CEPHALOMETRIC CHANGES IN ORTHODONTICALLY TREATED CLASS II, DIVISION 1 MALOCCLUSIONS WITH MAXILLARY FIRST AND MANDIBULAR SECOND PREMOLARS EXTRACTED

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INTRODUCTION

A review of the history of orthodontic therapy will show numerous methods and philosophies of orthodontic therapy, most of which have been effective when used by capable orthodontists. Many of these methods and philosophies have waxed and waned in favor. One example of this is the use of extractions in orthodontic treatment. Seventy years ago the suggestion of extracting a healthy tooth as an adjunct to orthodontic treatment was akin to blasphemy. As orthodontists reported on successful retreatment of patients, extracting in previously treated nonextraction cases, extraction became very much accepted as part of treatment.

Many combinations of teeth have been suggested as best choice for extraction: third, second, or first molars; second premolars; first premolars; second premolars and first or second molars; and first and second premolars; First premolar extractions are probably the combination of teeth most commonly chosen to be removed for orthodontic correction. Some clinicians, however, will choose to extract maxillary first and mandibular second premolars if the patient meets certain criteria.

The purpose of this study is to document cephalometric changes in a group of patients with Class II division 1 malocclusions who, as an adjunct of orthodontic treatment, have had their maxillary first and mandibular second premolars extracted. Changes occurring during and after treatment are analyzed and compared to an untreated Class II division 1 sample.

REVIEW OF THE LITERATURE

Orthodontic treatment has as one of its major goals the establishment of ideal occlusion and intercuspation with either an improved facial profile, or at worst, no deleterious change having been done to the profile.

During the past century many different analytic, diagnostic and treatment modalities have been proffered, used, and in many cases, rejected. Edward H. Angle[1] was one of the earliest and most forceful proponents of treatment to achieve not only an ideal occlusion but also improved facial aesthetics, stating, "Only in normal occlusion is their (teeth) greatest usefulness realized, and by intelligently directing our effort we can render plain or even distorted facial lines pleasingly symmetrical, or even beautiful, . . . but efforts may also result in producing or enhancing ugliness and deformity if unintelligently directed."

Malocclusion of the teeth, according to Angle,[2] was not as a result of heredity but was always associated with insufficient or perverted growth of bone and that to successfully move and retain teeth, bone must be grown so as to maintain that new position. He felt that by placing the crowns of the teeth into proper occlusion and then maintaining them in that position normal occlusion forces would then remodel or grow bone to properly support the teeth and thus improve facial balance, that nature's will would be expressed with the full complement of teeth.

Angle[1] did not have access to cephalometric equipment so diagnosis was based on study of plaster models of the dentition as well as study of the facial structure of the patient. Attention was given to "interpreting Nature's wishes and assisting her to carry out her original plan in the building of the denture. Treatment demands the removal of pernicious causes, the retention of the full complement of teeth and the compelling of their normal locking during or subsequent to their normal period of eruption."

In cases of Cl II molar relationship, the maxilla was thought to be in good position, the mandible being underdeveloped. The maxillary arch was aligned, then the mandibular arch aligned to it, either arch being expanded if necessary to accommodate all the teeth.

Contemporaries of Angle, although agreeing with the need to improve facial aesthetics, disagreed with many of his ideas on analysis and treatment. Case[3] had studied the laws governing development of plants and animals and the mixtures of dissimilar types and thus believed that malocclusions were at least partly the results of heredity and associated laws. Through patterns of inheritance, an individual could, in fact, inherit small jaw structure and large tooth material and in these cases extraction of certain teeth would be required so as to allow space to properly align the remaining teeth. He rejected Angle's concept of "growing new bone." Case gave three rules as a guide for extraction:

1. Never extract simply for ease of treatment.

2. Extract only in cases of severe protrusion producing decided facial deformities.
3. All teeth are required for final development of the jaws and features so in children extract only in cases of inherent protrusion that will ultimately mar the beauty of the face for life.

Applying these rules to patients in his own practice, Case extracted teeth in one out of 12 to 15 patients.

Cryer[4] rejected Angle's new bone growth and was more liberal than Case on the need for extraction, advocating extractions in some cases for easier treatment.

Angle and Case were contemporaries and differed mainly in their treatment philosophies as to indications and need for premolar extractions. Angle had the ability to gather the greatest number of influential followers and by the early 1920's, extraction was a word not to be uttered in polite orthodontic circles.[5]

Following a series of relapses subsequent to orthodontic treatment, orthodontists throughout the country began to reconsider the extraction ideas of Case and Cryer. Tweed and Grieve became perhaps the leading proponents of first premolar extractions in the permanent dentition. Grieve[6] rejected Angle's theory that in Cl II molar cases the mandibular teeth are distal to their normal position in t he body of the mandible and must be moved forward. He found that in the majority of cases where the mandibular teeth had been moved or tipped forward they would later tip back, relapsing and crowding the arch. In the majority of Cl II cases that he analyzed, he found that rather than the mandible being retrognathic as Angle had taught, the maxilla was in fact protrusive. He advocated extracting in both arches to give room for alignment without moving teeth off their normal base position.

Tweed[7] spent 17 years analyzing his treated patients, separating them into two groups: one termed successful with pleasing facial aesthetics, the other termed failures without pleasing balance and harmony of the face.

In studying the successes, he determined that their lower incisors were consistently upright over basal bone at an angle between 85 and 95 degrees. Those termed failures consistently had their lower incisors bodily forward of basal bone, proclined forward off basal bone, or both. To verify this he treated similar groups of bimaxillary protrusive patients.[8] One group retained a full complement of teeth and the cases were finished with the mandibular incisors either tipped or bodily displaced forward. Facial aesthetics were poor and relapse generally occurred.

The second group was treated with all four first premolars extracted. Aesthetics were excellent and there was no serious relapse. The third group was treated with their dentures left in bimaxillary protrusion. They exhibited poor aesthetics and serious relapse. They were retreated extracting four first premolars and their results were very similar to the second group.

In 1931 when Broadbent[9] reported the development of the cephalometer, orthodontists were given the means to study hard tissue landmarks within the skull of a living person. This enabled documentation of changes occurring in a skull whether from growth as a result of surgery, trauma, orthodontic treatment, or other causes.[10-22] Much of current orthodontic analysis, diagnosis and treatment planning is based upon distances, angles, and other relationships measured on cephalometric records of patients.

Tweed,[23] after reviewing cephalometric literature and records of his own treated patients including 26 patients that had been initially treated nonextraction then retreated with extraction of four first premolars, developed the Frankfurt/Mandibular Incisor Angle (FMIA) as optimum at 65 degrees.

From 95 samples of what he considered pleasing facial aesthetics, Tweed[24] found the mean of the measured FMIA to be 68.2 degrees. He then established 69 degrees as his preferred FMIA with a minimum of 65 degrees. Whenever the FMIA was less than 62 degrees, extraction was deemed necessary so as to enable the lower incisors to be retracted and uprighted to achieve the preferred FMIA. He stressed the importance of measuring this FMIA from a lateral cephalometric record rather than trying to estimate the angle directly in the mouth.

Downs[18] and Wylie, both contemporaries of Tweed, rejected the 69-degree optimum FMIA. Wylie,[25] in analyzing 29 of Tweed's cases, rejected the FMIA as the key to reducing soft tissue convexity showing an extremely low correlation of changes between FMIA and angle of convexity. He gave more credit to lingual movement of the incisal edge of the lower incisor and greatest correlation, $r = 0.44$, to the uprighting of the maxillary incisor with profile flattening. He also felt that mandibular growth was important in flattening the profile.

Holdaway,[26] in studying records of 37 of Tweed's patients, determined the greatest number of well-harmonized faces had an ANB angle of two degrees or slightly less, with the lower incisor 3 mm anterior to the NB line. Treatment to reduce the ANB angle to zero to two degrees was found to be most effective if implemented in growing individuals. The angle SNA exhibits greater change than does the angle SNB. If the ANB angle cannot be reduced to less than four degrees, he felt the lower incisor must be placed more labially than the desired 3 mm to NB line. He found also that reduction in the ANB angle is not possible in nongrowing individuals--females generally over 13 years old and males over 16.

The cephalometric x-ray procedure allowed orthodontists to evaluate hard-tissue landmarks and changes in these landmarks, and many treatment guidelines and procedures have been developed based on these hard-tissue points. Many researchers have worked with the cephalometric records of soft-tissue to develop guidelines and procedures similar to those for hard-tissue.[15,28-35] However, due to the compressibility and flexibility of soft tissue, it is difficult to get repeatable accurate measurements. Hillesund[32] found considerable inconsistency in some soft tissue points due to differing facial expressions. He found that horizontal registrations were mostly within ± 1 to 1.5 mm although each point varied in distribution pattern.

Rudee[33] found that the lower lip will retract an average of 1 mm for each 0.6 mm of lower incisor retraction and 1 mm for each 1 mm of upper incisor retraction. The upper lip will retract 1 mm for each 3 mm the upper incisor is retracted. Roose[34] found large variations in soft tissue changes with orthodontic tooth movement. In general, the upper lip thickens, the lower lip thins. The sulcus inferior retracts an average of 1 mm for each 2.2 mm of lower incisor retraction and 1 mm for each 8.9 mm of upper incisor retraction. Point B retracts 1 mm for each 2.25 mm the lower incisor is retracted.

Hershey[15] found that soft-tissue movement in nongrowing individuals exhibited a lower correlation to tooth movement than in growing individuals. Koch[28] found no change in lip profile during orthodontic treatment. In 30 cases of normal growth followed from age three months to 18 years, Subtelny[35] found that the chin, both bony and soft tissue, became placed more forward, the bony profile became less convex while the soft-tissue profile became more convex. The soft-tissue profile was (with the exception of the nose) relatively stable. The nose increases convexity, growing downward and forward.

To correlate orthodontic changes with the normal growth pattern, Holdaway[36] felt that with tissue of average thickness, the relation of mandibular incisors and the chin should be set in a definite relationship. The Holdaway ratio was developed in which the distance from the labial surface of the mandibular incisors to the line NB, and the distance from Pogonion to line NB should be in a 1:1 ratio with no more than 3, preferably 2 mm variation.

Hasund[13] derives a multiple regression equation for placement of the lower incisors based on the ANB angle, nasion line, mandibular line angle and the N-angle of Norderval. He rejects the placement of the lower incisor in relation to the bony chin, evaluating in relation to the sagittal and vertical configuration of the face.

Holdaway[37] has changed his evaluation from hard-tissue reference points to an analysis of soft-tissue landmarks. He states that 20% of those treated to the Holdaway ratio of hard-tissue points are left with poor facial balance. His analysis uses the H-angle (formed by the nasion/pogonion soft-tissue line and the H-line which is tangent to the upper lip and soft-tissue of the chin). With zero degrees hard-tissue convexity, the H-angle should be 10 degrees. For each degree of convexity, add one degree to the H-angle. For soft-tissue requirements, he drops a line perpendicular to the Frankfurt plane tangent to the upper lip. The superior sulcus should be preferably 3 mm but no less than 1 mm posterior to that line. From the H-line the superior sulcus should preferably be 5 mm but can vary 3 to 7 mm posterior to the line. The lower lip should be on or near to the H-line, from 1 mm posterior to 2 mm anterior to the line.

The first premolars have traditionally been the teeth of choice for extraction[3,4,6,7] although other choices have been advocated. Carey[38] would extract in cases of 2.5 to 5 mm arch length discrepancy. In the arch with less discrepancy, he advocated extraction of the second premolars. He felt the upper first premolar has a longer and slightly larger crown and is aesthetically more pleasing than is the second premolar. The lower first premolar is a poorer anatomic specimen than is the lower second. Thus he often advocated upper second and lower first premolar extractions. He stated that in cases of greater than 5 mm discrepancy the first premolars must be removed to allow greater distal cuspid movement. He would remove the first molars if they were of poor structure. If the discrepancy was about

2.5 mm and the patient was over 14 years old, he would remove second molars if they were of poor structure or even third molars before beginning treatment. If the lower second premolars were missing and there was lower anterior crowding, he would remove the deciduous second molars and close space. In these cases he most often would remove the upper second premolars also, especially if there were no maxillary crowding and did not want to retract the anteriors.

Dewel[39] reported on a case of moderate anterior crowding in which mandibular second premolars were extracted. He desired moderate arch length reduction, the mandibular incisors were reasonably well placed needing only minor uncrowding, and no lingual movement was desired. The first premolar acted as an anchor to effect mesial movement of the posterior segment.

Rushton[40] reported on the treatment of a Cl II, div 1 case with severe protrusion, no crowding in the anterior region, and minor deficiency in the middle portion of the lower arch. The upper first premolars were extracted for retraction space and lower second premolars to allow easier correction to a Cl I molar relationship and minor mid-arch crowding correction as the arch was leveled. This was accomplished without lingual movement of the lower anteriors.

Grossman[41] reported on 33 English patients eight to nine years after they had extractions for orthodontic treatment. They were originally Cl I or Cl II div 1 molar cases. The majority were treated with an upper removable appliance and nothing on the lower arch so space closure was primarily by tipping. In the maxilla of the first premolar extraction cases, 20% had extraction spaces still open. Of the second premolar extraction cases, none had spaces open but had more unsatisfactory contacts. In the mandible the first premolar extraction cases had more open contacts and the second premolar extraction cases had a higher percent of satisfactory contacts. The occlusion was better in those with mandibular first premolar extractions. Mandibular incisor crowding remained the same in both groups.

Nance[42] advocates upper first and lower second premolar extractions when the mandible has only slight irregularities but with some forward displacement of these teeth from their base, and the upper molars are in a forward or Cl II relation.

Others[43,44] elect upper first and lower second premolar under the following conditions: 2 to 5 mm crowding in the mandibular arch, lower incisors close to 65-degree FMIA, Holdaway ratio near the desired 1:1, and a satisfactory profile. In a nongrowing individual, the Cl II tendency has much influence in second premolar extraction. In a growing individual the FMIA and Holdaway ratio are given greater consideration than the Cl II tendency.

De Castro[45] advocates mandibular second premolar extraction because space closure is more rapid, there is little retraction of the anterior segment, depressing action on canines and incisors is limited, the mandibular canine width is easier to maintain, and moving the buccal segment forward tends to close the bite; but it is still easy to extrude the molars if it is so desired to open the bite.

MATERIALS AND METHODS

The material for this study consisted of 18 Class II division 1 malocclusions, six males and 12 females who in the course of orthodontic treatment had had extractions of their maxillary first and mandibular second premolars. These patients were selected from the private practice of Larry B. Kerr, Portland, Oregon. Selection criteria were: specified extractions, Cl II div 1 malocclusion, and debanded at least four years previously. Eighteen patients were available for recall and cephalometric records.

Radiographic records for each of the sample group consisted of three lateral cephalometric films: one before treatment taken at an average age of 12.6 years, s.d. 2.4; one at the end of treatment taken at an average age of 15.7 years, s.d. 2.0; and one at a mean age of 21.3 years, s.d. 2.3. The three stages of observation were referred to as "before," "final," and "after" records.

The untreated control group consisted of 12 individuals with Cl II, div 1 malocclusions followed to age 18. These records were not available so findings taken from a previous study[46] were used.

Tracings of the cephalometric films were performed according to an accepted standard technique. To establish a common reference for change, the Frankfort line was established on the beginning film and transferred to the final and after tracings by superimposing on the

SN line and copying Frankfort. The mandibular plane was established on the beginning record then transferred to the final and after tracings by superimposing mandible tracings on a "best fit" procedure after Steiner.[27] Angles were read to the nearest degree, linear measurement to the nearest 1.0 mm except in five instances when the landmark appeared to be exactly between mm markings in which cases the measurement was read to 0.5 mm. Routine statistical procedures were used.

To determine the combined error in tracing, landmark identification and measurement, 16 beginning films were retraced after a two-week interval. The standard error of the measure for the angle SNA was 0.66 degrees and for lower incisor/mandibular plane angle 1.19 degrees.

$$\text{S.E.Meas.} = \sqrt{\frac{\Sigma d^2}{2N}}$$

Treatment records were consulted to determine the total months of prescribed Kloehn headgear and Cl II elastic wear.

In addition to standard hard-tissue landmarks, the following soft-tissue points were recorded:

1. Nasion_{ST}: The deepest point of concavity of the soft tissue of the bridge of the nose. If no concavity existed, the intersection of the SN line with the soft-tissue profile.
2. Chin_{Po}: The most anterior point on the convexity of the soft tissue of the chin inferior to the inferior labial sulcus.
3. Upper lip (UL): The most anterior point on the convexity of the upper lip.

The Holdaway angle was measured as that angle formed by the intersection of the line joining Nasion_{ST} and Chin_{Po} and the line from UL tangent to the soft tissue of the chin.

FINDINGS AND DISCUSSION

The ANB and mandibular plane angles were the only measurements corresponding to those of the control group. Table I summarizes those comparisons.

Both angles decreased. The treated ANB angle decreased an average of 2.6 degrees more than did that of the control group and the mandibular plane angle of the treated group decreased an average of 0.6 degrees less than did that of the control group. These changes were "t" tested and found to be statistically significant.

Table II summarizes the changes occurring in the treated group during treatment as well as the overall changes from beginning to after treatment.

The facial angle exhibited no significant change during treatment but it did change significantly during the overall period. The six male subjects increased an average of two degrees with a range of -1 to +4 degrees. The females increased an average of 0.8 degrees with a range of -3 to +2 degrees. In the females the SNB angle decreased an average of 0.1 degrees overall while in the males, SNB increased an average of 1.3 degrees. The correlation of SNB to facial angle changes was $r = 0.60$ overall. The females showed no correlation at $r = 0.01$, while the male sample was relatively high at $r = 0.80$. In this sample change in facial angle in the males was attributed mainly to mandibular growth while in the females, to bony apposition at the chin.

Reduction of a skeletal Class II relation was apparent by the reduction of both the ANB angle and the angle of convexity (NAPo angle) which indicate a flattening of the hard tissue profile.

The Holdaway angle demonstrated a flattening of the soft tissue profile and this change correlated at a level of r = 0.56 with the change in angle of convexity.

In this study it was not feasible to check the reliability of soft tissue points since repeat films on the same patient would have been required. Consequently, the soft tissue measurements are subject to unknown error in this study. Hillesund,[32] however, claimed $\pm$1-1.5 mm variation on his soft tissue point location.

A Kloehn-type headgear was prescribed for each of these patients to be worn 14-16 hours daily for a mean wearing time of 28.1 months, s.d. 15.5. Class II elastics were prescribed for an average of 10.9 months, s.d. 7.6. There was no statistically significant tipping of the occlusal plane nor was there an increased mandibular plane angle. On the contrary, the mandibular plane angle exhibited a significant reduction although it did so significantly less than the control group. Wieslander's study[46] showed a slight increase in mandibular plane angle in those treated with a Kloehn headgear.

The lower incisor was uprighted nearly perpendicular to the mandibular plane and the labial surface of the crown moved more distally toward the NB line. The range of movement was 4 mm distally to 1 mm mesially. Uprighting the lower incisor accounted for much of the distal movement, with a correlation at r = 0.69 during treatment and r = 0.55 overall. The lower incisor was very stable relapsing less than 0.5 mm and 0.5 degree with a range of $\pm$ 1 mm and -3 to +4 degrees. The lower incisor had very little effect on the soft tissue profile of upper lip and upper face since the correlation of the overall change in the lower incisor position relative to the NB line and the change in the Holdaway angle was insignificant at r = 0.07.

SUMMARY AND CONCLUSION

In this study lateral cephalometric radiographs of 18 Class II division 1 patients, 12 females, six males, were taken at the beginning of treatment, after band removal, and at least four years after band removal. One linear and eight angular measurements were recorded from the tracing of each film. The overall change of two angles was statistically compared to those of an untreated control group and were found to be significantly different: the ANB angle decreasing more and the mandibular plane angle decreasing less than the same angles in the control group.

The changes within the sample group were analyzed. The soft tissue profile became much less convex as did the hard tissue profile. The hard tissue profile flattened due to a combination of apparent retraction of the "A" point on the maxilla and mandibular growth. The occlusal plane remained unchanged. The mandibular plane flattened slightly. The lower incisor was uprighted and slightly retracted.

If the records of the untreated control group had been available for study, a more comprehensive and meaningful comparison of growth versus treatment changes could have been made.

For a valid comparison of the changes occurring between groups treated with upper first and lower second premolar extractions and those with upper and lower first premolars extracted, another treated group would have to be selected. This second group would be selected from the records of an orthodontist who treats using upper and lower first premolar extractions. Beginning records would be analyzed and those which in another practice would have been treated with extraction of upper first and lower second premolars selected as the second treatment group. Analysis of the corresponding changes between these two groups, a valid comparison of treatment methodology, could be studied.

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TABLE I

A Comparison of Change in the Treated Group and Control Group

Beginning - After

Age	Beginning	After
Control	9	18
Sample	12.6	21-3

Changes in degrees	Treated N = 18		Control N = 12		
	$\bar{x}$	S.D.	$\bar{x}$	S	t
ANB	-3.1	2.2	-0.51	1.10	4.96**
Mandibular Plane	-1.7	2.6	-2.31	1.85	6.26**

**P = 0.01

TABLE II

Changes Within Treated Group

N = 18

Changes in Degrees or Millimeters	Beginning Measure		Beginning - Final			Beginning - After		
			Age	12-6	15-7	Age	12-6	21-3
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t
Facial Angle	81.4	8.9	0.2	1.4	0.66	1.1	1.7	2.69*
SNB	74.1	3.9	-0.1	1.4	0.33	0.1	1.9	0.25
ANB	6.8	3.2	-3.4	1.7	8.66**	-3.1	2.2	5.94**
Mandibular Plane	28.1	5.3	-0.4	2.9	0.65	-1.7	2.6	2.78*
Lower Incisor to Mandibular Plane	95.3	5.9	-4.0	6.3	2.70*	-3.8	6.2	2.61*
Occlusal Plane	7.9	3.9	-0.1	3.3	0.14	-0.6	4.4	0.54
Lower Incisor to NB line (mm)	5.8	2.1	-1.9	1.4	5.71**	-1.6	1.4	4.67**
NAPo Angle of Convexity	9.5	4.2	-8.1	3.4	9.94**	-7.8	4.0	8.20**
Holdaway Angle	19.2	4.9	-7.3	3.9	8.08**	-9.3	4.3	9.30**

*P = 0.05
**P = 0.01

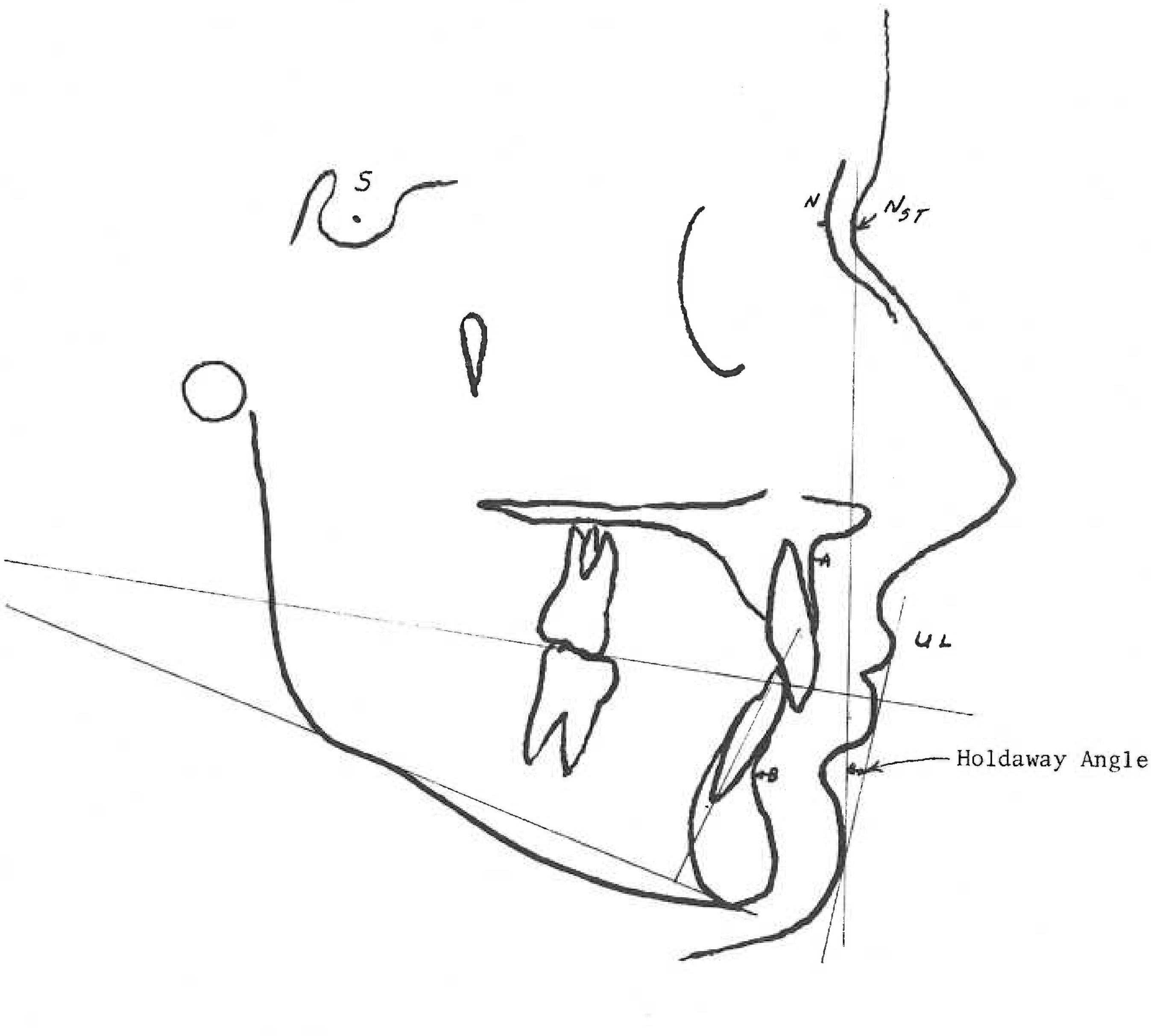

Figure 1