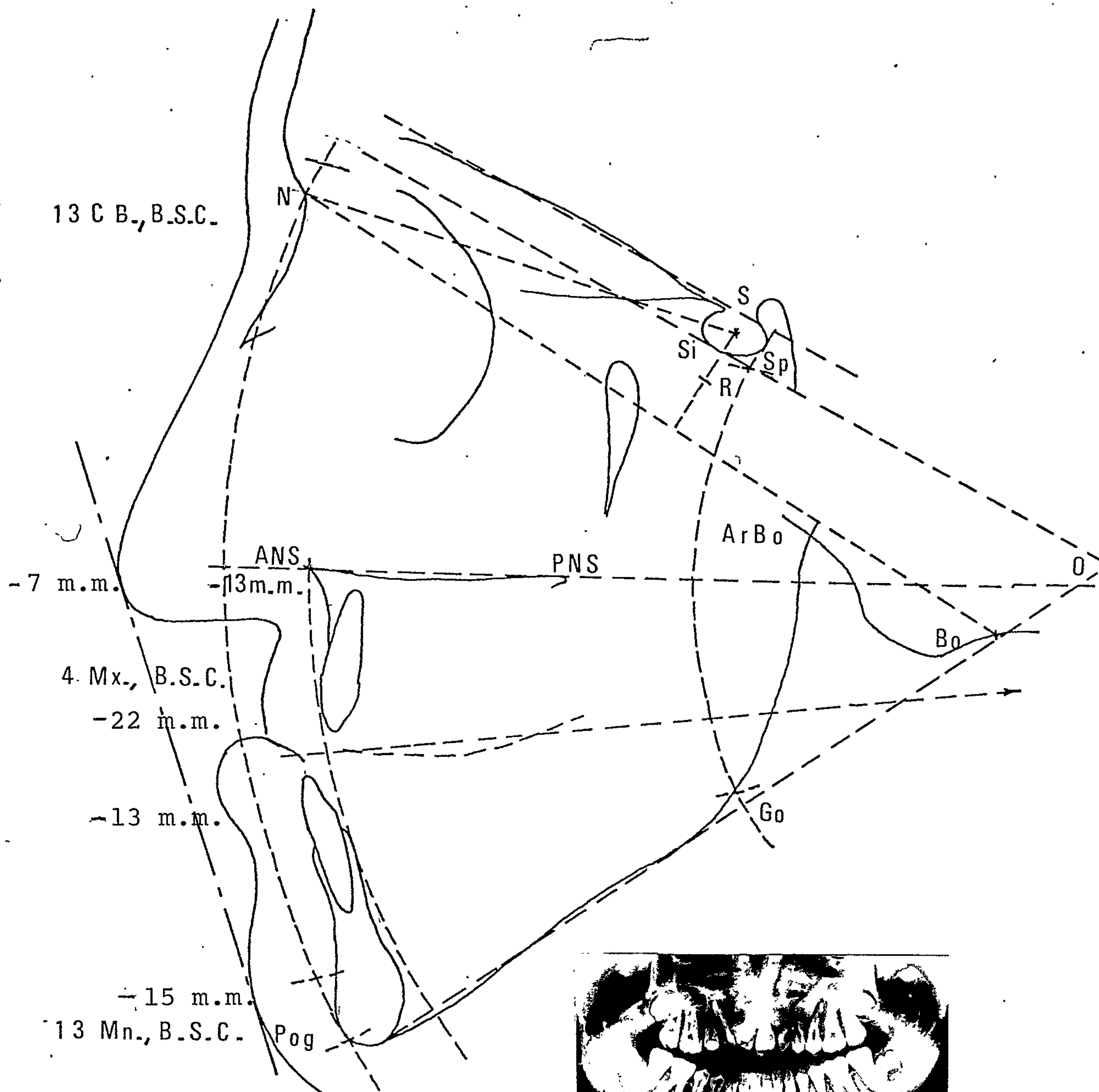
No nasal or other significant medical findings.

BOLTON STANDARD
13 Year ♂-♀ Average



CASE 4 DIAGNOSTIC TRACING

11-5-77



CASE 4 DISCUSSION

Diagnostic tracing shows that the cranial base and the mandible are of normal size antero-posteriorly (13 CB., 13 Mn., B.S.C.), while the maxilla is very much under-developed (4 Mx., B.S.C.). With reference to Sassouni Archial Analysis, mandibular pogonion is on the anterior arc while maxillary A-N-S is found to be -13 mm. behind the anterior arc, indicating that maxilla is the area of deformity. Bolton Standard templates of 13 years confirms this finding. The patient has 7 mm. open bite. Moreover, soft tissue nasal height, upper lip, lower lip and soft tissue pogonion are -7 mm., -22 mm., -13 mm. and -15 mm, respectively, behind the Bolton Standard of 13 years.

In order to correct the mid-face deficiency , open bite and nasal height, high Le Fort I maxillary osteotomy is indicated in this case. The surgeon decided to do a high Le Fort I maxillary osteotomy in this case. Model surgery shows a forward movement of 9 mm and downward anterior tilt of 6 mm. of the maxilla, may provide a stable occlusion and proper over-bite. The predicted profile (from cephalometric and photographic profile prediction) is satisfactory when related to esthetic plane and Bolton Standard template of 13 years.

Post-operative changes can be evaluated with

Sassouni Archial Analysis, Bolton Standards, normal cephalometric analysis and model studies, as shown in (1) pre- and post-surgical cephalometric assessment, and (2) model study assessment.

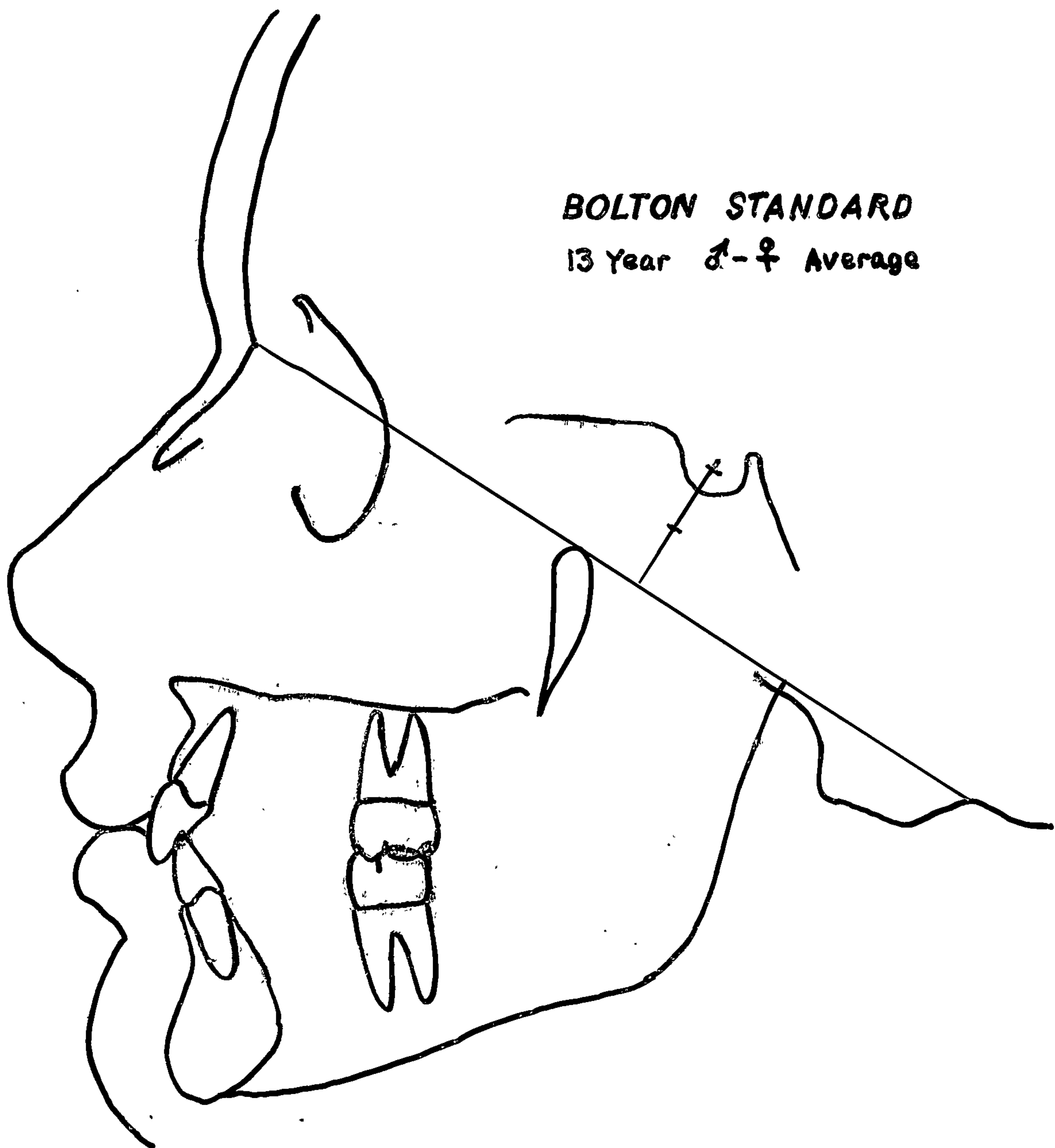
Intra-oral and extra-oral fixation appliances were used for immobilization for 9 weeks, as shown :



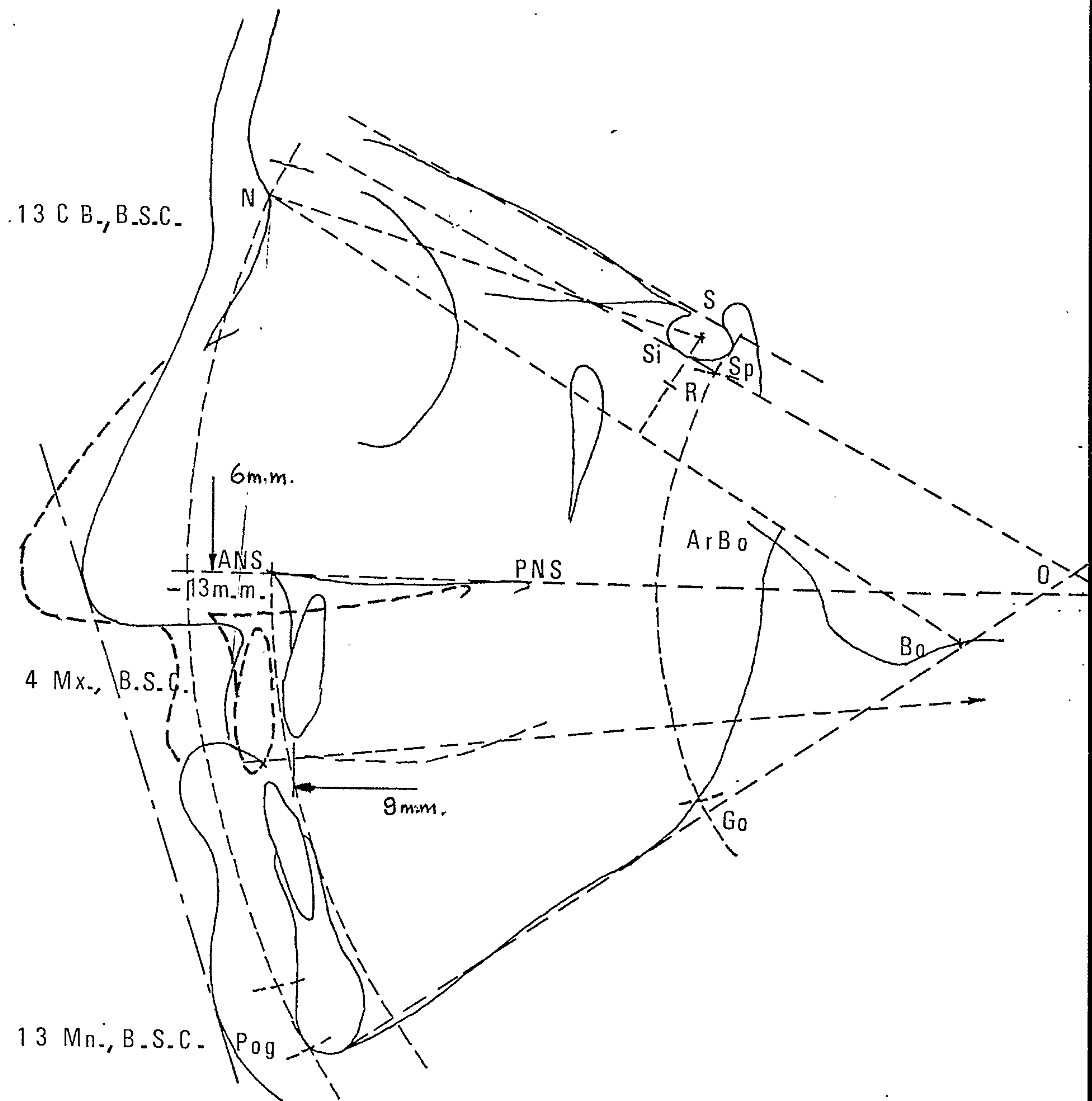
Planes used to locate center "O" in Sassouni Archial Analysis were : (1) parallel to supra-orbital plane, (2) palatal plane and (3) mandibular plane.

Radius of the anterior arc in Sassouni Archial Analysis was found to be 13.7 cm.

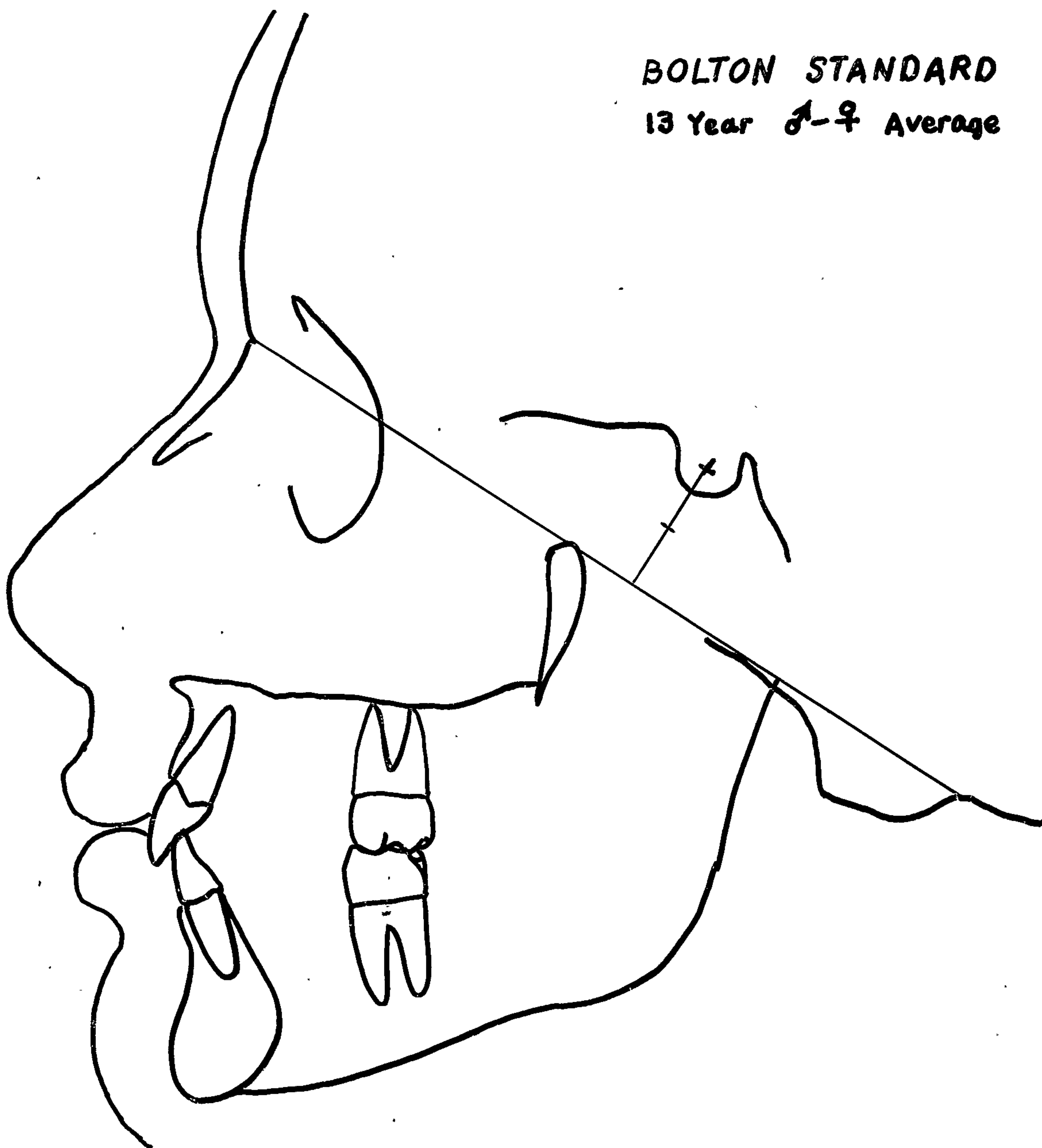
BOLTON STANDARD
13 Year ♂-♀ Average



CASE 4
PROFILE PREDICTION TRACING
11-5-77

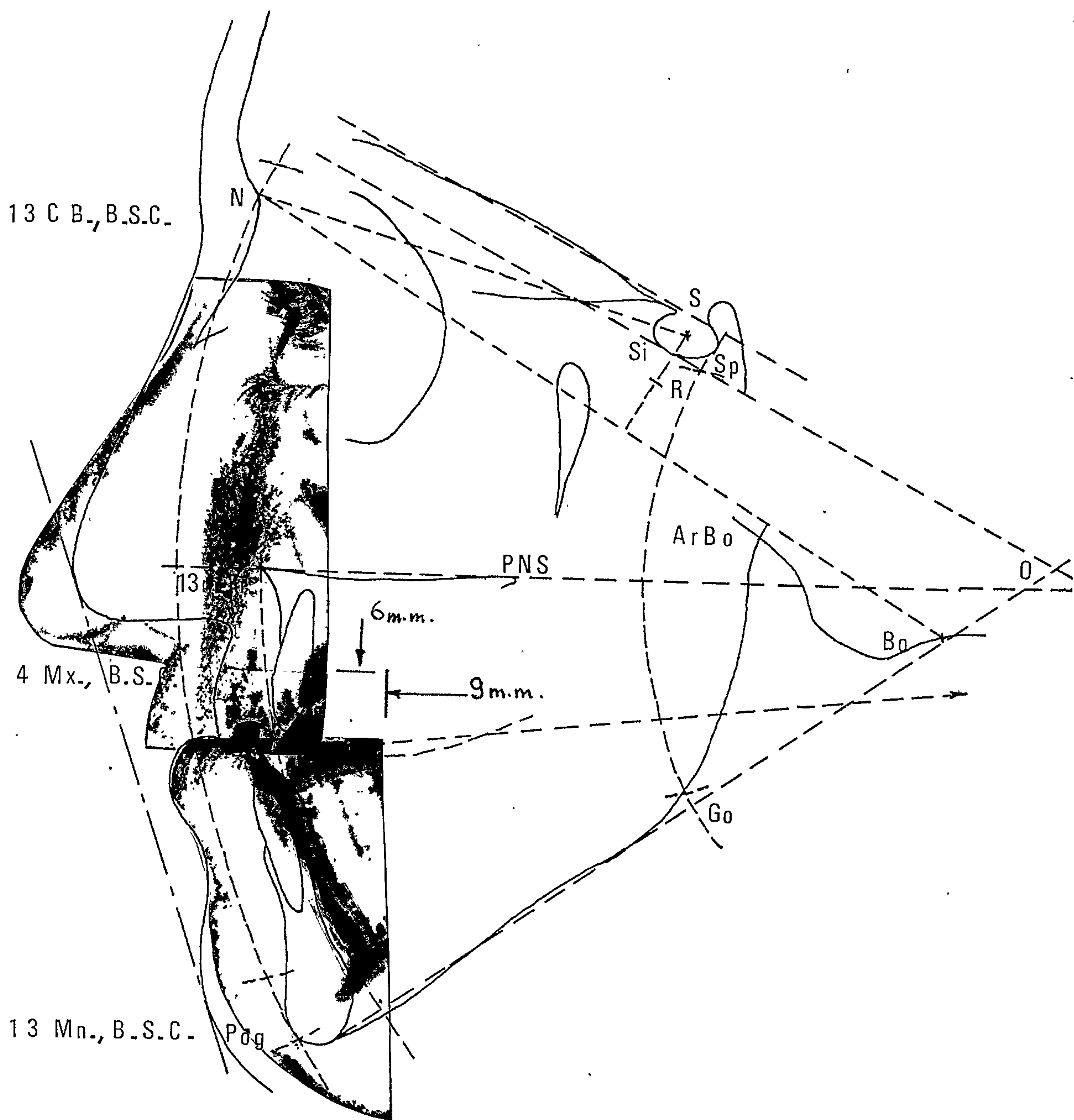


BOLTON STANDARD
13 Year ♂-♀ Average

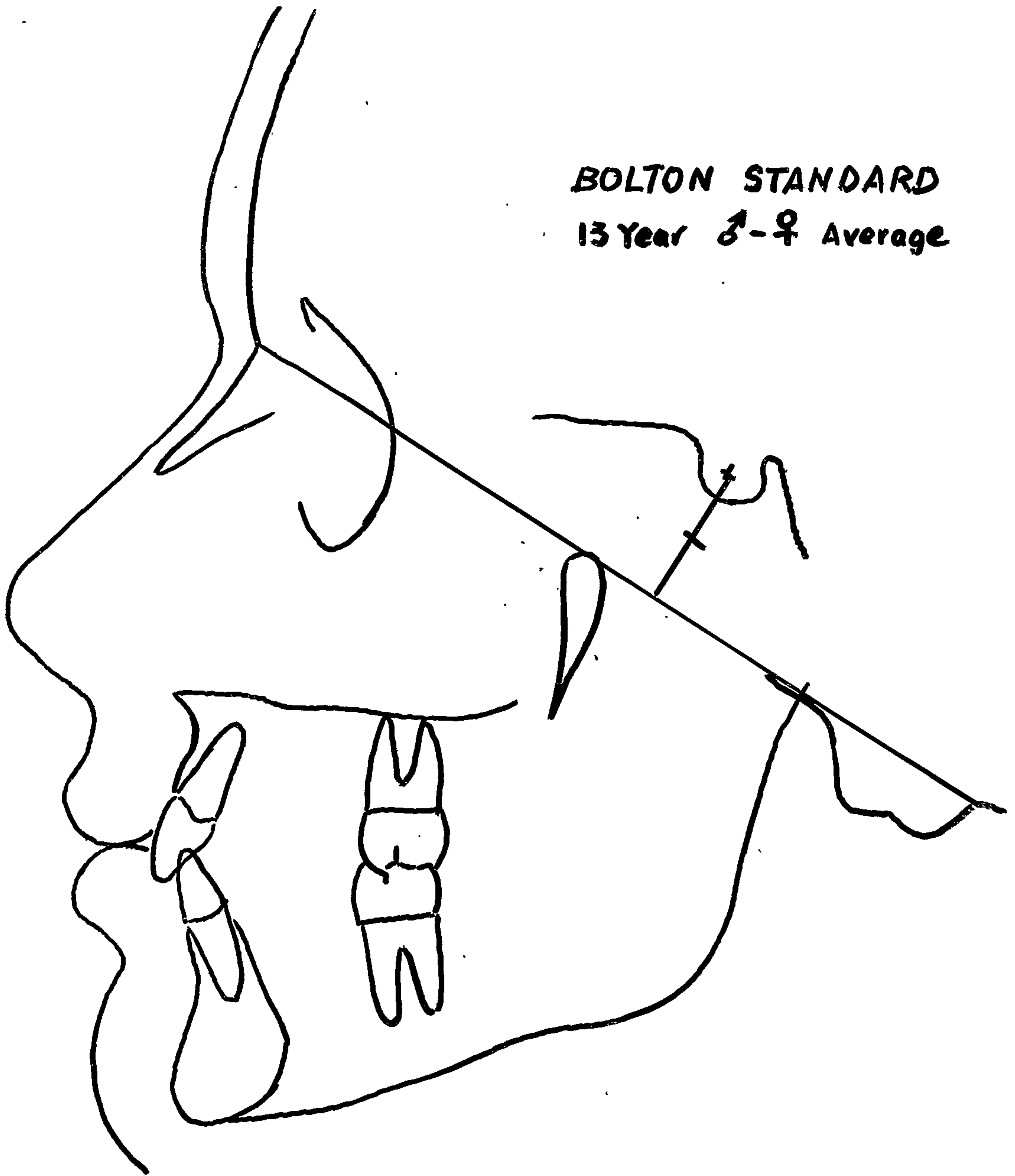


CASE 4
PHOTOGRAPHIC PROFILE PREDICTION

11-5-77



BOLTON STANDARD
13 Year ♂-♀ Average

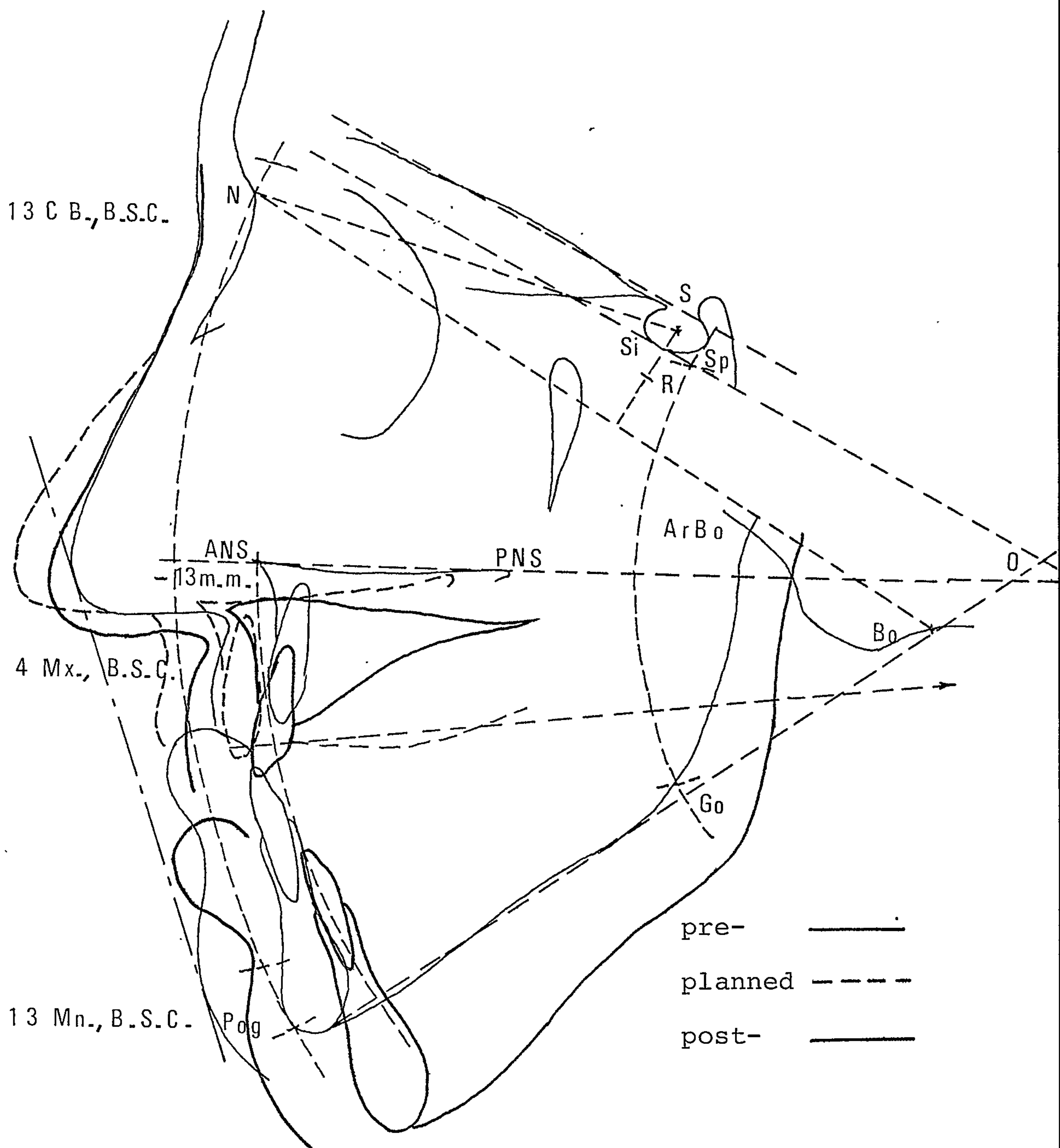


CASE 4

PRE- and POST-SURGICAL CEPHALOMETRIC ASSESSMENT

11 - 5 - 77

30 - 6 - 77



PRE-, PLANNED, AND POST-SURGICAL CEPHALOMETRIC ANALYSIS

		PRE-	PLANNED	POST-
SKELETAL ANALYSIS	S-N-A	69°	76°	72°
	S-N-B	70°	70°	66°
	A-N-B	-1°	6°	6°
	Angle of convexity (N-A-P)	-3°	15°	13°
	Y axis to N-S	79°	79°	88°
	Mn. pl. to N-S	50°	50°	57°
DENTAL ANALYSIS	U1 to A-Pog.	-1 mm.	0 mm.	4 mm.
	L1 to A-Pog.	3 mm.	-2 mm.	-1 mm.
	L1 to Mn. pl.	75°	75°	72°
	U1 to L1	153°	160°	147°
	U1 to S-N	82°	76°	85°
SASSOUNI ARCHIAL ANALYSIS	A-N-S to Sassouni Anterior Arc	-13 mm.	-4 mm.	-8 mm.
	U1 Tip to Sassouni Anterior Arc	-14 mm.	-6 mm.	-8 mm.
	Pog. to Sassouni Anterior Arc	0 mm.	0 mm.	-2 mm.
BOLTON STANDARD ANALYSIS	Nasal Height to Bolton Standard	7 -8 mm.	1 mm.	-5 mm.
	Upper Lip Height to Bolton Standard	-22 mm.	-14 mm.	-18 mm.
	Lower Lip Height to Bolton Standard	13 -14 mm.	-14 mm.	-15 mm.
	Soft tissue Pog. to Bolton Standard	-15 mm.	-16 mm.	-25 mm.

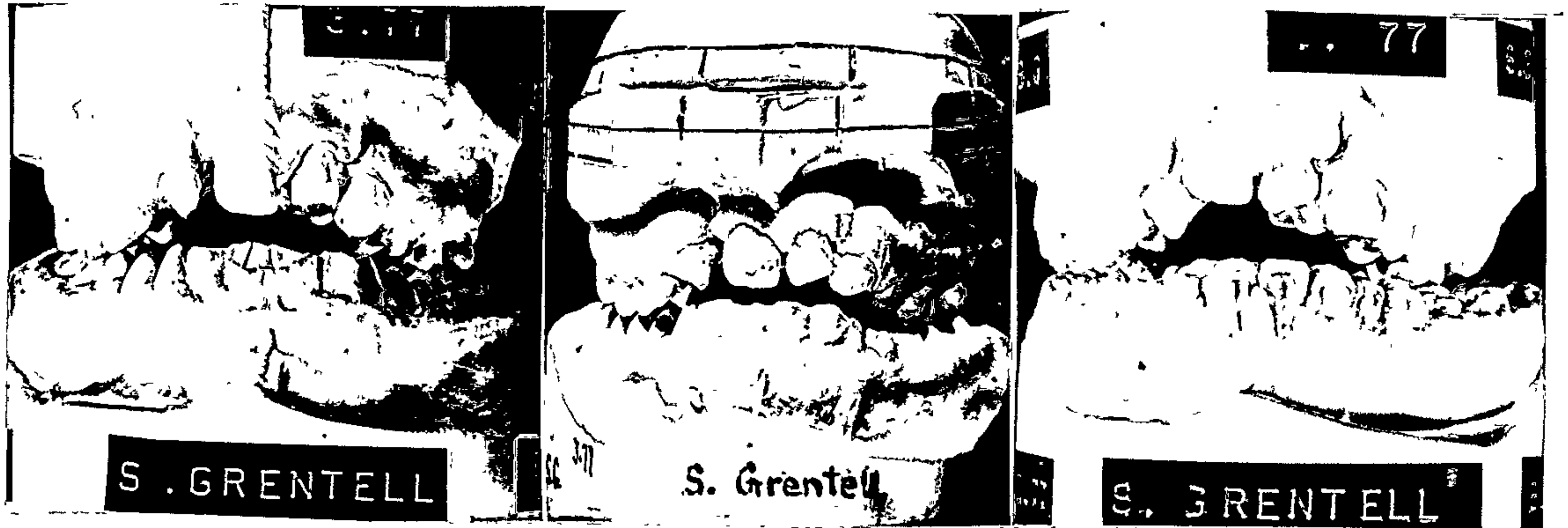
CASE 4

MODEL STUDY ASSESSMENT

Pre-Surgery

Model Surgery

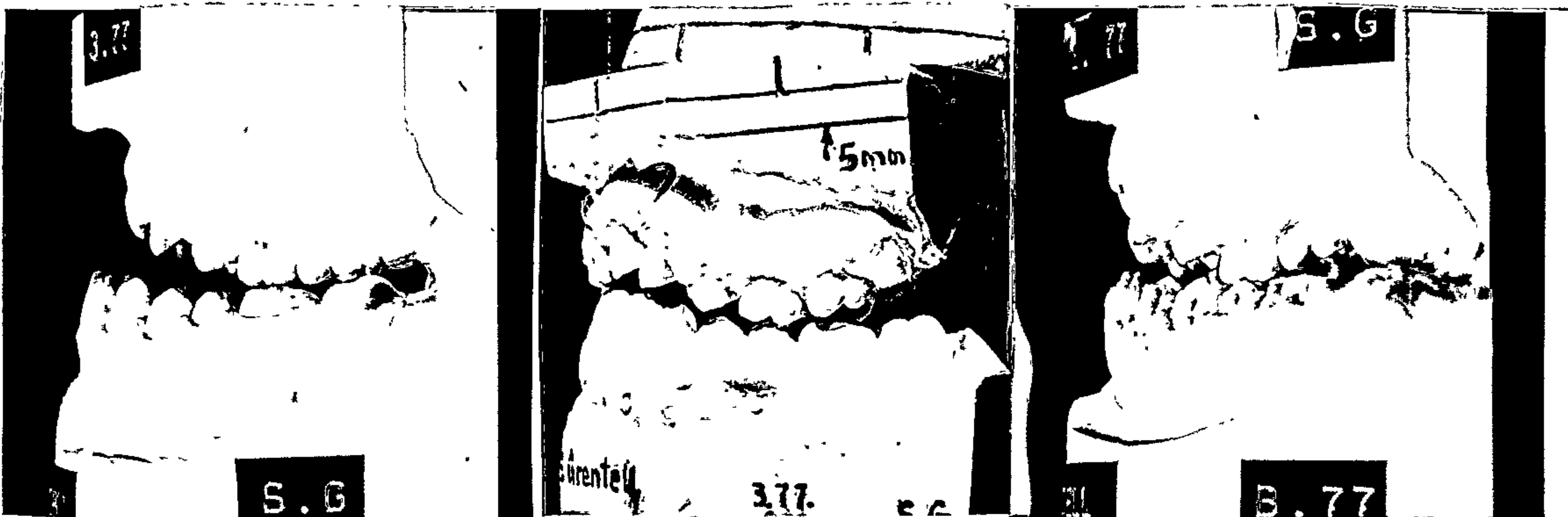
Post-Surgery



Front

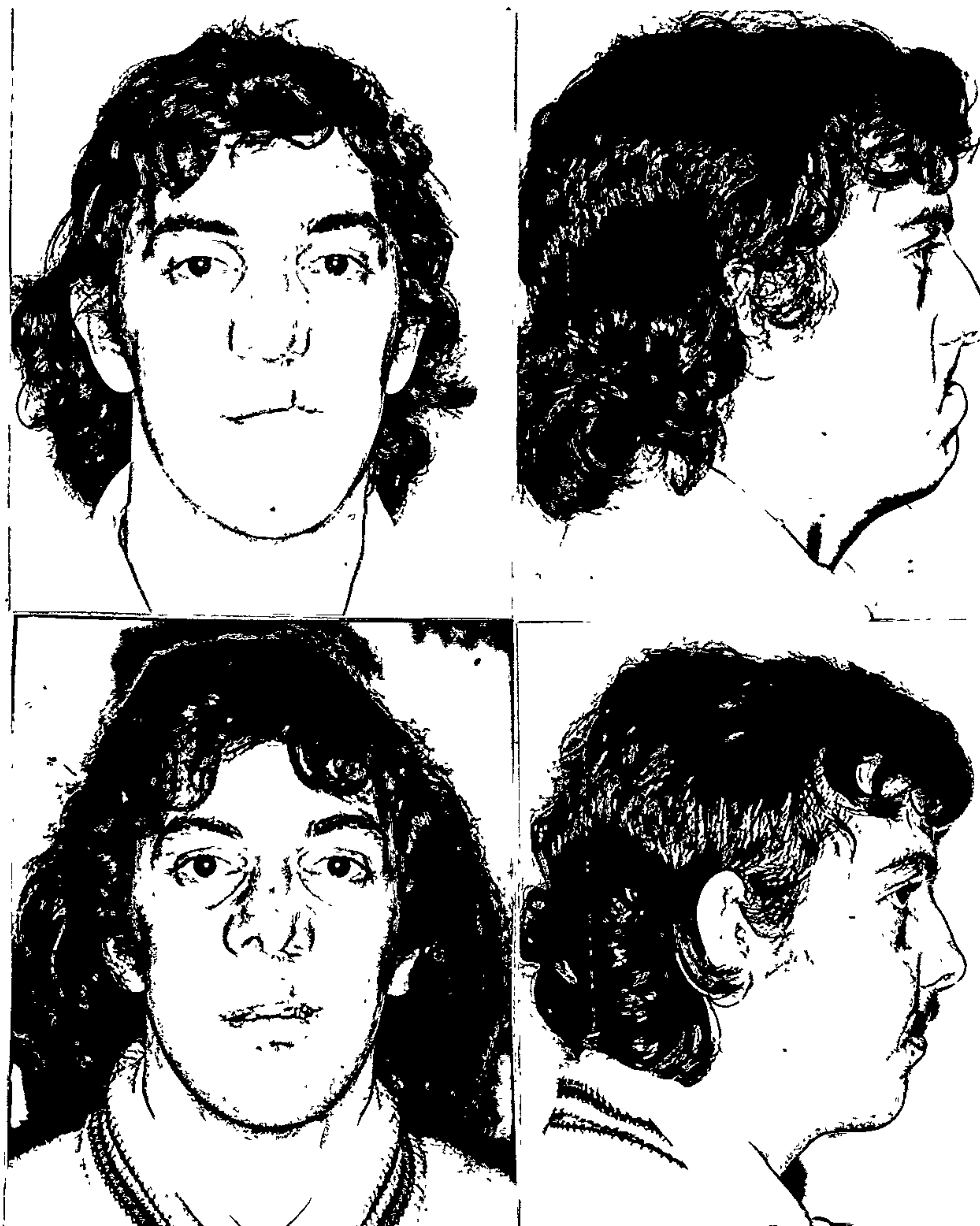


Right Side



Left Side

LE FORT I MAXILLARY OSTEOTOMY



Before
Surgery

After
Surgery

Age : 22 years old.

Sex : Male.

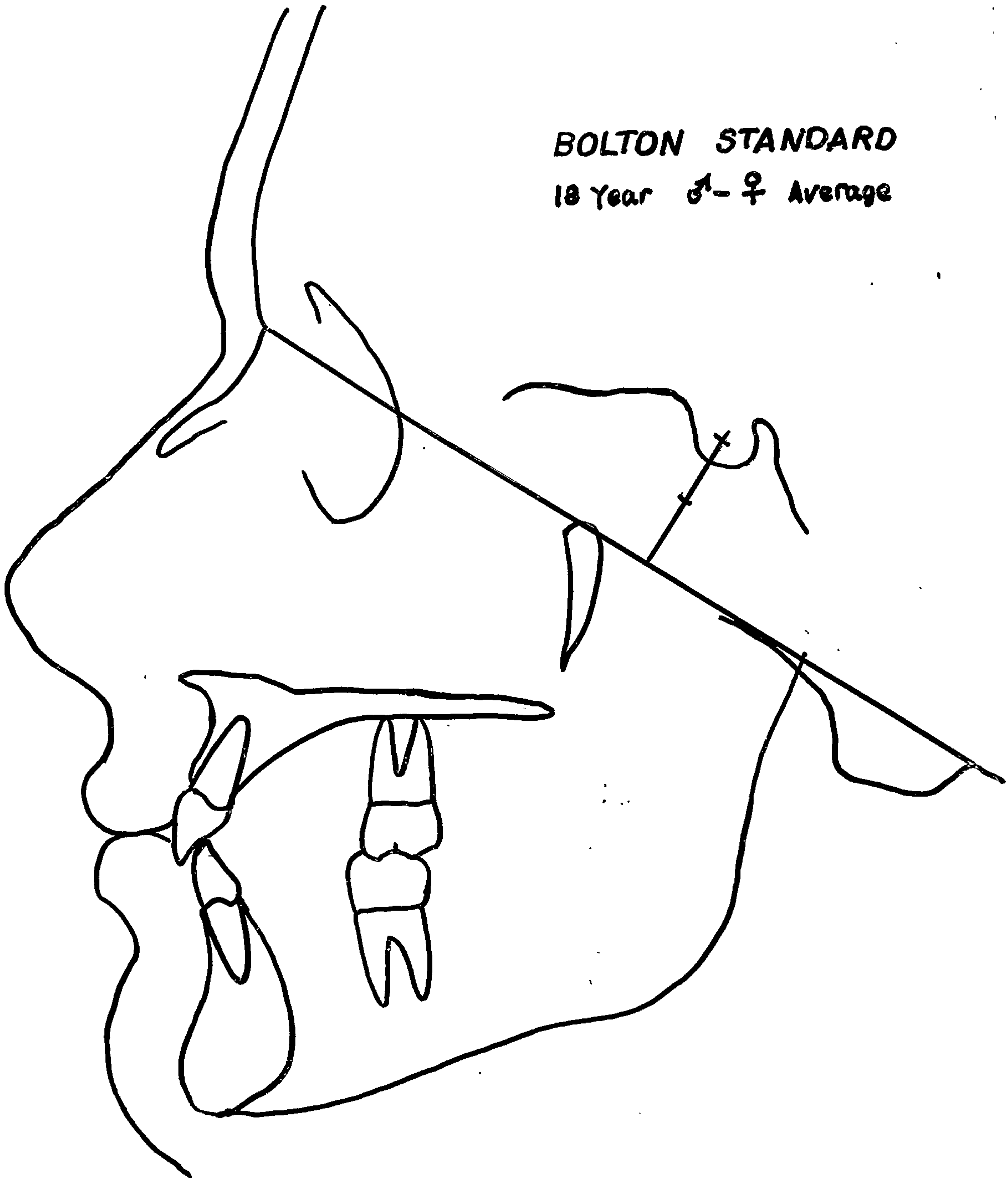
Original Condition : Unilateral Complete Left Cleft Lip
and Palate.

History : Repair of cleft lip and palate at age 2 years
old.

Abbe flap operation at 19 years old.

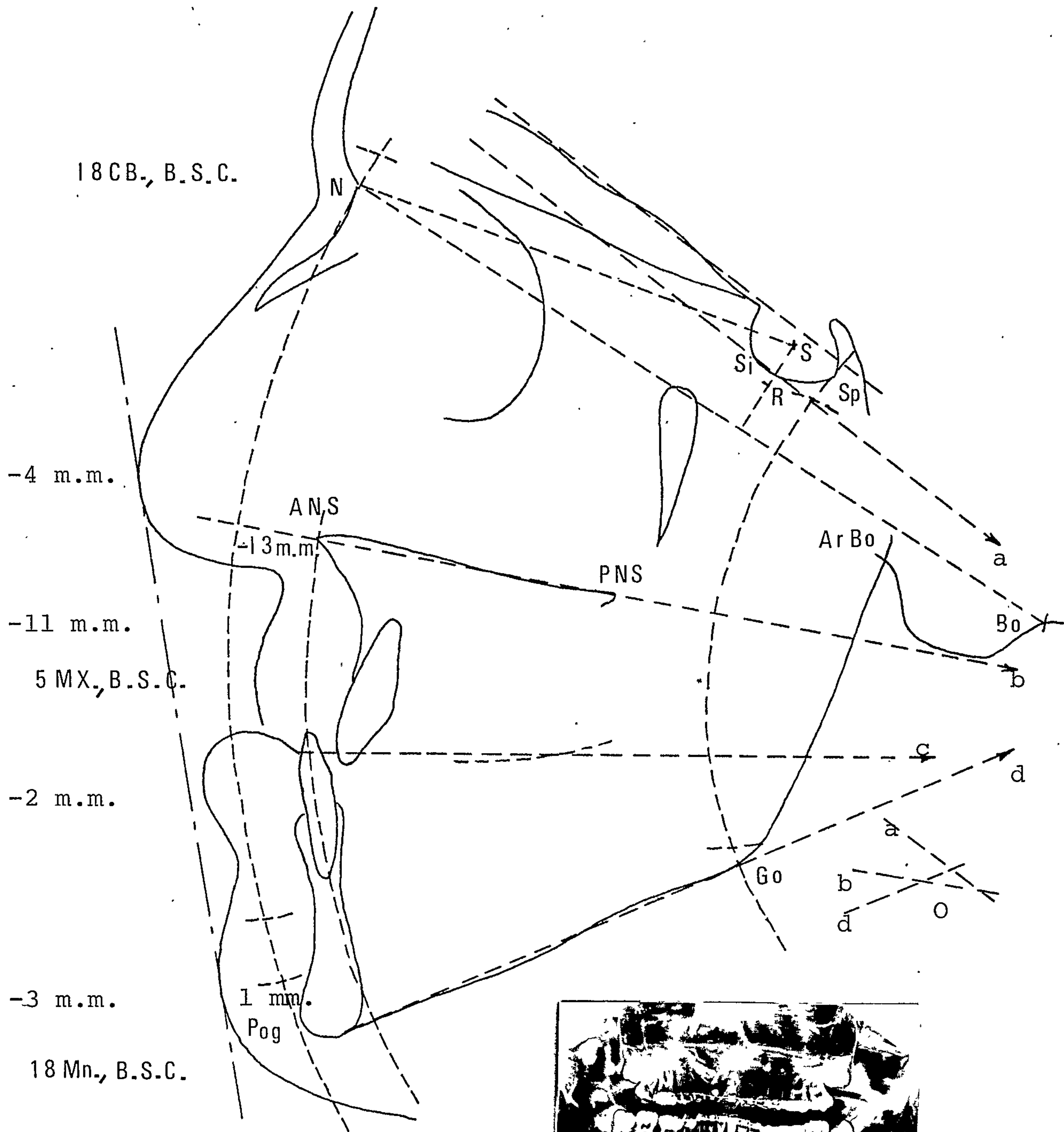
No nasal or other significant medical findings.

BOLTON STANDARD
18 Year ♂-♀ Average



DIAGNOSTIC TRACING

4 - 4 - 77



CASE 5 DISCUSSION

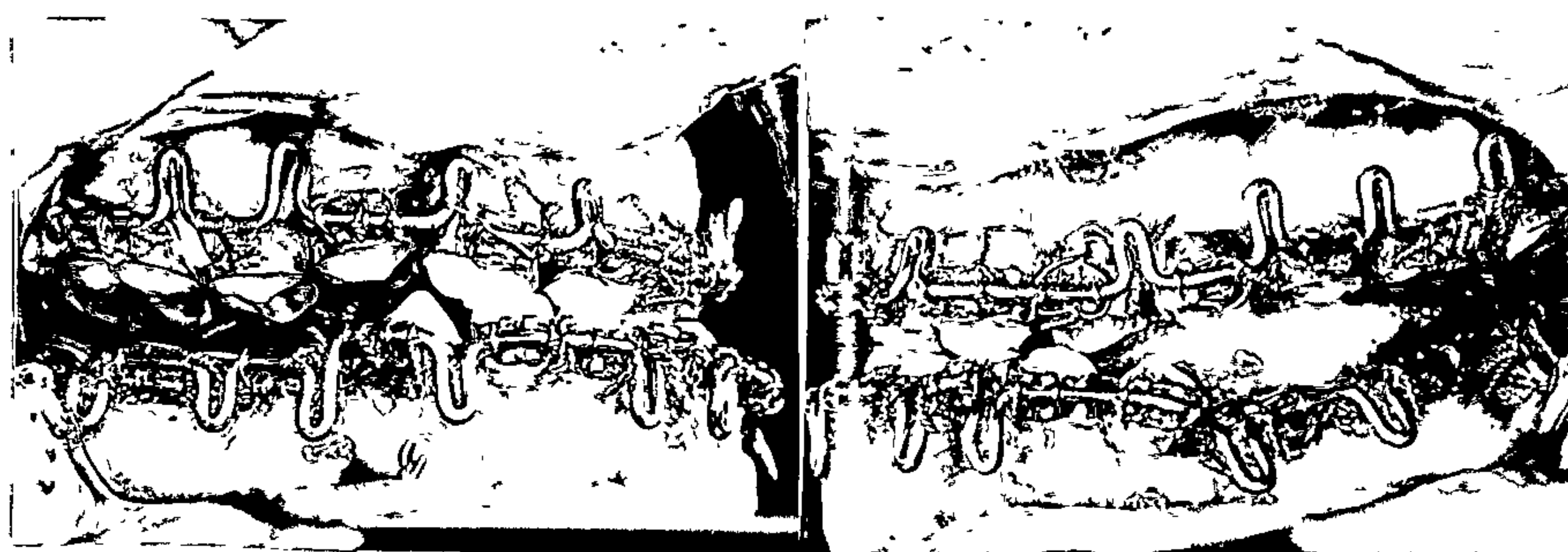
Diagnostic tracing shows that the cranial base and mandible are of normal size antero-posteriorly (18 CB., 18 Mn., B.S.C.) while the maxilla is very much under-developed (5 Mx., B.S.C.). With reference to Sassouni Archial Analysis, the mandibular pogonion is not too far away from the anterior arc. The maxillary A-N-S is far behind the arc (-13 mm.), indicating that this is a region of deficiency. Bolton Standard templates of 18 years confirms this finding. Moreover, soft tissue nasal height, lower lip and soft tissue ~~p~~ogonion are well within the normal range when compared to Bolton Standard template of 18 years. The upper lip falls behind Bolton Standard by 11 mm.

In order to correct the mid-face deficiency, it is suggested to move the lower part of the maxillary complex forward via a low Le Fort I maxillary osteotomy. The surgeon decided to do the same. Model surgery indicated that a forward movement of 9 mm. of the maxilla would provide a stable occlusion and correct skeletal discrepancy. The profile predicted (from cephalometric and photographic profile prediction) is satisfactory when compared to esthetic plane and Bolton Standard template of 18 years.

Post-operative changes can be evaluated with Sassouni Archial Analysis, Bolton Standards, normal cepha-

lometric analysis and model study, as shown in (1) pre- and post-surgical cephalometric assessment, and (2) model study assessment.

Intra-oral fixation with orthodontic bands and heavy labial arch wires were used for immobilization for 6 weeks, as shown :

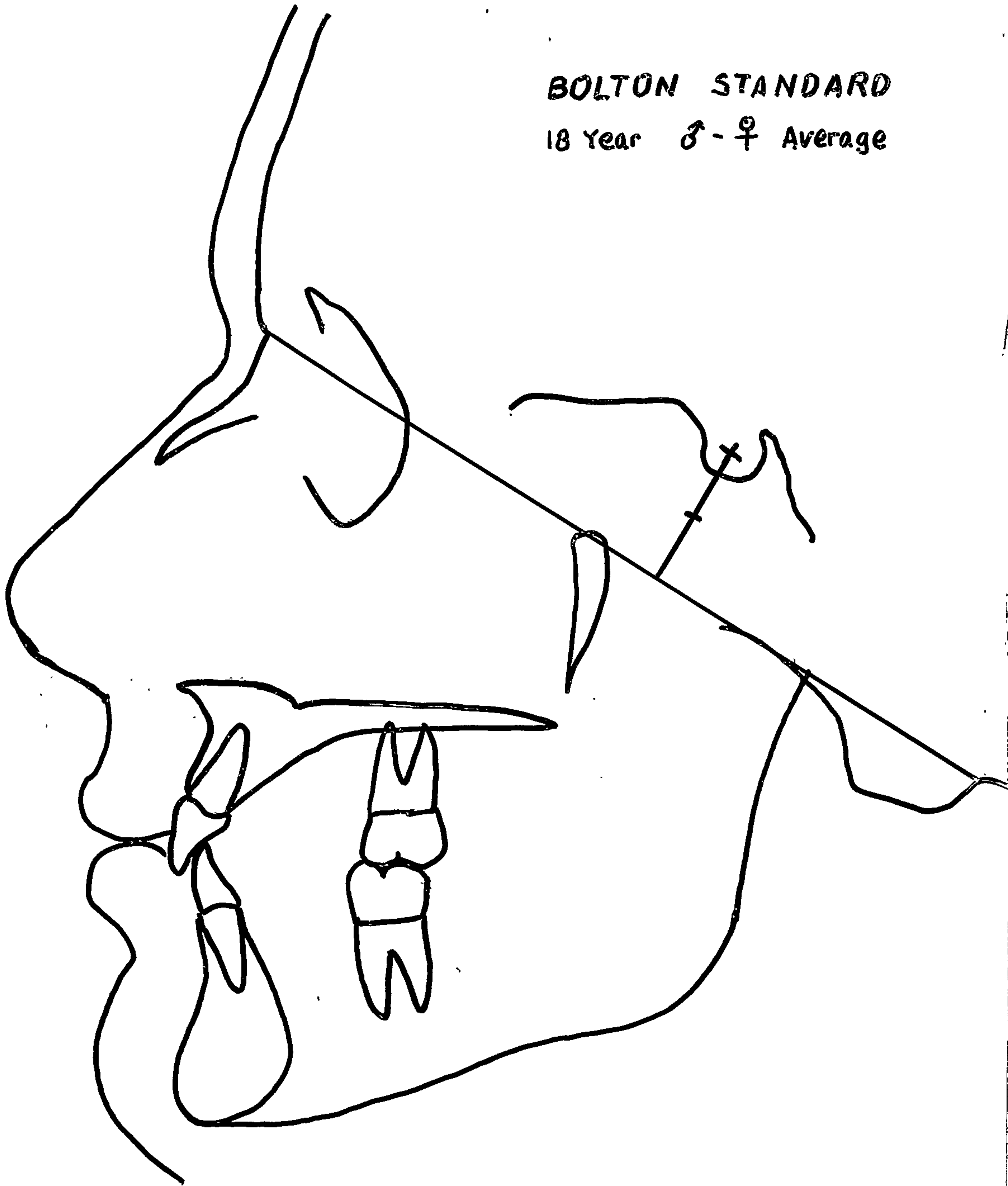


Planes used to locate center "O" in Sassouni Archial Analysis were : (1) parallel to supra-orbital plane, (2) palatal plane and (3) mandibular plane.

Radius of the anterior arc in Sassouni Archial Analysis was found to be 15.2 cm.

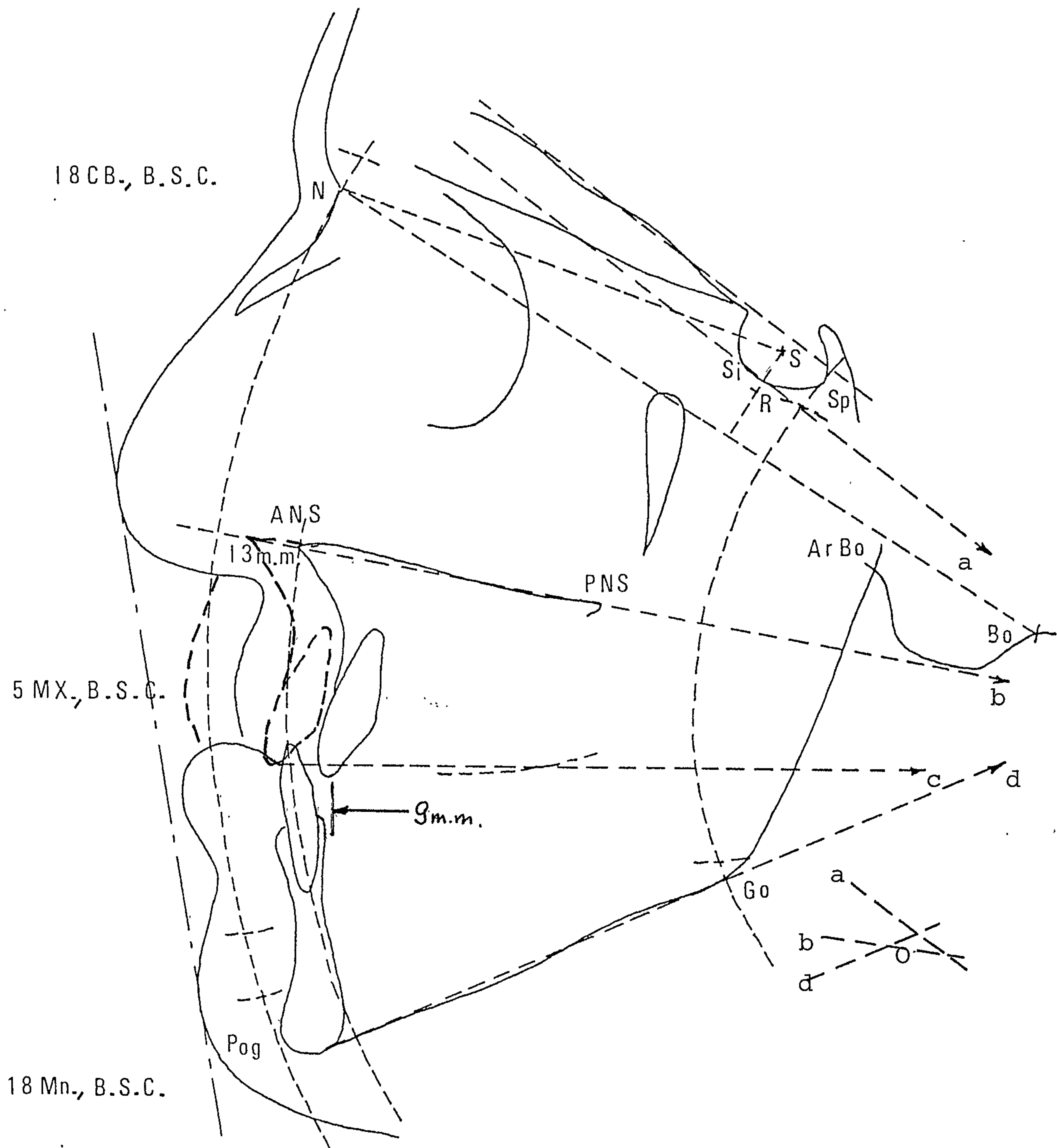
BOLTON STANDARD

18 Year ♂ - ♀ Average

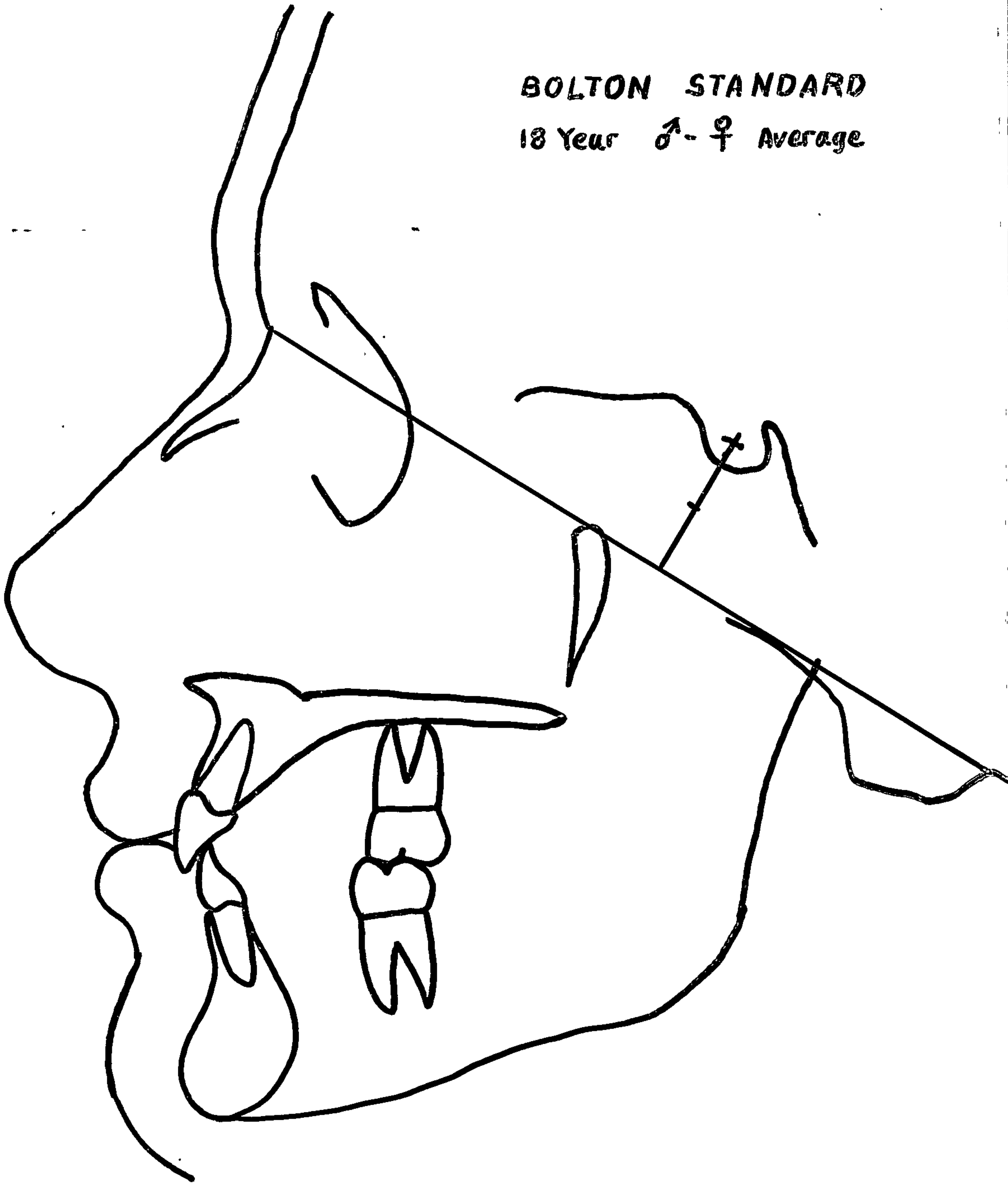


PROFILE PREDICTION TRACING

4-4-77

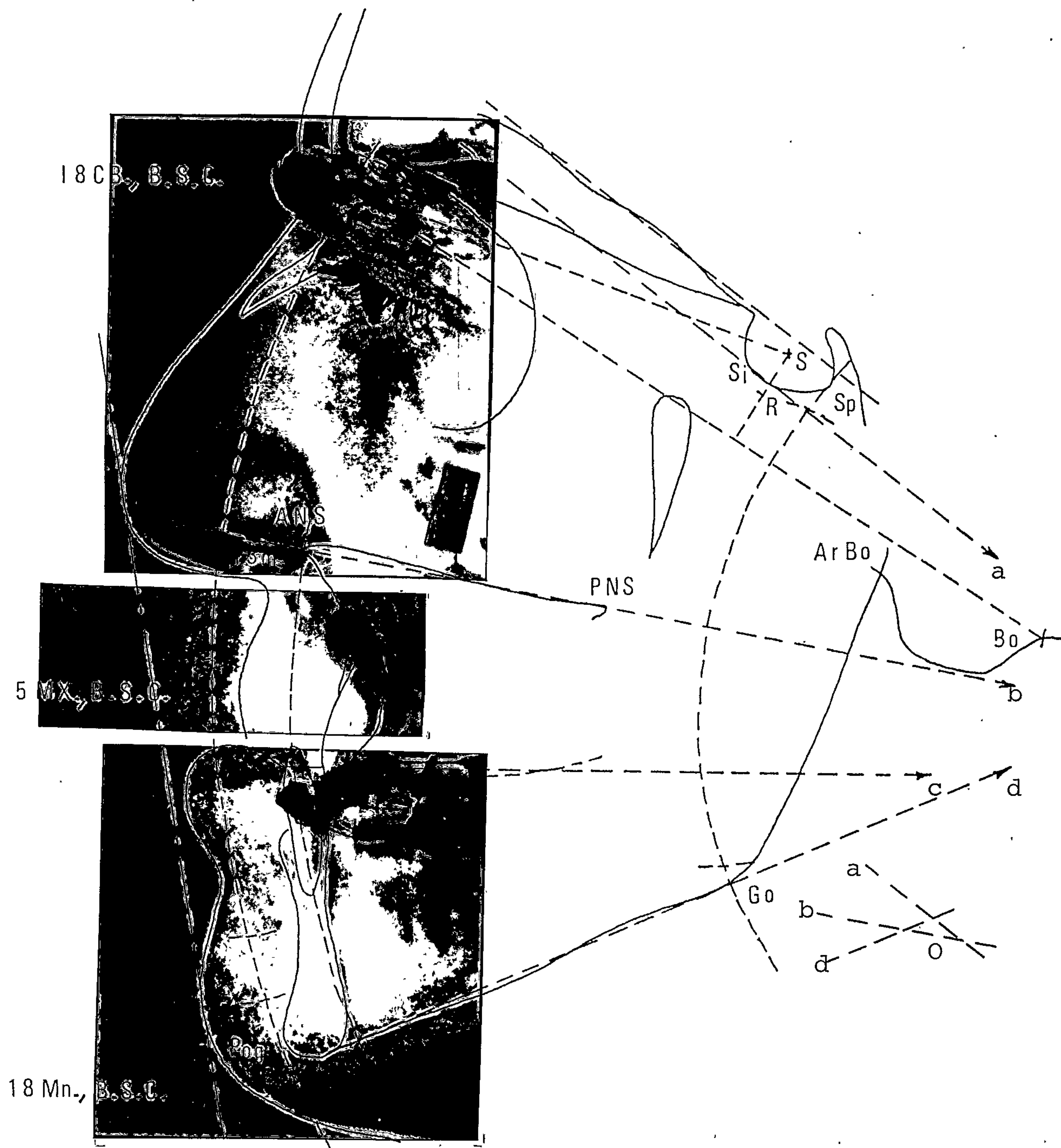


BOLTON STANDARD
18 Year ♂-♀ Average

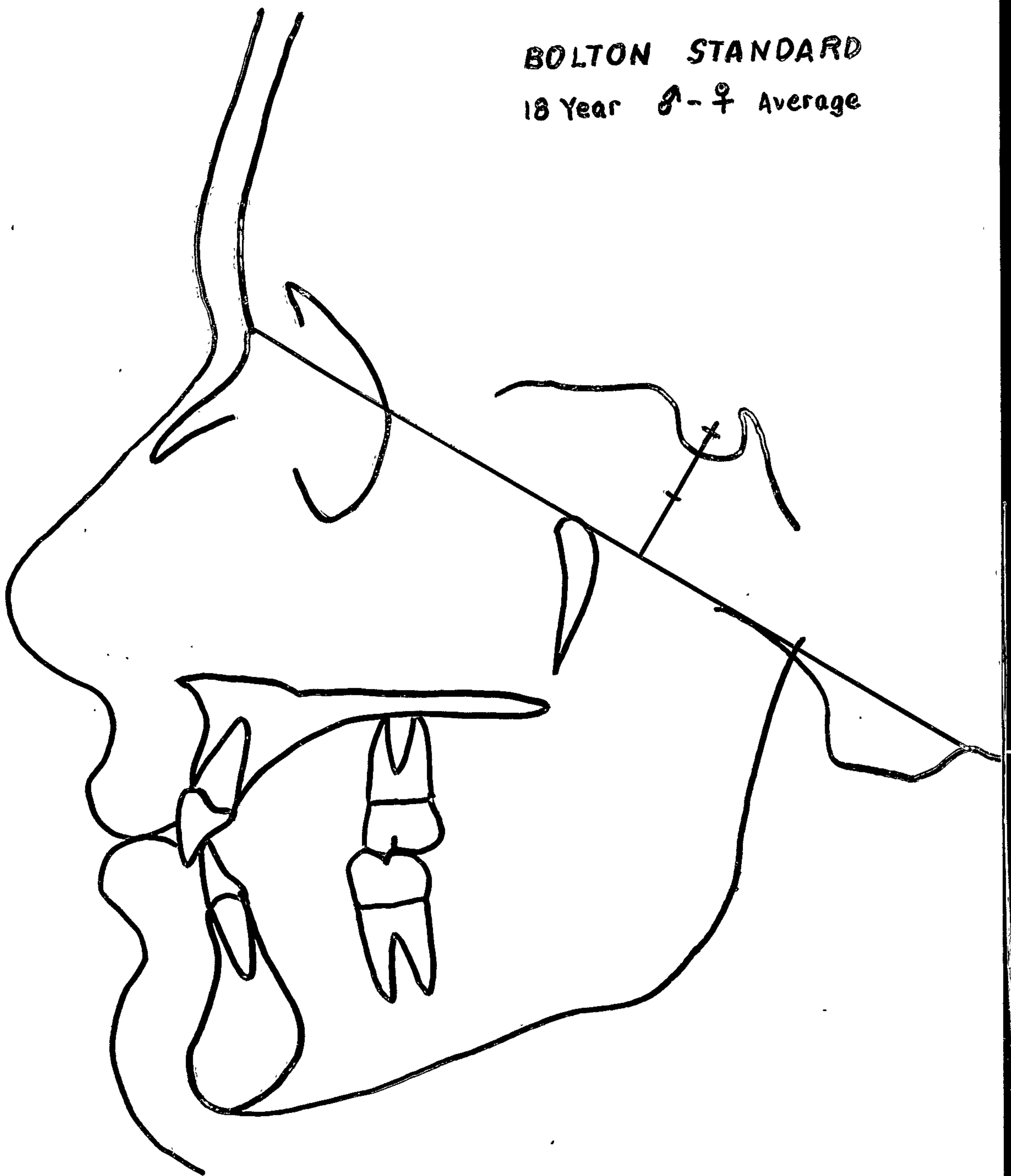


PHOTOGRAPHIC PROFILE PREDICTION

4-4-77



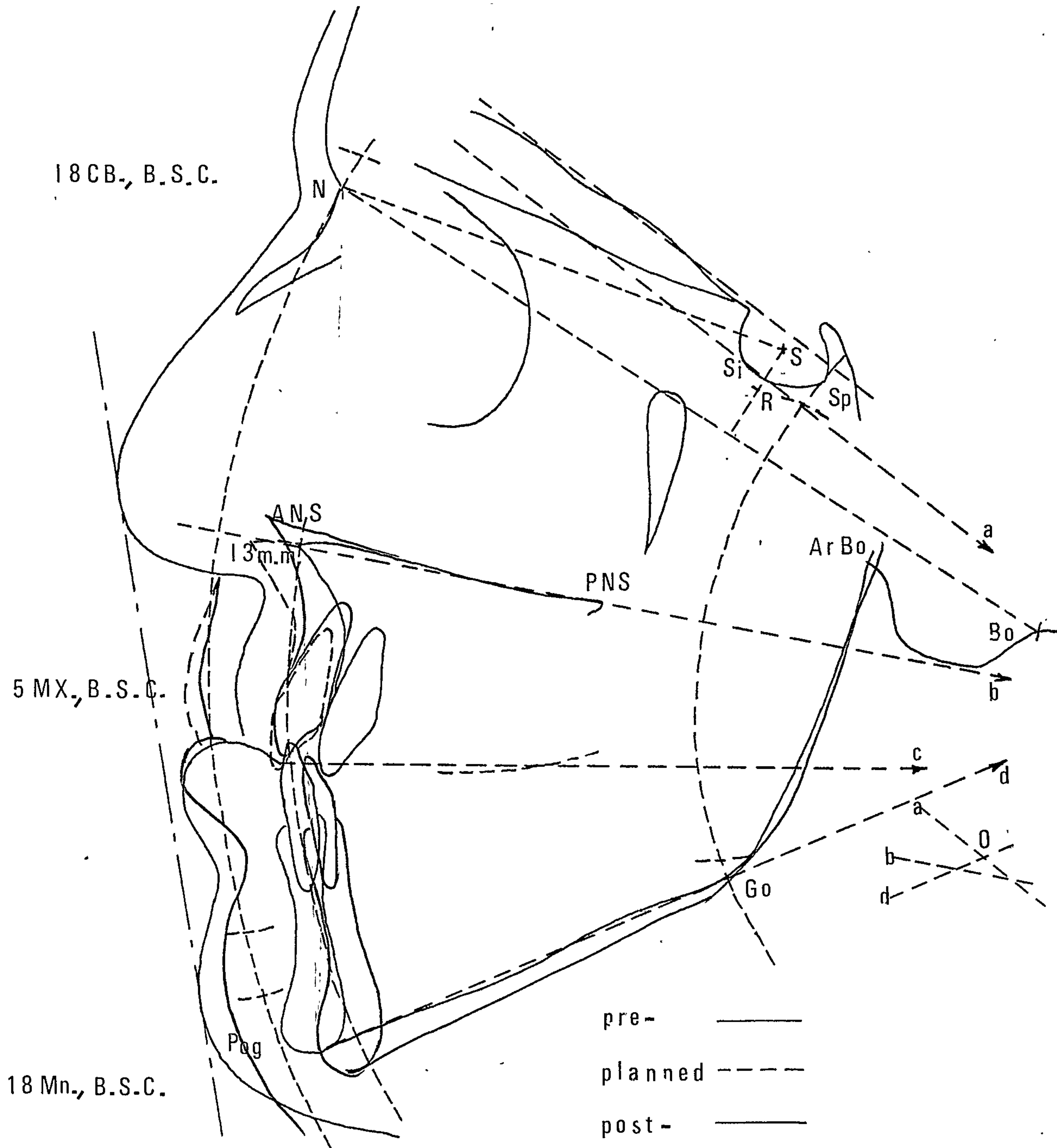
BOLTON STANDARD
18 Year ♂-♀ Average



PRE-and POST- SURGICAL CEPH. ASSESSMENT

4-4-77

23-8-77



PRE-, PLANNED, AND POST-SURGICAL CEPHALOMETRIC ANALYSIS

		PRE-	PLANNED	POST-
SKELETAL ANALYSIS	S-N-A	69°	77°	75°
	S-N-B	74°	74°	71.5°
	A-N-B	-5°	3°	3.5°
	Angle of convexity (N-A-P)	-9°	6°	8°
	Y axis to N-S	75°	75°	77°
	Mn. pl. to N-S	42°	42°	45°
DENTAL ANALYSIS	U1 to A-Pog.	-2 mm.	3 mm.	4 mm.
	L1 to A-Pog.	6 mm.	0 mm.	0 mm.
	L1 to Mn. pl.	74°	74°	74°
	U1 to L1	152°	152°	146°
	U1 to S-N	90°	90°	94°
SASSOUNI ARCHIAL ANALYSIS	A-N-S to Sassouni Anterior Arc	-13 mm.	-4 mm.	-6 mm.
	U1 Tip to Sassouni Anterior Arc	-17 mm.	-8 mm.	-11 mm.
	Pog. to Sassouni Anterior Arc	-1 mm.	-1 mm.	-5 mm.
BOLTON STANDARD ANALYSIS	Nasal Height to Bolton Standard	-4 mm.	-4 mm.	-4 mm.
	Upper Lip Height to Bolton Standard	-11 mm.	-3 mm.	-6 mm.
	Lower Lip Height to Bolton Standard	-2 mm.	-2 mm.	-2 mm.
	Soft tissue Pog. to Bolton Standard	-3 mm.	-3 mm.	-6 mm.

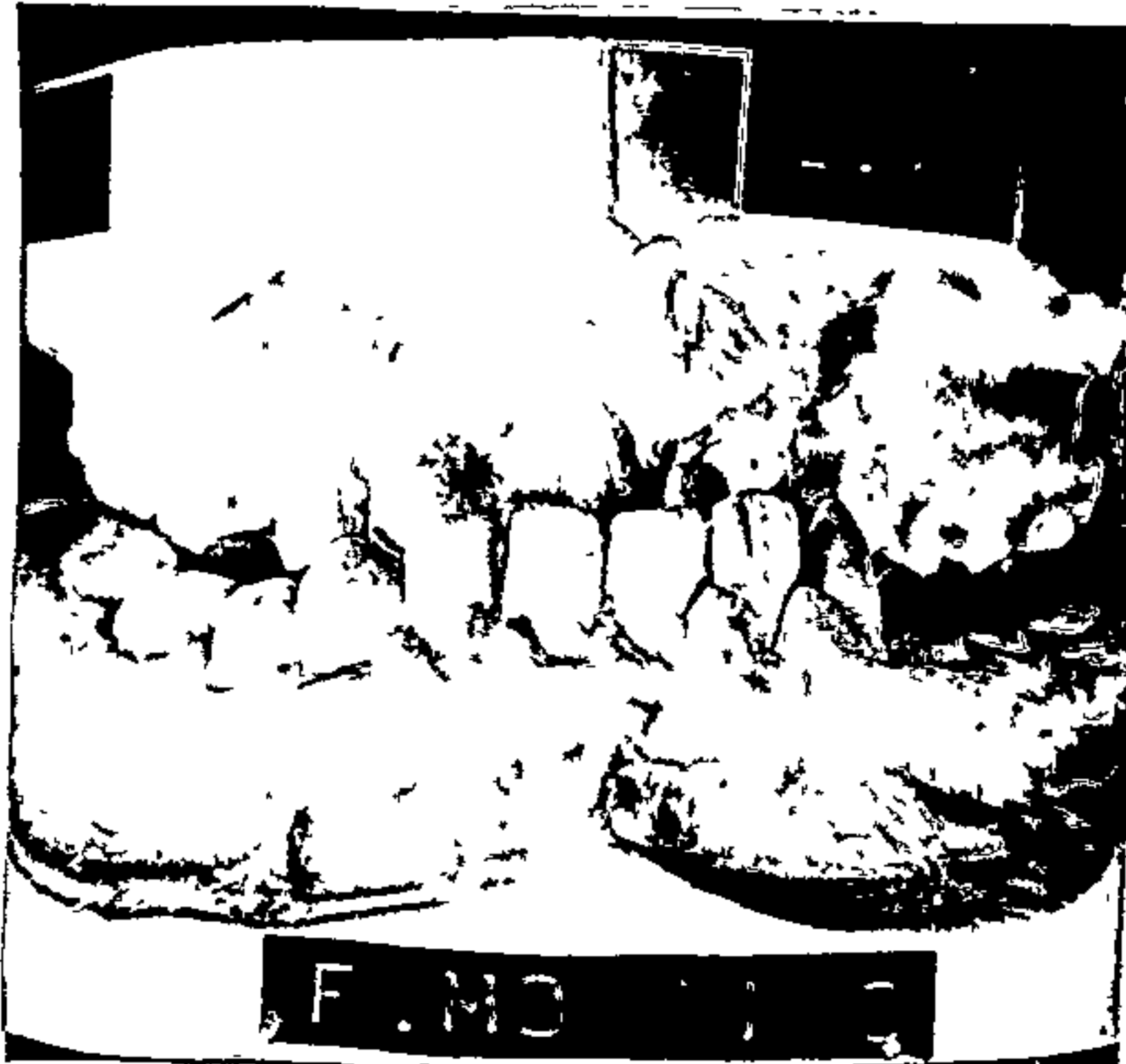
CASE 5

MODEL STUDY ASSESSMENT

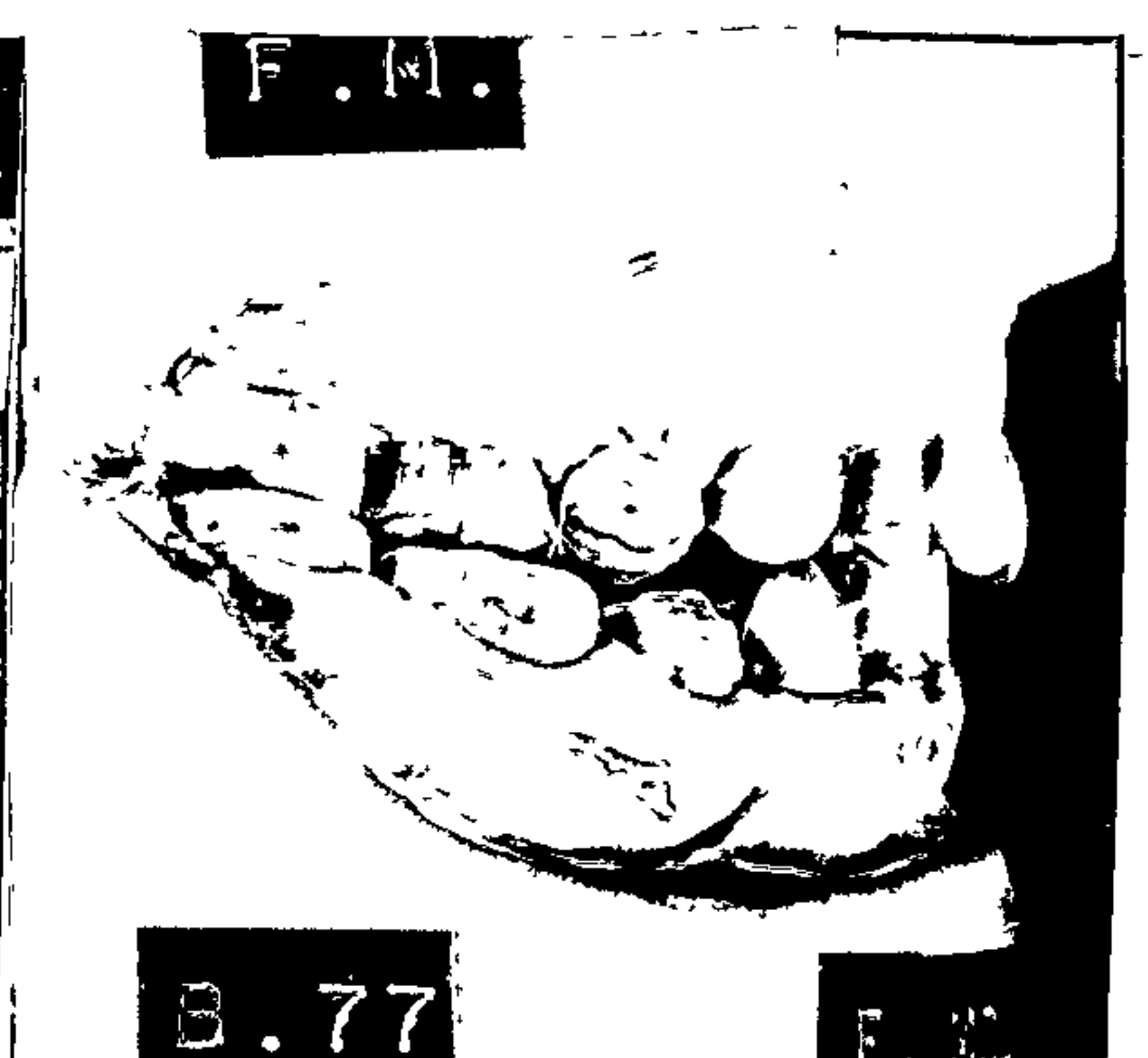
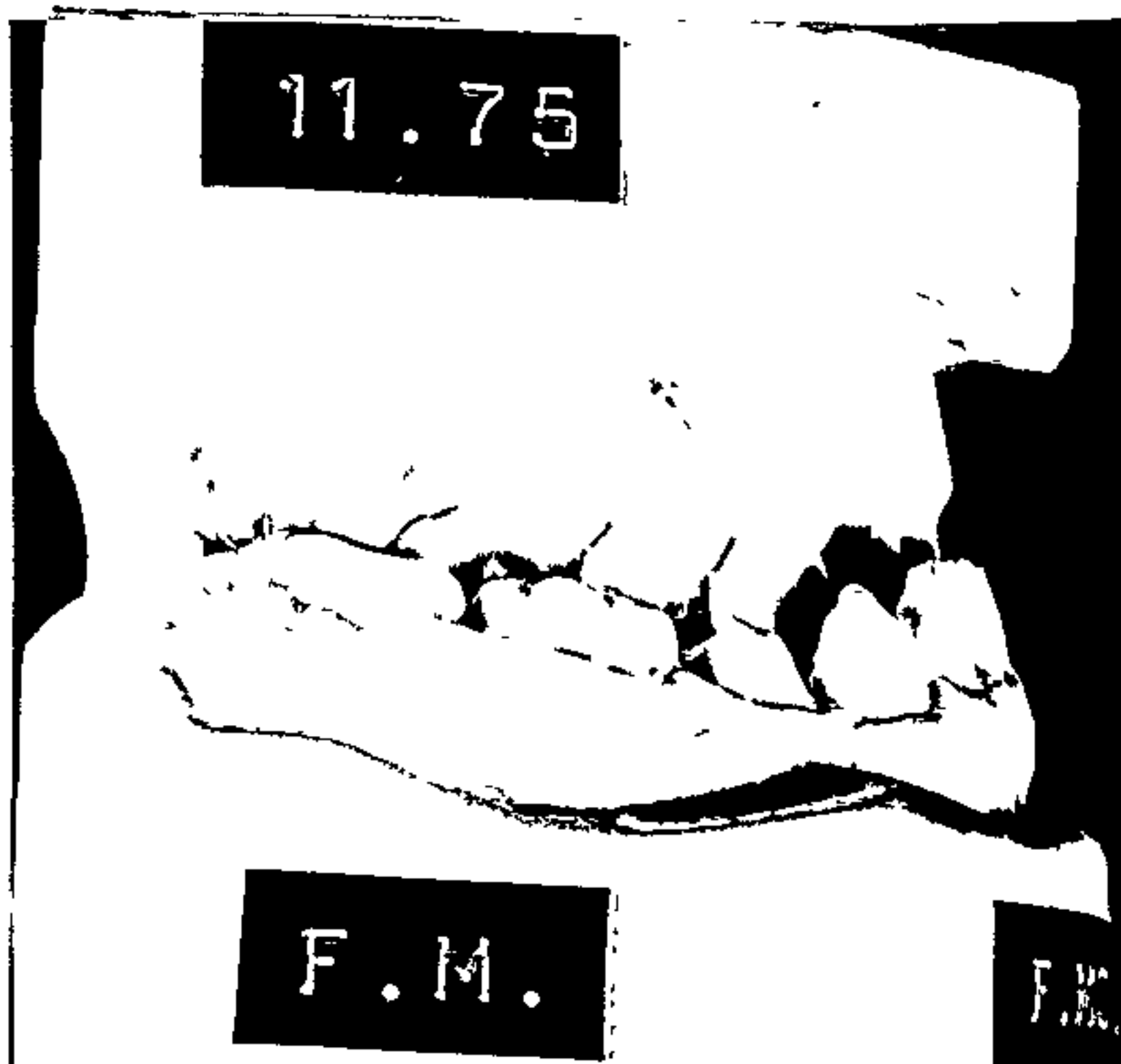
Pre-Surgery

Model Surgery

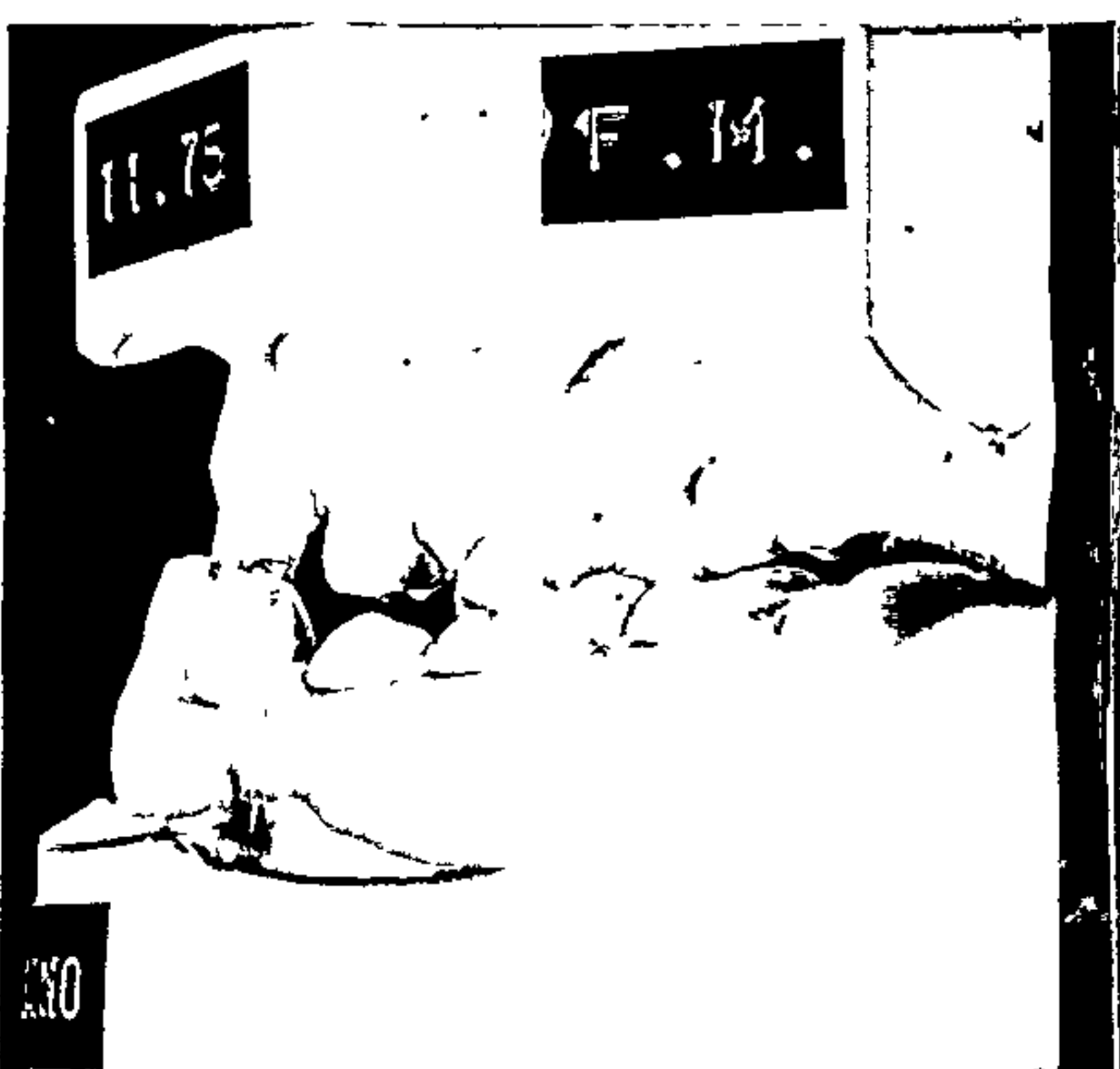
Post-Surgery



Front



Right Side



Left Side

HIGH LE FORT I MAXILLARY OSTEOTOMY AND MANDIBULAR SURGERY



Before
Surgery



After
Surgery

Age : 21 years old.

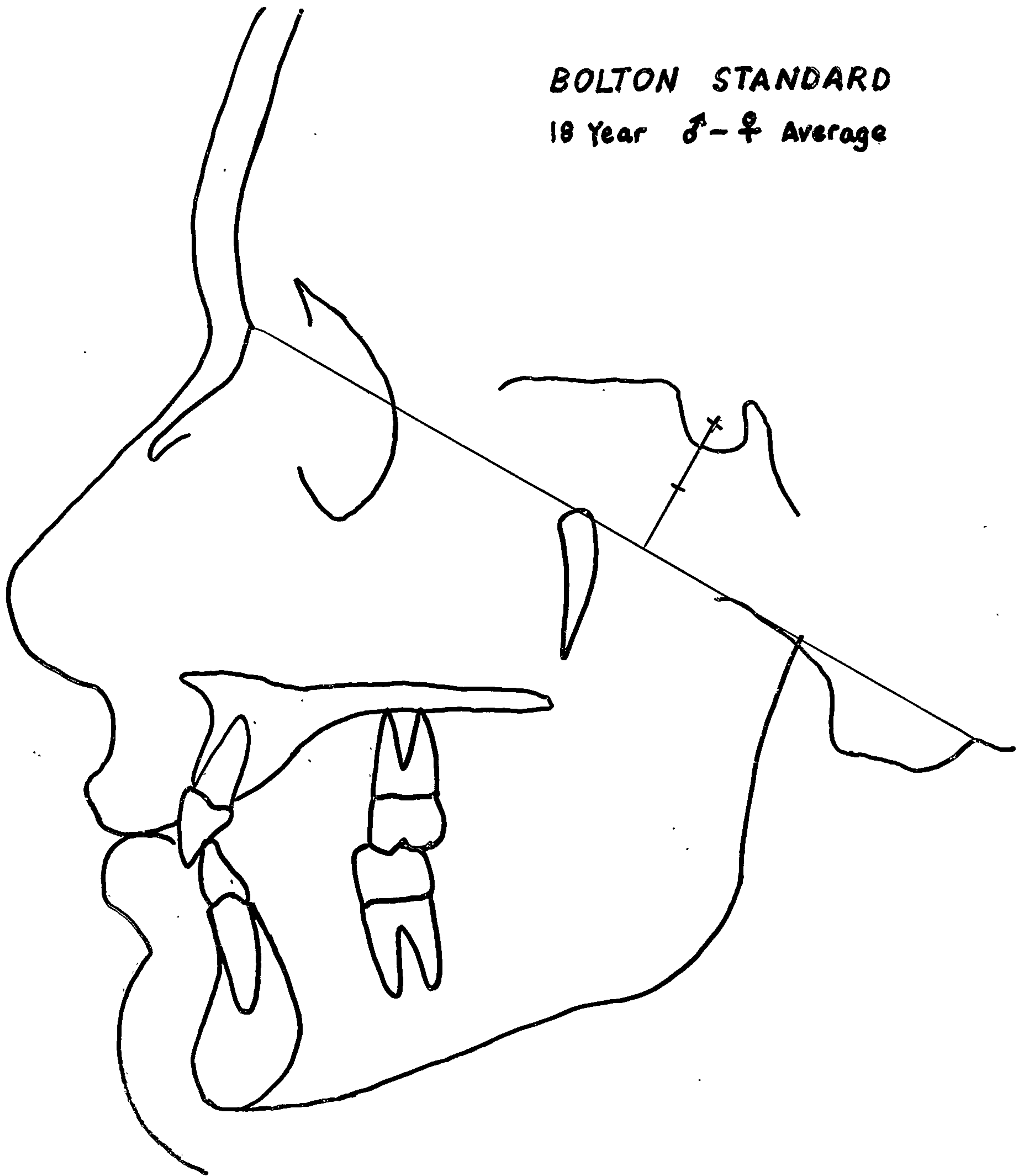
Sex : Female.

Original Condition : Unilateral Complete Left Cleft Lip
and Palate.

History : Repair of cleft lip and palate at age 11 months.

No nasal or other significant medical findings.

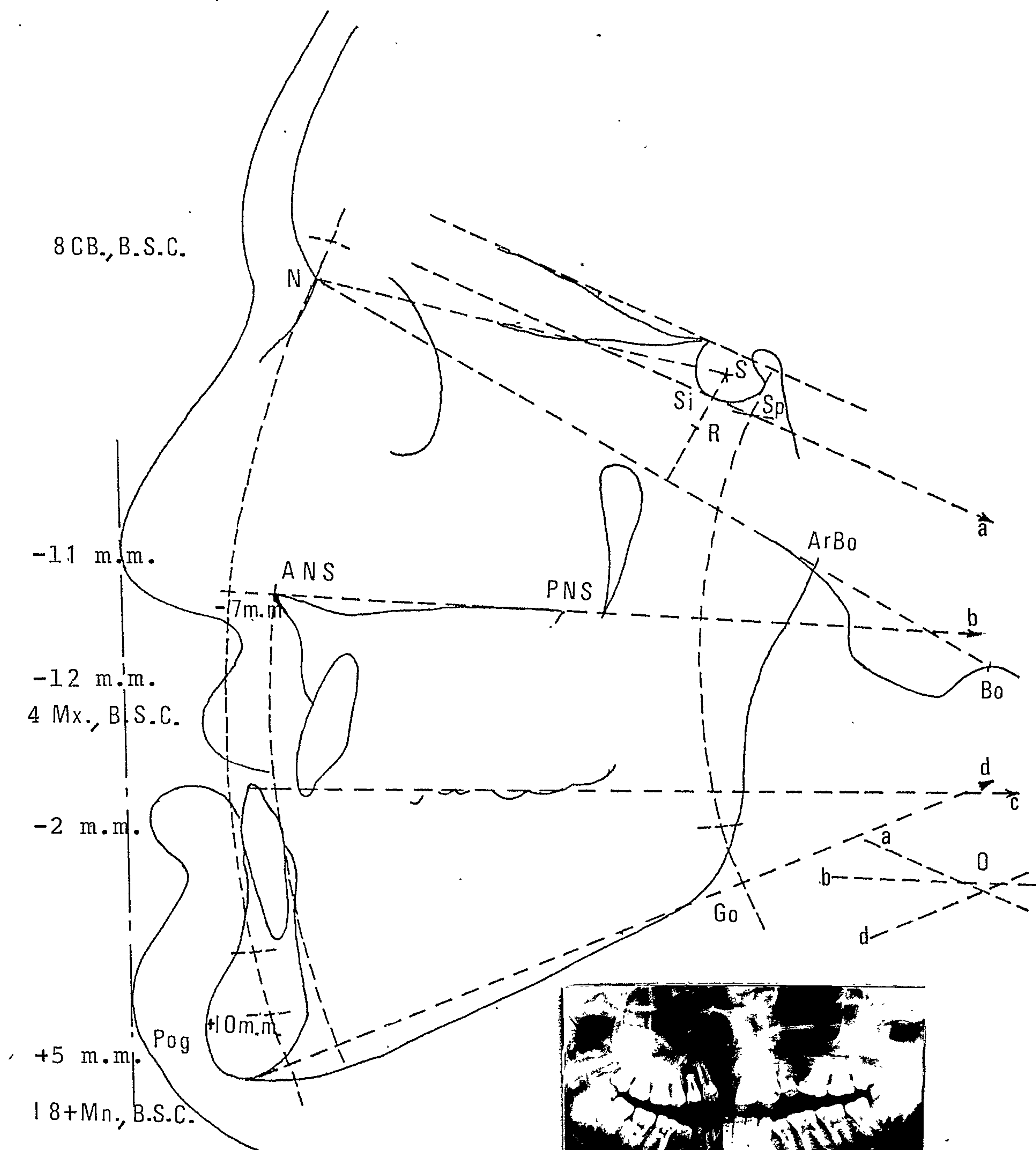
BOLTON STANDARD
18 Year ♂ - ♀ Average



CASE 6
DIAGNOSTIC TRACING

189

16-7-76



CASE 6 DISCUSSION

Diagnostic tracing shows an unbalanced antero-posterior development between the cranial base, maxillary complex and the mandible. The smallest in size (antero-posteriorly) is the maxilla (4 Mx., B.S.C.); next is the cranial base (8 CB., B.S.C.) and the largest is the mandible (18 Mn., B.S.C.), which is even larger than that of Bolton Standard of 18 years. With reference to Sassouni Archial Analysis, maxillary A-N-S is found to be -7 mm. behind the anterior arc. The mandibular pogonion is found to be +10 mm. in front of the anterior arc. This agrees with the previous findings, i.e. the major causes of facial deformity are due to a large mandible (expecially the chin region) and an under-developed maxilla and maxillary complex. In relation to Bolton Standard template of 18 years, the soft tissue nasal height, upper lip, lower lip and soft tissue pogonion are -11mm., -12mm., -2mm., and +5mm., respectively.

In order to correct the mid-face deficiency and the over-developed mandible, a high Le Fort I or Le Fort II maxillary Osteotomy together with mandibular set-back are indicated in this case. The surgeon decided to do a combined high Le Fort I maxillary osteotomy and mandibular surgery (genioplasty) in this case. Model surgery indicated that a forward movement of 11 mm. of the maxilla would pro-

vide a stable occlusion. The predicted profile (from cephalometric and photographic profile prediction) is satisfactory when related to esthetic plane and Bolton Standard template of 18 years.

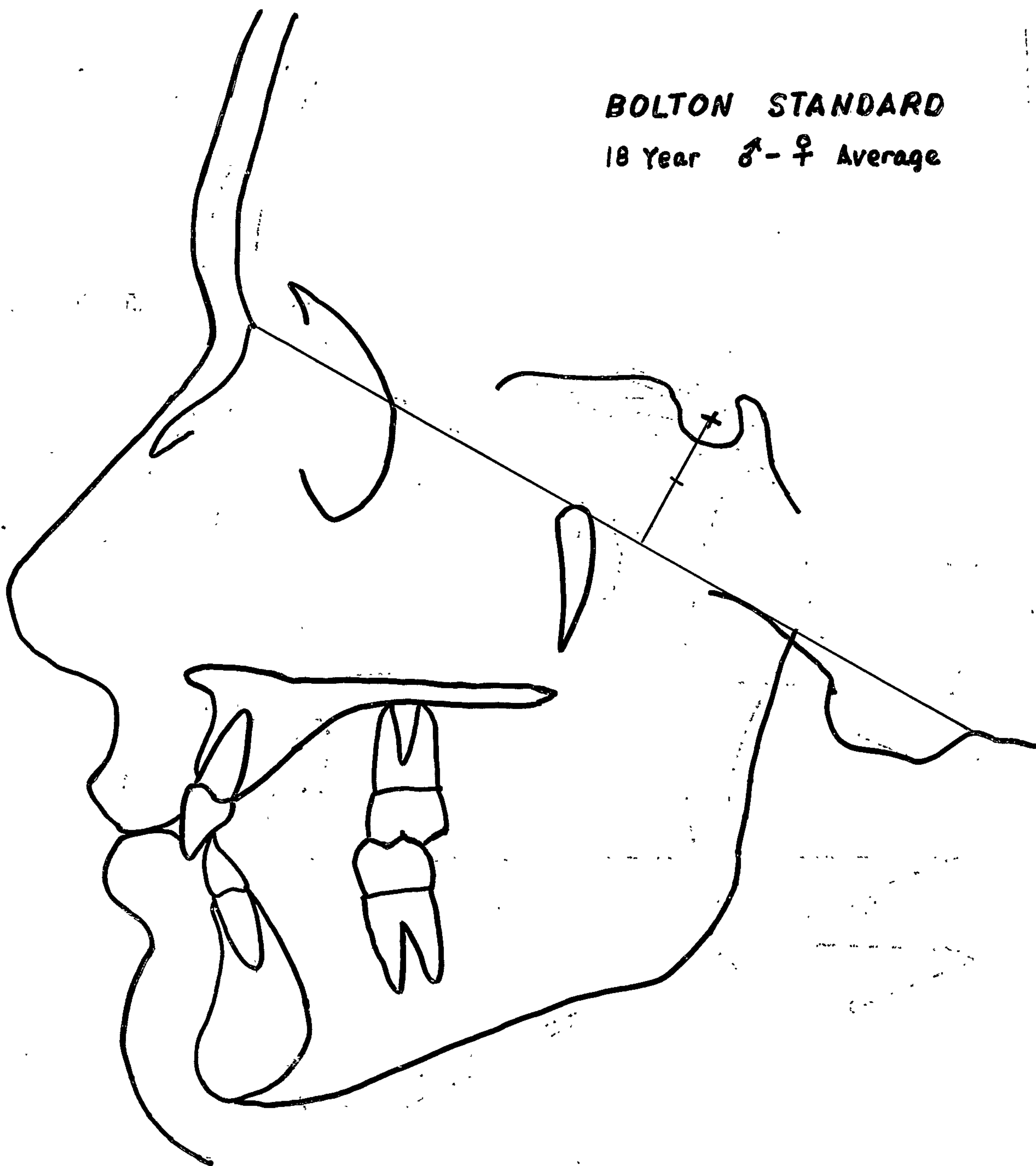
Intra-oral casted silver splints combined with head-frame were used for immobilization for 3 months.

Planes used to locate center "O" in Sassouni Archial Analysis were : (1) parallel to supra-orbital plane, (2) palatal plane and (3) mandibular plane.

Radius of the anterior arc in Sassouni Archial Analysis was found to be 16 cm.

BOLTON STANDARD

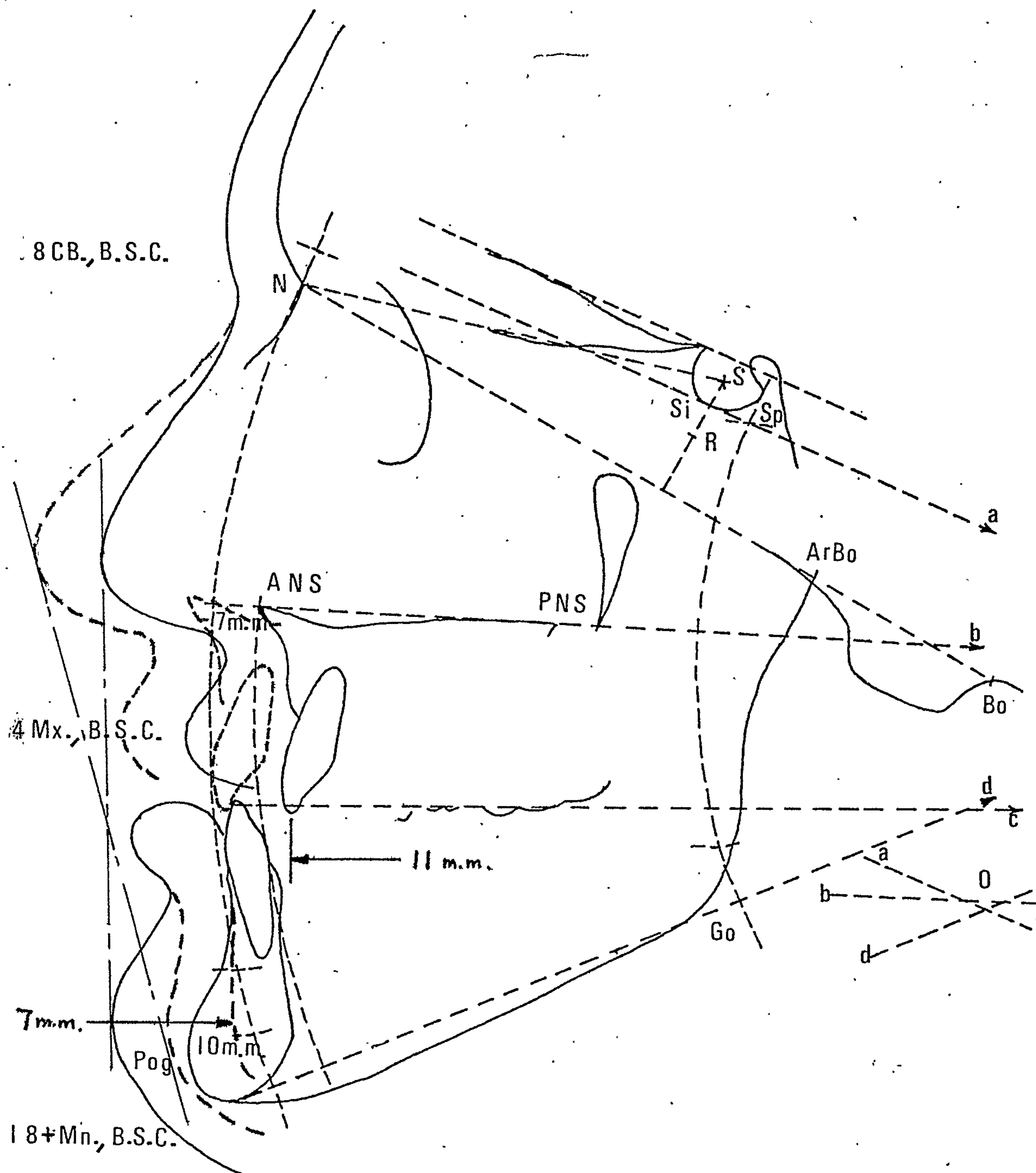
18 Year ♂ - ♀ Average



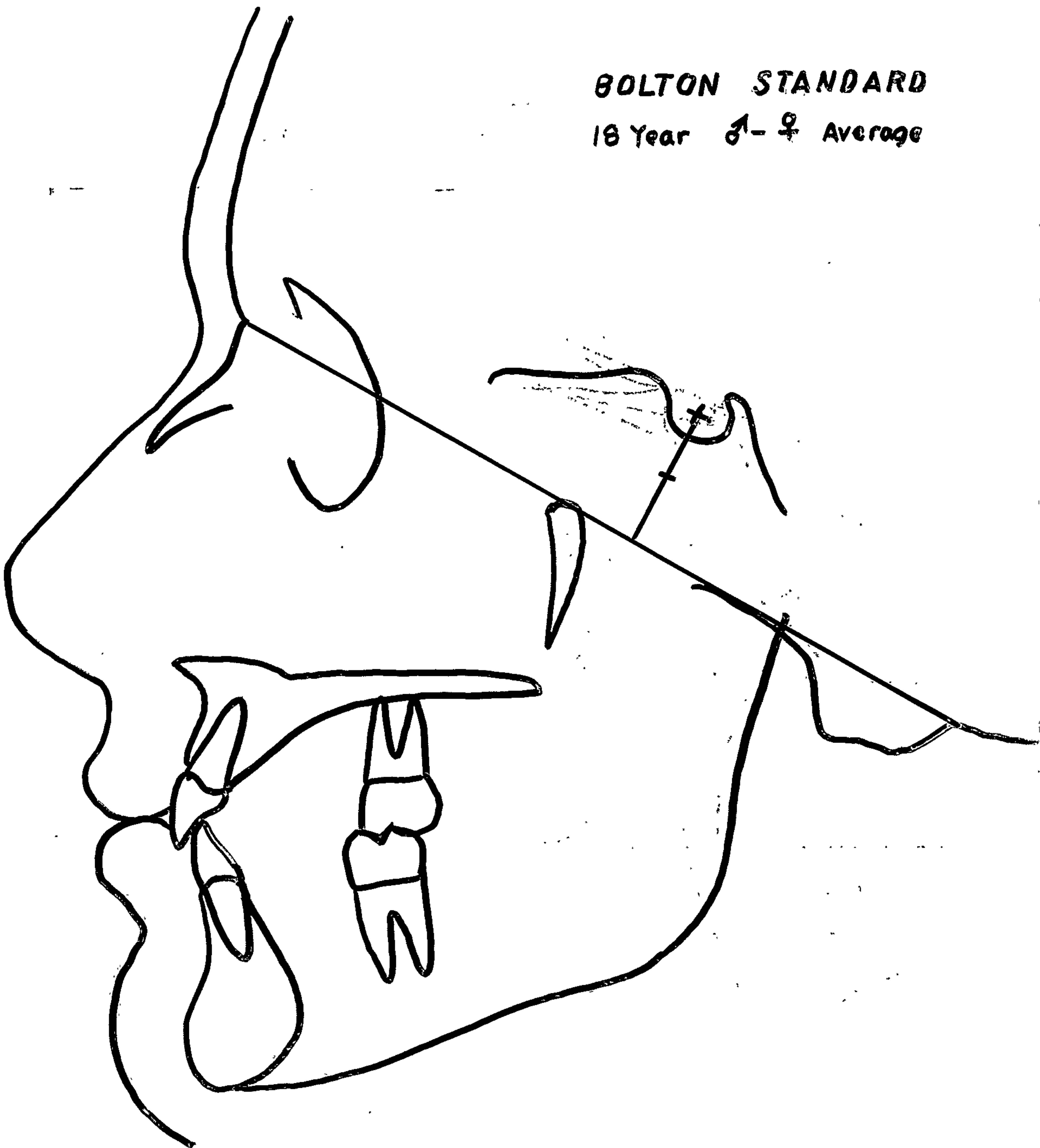
CASE 6
PROFILE PREDICTION TRACING

192

16-7-76



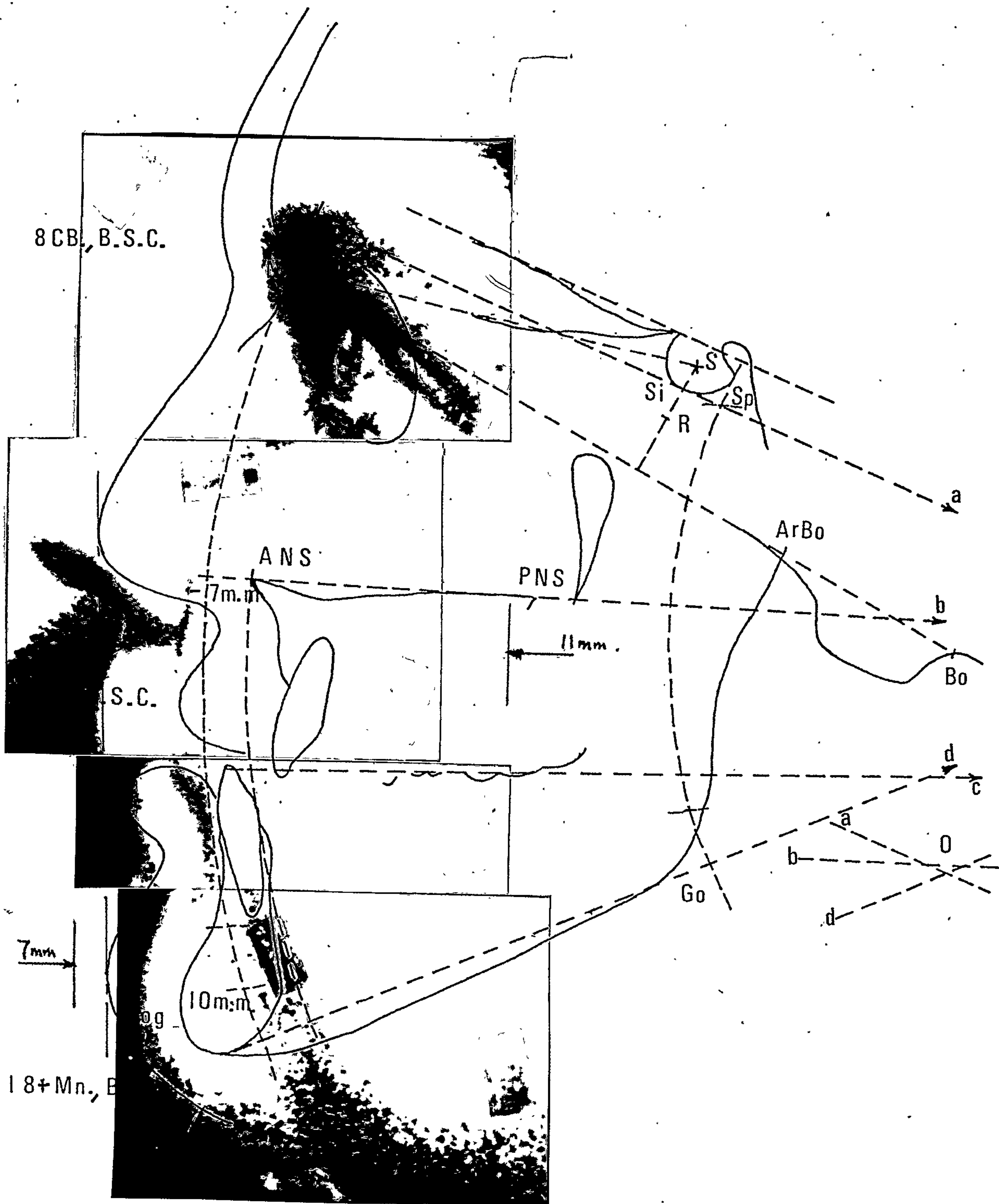
BOLTON STANDARD
18 Year ♂ - ♀ Average



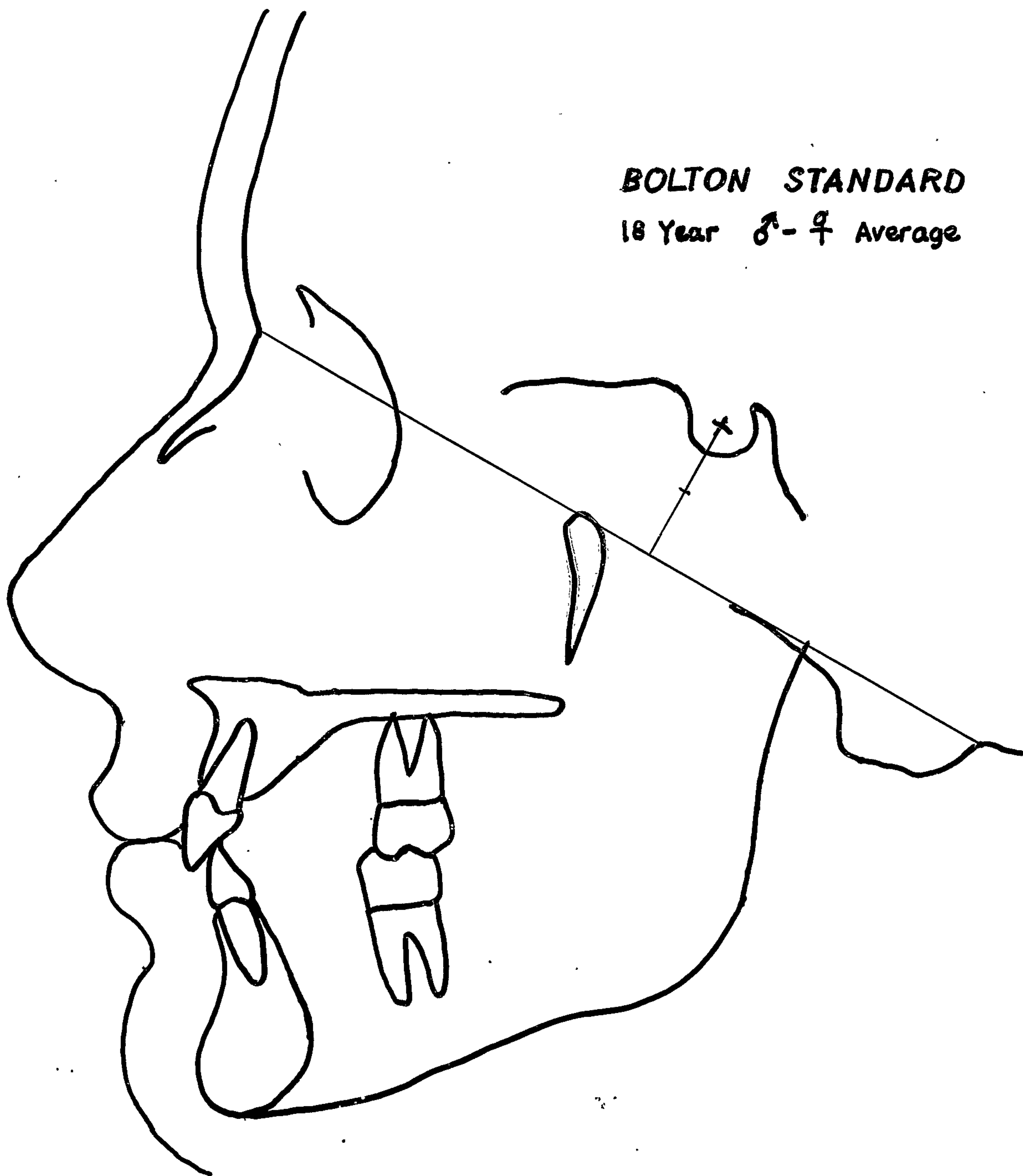
CASE 6
PHOTOGRAPHIC PROFILE PREDICTION

193

16-7-76



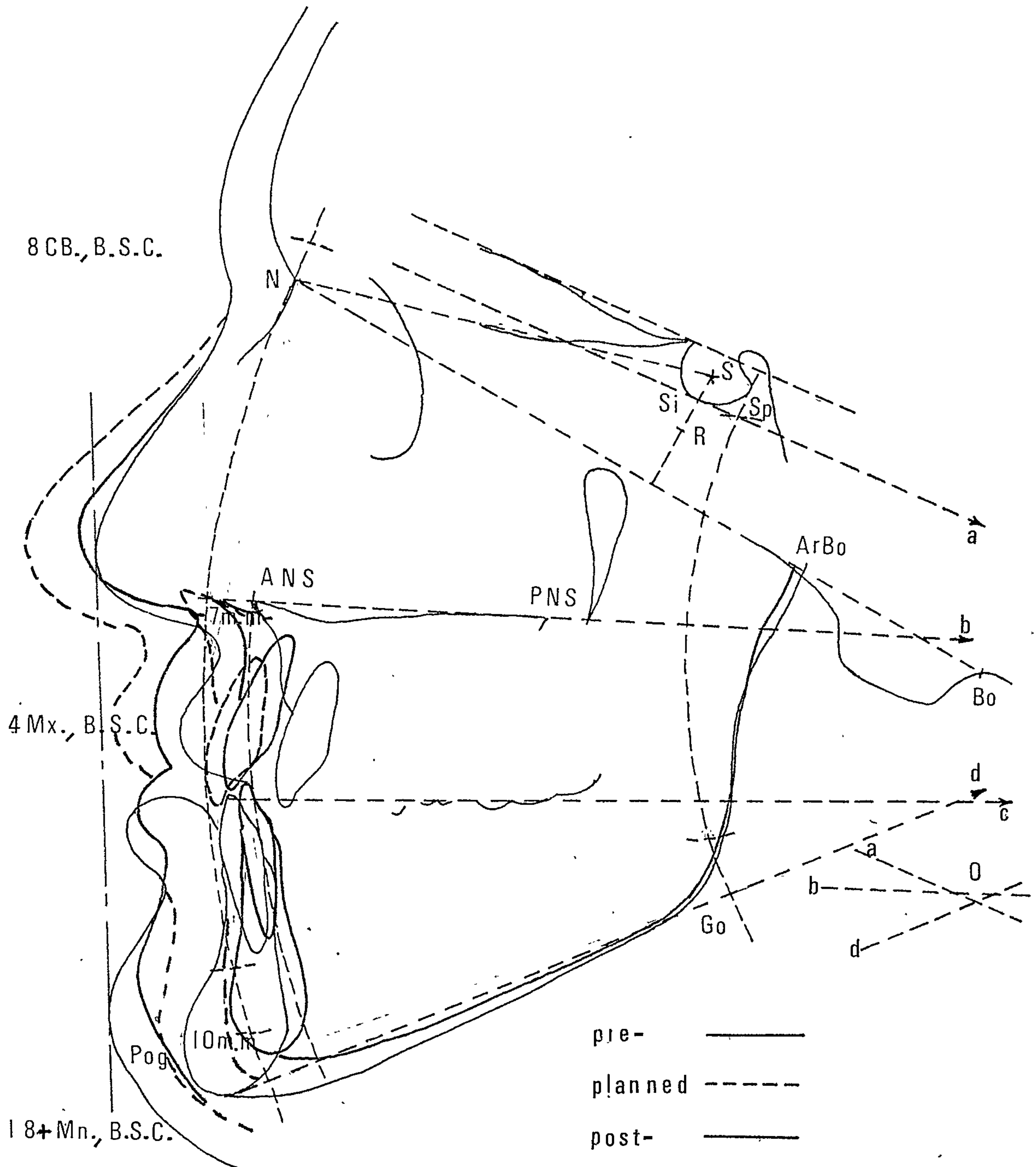
BOLTON STANDARD
18 Year ♂ - ♀ Average



PRE- and POST- SURGICAL CEPH. ASSESSMENT

16-7-76

23-8-77



PRE-, PLANNED, AND POST-SURGICAL CEPHALOMETRIC ANALYSIS

		PRE-	PLANNED	POST-
SKELETAL ANALYSIS	S-N-A	79°	90°	86°
	S-N-B	84°	84°	82°
	A-N-B	-5°	6°	4°
	Angle of convexity (N-A-P)	-13°	15°	6°
	Y axis to N-S	66°	68°	67°
	Mn. pl. to N-S	35°	35°	32°
DENTAL ANALYSIS	U1 to A-Pog.	-6 mm.	0 mm.	1.5 mm.
	L1 to A-Pog.	2 mm.	-2 mm.	-1 mm.
	L1 to Mn. pl.	78°	78°	80°
	U1 to L1	152°	152°	146°
	U1 to S-N	95°	95°	101°
SASSOUNI ARCHIAL ANALYSIS	A-N-S to Sassouni Anterior Arc	-7 mm.	4 mm.	-2 mm.
	U1 Tip to Sassouni Anterior Arc	-12mm.	-1 mm.	-4 mm.
	Pog. to Sassouni Anterior Arc	10mm.	3 mm.	2 mm.
BOLTON STANDARD ANALYSIS	Nasal Height to Bolton Standard	-11 mm.	-1 mm.	-9 mm.
	Upper Lip Height to Bolton Standard	-12 mm.	-2 mm.	-8 mm.
	Lower Lip Height to Bolton Standard	-2 mm.	-2 mm.	-4 mm.
	Soft tissue Pog. to Bolton Standard	4 mm.	-4 mm.	-2 mm.

CASE 6

MODEL STUDY ASSESSMENT

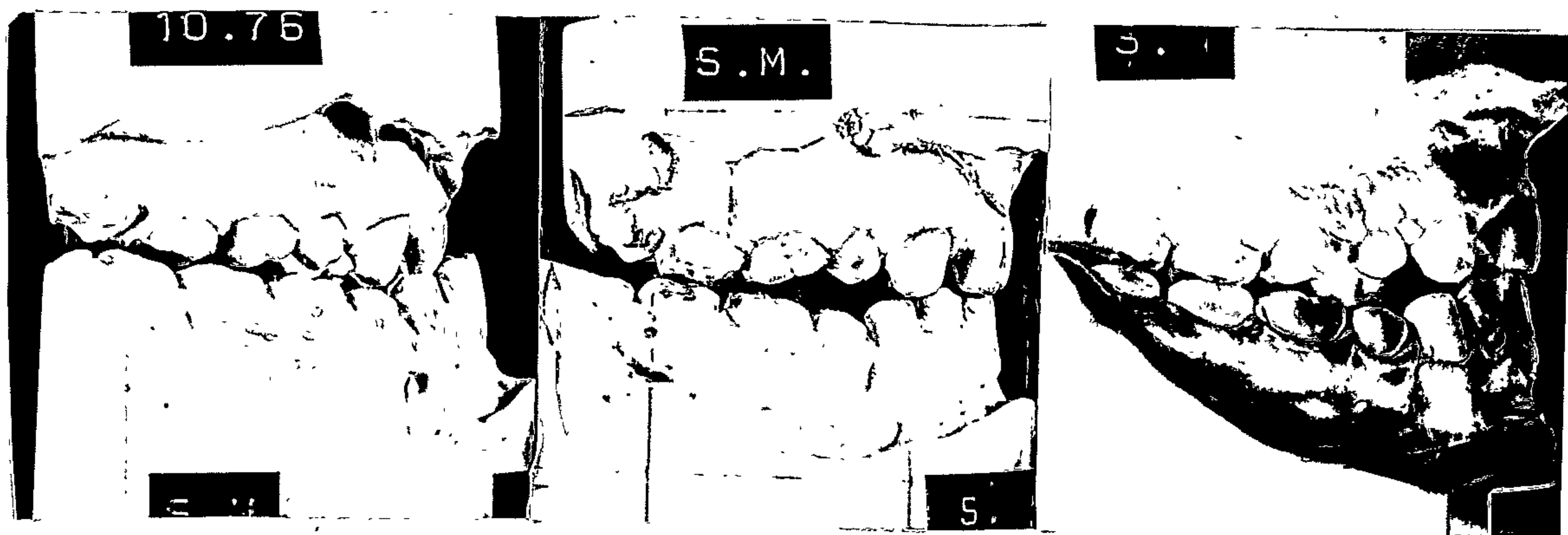
Pre-Surgery

Model Surgery

Post-Surgery



Front



Right Side



Left Side

CASE 7

LE FORT I MAXILLARY OSTEOTOMY



Before
Surgery

After
Surgery

Age : 17.5 years old.

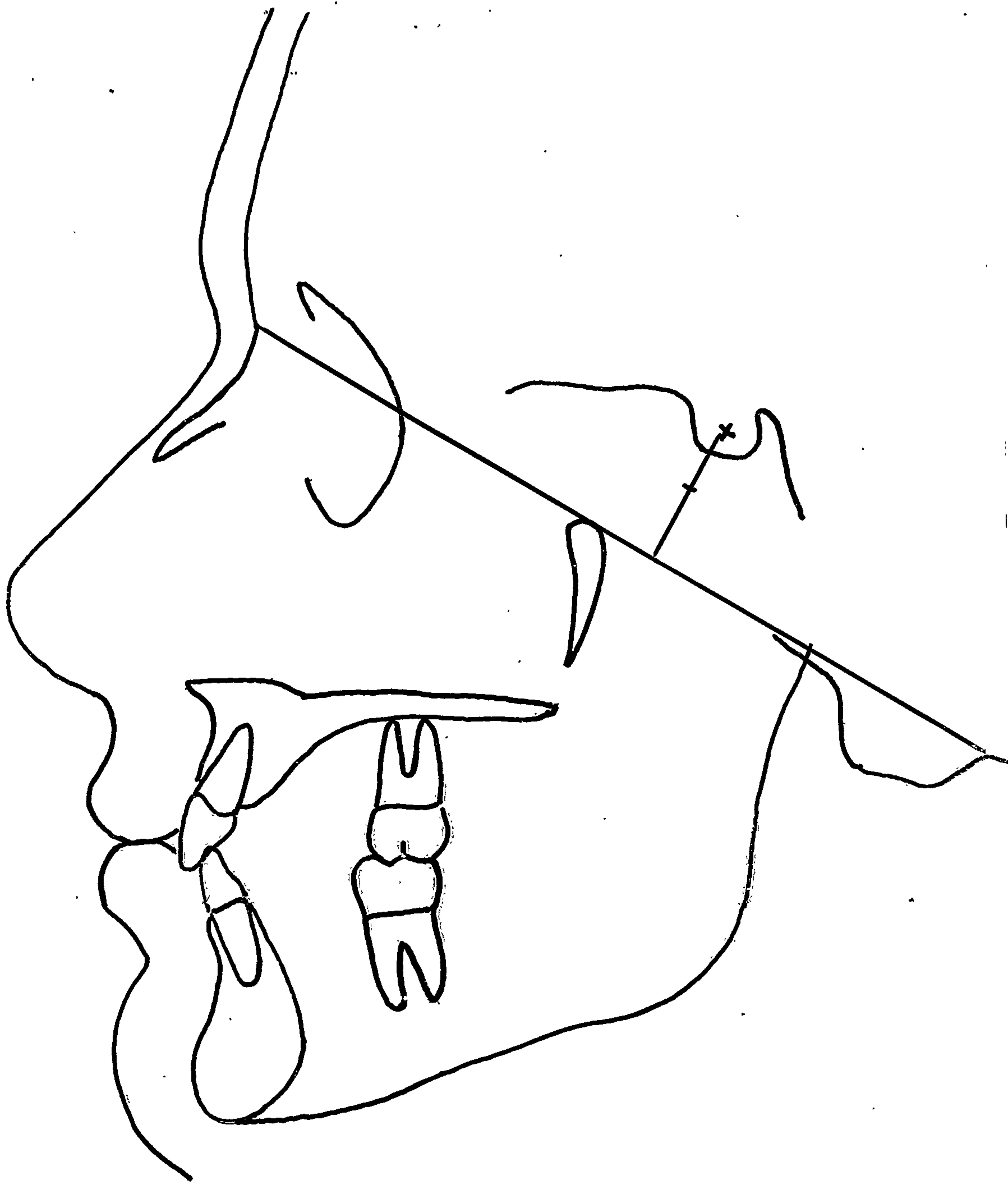
Sex : Male.

Original Condition : Unilateral Complete Left Cleft Lip
and Palate.

History : Repair of cleft lip at 3 months old.

Repair of cleft palate at 17 months old.

No nasal or any other significant medical
findings.



BOLTON STANDARD
18 Year ♂ - ♀ Average

DIAGNOSTIC TRACING

5-11-75



18CB., B.S.C.

N

Si

Sp

R

ArBo

a

BO

b

c

d

GO

a

b

d

o

0 m.m.

ANS/

-15m.m.

PNS

10MX., B.S.C.
-5 m.m.

+4 m.m.

18MN., B.S.C.

+4 m.m.

POG

CASE 7 DISCUSSION

Diagnostic tracing reveals that the cranial base and mandible are of normal size antero-posteriorly (18 CB., 18 Mn., B.S.C.) while the maxilla is under-developed (10 Mx., B.S.C.). With reference to Sassouni Archial Analysis, maxillary A-N-S is found to be -15 mm. behind the anterior arc and the mandibular pogonion is almost on the anterior arc, indicating that the maxilla is the region of deficiency. Bolton Standard template of 18 years confirms this finding. Moreover, the soft tissue nasal height, upper lip, lower lip and soft tissue pogonion are 0 mm., -5 mm., +4 mm. and +4 mm., respectively, when compared to Bolton Standard template of 18 years. Coupled with this, the open bite (5mm.) indicates that the maxilla is also under-developed in vertical dimension.

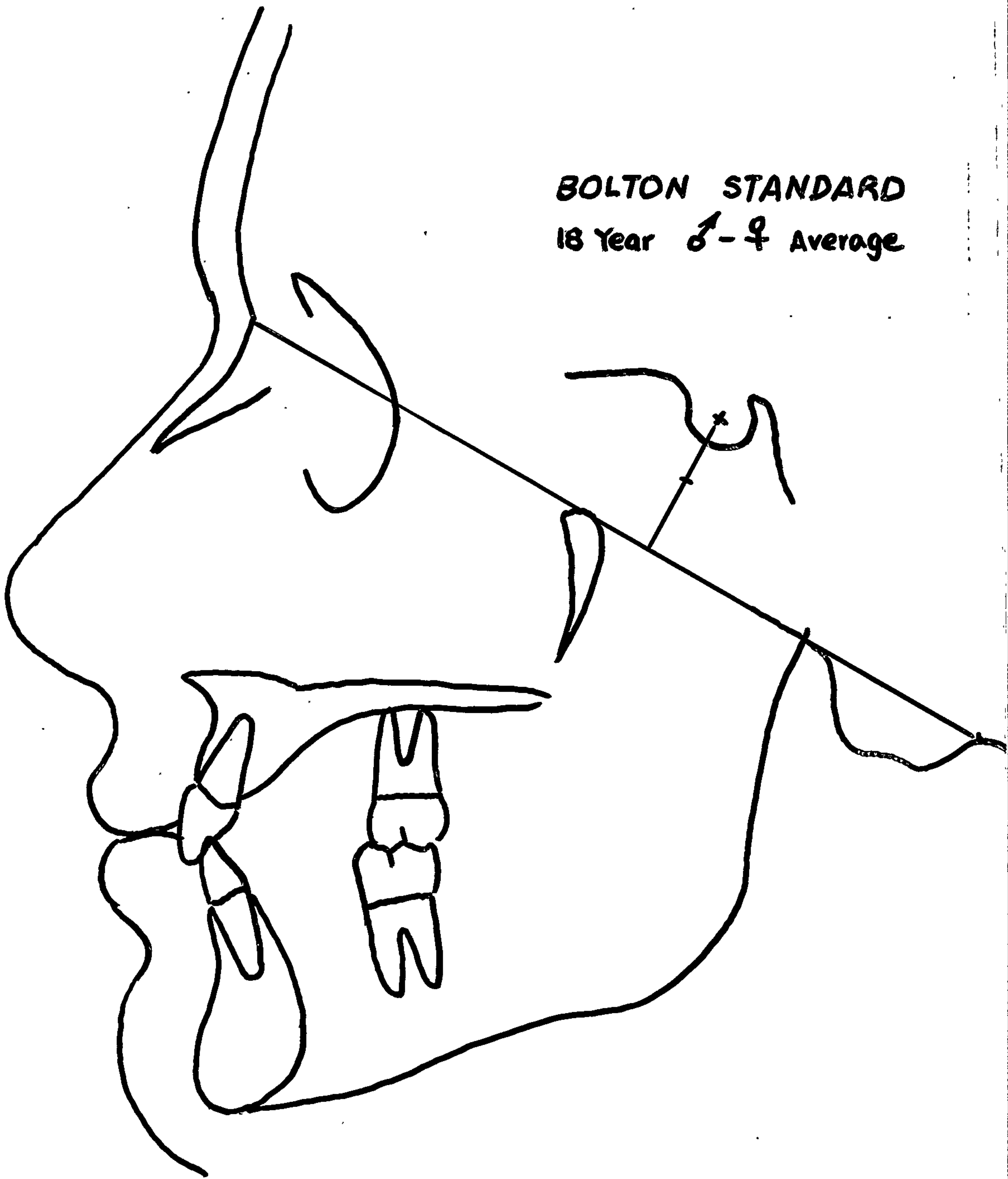
In order to correct the mid-face deficiency and open bite ; a low Le Fort I maxillary osteotomy is indicated in this case. The surgeon decided to do the same. Model surgery shows that the maxilla should move forward 7 mm. and tilt downward 6 mm. in order to achieve a stable occlusion. The profile predicted (from cephalometric and photographic profile prediction) is also satisfactory when compared to esthetic plane and Bolton Standard template of 18 years.

Intra-oral fixation with orthodontic bands and heavy labial arch wires were used for immobilization for 7 weeks.

Planes used to locate center "O" in Sassouni Archial Analysis were : (1) parallel to supra-orbital plane, (2) palatal plane and (3) mandibular plane.

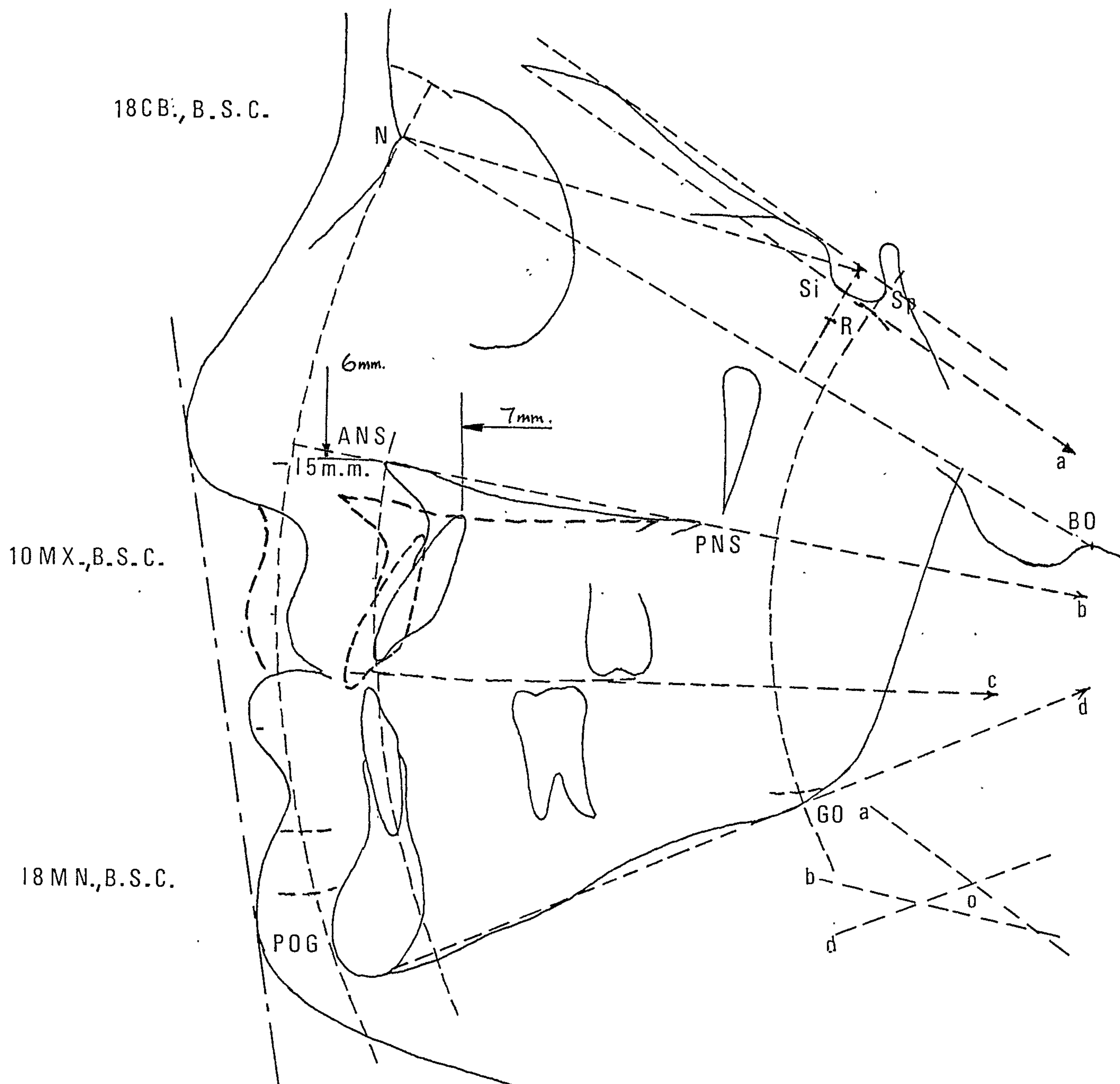
Radius of the anterior arc in Sassouni Archial Analysis was found to be 16.4 cm.

BOLTON STANDARD
18 Year ♂ - ♀ Average

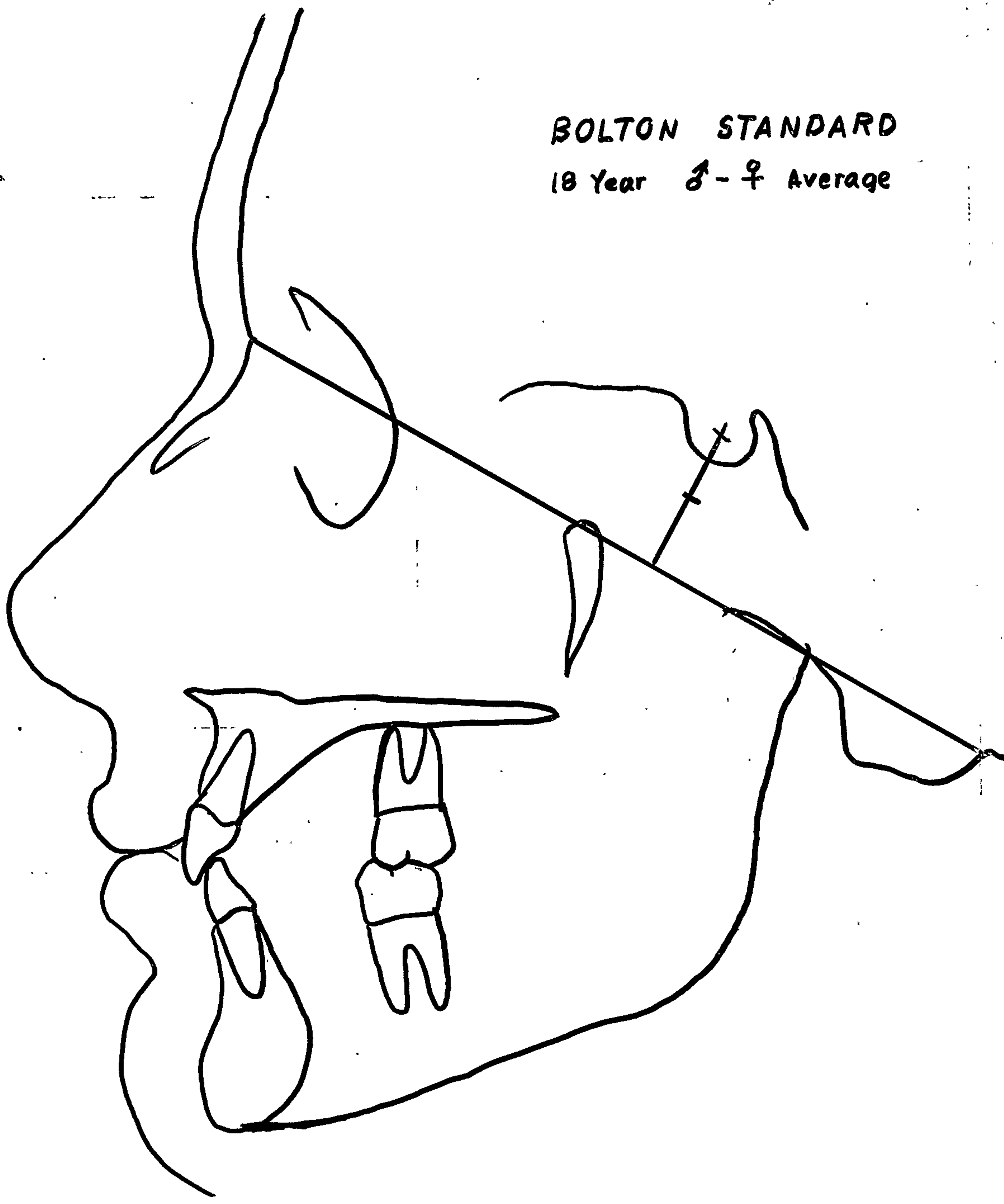


PROFILE PREDICTION TRACING

5-11-75

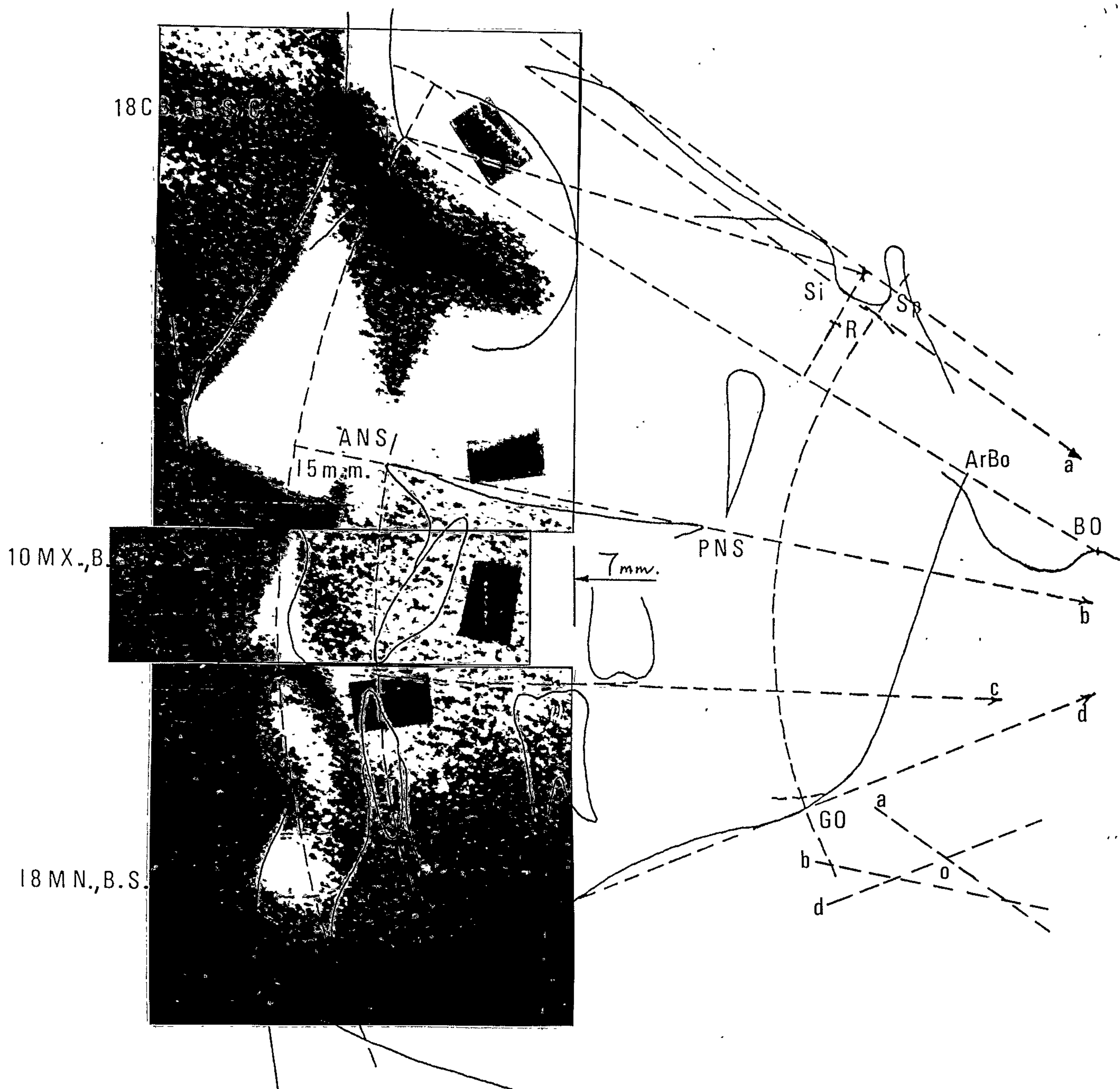


BOLTON STANDARD
18 Year ♂ - ♀ Average

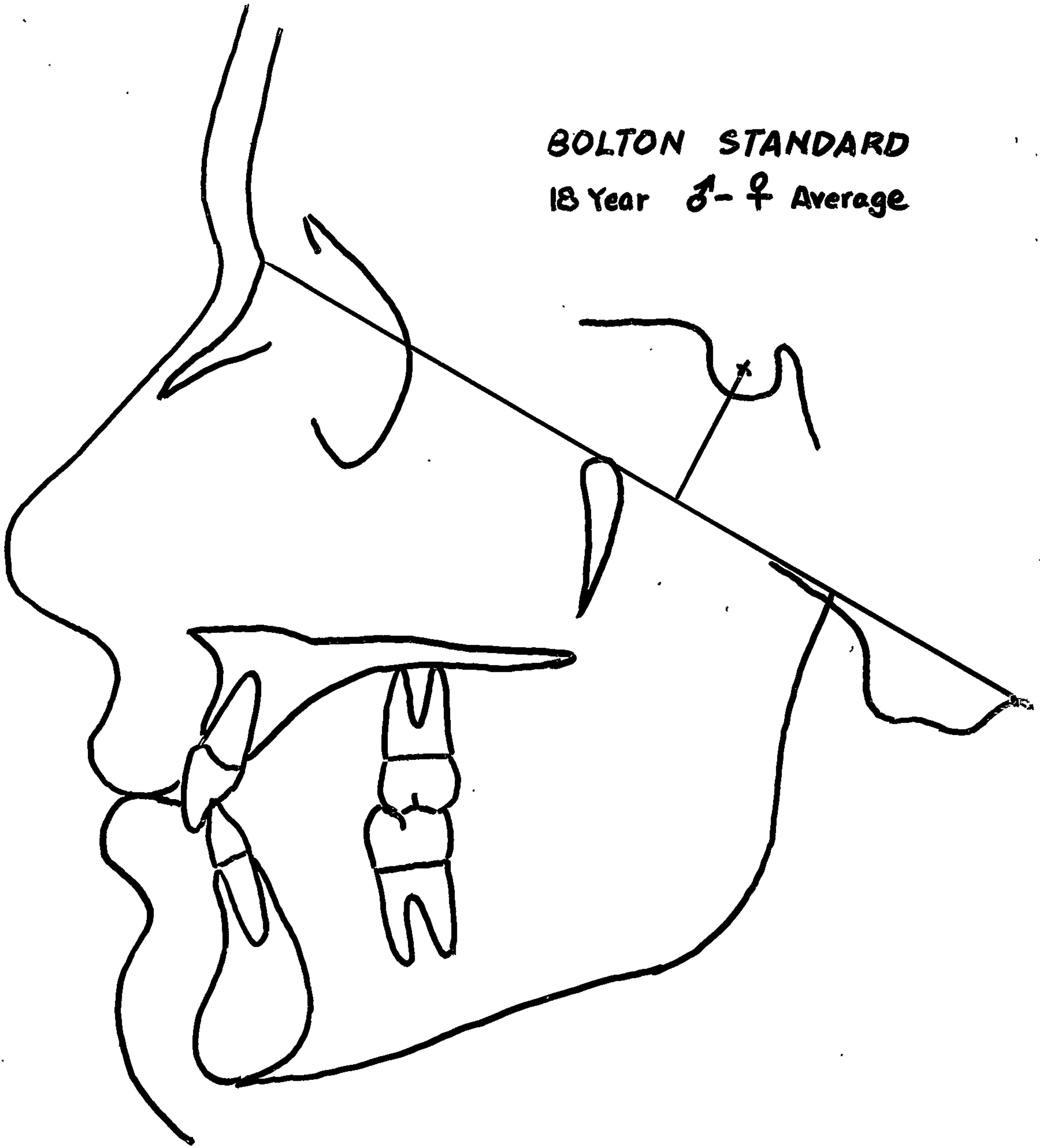


PHOTOGRAPHIC PROFILE PREDICTION

5-11-75



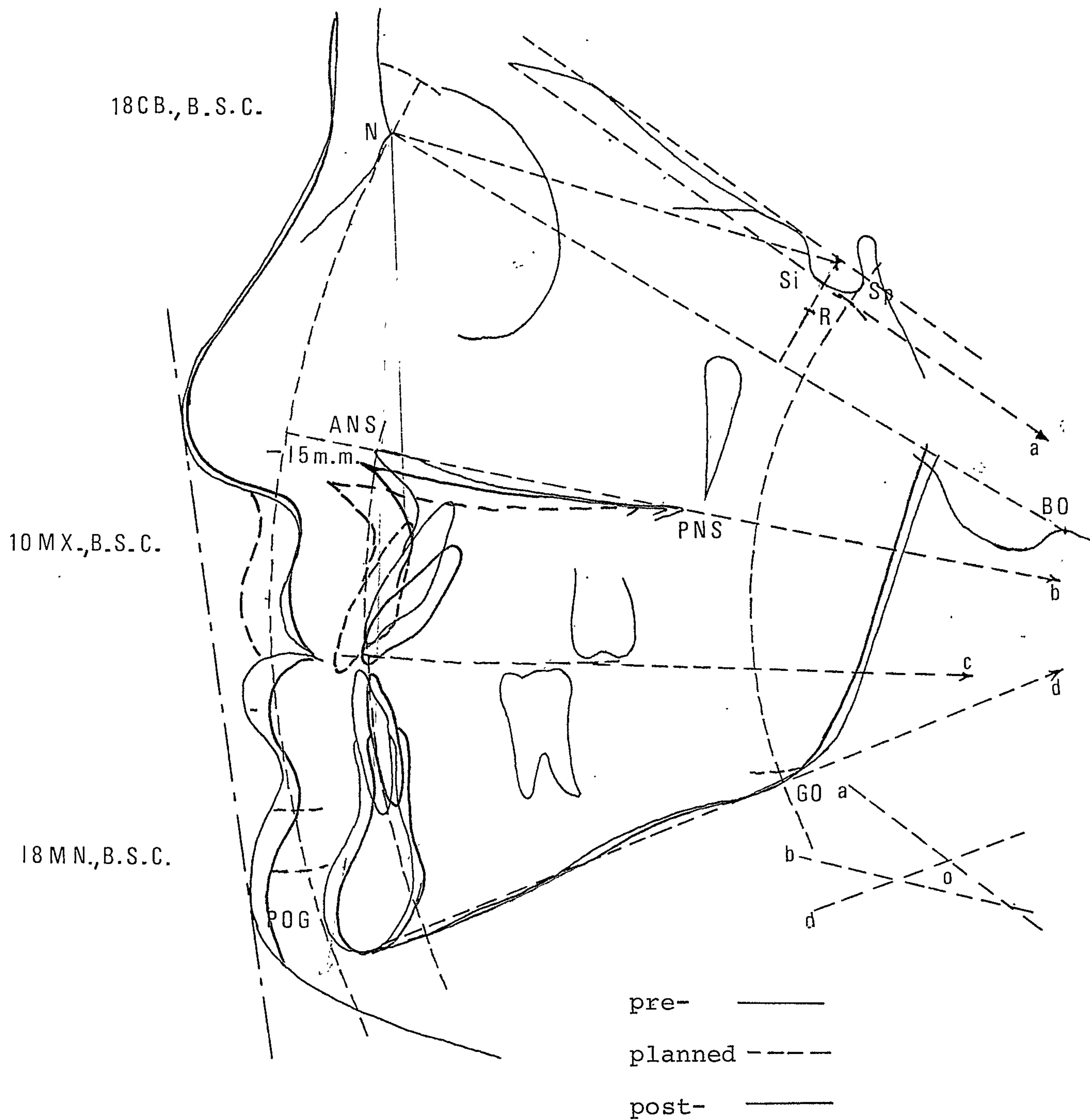
BOLTON STANDARD
18 Year ♂-♀ Average



PRE- and POST- SURGICAL CEPHALOMETRIC ASSESSMENT

4-4-77

5-11-75



PRE-, PLANNED, AND POST-SURGICAL CEPHALOMETRIC ANALYSIS

		PRE	PLANNED	POST-
SKELETAL ANALYSIS	S-N-A	70°	76°	72°
	S-N-B	77°	77°	75°
	A-N-B	-7°	-1°	-3°
	Angle of convexity (N-A-P)	-18°	-6°	-14°
	Y axis to N-S	69°	69°	70°
	Mn. pl. to N-S	38°	38°	38°
DENTAL ANALYSIS	U1 to A-Pog.	3 mm.	3 mm.	3 mm.
	L1 to A-Pog.	3 mm.	0 mm.	1.5 mm.
	L1 to Mn. pl.	78°	78°	79°
	U1 to L1	138°	145°	130°
	U1 to S-N	105°	100°	113°
SASSOUNI ARCHIAL ANALYSIS	A-N-S to Sassouni Anterior Arc	-15mm.	-9 mm.	-13 mm.
	U1 Tip to Sassouni Anterior Arc	-16mm.	-11 mm.	-15 mm.
	Pog. to Sassouni Anterior Arc	0 mm.	0 mm.	-2 mm.
BOLTON STANDARD ANALYSTS	Nasal Height to Bolton Standard	0 mm.	0 mm.	0 mm.
	Upper Lip Height to Bolton Standard	-5 mm.	2 mm.	-5 mm.
	Lower Lip Height to Bolton Standard	4 mm.	4 mm.	-2 mm.
	Soft tissue Pog. to Bolton Standard	4 mm.	4 mm.	2 mm.

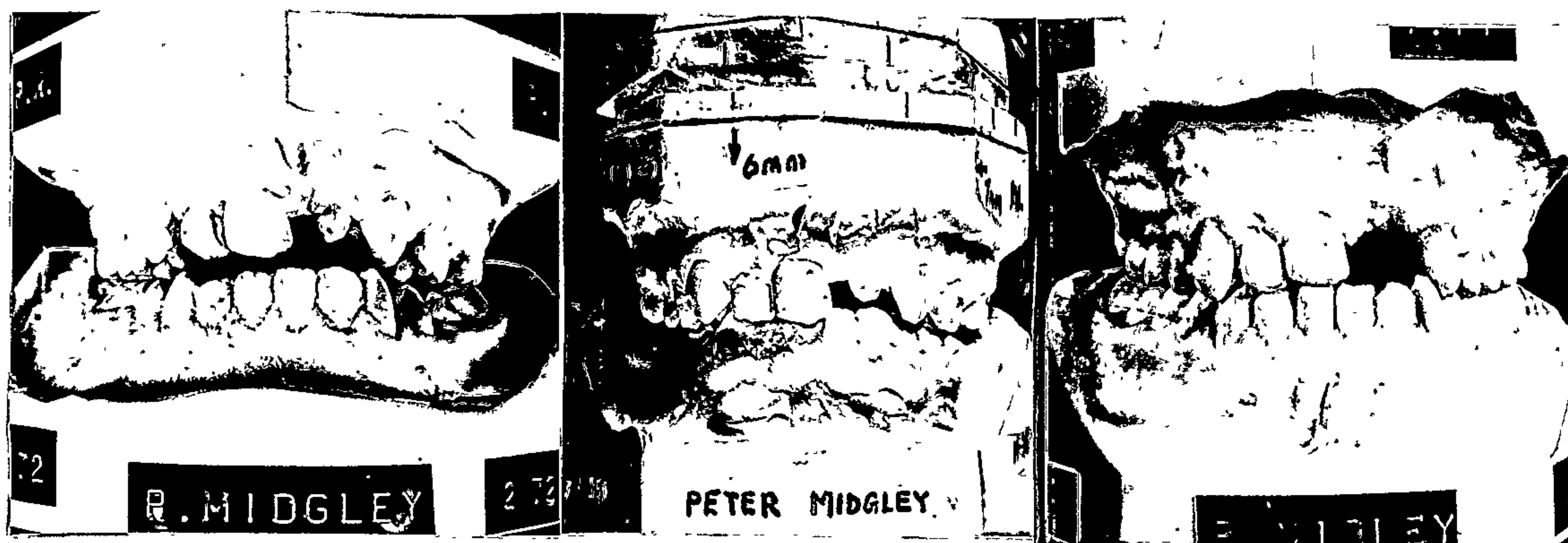
CASE 7

MODEL STUDY ASSESSMENT

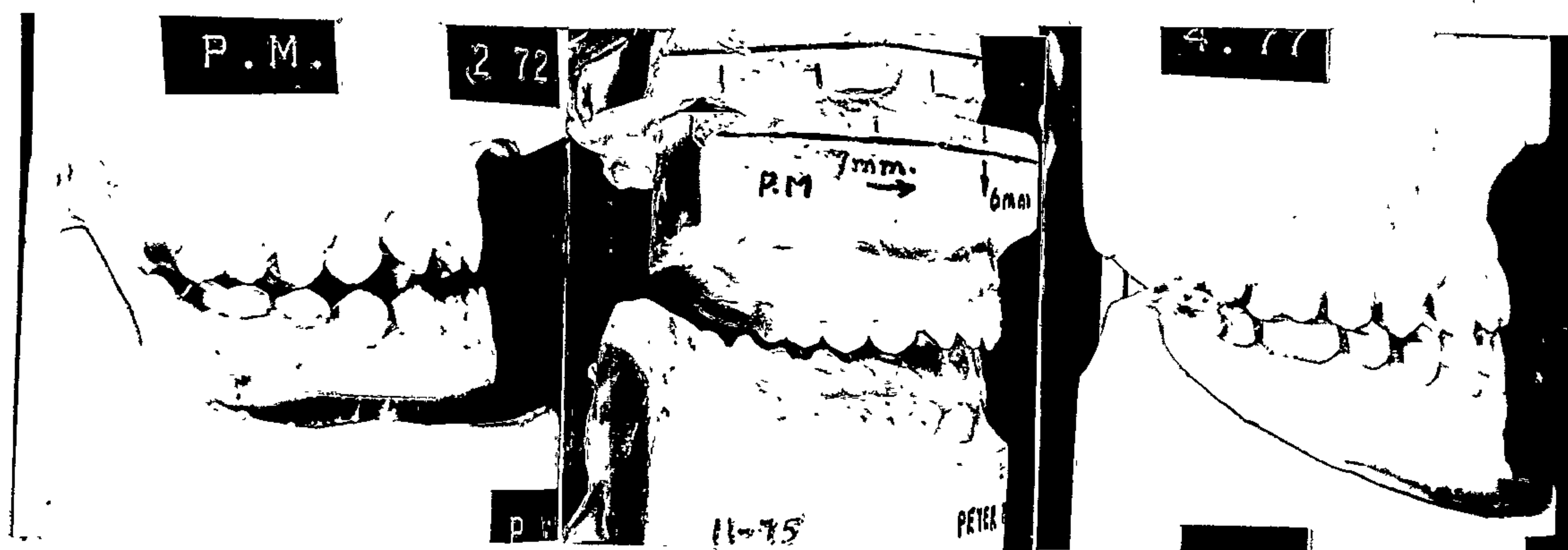
Pre-Surgery

Model Surgery

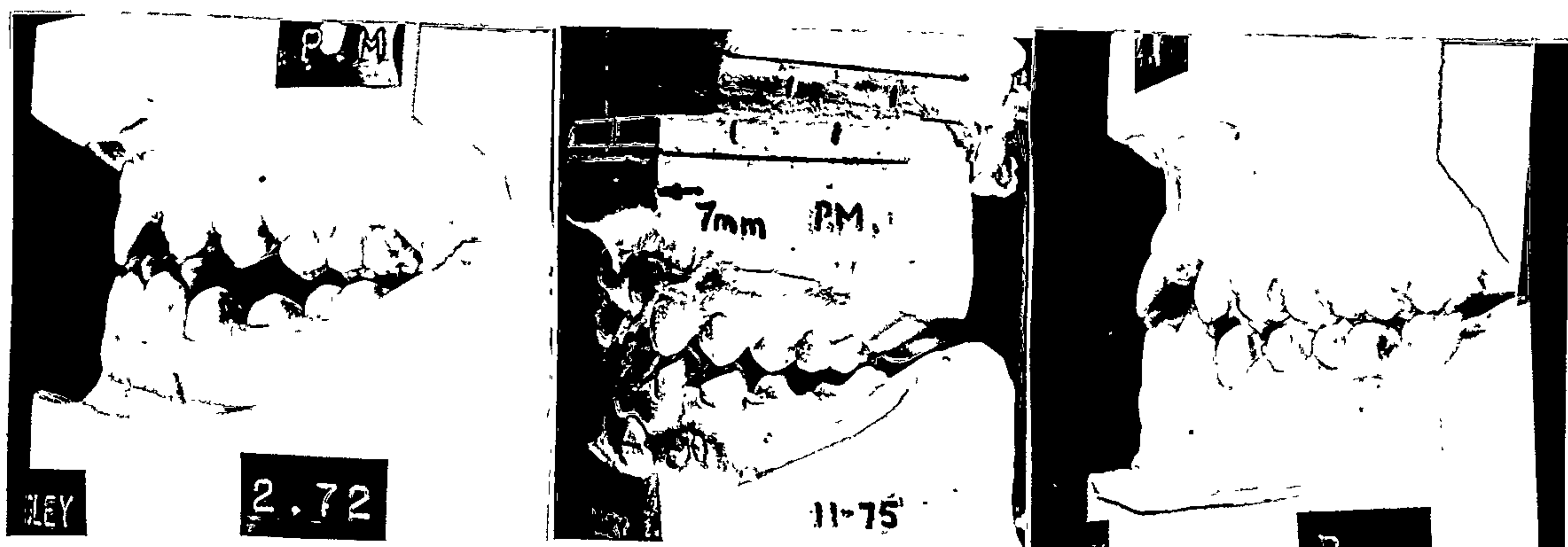
Post-Surgery



Front



Right Side



Left Side

PART IV

DISCUSSION

Nowadays, there is still a small number of cleft lip and palate patients who grow up with a concave profile demonstrating severe maxillary retrognathism and mid-face deficiency. Sometimes, this type of facial deformity is so severe that only combined surgical and orthodontic approach can improve the facial appearance of the patient. The facial deformity is usually due to an under-developed maxilla and this is true in all the seven cases presented. In order to improve their esthetic appearance, the first step is to restore skeletal balance as Obwegeser (1971)¹⁶⁴ stated : "... first the bone, then the soft tissue."

Consequently, maxillary osteotomy is often indicated for cleft lip and palate adult patients who present maxillary retrognathism in order to put the maxilla into its normal position. However, the facial deformity is not always solely because of an under-developed maxilla, such as in cases 3 and 6. The patients also have large mandibles. Therefore, it is important to diagnose accurately the region of deformity for the right treatment approach.

The diagnostic method (combined Bolton Standard Analysis and Sassouni Archial Analysis) presented in this thesis describes reasonably accurately the amount of discrepancy between cranial base, maxilla, mandible and soft tissue profile. Model study, model surgery, cephalometric and photographic prediction help to visualize before-hand

the amount and direction of movement needed to correct the skeletal discrepancy, the possible profile after surgery and the occlusion after surgery.

In this study, there are only seven patients (two females and five males), four of which have complete unilateral cleft (cases 1, 5, 6 and 7); two bilateral cleft (cases 2 and 4) and only one case with cleft of the lip and alveolus. This distribution agrees with Harvold's (1964)⁸³ finding. He stated that it is the unilateral and bilateral cleft that present the morphologic problem among the cleft adults. All the seven patients have concave profile, flattening of the mid-face area, Angle's Class III malocclusion and some degree of open bite (as seen in cases 1, 3, 4 and 7).

The average age of this group of patients is 19.8 years old, with a range from 16 to 24 years. We prefer to withhold operation until all active growth becomes static among cleft lip and palate patients for the following reasons :

(1) A more definite amount of skeletal discrepancy can be evaluated and consequently we can expect a better treatment planning and result from the surgery.

(2) The true desire of the patient can be evaluated. Not all the cleft lip and palate adult patients who have this type of facial deformity like to go through this radical

plastic surgery. In fact, we had two other patients who decided to forego such surgical procedure.

(3) A better immobilization can be achieved in the permanent dentition, such as when orthodontic bands can be used as the fixation appliance, as in cases 3, 4 and 5.

1. COMPARISON BETWEEN THE SUGGESTED TREATMENT APPROACH
BASED ON ASSESSMENT MADE IN THIS STUDY AND THE SUR-
GEON'S DECISION.

The following is a tabulation of the suggested treatment approach based on assessment made in this study and the decision made by the surgeon in all the seven cases.

Table 2 . Comparison Between the Treatment Approach in this Study and the Surgeon's Decision.

	Suggested Treatment Approach Based on Assessment Made in this Study	Surgeon's Decision
Case 1	High Le Fort I or Le Fort II maxillary osteotomy	Le Fort III maxillary osteotomy
Case 2	High Le Fort I maxillary osteotomy or Le Fort II maxillary osteotomy	High Le Fort I maxillary osteotomy
Case 3	Low Le Fort I maxillary osteotomy and mandibular surgery	Low Le Fort I, followed by mandibular surgery if necessary
Case 4	High Le Fort I maxillary osteotomy	High Le Fort I maxillary osteotomy
Case 5	Low Le Fort I maxillary osteotomy	Low Le Fort I maxillary osteotomy
Case 6	High Le Fort I or Le Fort II maxillary osteotomy and mandibular surgery	High Le Fort I maxillary osteotomy and mandibular surgery
Case 7	Low Le Fort I maxillary osteotomy	Low Le Fort I maxillary osteotomy

Generally speaking, the quantitative evaluation and suggestion made in this study agree well with the surgeon's decision, which is made mostly by clinical qualitative assessment of the case. The differences between the suggested treatment approach based on the assessment made in this study and the surgeon's decision may be explained as follows :

- (1) The preference of the surgeon in treatment approach;
- (2) The medical and anatomical condition of the patient;
- (3) Surgeon's experience ; and
- (4) Surgeon's imaginative and intuitive factors as suggested by Obwegeser (1971)¹⁶⁴.

In case 1, our quantitative assessment indicated that a high Le Fort I or a Le Fort II maxillary osteotomy would be suitable due to under-developed maxilla and short nasal height. However, clinical examination revealed flatness of the whole mid-face including the zygomatic region. This may be the reason why the surgeon decided to carry out a Le Fort III maxillary osteotomy, instead of a high Le Fort I or a Le Fort II maxillary osteotomy. This case brought out the fact that clinical qualitative examination is as important as the quantitative assessment which was done in this study. Qualitative and quantitative assessment should go hand in hand in forming the diagnosis of all cases in order to compensate for the shortcomings inherent in each type of assessment.

Case 3 and 6 were found to have a relatively large mandible, both in this study and clinical examination. In case 3, the surgeon agreed on the finding of the quantitative assessment but preferred to delay mandibular surgery. In case 6, a combined maxillary osteotomy and genioplasty was completed for the patient.

2. NASAL HEIGHT.

Aside from the under-developed maxilla, restricted nasal development is another cause of the facial deformity. Of the seven cases in this study, four (cases 1, 2, 4 and 6) had low nasal height (more than 7 mm. when compared to Bolton Standard template). In order to achieve facial balance, restoration of nasal height should be part of the planning in the surgical correction of the facial deformity.

3. CHANGES IN S-N-A ANGLE AND FACIAL CONVEXITY ANGLE (N-A-P), BEFORE AND AFTER SURGERY.

Up to the time when these records were taken, there were improvements in S-N-A angle and N-A-P angle in all seven cases. S-N-A increased 1° in case 1, and an increase of 7° was noted in case 6. Similarly, facial convexity angle increased 1° in case 1, and an increase of 19° was noted in case 6. The following table summarizes the improvement in S-N-A angle and N-A-P angle in all cases so gathered.

Table 3 . Summary of the Increase in S-N-A Angle and Facial Convexity Angle (N-A-P) in this Study.

	Increased S-N-A Angle	Increased N-A-P Angle
Case 1	1°	1°
Case 2	3°	8°
Case 3	4°	14°
Case 4	3°	16°
Case 5	6°	17°
Case 6	7°	19°
Case 7	1°	4°

This table shows that N-A-P angle does not increase in proportion with the increase in S-N-A angle. This can be easily explained by the fact that surgery may change the position of the pogonion, like in cases 3, 4, 5 and 6. Changes in the position of the pogonion may be the result of the mandibular surgery, like in case 6, or it may be due to the increase in vertical dimension as a result of bone-grafting in the horizontal cut in Le Fort I maxillary osteotomy. The increase in vertical dimension may result in the open rotation of the mandible and con-

sequently backward and downward positioning of the pogonion.

4. COMPARISON BETWEEN FINDINGS FROM BOLTON STANDARD ANALYSIS AND SASSOUNI ARCHIAL ANALYSIS.

Table 4 . Comparison of Findings from the Two Analyses.

Case No.	Bolton Standard Template Used	B.S.C.* of the Maxilla	Distance between A-N-S and Sassouni Anterior Arc	B.S.C.* of the mandible	Distance between Pog to Sassouni Anterior Arc
1	18 yrs.	5Mx,B.S.C.	-11 mm.	18Mn,B.S.C.	+7 mm.
2	18 yrs.	3Mx,B.S.C.	-15 mm.	18Mn.B.S.C.	-3 mm.
3	18 yrs.	14Mx,B.S.C.	- 8 mm.	18+MnB.S.C.	+18 mm.
4	13 yrs.	4Mx,B.S.C.	-13 mm.	13Mn,B.S.C.	0 mm.
5	18 yrs.	5Mx,B.S.C.	-13 mm.	18Mn,B.S.C.	-1 mm.
6	18 yrs.	4Mx,B.S.C.	- 7 mm.	18+MnB.S.C.	+10 mm.
7	18 yrs.	10Mx,B.S.C.	-15 mm.	18Mn,B.S.C.	0 mm.

* Bolton Standard Correlation.

This table reveals that the smaller the maxilla (from Bolton Standard Correlation), the more it is behind the Sassouni anterior arc, except in case 7. Furthermore, when the mandible is larger than that of the Bolton Standard of corresponding age, the more it is in front of the Sassouni anterior arc. Because of the small group of patients

in this study, no conclusive statement about these findings can be drawn. But it may serve as an indication that Bolton Standard Analysis and Sassouni Archial Analysis support each other's findings without any conflicting results. Aside from skeletal assessment, Bolton Standard provides soft tissue appraisal.

5. PLANES USED TO LOCATE CENTER "O" IN SASSOUNI ARCHIAL ANALYSIS.

In six of the seven cases in this study, three planes were used to locate the center "O", they are :

- (1) parallel to supra-orbital plane,
- (2) palatal plane and
- (3) mandibular plane.

The manner in which these three planes meet was shown in all the diagnostic tracings. The three planes usually converge posteriorly and meet each other within a small area which Sassouni (1955)¹⁹⁷ described as 'within a small area of a dime'.

Occlusal plane was not used at all in any of the seven cases due to the fact that it diverges in another direction. This again may indicate that occlusal plane is not useful in locating center "O" among cleft lip and palate patients.

Center "O" is usually located not far behind the skull. In this study of seven cleft patients, the average radius of the anterior arc (O-N) is 16.3 cm. and

the range is narrow, i.e. from 13.7 cm. to 18.6 cm. This indicated that center "O" can also be located easily among cleft lip and palate patients who demonstrate facial deformity.

6. RATIO OF SOFT TISSUE CHANGES TO BONY MOVEMENT.

The following table shows the relation between bony changes and soft tissue changes after maxillary osteotomy in each case :

Table 5 . Ratio of Soft Tissue and Bony Changes.

Case No.	Movement of Incisal Tip	Movement of Upper Lip	Ratio
1	+3 mm.	+2 mm.	0.66
2	+4 mm.	+3 mm.	0.75
3	+5 mm.	+4 mm.	0.80
4	+6 mm.	+4 mm.	0.66
5	+7 mm.	+5 mm.	0.71
6	+8 mm.	+4 mm.	0.50
7	+2 mm.	+0 mm.	0
Average	+5 mm.	+3.14 mm.	0.63

This table indicates that an average of +5 mm. incisor forward movement brings about an average of +3.14 mm. in soft tissue changes, i.e. 1 mm. incisor forward movement brings about 0.63 mm. upper lip changes. This figure is quite close to the finding of Lines and Steinhäuser (1974)¹³². Their figure was 1:0.66 or a 3:2 ratio. Again, with such a small group of cases here, it may only serve as a preliminary indicator for future study.

7. MAXILLARY OSTEOTOMY.

Maxillary osteotomy is a tedious and radical plastic surgery. The average operation time for each case was 6.8 hours and the range was from 3 hours to 8-1/2 hours. The average length of time for hospital confinement after surgery was 2-1/2 weeks and the average time for the patient to wear the splint was 7.7 weeks.

General impressions about the surgery are favorable. The patients are all happy after surgery. The comments from the patients' parents, relatives and friends are good. Another interesting result after surgery from this group of patients was the improvement of speech in four cases (cases 1, 2, 5 and 6). They feel that they can speak better.

It becomes evident that post-surgical evaluation (short-term as well as long-term evaluations) of such operations is necessary. However, such detailed

evaluation concerning the ultimate success or failure of the treated cases is beyond the scope and objectives of this thesis.

PART V

SUMMARY

V. SUMMARY

Literature was reviewed with reference to (1) cleft lip and palate (2) Etiology of maxillary retrognathism among cleft patients (3) Morphology of adult repaired cleft patients (4) Diagnosis and treatment planning (5) Treatment of maxillary retrognathism. In the literature, cranial base was revealed deficient as reliable area of reference in cephalometric analysis among cleft patients especially with maxillary retrognathism. Sassouni Archial Analysis in conjunction with Bolton Standards Analysis were chosen in this study for the reason that the former do not rely solely on the cranial base line.

For each of the patients in this group, ⁽¹⁾ Sassouni-Bolton combined cephalometric analysis was used to locate the site or sites of deformity and disclose the amount of skeletal discrepancy that need to be corrected during surgery. ⁽²⁾ Model study provides details on the occlusal relationship as seen in the original, planned and post-surgical stages. ⁽³⁾ Profile evaluation and prediction is intended to project the expected profile after surgery by arranging different segments of the patient's profile according to the planned surgery. Furthermore, the same cephalometric analysis and model study were used to assess these seven cases shortly after surgery (after 7 weeks).

PART VI

CONCLUSION

V. CONCLUSION

This is a pilot study of using a methods (combined Sassouni and Bolton cephalometric analysis, model study and profile evaluating and prediction) for pre-surgical assessment and post-surgical evaluation of seven cleft patients with maxillary retrognathism indicated for maxillary surgery.

The results from this group of patients seem encouraging. Using the diagnostic method, as described, no conflicting findings between clinical qualitative assessment and the quantitative assessment were found. Moreover, the combined Sassouni and Bolton cephalometric analysis can disclose accurately the area of deformity, to estimate the amount of skeletal discrepancy to be corrected and to predict the possible outcome of the surgery.

The results presented here are only on a short term basis and should not be regarded as final. Using this method to compare the short-term and long-term results, planned results and original conditions will enable a better judgement of the utilization of this method.

PART VII

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Ackerman, J.L. and Proffit, W.R. (1975). Diagnosis and planning treatment in orthodontics. (In: Graber, T.M. and Swain, B.F., eds. Current Orthodontic Concepts and Techniques. Philadelphia, W.B. Saunders Co., 2nd ed. Vol.I. xvi+1139p.). p.45.
2. Ibid. p.66.
3. Aduss, H. and Pruzansky, S. (1967). The nasal cavity in complete unilateral cleft lip and palate. Arch. Otolaryng., 85:53.
4. Aduss, H. (1971). Cranio-facial growth in complete unilateral cleft lip and palate. Angle Ortho., 41:202.
5. Atherton, J.D. (1967). Morphology of facial bones in skulls with unoperated unilateral cleft palate. Cleft Palate J., 4:18.
6. Avery, J.K. (1972). Prenatal facial growth. (In: Moyer, R., ed. Handbook of Orthodontics. Chicago, Yearbook Medical Publisher, 3rd. ed., 1972. xiv+778 p.). p.27.
7. Avery, J.K. and Devine, R.K. (1959). The development of ossification centers in the face and palate of normal and cleft palate human embryos. Cleft Palate Bull., 9:25.
8. Bala, S. (1970). Maxillary osteotomy as a secondary cleft palate procedure. Trans. Congr. Int. Assoc. Oral Surg., p. 32-36.
9. Bauer, T.B. Trusler, H.M. and Tondra, T.M. (1959). Changing concepts in the management of bilateral cleft lip deformities. Plastic & Reconstr. Surg., 24:231.
10. Bauer, T.B., Trusler, H.M. and Tondra, T.M. (1966). The management of the bilateral cleft lip deformities. Acta Chir. Plast., 8:173.
11. Bell, W.H. and Dam, J.J. (1973). Correction of dento-facial deformities by surgery in the anterior part of the jaw. A study of stability and soft

- tissue changes. *Am. J. Ortho.*, 64:162.
12. Bell, W.H. (1975). Le Fort I osteotomy for correction of maxillary deformities. *J. Oral Surg.*, 33:412.
 13. Bell, W.H., Kennedy, J.W. and Levy, R.M. (1975). Bone healing and revascularization after total maxillary osteotomy. *J. Oral Surg.*, 33:253.
 14. Bell, W.H. Creekmoore, T.D. and Alexander, R.G. (1977). Surgical correction of the long face syndrome. *Am. J. Ortho.*, 71:40.
 15. Bergland, O. and Borchgrevink, H. (1974). The role of the nasal septum in mid-face growth in man elucidated by the maxillary development in certain types of facial clefts. *Scand. J. Reconstr. Surg.*, 8:42.
 16. Berlin, A.J. (1971). Classification of cleft lip and palate. (In: Grabb, W.G., et al, eds. *Cleft Lip and Palate*. London, J.L.A. Churchill Publisher. xxxiii+916p.). p.66.
 17. Bishara, S. and Iversen, W. (1974). Cephalometric comparison on the cranial base and face in individuals with isolated cleft of the palate. *Cleft Palate J.*, 11:162.
 18. Bjerin, R. (1957). Comparison between the Frankfort horizontal and the sella turcica-nasion as reference planes in cephalometric analysis. *Acta Odontol. Scand.*, 15:1-12.
 19. Bloom, L.A. (1961). Perioral profile changes in orthodontic treatment. *Am. J. Ortho.*, 47:371.
 20. Borden, G.H. (1953). Mandibular growth in the cleft palate infants. Thesis. Univ. Illinois. Cited from Wepner, F. and Hollmann, R. (1975). Mid-face anthropometry on the cephalometric radiograph in cleft lip and palate case. *J. Max-fac. Surg.*, 3:188.
 21. Borden, G.H. (1957). Mandibular growth in the cleft palate infant. *Angle Ortho.*, 27:197.
 22. Brophy, T.W. (1923). *Cleft Lip and Palate*. Philadelphia, Blakiston's Sons & Co., 1st ed. xxiv+340p.). p.73.

23. Broadbent, B.H., Sr., Boradbent, B.H., Jr. and Golden, W.H. (1975). Bolton Standard of Dento-facial Developmental Growth. Saint Louis, C.V. Mosby Co. xiii+166p. p.1.
24. Ibid. p.82.
25. Broca, M. (1862). Sur les projections de la tete, et sur un nouveau procede de cephalometrie. Bull. de la Societe d'Anthropologie de Paris, 3:514-544. Cited from Moorrees, C.F.A. and Kean, M.R. (1958). Natural head position. A basic consideration in the interpretation of cephalometric radiographs. Am. J. Phys. Anthropol., 16:213.
26. Browne, D. (1949). Ann Royal Coll. Surg., 5:169. Cited from Matthews, D.M. (1952). The pre-maxilla in bilateral clefts of lip and palate. 5:77.
27. Burdi, A.R. (1968). Distribution of mid-palatine cysts. A re-evaluation of human palatal closure mechanism. J. Oral Surg., 26:41.
28. Burke, G.W., Feagans, W.M., Elzay, R.P. and Schwartz, L.D. (1966). Some aspects of the origin and fate of mid-palatal cysts in human fetuses. J. Dent. Res., 45:159.
29. Chapman, J.H. (1966). A serial growth study of children with unilateral cleft lip and palate from 6-12 years. Australian Ortho. Bull., 4(6):4.
30. Chierici, G., Harvold, E. and Dawson, C. (1970). Morphologic adaptation secondary to the production of experimental cleft palate in primates. Cleft Palate J., 7:59.
31. Chierici, G., Harvold, E. and Vargerrik, K. (1973). Morphogenetic experiments in cleft palate : mandibular response. Cleft Palate J., 10:58.
32. Coben, S.E. (1955). The integration of facial skeletal variants. Am. J. Ortho., 41:407.
33. Cocoaro, P.J. (1969). Orthodontics in cleft palate children. A continuing process. Cleft Palate J., 6:495.
34. Cocoaro, P.J. and Pruzansky, S. (1965). Longitudinal

study of skeletal and soft tissue profile in children with unilateral cleft lip and cleft palate. *Cleft Palate J.*, 2:1.

35. Coerd, I. (1970). Fehllindikation bieplastischen eingriffen langinbecks. *Arch. Klin. Chir.*, 327; 652. Cited from Wolfgang, R.K. (1973). Present view on bone grafting in cleft palate. *J. Max-fac. Surg.*, 1:185.
36. Converse, J.M. and Shapero, H.H. (1952). Treatment of developmental malformation of the jaw. *Plastic & Reconstr. Surg.*, 10:473.
37. Converse, J.M. (1954). Bone grafting in malformation of the jaw. *Am. J. Surg.*, 88:858.
38. Converse, J.M., Horowitz, S.L., Guy, C.L. and Woodsmith, D.C. (1964). Surgical orthodontic correction in the bilateral cleft lip. *Cleft Palate J.*, 2:153.
39. Converse, J.M. and Woodsmith, D. (1971). An atlas and classification of mid-face and cranio-facial osteotomies. In *Trans. Fifth Internat. Congr., Plast. & Reconstr. Surg.*, p.931, Butterworth's, Melbourne.
40. Converse, J.M., Woodsmith, D. and McCarthy, J.G. (1975). Report on a series of 50 cranio-facial operations. *Plastic & Reconstr. Surg.*, 55:283.
41. Conway, H., Smith, J.W. and Behrman, S.J. (1970). Another method of bringing the mid-face forward. *Plastic & Reconstr. Surg.*, 46:325.
42. Coupe, T.B. and Subtelny, J.D. (1960). Cleft palate-deficiency or displacement of tissue. *Plastic & Reconstr. Surg.*, 26:600.
43. Dahl, E. (1970). Cranio-facial morphology in congenital clefts of the lip and palate. *Acta Odontologica Scand.*, Supplementum, 28:57.
44. Davis, J.S. and Ritchie, H.P. (1922). Classification of congenital cleft of the lip and palate. *J. A.M.A.*, 19:1323. Cited from Berlin, A.J. (1971). Classification of cleft lip and palate. (In: Grabb, W.C., et al, eds. *Cleft Lip and Palate*. London, J & A Churchill Publisher. xxxiii+916p.). p.66.

45. Despreg, J.D. and Kiehn, C.L. (1968). Maxillary osteotomy for late correction of occlusion and appearance in cleft lip and palate patients. *Plastic & Reconstr. Surg.*, 42:203.
46. Deusckle, F.M. and Kalter, H. (1962). Observations on the mandible in association with defects of the lip and palate. *J. Dent. Res.*, 41:1085.
47. Dey, D.L. (1970). Total care of children with cleft lip and cleft palate. *Med. J. Australia*, 2:738.
48. Dingman, R. and Natvig, D. (1964). *Surgery of Facial Fractures*. Philadelphia, Saunders. p.339.
49. Downs, W.B. (1952). The role of cephalometric in orthodontic case analysis and diagnosis. *Am. J. Ortho.*, 38:162.
50. Epker, B.N. and West R.A. (1972). Posterior maxillary surgery :its place in the treatment of dento-facial deformities. *J. Oral Surg.*, 30:562.
51. Epker, B.N. and Wolford, L.M. (1975). Middle-third facial osteotomies, their use in the correction of acquired and developmental dento-facial and cranio-facial deformities. *J. Oral Surg.*, 30:562.
52. Epker, B.N. and Wolford, L.M. (1975). The combined anterior and posterior maxillary osteotomy : a new technique. *J. Oral Surg.*, 33:842.
53. Fara, M. and Hrionakova, J. (1965). The problem of protruding premaxilla in bilateral total cleft. *Acta Chir. Plast.*, 7:281.
54. Farkas, L.G. and Lindsay, W. (1971). Morphology of adult face following repair of bilateral cleft lip and palate in childhood. *Plastic & Reconstr. Surg.*, 47:25.
55. Farkas, L.G. and Lindsay, W. (1972). Morphology of adult face after repair of isolated cleft palate in childhood. *Cleft Palate J.*, 9:132.
56. Farkas, L.G. and Lindsay, W. (1973). Morphology of the adult face following repair of unilateral cleft lip and palate in childhood. *Plastic & Reconstr. Surg.*, 52:652.

57. Fogh-Andersen, F. (1942). Inheritance of Hare-lip and cleft palate. Cited from Pattern, B.M. (1971). Embryology of the palate and the maxillo-facial region. (In: Grabb, W.C., et al eds. Cleft Lip and Palate. London, J & A Churchill Publisher. xxxiii+916p.). p.21.
58. Fogh-Andersen, F. (1968). Rare cleft of the face. (In : Longacre, J.J., ed. Cranio-facial Anomalies: Pathogenesis and Repair. Philadelphia & Toronto, J.B. Lippincott Publisher. xii+389p.). p.163.
59. Foster, T.D. (1959). Trans.Int. Soc. Plastic Surg., p.36.
60. Foster, T.D. (1962). Maxillary deformities in repair clefts of lip and palate. British J. Plastic Surg., 15:173.
61. Fraser, F.C. (1967). Cleft lip and cleft palate. Science 158:1603. Cited from Pattern B.M. (1971). Embryology of the palate and the maxillo-facial region. (In: Grabb, W.C., et al eds. Cleft Lip and Palate. London, J & A Churchill Publisher. xxxiii+916p.). p.21.
62. Fraser, F.C. (1968). Workshop on embryology of cleft lip and palate. Teratology, 1:353.
63. Friehofer, H.M.P. (1973). Results after mid-face osteotomies. J. Max-fac. Surg., 1:30.
64. Friede, H. and Pruzansky, S. (1972). Longitudinal study of growth in bilateral cleft lip and palate from infancy to adolescence. Plastic & Reconstr. Surg., 49:392.
65. Fulton, J.T. (1957). Closure of the human palate in embryo. Am. J. Obstet. Gynec., 74:179.
66. Gans, B.T. and Kallal, R.H. (1975). Surgical management of oro-facial deformities. (In: Graber, T.M. et al, eds. Current Orthodontic Concept and Techniques. Philadelphia, W.B. Saunders Co., 2nd ed. Vol. II. vi+1137p.). p.1095.
67. Gilley, F.M. (1947). A cephalometric analysis of the developmental pattern and facial morphology in cleft palate. Northwestern Univ. Bull., xlvIII, 13-15. Cited from Harvold, E. (1954). Cleft lip and palate morphologic studies of facial skeleton,

40:493.

68. Gilley, F.M. (1947). A cephalometric analysis of the developmental pattern and facial morphology in cleft palate. M.S.D. thesis. Northwestern Univ. Cited from Pinkerton, C.T., et al. (1966). Cephalometric studies of the mandible in individuals with cleft. Part I, a review. Cleft Palate J., 3:258.
69. Gillies, H.D. (1923). Deformities of the syphilitic nose. British Med. J., 2:977. Cited from Converse, J.M. and Woodsmith, D. (1971). An atlas and classification of mid-facial and cranio-facial osteotomies. In Trans Fifth Internat. Congr., Plastic & Reconstr. Surg., p.931. Butterworth, Melbourne.
70. Gillies, H. and Harrison, S.H. (1951). Operative correction by osteotomy of recessed malar maxillary compound in case of oxycephaly. British J. Plast. Surg., 3:123.
71. Gillies, H. and Millard, D.R. (1957). The Principles and Art of Plastic Surgery. Surgery of the Maxilla. London, Butterworth Publisher. xxiii+637p.. p.544.
72. Glover, D.M. and Newcomb, M.R. (1961). Bilateral cleft lip repair and the floating premaxilla. Plastic & Reconstr. Surg., 28:365.
73. Godfrey, K. (1973). Recognition and documentation of oral cleft conditions. Aust. Ortho. J., 3:79.
74. Godfrey, K. (1976). Cleft Lip and Palate Slide-tape Sequence. University of Sydney.
75. Godfrey, K. (1977). Personal Communications.
76. Graber, T.M. (1949). An appraisal of the developmental deformities in cleft palate and cleft lip Individuals. Quart. Bull., Northwestern Univ. Med. School, 23:153. Cited from Pinkerton, C.J., et al. (1966). Cephalometric studies of the mandible in individuals with cleft. Part I, a review. Cleft Palate J., 3:258.
77. Graber, T.M. (1949). Cranio-facial morphology in cleft palate and cleft lip deformities. Surg. Gynec. Obstet., 88:359.

78. Graber, T.M. (1949). A cephalometric analysis of the developmental pattern and facial morphology in cleft palate. *Angle Ortho.*, 19:91.
79. Graber, T.M. (1954). Congenital cleft palate deformity. *J.A.D.A.*, 48:375.
80. Graber, T.M. (1969). Diagnostic procedures, aids and their interpretation. (In: Graber, T.M. *Orthodontic Principles and Practice*. Chapter 8. Philadelphia and London, W.B. Saunders Co., 2nd ed. x+922p.). p.465.
81. Graf-Pinthus, B. and Bettex, M. (1975). Long term observation following pre-surgical orthopaedic treatment in complete cleft of the lip and palate. *Cleft Palate J.*, 11:253.
82. Hagerty, R.F. and Hill, M.J. (1963). Facial growth and dentition in the unoperated cleft palate. *J. Dent. Res.*, Supplement to No.1, 42:412.
83. Harkins, C.S., Berlin, A., Harding, R., Longacre, J.J. and Snodgrasse, R. (1962). A classification of cleft lip and cleft palate. *Plastic & Reconstr. Surg.*, 29:31.
84. Harvold, E. (1954). Cleft lip and palate, morphologic studies of the facial skeleton. *Am. J. Ortho.*, 40:493.
85. Harvold, E. (1960). Mandibular morphogenesis (abstract). *Am. J. Ortho.*, 46:144.
86. Harvold, E. (1960). Environmental influences on mandibular morphogenesis. *Am. J. Ortho.*, 46:144.
87. Harvold, E. (1968). The role of function in the aetiology and treatment of malocclusion. *Am. J. Ortho.*, 5:883.
88. Hellquist, R. (1971). Early maxillary orthopedics in relation to maxillary cleft repair by periosteoplasty. *Cleft Palate J.*, 8:36.
89. Hellquist, R. (1973). The influence of periosteoplasty on dental orthopedics. *Trans European Ortho. Socety*, p.559.
90. Hendersen, D. and Jackson, I.T. (1973). Naso-maxillary

hypoplasia. The Le Fort II osteotomy. British J. Oral Surg., 11:77.

91. Herfert, O. (1963). Two stages operation for cleft palate. British J. Plast. Surg., 16:37.
92. Hotz, R. (1970). The role of orthodontics in treatment management of cleft lip and palate. Cleft Palate J., 7:371.
93. Hotz, M. (1973). Aims and possibilities of pre- and post-surgical orthopedic treatment in uni- and bilateral clefts. European Ortho. Socety and Third Internat. Congress, p.553.
94. Hotz, R. (1973). Introduction to cleft palate symposium. Trans European Ortho. Socety and Third Internat. Congress, p.535.
95. Hotz, M. (1976). Comprehensive care of cleft lip and palate children in Zurich University. A preliminary report. Am. J. Ortho., 70:481.
96. Huddart, A.G. (1967). An analysis of the maxillary changes following pre-surgical dental orthodontic treatment in unilateral cleft lip and palate case. European Ortho. Socety, p.299.
97. Innis, C.O. (1962). Some primary observations on unoperated hare-lip and celft palate in adult members in the Dusan tribes of North Borneo. British J. Plast. Surg., 15:173.
98. Jabaley, M.E. and Edgerton, M.E. (1969). Surgical correction of congenital mid-face retrusion in the presence of mandibular prognathism. Plastic & Reconstr. Surg., 1:1.
99. Johanson, B. (1966). Modern procedures in uni- and bilateral clefts of lip, alveolus and hard palate with respect to primary osteoplasty. (In: Treatment of Patients with Cleft Lip, Alveolus and Palate. 2nd Hamburg Internat. Symp. July 1964. Thieme, Stuttgart.).
100. Jolly, A. (1954). A review of the result of operation in cleft palate with reference to maxillary growth and speech function. British J. Plast. Surg., 7:229.

101. Jolleys, A. and Robertson, N.R.E. (1972). A study of the effects of early bone grafting in complete cleft of the lip and palate. Five year study. British J. Plast. Surg., 25:229.
102. Kernahan, D.A. and Stark, R.B. (1958). A new classification for cleft lip and palate. Plastic & Reconstr. Surg., 22:435.
103. Kettle, M.A. (1954). The orthodontic treatment of dental deformities due to cleft lip and palate. British Society for the Study of Orthodontics, 5:46.
104. Khoo Boo Chai (1971). The unoperated adult bilateral cleft of the lip and palate. British J. Plast. Surg., 24:250.
105. Khouw, F.E., Proffit, W.R. and White, R.P. (1970). Cephalometric evaluation of patients with dento-facial disharmonies requiring surgical correction. Oral Surg. Oral Med. Oral Path., 29:789.
106. Kiehn, C.L., Desprez, J.D. and Brown, F. (1968). Maxillary osteotomy for late correction of occlusion and appearance in cleft lip and palate patients. Plastic & Reconstr. Surg., 42:203.
107. Kim, Y.H. (1958). A comparative cephalometric study of the relationship of facial structures in normal and cleft palate children. M.S. thesis. Univ. Rochester. Cited from Harvold, E. (1954). Cleft lip and palate, morphologic studies of the facial pattern. Am. J. Ortho., 40:493.
108. King, E.W. (1960). Variation in profile changes and their significance in timing treatment. Angle Ortho., 30:141.
109. Kirchner, L. (1961). Die bedeutung der gesichtsproportionen für die wiederherstellungschirurgie. (In: Schuchardt, K. ed. Fortschritte der Kiefer-Gesichtschirurgie. Bd. VII. Stuttgart, Thieme. 1961).
110. Kiunnsland, S. (1970). The relationship between the cartilagenous nasal septum and maxillary growth during human fetal life. Cleft Plate J., 4:523.
111. Kling, A. (1964). Evaluation of results with references

to the bite. (In: Hotz, R. ed. Early Treatment of Cleft Lip and Palate. Huber, Bern.).

112. Kling, A. (1966). Procedure and limitation of orthodontic treatment (In: Treatment of Patients with Cleft of Lip, Alveolus and Palate. 2nd Hamburg Internat. Symp. July 1964. Thieme, Stuttgart.).
113. Knowles, C.C. (1969). The place of mandibular osteotomy in the treatment plan for cleft lip and palate conditions. British J. Plast. Surg., 22:365.
114. Kogeman, K.E. and William, K. (1974). On Le Fort III osteotomy for Crouzon's disease in children. Scand. J. Plast. Surg., 8:169.
115. Kraus, B.S. and Ahern, F. (1960). Deviation in the sequence of appearance of ossification center in the feet of human fetuses. Am. J. Anat., 118:735.
116. Kraus, B.S., Kitamura, H. and Latham, R.A. (1966). Atlas of developmental anatomy of the face. New York, Hoeber Med. Div., Harper & Bow. Cited from Pattern, B.M. (1971). Embryology of the palate and the maxillo-facial region. (In: Grabb, W.C. et al, eds. Cleft Lip and Palate. London, J & A Churchill Publisher. xxx+916p.) p.21.
117. Kremenak, C.K., Hartshorn, D.F. and Demjin, S.E. (1969). The role of the cartilagenous nasal septum in maxillo-facial growth. Experimental septum removal in Beagle pups. I.A.D.R. 47th General Meeting, Abstract, 32:48.
118. Kremenak, C.K., Huffman, W.C. and Olin, W.H. (1970). Growth of maxilla in dogs after palatal surgery II. Cleft Palate J., 7:719.
119. Kremenak, C.K., Huffman, W.C. and Olin, W.H. (1970). Maxillary growth inhibition by mucoperiosteal denudation of palatal shelf bone in non-cleft Beagles. Cleft Palate J., 8:817.
120. Kriens, O. (1969). Primary osteoplasty in patients with cleft of lip, alveolus and palate. Acta oto-rhino-laryngkelg., 22:687.

121. Krogman, W.M., Mazaheri, M., Harding, R.L., Ishiguro, K., Bariana, G., Meiur, J., Canter, H. and Ross, R.B. (1975). Longitudinal study of the cranio-facial growth pattern in children with cleft as compared to normal, from birth to six years. *Cleft Palate J.*, 12:59.
122. Kufner, J. (1971). Four years experience with major maxillary osteotomy for retrusion. *J. Oral Surg.*, 29:549.
123. Lungman, J. (1969). *Medical Embryology*. Chapter 3, Digestive tube and its derivatives. Baltimore, Williams & Wilkins, 2nd ed. xii+386p. p.40.
124. Latham, R.A. (1967). Facial growth mechanism in human and their role in the formation of the cleft lip and palate deformity. Ph.D. thesis. Univ. Liverpool. Cited from Smiley, G.R. (1972). A possible genesis for cleft palate formation. *Plastic & Reconstr. Surg.*, 50:390.
125. Latham, R.A. (1969). The septo-premaxillary ligament and maxillary development. *J. Anat. London*, 104: 584.
126. Latham, R.A. and Burston, W.R. (1964). The effect of unilateral cleft of the lip and palate on maxillary growth pattern. *British J. Plast. Surg.*, 17:10.
127. Latham, R.A., Deaton, U.G. and Calabrese, C.T. (1975). A question of the role of the vomer in the growth of the premaxillary segment. *Cleft Palate J.*, 12:351.
128. Leech, H.L. (1958). A clinical analysis of oro-facial morphology and behaviour of 500 patients attending an upper respiratory research clinic. *Dent. Practit.*, 9:57.
129. Levin, H.S. (1963). A cephalometric analysis of cleft palate deficiencies in the middle third of the face. *Angle Ortho.*, 33:186.
130. Lewin, M.L., Argamso, R.U. and Fingerroth, A.I. (1971). Maxillary osteotomies and bone grafts for correction of contour and occlusal deformities. *Cleft Palate J.*, 8:18.

131. Lines, P.A. and Steinhauser, E.W. (1974). Diagnosis and treatment planning in surgical and orthodontic therapy. *Am. J. Ortho.*, 66:318.
132. Lines, P.A. and Steinhauser, E.W. (1974). Soft tissue changes in relationship to movement of hard structures in orthognathic surgery. A preliminary report. *J. Oral Surg.*, 32:891.
133. Longacre, J.J. (1966). Modern procedures in uni- and bilateral clefts of lip, alveolus and hard palate with respect to primary osteoplasty. (In: *Treatment of Patients with Cleft of Lip, Alveolus and Palate*. 2nd Hamburg Internat. Symp, July 1964. Thieme, Stuttgart.)
134. MacIntosh, R.B. (1970). Orthodontic surgery comments on diagnostic modalities. *J. Oral Surg.*, 28:249.
135. Monroe, C.W. (1959). The surgical factors influencing bone growth, in middle third of the upper jaw in the cleft palate. *Plastic & Reconstr. Surg.*, 24:481.
136. Monroe, C.W., Griffith, B.H., McKinney, P., Rosenstein, S.W. and Jacobson, B.N. (1970). Surgical recession of the premaxilla and its effect on maxillary growth in patients with bilateral cleft. *Cleft Palate J.*, 9:784.
137. Margolis, H. (1947). A basic facial pattern and its application in clinical orthodontia. *Am J. Ortho.*, 33:631.
138. Mario Gonzalez-Ullva . (1969). Syndrome of retraction of middle third of the face. Its importance in profileplasty. *Int. Surg.*, 51:345-53.
139. Matthews, D.N. (1952). The premaxilla in bilateral cleft of lip and palate. *British J. Plast. Surg.*, 5:77.
140. Matthews, D.N. (1971). Hare-lip and cleft palate. Chapter 1. (In: Mustarde, J.C., ed. *Plastic Surgery in Infancy and Childhood*. London, Livingstone. xiii+581p.)p.1.
141. Mathews, V.L. and Broadbent, T.R. (1957). Artistic relationship in surface anatomy of the face. *Plastic & Reconstr. Surg.*, 20:1.

142. McNeil, C.K. (1956). Congenital and oral deformities. *British Dent. J.*, 101:191.
143. McNeil, R.W. (1962). A roentgen cephalometric study of nasopharyngeal and cranial base growth in cleft palate children. *I.A.D.R.*, 41:53.
144. McNeil, C.K. (1964). The orthopedic principles in the treatment of cleft lip and palate. p.57. *International Symposium*. Edited by R. Hotz. Bern, Hans Huber Publisher.
145. McNeil, R.W. et al. (1972). Cephalometric prediction for orthodontic surgery. *Angle Ortho.*, 42:154.
146. McWilliam, J. and Aronson, L. (1976). Hypoplasia of the middle third of the face. A morphological study. *Angle Ortho.*, 46:260.
147. Mestre, J.C., Jesus, J.D. and Subtelny, J.D. (1960). Unoperated oral clefts at maturation. *Angle Ortho.*, 30:78.
148. Mills, P.B. (1965). The orthodontist's role in surgical correction of dento-facial deformities. *Am. J. Ortho.*, 56:266.
149. Moorrees, C.F.A. and Kean, M. (1958). Natural head position, a basic consideration for the analysis to cephalometric radiographs. *Am. J. Phy. Anthropol.*, 16:213-34.
150. Moorrees, C.F.A. and Lebet, L. (1962). The mesh diagram in cephalometrics. *Angle Ortho.*, 32:214-31.
151. Moorrees, C.F.A. and Gron, A.M. (1966). Principles of orthodontic diagnosis. *Angle Ortho.*, 36:258.
152. Moss, M.L. (1956). Malformation of the skull base associated with cleft palate deformity. *Plastic & Reconstr. Surg.*, 17:226.
153. Moss, M.L. and Salentizn, L. (1969). The primary role of functional matrices in facial growth. *Am. J. Ortho.*, 55:566.
154. Moss, M.L., Bromberg, B.E., Song, I.C. and Eisenman, G. (1968). The passive role of nasal cartilage in mid-face growth. *Plastic & Reconstr. Surg.*, 41:536.

155. Mowbray, J. (1977). A cephalometric appraisal of a group of children with surgically repaired unilateral cleft lip and palate. *British J. Ortho.*, 4(1):33.
156. Murray, J.E. and Swanson, L.T. (1968). Mid-face osteotomy and advancement for craniostenosis. *Plastic & Reconstr. Surg.*, 41:299.
157. Nakamura, S., Savara, B.S. and Thomas, D.R. (1972). Facial growth of children with cleft lip and/or palate. *Cleft Palate J.*, 9:119.
158. Narula, J. and Ross, R.B. (1970). Facial growth in children with complete bilateral cleft lip and palate. *Cleft Palate J.*, 7:239.
159. Nordin, R.E. and Johanson, B. (1955). Freie knochen-transplantation bei defekten in alveolarkamm nach kieferortho-padischer einstellung der maxilla bei lippen-kiefer-gaumenspalten. *Fortschr Kiefer Gesichtch*, 1:168. Cited from Koberg, R. Wolfgang (1973). Present view on bone grafting in cleft palate. *J. Max-fac. Surg.*, 1:185.
160. Nordin, R.E. et al. (1974). Primary, early bone grafting in complete cleft of the lip and palate - a follow-up of 53 cases. *Scand. J. Plastic & Reconstr. Surg.*, 8:79.
161. Oblak, P. (1975). New guiding principles in the treatment of cleft. *J. Max-fac. Surg.*, 3:231.
162. Obwegeser, H.L. (1967). Surgery as an adjunct to orthodontics in normal and cleft palate patients. *Trans European Orthodontic Society*. p.343.
163. Obwegeser, H.L. (1969). Surgical correction of small or retrodisplaced maxillae. *Plastic & Reconstr. Surg.*, 43:351.
164. Obwegeser, H.L. (1971). Surgical correction of maxillary deformities. Chapter 35. (In: Grabb, W.C., et al eds. *Cleft Lip and Palate*. London, J & A Churchill Publisher. xxxiii+916p.) p.515.
165. Ortiz-Monasterio, F., Rebiel, A.S., Valderrana, M. and Cruz, R. (1959). Cephalometric measurement on adult patients with non-operated cleft palate. *Plastic & Reconstr. Surg.*, 24:53.

166. Osborne, H.A. (1966). A serial cephalometric analysis of facial growth in adolescent cleft palate subjects. *Angle Ortho.*, 36:211.
167. Overton, J. (1977). Personal Communication. (Anaesthetist at the Royal Alexandra Hospital for Children).
168. Patten, B.M. (1971). Embryology of the palate and the maxillo-facial region. Chapter 2. (In: Grabb, W.C., et al eds. *Cleft Lip and Palate*. London, J & A Churchill Publisher. xxxiii+916p.) p.21.
169. Pedersen, G.W. and Blaho, D.M. (1975). Total maxillary osteotomy for cleft palate rehabilitation. *Oral Surg.Oral Med. Oral Path.*, 39:669.
170. Peyton, W.T. and Ritchie, H.P. (1936). Quantitative studies on congenital cleft of the lip. *Arch. Surg. (Chicago)*, 33:1046. Cited from Ross, R.B. and Johanston, M.C. (1972). Facial growth in surgically repaired cleft lip and palate. *Cleft Lip and Palate*. Baltimore, William & Wilkins Co. ix+319p. p.158.
171. Pognel, H. (1960). Malocclusion and the first permanent molar. *British Dent. J.*, 108:225.
172. Ponterio, A.E. (1952). A cephalometric appraisal of the facial pattern of children with cleft of the palate as compared to normal children. M.S. thesis. Univ. Washington. Cited from Pinkerton, C.J., et al. (1966). Cephalometric studies of the mandible in individuals with cleft. Part I, a review. *Cleft Palate J.*, 3:258.
173. Popescu, V.C. (1974). Advancement of the middle third of the face without bone grafting in a case of Crouzon's disease. *J. Max-fac. Surg.*, 2:219.
174. Poulton, D.R. (1976). Surgical orthodontics, maxillary procedures. *Angle Ortho.*, 46:312.
175. Pruzansky, S. (1950). Description, classification and analysis of unoperated clefts of the lip and palate. *Am. J. Ortho.*, 41:590.
176. Pruzansky, S. (1955). Factors determining arch form in cleft lip and palate. *Am. J. Ortho.*, 41:827.

177. Pruzansky, S. (1964). Presurgical orthopaedics and bone grafting in infants with cleft lip and palate. A dissent. Cleft Palate J., 2:164.
178. Pruzansky, S. and Friede, H. (1972). Longitudinal study of growth in bilateral cleft lip and palate from infancy to adolescence. Plastic & Reconstr. Surg., 49:392.
179. Pruzansky, S. (1973). Monitoring growth of the infants with cleft lip and palate. Trans. European Orthodontic Society. p.538.
180. Quinn, G.W. (1973). Orthodontic treatment for the cleft palate children. Trans. European Orthodontic Society and Third International Congress. p.567.
181. Ricketts, R.M., Schulhof, R.J. and Bagha, L. (1976). Orientation - sella-nasion or Frankfort horizontal. Am. J. Ortho., 69:648.
182. Robertson, N.R.E. (1971). Recent trends in the early treatment of cleft lip and palate. Dent. Pract., 21:326.
183. Robertson, N.R.E. and Jolley, A. (1974). The timing of hard palate repair. Scand. J. Plastic & Reconstr. Surg., 8:49.
184. Rosenstein, S.W. (1964). Early orthodontic considerations for treatment of complete clefts of the lip and palate. (In: Hotz, R., ed. Early Treatment of Cleft Lip and Palate. International Symposium, Univ. Zurich, Dental Institute. Berne, Hans Huber Publisher.) p.141.
185. Rosenstein, S.W. (1975). Orthodontic and bone grafting procedures in a cleft lip and palate series: an interim cephalometric evaluation. Angle Ortho., 45:227.
186. Ross, R.B. (1965). Cranial base of children with lip and palate clefts. Cleft Palate J., 2:157.
187. Ross, R.B. (1967). The effect of early orthodontic treatment on facial growth in cleft lip and palate. Cleft Palate J., 4:157.
188. Ross, R.B. (1970). The clinical implication of facial growth in cleft lip and palate. Cleft Palate J.,

7:37.

189. Ross, R.B. and Johnston, M.C. (1967). The effect of early orthodontic treatment on facial growth in cleft lip and palate. *Cleft Palate J.*, 4:157.
190. Ross, R.B. and Johnston, M.C. (1972). Facial growth in surgically repaired cleft lip and palate. Chapter 10. *Cleft Lip and Palate*. Baltimore, William & Wilkins Co. ix+319p. p.159.
191. Rowe, N.L. (1954). Secondary surgical procedures for the correction of deformity in the cleft lip and palate patients. *British Socceity for the Study of Orthodontics*, 5:112.
192. Rudee, L.A. (1961). Proportional profile changes concurrent with orthodontic therapy. *Am. J. Ortho.*, 50:421.
193. Sadowsky, C., Aduss, H. and Pruzansky, S. (1973). The soft tissue profile in unilateral clefts. *Angle Ortho.*, 43:233.
194. Sarnat, B.G. (1970). The face and jaw after surgical experimentation with the septo-vomer region in growing and adult rabbits. *Acta Oto-laryngologica, Supplement*, 268:1.
195. Sarnat, B.G. (1973). Post-natal growth of the upper face, some experimental considerations. *Angle Ortho.*, 33:139.
196. Sarnat, B.G. and Wexler, M.R. (1969). Longitudinal development of snout deformity after septal resection in growing rabbits. *British J. Plastic Surg.*, 22:313.
197. Sassouni, V. (1955). A roentgenographic cephalometric analysis of cephalo-facial-dental relationship. *Am. J. Ortho.*, 41:735.
198. Sassouni, V. (1975). Dento-facial orthopaedics. A multidisciplinary approach. (In: Archer, W.H. ed. *Oral and Maxillo-facial Surgery*. Vol. II, 5th ed. U.S.A., W.B. Saunder Co. xvii+1859p.). p.1427.
199. Sassouni, V. and Sofereanos, G.C. (1974). Roentgenographic cepahlometric analysis. Chapter 6.

Diagnosis and Treatment of Dento-facial Abnormalities. Springfield, U.S.A., Charles C. Thomas Publisher. xii+500p. p.57.

200. Schmid, E. (1955). Die Annäherung der kieferstumpfe bie Lippen-Kiefer-Gaumenspalten, ihre schadliehen Folgen und Vermeidung. Fortschr. Kiefer Gesichtschir, 1:37. Cited from Koberg, R. Wolfgang. (1973). Present view on bone grafting in cleft palate. J. Max-fac. Surg., 1:185.
201. Schmid, E., Widmaier, W., Richert, H. and Stein, K. (1974). The development of the cleft upper jaw following primary osteoplasty and orthodontic treatment. A report of 87 cases. J. Max-fac. Surg., 2:32.
202. Schruddle, J. and Stellmach, R. (1959). Primäre osteoplastik und kieferbogenformung bie lippen-kiefer-gaumenspaltung. Fortschr. Kiefer- u. Gesichtschir., Bd. 5. Thieme, Stuttgart 1959. Cited from Koberg, R. Wolfgang. (1973). Present view on bone grafting in cleft palate. J. Max-fac. Surg., 2:32.
203. Schwarz, A.M. (1951). Lehigang der Gebissregelang, Bd. I. Wien: Urban & Schwarzenberg. Cited from Obwegeser, H.L. (1971). Surgical correction of maxillary deformities. (In: Gräbb, W.C., et al, eds. Cleft Lip and Palate. London, J & A Churchill Publisher. xxxiii+916p.)p.515.
204. Scott, J.H. (1953). The cartilage of the nasal septum. British Dent. J., 95:37.
205. Scott, J.H. (1955). The early development of oral cyst in man. British Dent. J., 98:109.
206. Searl, J.C. and Biggs, D.R. (1974). Surgically induced maxillary growth inhibition in rats. Cleft Palate J., 10:1.
207. Shibisaki, Y. and Ross, R.B. (1969). Facial growth in children with isolated cleft palate. Cleft Palate J., 6:290.
208. Sicher, H. (1966). Development of the face and oral cavity. Chapter 1. Orban's Oral Histology and Embryology. 6th ed. Saint Louis, C.V. Mosby. xii+416p. p.4.

209. Silla, M. (1970). Observations on the treatment of unilateral cleft lip and palate. *Cleft Palate J.*, 7: 465.
210. Skoog, T. (1965). The management of the bilateral cleft of the primary palate (lip and alveolus). Part II. Bone grafting. *Plastic & Reconstr. Surg.*, 35:140.
211. Skoog, T. (1965). The use of periosteal flaps in the repair of the primary palate. *Cleft Palate J.*, 2:332.
212. Skoog, T. (1967). The use of periosteum and Surgicel for bone formation in congenital clefts of the maxilla. *Scand. J. Plastic & Reconstr. Surg.*, 1:113.
213. Slaughter, W.B. and Brodie, A.B. (1949). Facial cleft and their management in view of recent research. *Plastic & Reconstr. Surg.*, 4:311.
214. Smiley, G.R. (1972). A possible genesis for cleft palate formation. *Plastic & Reconstr. Surg.*, 50:390.
215. Snodgrass, R.M. (1954). Heredity and cephalo-facial growth in cleft lip and/or cleft palate patients. *Cleft Palate Bull. Mongr.*, Supplement 1. Cited from Pinkerton, C.J., et al. (1966). Cephalometric studies of the mandible in individuals with clefts. Part I, a review. *Cleft Palate J.*, 3:258.
216. Stark, R.B. (1954). The pathogenesis of hare-lip and cleft palate. *Plastic & Reconstr. Surg.*, 13:20.
217. Stark, R.B. (1968). Anesthesia. Chapter 8. *Cleft Palate. A Multidiscipline Approach*. New York, Harper & Row Publisher. xi+339p. p.100.
218. Steiner, C.C. (1953). Cephalometric for you and me. *Am. J. Ortho.*, 39:129.
219. Stenstrom, S.J. and Thilander, B.L. (1963). Bone grafting in secondary cases of cleft lip and palate. *Plastic & Reconstr. Surg.*, 32:353.
220. Stenstrom, S.J. and Thilander, B.L. (1970). Effects of nasal septal cartilage resection on young guinea pigs. *Plastic & Reconstr. Surg.*, 45:160.

221. Stockli, P.W. (1973). Orthodontic planning and treatment in combination with secondary surgical procedures in cleft lip and palate. Trans European Orthodontic Soceity, p.564.
222. Subtelny, J.D. (1955). Width of the nasopharynx and related anatomic structures in normal and un-operated cleft palate children. Am. J. Ortho., 41:889.
223. Subtelny, J.D. (1961). Studies of the configuration of the nasopharynx and palatal segment in children with cleft as they related to embryonic studies. (In: Pruzansky, S., ed. Congenital Anomalies of the Face and Associated Structures. Springfield, Charles C. Thomas. x+385p.). p.3.
224. Swanson, L.T. (1955). A cephalometric evaluation of one hundred patients who have had cleft palate repair. Cleft Palate Bull., 5:8.
225. Tessier, P. (1967). Osteotomies totales de la face syndrome de Crouzon, syndrome d'Apert oxycephalies, scalpholocephalies, turricephalies. Annls. Chir. Plast., 12:273.
226. Tessier, P., Guiot, G., Rongerie, J., Delbet, J.D. and Pastoriza, J. (1967). Osteotomies cranio-naso orbito-faciales hypertelorism. Annls. Chir. Plast., 12:163.
227. Thompson, D.W. (1942). On growth and form. Cambridge, Cambridge Press. 2nd ed. Cited from Moorrees, C.F.A. and Lebert, L. The mesh diagram and cephalometrics. Angle Ortho., 32:214.
228. Tondury, G. (1961). On the mechanism of cleft formation. (In: Pruzansky, S. Congenital Anomalies of the Face and Associated Structures. Springfield, Charles C. Thomas. x+385p.). p.85.
229. Tong, W.Y. (1960). A roentgenographic appraisal of growth and function of the oro-facial structures of oeprated cleft palate children. M.S.D. thesis, Univ. Nebraska. Cited from Pinkerton, C.T., et al. (1966). Cephalometric studies of the mandible in individuals with clefts. Part I, a review. Cleft Palate J., 3:258.
230. Tweed, C.H. (1946). The Frankfort mandibular plane

angle in orthodontic diagnosis, classification, treatment planning and prognosis. Am. J. Ortho., 32:175.

231. Veau, V. (1931). Division palatine. Paris, Masson.
Cited from Berlin, A.J. (1971). Classification of cleft lip and palate. Chapter 4. (In: Grabb, W.C., et al, eds. Cleft Lip and Palate. London, J & A Churchill Publisher. xxxiii+916p.). p.66.
232. Walter, T. (1960). Some of the causes of effects of malocclusion. Dent. Pract., 10:139.
233. Wardill, W.E.M. (1928). Cleft Palate. British J. Surg., 16:127.
234. Wepner, Hollmann, H. (1975). Mid-face anthropometry on the cephalometric radiograph in cleft lip and palate cases. J. Max-fac. Surg., 3:188.
235. Worms, F.W., Isaacson, R.J. and Speidel, T.M. (1976). Surgical orthodontic treatment planning : profile analysis and mandibular surgery. Angle Ortho., 46:1.
236. Wylie, W.L. (1947). The assessment of antero-posterior dysplasia. Angle Ortho., 17:97.
237. Wylie, W.L. and Johnson, E.L. (1952). Rapid evaluation of facial dysplasia in the vertical plane. Angle Ortho., 22:3.
238. Zeiler, K.B., Weinstein, S. and Gibson, R.D. (1964). A study of the morphology and the time of closure of the palate in the albino rats. Arch. Oral Biol., 5:545.