LIP PROFILE

A Cephalometric Soft-tissue Study.

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DEDICATION

To my wife Ida for her endless encouragement, support, assistance and patience and to the children Reza and Rosi

and

to the memory of my parents
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INTRODUCTION

The subject of facial esthetics is very important to the orthodontist. But more than this, it is a subject which concerns all people everywhere. The orthodontist influences dental appearance of the soft-tissue of the face, which is influenced only indirectly, and secondarily to tooth movement.

Specifically the parts of the soft-tissue or integumental profile are: the nose, the lips, the chin and the cheeks. If orthodontists are to consider soft-tissue in their planning, especially for children and adolescents, then the orthodontists must know what will happen to these structures as a consequence of continuing growth with or without orthodontic treatment. It has been demonstrated that the nose grows downward and forward. As the nose grows it brings the lip forward with it, (Subtelny, 1959).

The lips are really the middle part of the face. The upper lip shows growth away from the palate and the lower grows upward and forward from the mandibular base, (Subtelny, 1959).

The soft-tissue covering the mandible or the chin follows the dentoskeletal growth and comes forward accordingly. The soft-tissue of the maxilla does not follow the bony structure; as the bone becomes less convex, the tissue here grows thicker. Consequently, with general growth from birth
to maturity the face becomes more concave or less prominent/convex, (Bjork, 1951; Coben, 1955).

The combination of occlusal harmony and facial balance has been the goal of the orthodontist. In many instances the orthodontist recognizes that the retention of all teeth in a stable alignment for long periods is impossible. Thus the extraction of certain teeth becomes an acceptable compromise in orthodontic practice.

In evaluating the probable soft-tissue response to the removal of the teeth, one must bear in mind the possibility of excessive retraction of incisors, which appear to support the lips, when premolars are removed for the correction of arch-length discrepancies. Another reason may be that skeletal patterns and growth direction, either singly or in combination, lead to a recessive dentoalveolar area in relation to the nose and chin following growth and maturation.

However, there is still difference of opinion regarding which teeth are to be extracted to attain the occlusal harmony and facial balance at the same time.

Angle (1907), used the terms, balance, harmony, beauty and ugliness, but did not describe specifically about what happens to the face during treatment or how to correct the imbalance or inharmonious face. Wueurpel (1937), stated that faces can be beautiful eventhough they are not proportioned. The important factor
is balance. Balance means that one part of the pattern must not be overemphasized at the expense of another.

Before one can assess the extent of any "dishing in" change to the lip profile as a consequence of orthodontic treatment combined with extraction of teeth, it is necessary to have some means of quantifying such change. In addition, it is desirable to set some quantitative norms for lip profile which can be used as esthetic standards and which can serve as standard orthodontic objectives. It may be a fact that such orthodontic standards have been determined, such as Ricketts(1957), Holdaway(1963), Steiner(1953) and others. But, none of these standards has been derived from local Australian samples. Thus, this thesis is concerned with obtaining some local standards which can be compared with the "imported values".
PART I: LITERATURE REVIEW

CHAPTER I.

A DEVELOPMENT OF FACIAL ESTHETICS CONCEPT.

1.1. IN ANCIENT TIMES. (Quoted from Peck & Peck, 1970)

1. Prehistoric.

From reconstruction of archeological artefacts the cranio-facial characteristics showed a robust face, alveolar prognathism and well developed chin.

2. The Egyptian: 5000 years ago.

The statues depicted the Egyptian ideal of beauty, harmony and proportion. The statues of Egyptian kings showed very full lips and prominent lower face.

3. The Ancient Greek.

The male sculpture shows a prominent nose and a flat lip profile. The statue of the Greek lady also demonstrates a straight profile. The Grecian sculpture blossomed in the fourth and fifth centuries B.C. which has often been called the Golden Age of Greece.

These few examples of the art of various centuries, and what was then considered beautiful, have revealed different standards of facial proportion.
1.2. IN MODERN TIME.

As far back as 1835, John Hunter stated that the esthetic appearance of the mouth is the prime reason for orthodontic procedures, (quoted by Riedel, 1950).

Angle (1907), interested and concerned with esthetics was much taken with the importance of beauty were to be found in the face of Apollo, which he used a standard of beauty. Case (1921), wrote: "Orthodontics, the science, relates to the correction of malocclusion for the promotion of normal function, esthetic relations and the beautifying of facial outlines".

One of the major purposes of orthodontics is for helping facial esthetics, and since some of the elements of the soft-tissue profile are modifiable by the orthodontist (Bloom, 1961) it would seem important to know the amount of change that could be expected in soft-tissue profile as a consequence of orthodontic treatment.

1.3. THE SOURCE OF THE STUDY OF FACIAL ESTHETICS.

The source from which orthodontic concepts of facial esthetics have been derived are:

1. From paintings, drawings and ancient sculpture. In the early writing of Angle we note frequent references to the classic profile of Apollo.

2. Concepts of facial esthetics developed through the
tremendous influence of Grieve (1944) and Tweed (1943) are based upon accepting as pleasing or satisfactory a face in which the orthodontist visualizes a denture as stable and incisors in an uncrowded upright position.

3. Cephalometric angular and linear standards have been established from lateral headfilms by Downs (1948) and others such as Brodie (1946) and Wylie (1947).

1.4. THE METHODS OF THE STUDY OF FACIAL ESTHETICS.

According to Peck and Peck (1970), from 1937 to 1969, thirty five studies describing normal dentofacial, craniofacial or soft-tissue relationships have been published in American Orthodontic literature.

The judgements from their studies were based on different assessments such as: occlusion only, occlusion and face, face only, and judged by the orthodontist, the artist or by general public opinion.

Table 1: (from Peck and Peck, 1970)

THE BASIS OF SAMPLE SELECTION IN STUDIES* OF NORMAL FACIAL PATTERNS

<table>
<thead>
<tr>
<th>No Documented Sample: Isolated Cases and Opinions</th>
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1.4.1. Studies Based on Lay Judgement.

Peck and Peck (1970), used 52 people for their study. Each participant had been acclaimed previously as those qualities of facial esthetics which are the most pleasing. The sample included professional models, beauty contest winners, or performing stars noted for their facial attractiveness. These individuals were photographed and x-rayed in standard positions, and cephalometric measures were obtained from these records. They came to the conclusion that the general public admires a fuller, more protrusive dentofacial pattern than customary cephalometric standards would like to permit.

On the other hand Riedel (1957) found that the public's concept of acceptable facial esthetics are apparently in good agreement with the standards established by orthodontist on the basis of normal occlusion.

1.4.2. Sample of Study Chosen by Artists.

The samples consisted of those who possessed good or excellent faces as chosen from frontal and lateral photographs. Particular attention was centered on the profile. This method was used by Burstone (1958).

1.4.3. Sample of Study Judged by an Orthodontist, based on the occlusion and/or face only.

Merrifield (1966), used forty cephalometric roentgenograms from normal faces, and eighty cephalometric roentgenograms
taken at completion of treatment, obtained from Tweed and his own files. "Normal faces" are persons with whom he comes in contact appraised by him as having excellent facial harmony.

1.4.4. Mass-Media.

Television, motion pictures, newspapers and magazines all provide daily reinforcement for facial stereotypes as good-looking. Therefore, the mass media are very influential in unifying people's tastes. The impact of these media has been so widespread that individuals of varying ethnic and racial groups ordinarily would expect the "Hollywood standard" of facial excellence, (Burstone, 1958; Srisuk, 1982). Moreover, the "normal" term used by the orthodontist refers not to average of the "Best of the population", (Peck and Peck, 1970).

1.5. DETERMINATION OF THE FACIAL PROFILE.

Dentofacial relationship is analyzed or studied from the relationship of the component parts of the face. Angle (1907), developed the first system of classifying esthetics using the upper and lower first permanent molars. This is known as Angle's molar classification. He said: "As the dental apparatus is only a part of the great structure of the human body and each part and organ of which was fashioned according to the line of occlusion should be in harmony in form and position with, and in proper relation to
all other parts of the great structure, according to the inherited type of the individual. It is furthermore, a law so plain and so simple that all can understand and apply it. It is that the best balance, the best harmony, the best proportion of the mouth in its relation to other features requires that there shall be the full complement of the teeth, and that each tooth shall be made to occupy its normal position - "normal occlusion".

Since the Angle's classification is based only on dental relationship, therefore, it could not be used to transfer analysis from one to other relation of the skeletal or the soft tissue parts. Since the inception of radiographic cephalometric analysis, following the introduction of the clinical use of craniostat by Broadbent in 1931, many analyses have been produced to assist orthodontists in assessing skeletal, dental, soft tissue, even incorporating a growth prediction.

1.5.1. Dental Analyses.

Tweed(1954), believed that the diagnostic triangle concept was his most important contribution to clinical orthodontics. This was evolved over many years from observations of changes achieved in tooth positions, and in particular, lower incisor position, which according to Tweed gave rise to desirable facial esthetics. From an analysis of 100 non-orthodontically-treated patients selected for profile esthetics, Tweed found a mean value of the Frankfort plane-Mandibular-Incisors axis angle (FMIA) of 69
degrees.
In addition, many cases exhibited a compensatory relation between the mandibular Incisor-Mandibular (IMPA) and Frankfort-Mandibular plane Angle (FMA). These three angles form the "Tweed Triangle" which was presented as a diagnostic aid in order to position the lower incisor for optimal facial esthetic by attempting to achieve a PMIA in order of 65 degrees.

Steiner(1953), considered the position of the lower incisors in relation to the cephalometric Nasion-B line. The prognosticated lower incisor position, is individualized according to the patient's age, sex and growth pattern, although it is not clear how this should be achieved.

Downs(1956), first utilized a line drawn from A point to Pogonion (A-Pog), as a reference line to relate the lower incisor position antero-posteriorly. Recognizing the important influence of lower incisor position on the facial profile, Holdaway(1956) and Ricketts(1956) could not but be influenced by the wide spread interest in the lower incisor angulation at that time of their investigation.

Ricketts'(1960), studies of stable cases and consideration of esthetic lip relationships led him to advocate positioning the lower incisors at 22 degrees and at plus 1 mm, slight ahead of the A-Pog line as a clinical objective.

For Holdaway(1983), the parameters of particular interest in incisor position are the hard tissue convexity (A to N-Pog)
and the Holdaway angle (H angle), the angle between the H line and the soft tissue of facial plane. According to Holdaway the lower lip falls on the H line. The "H angle" is a measure of upper lip support and will be influenced by mechanical repositioning of upper incisors and the required lower incisor movement is determined from the appropriate upper incisor movement.

Williams(1969), found that the common cephalometric denominator for a harmonious soft tissue profile and lip balance is the position of the incisal edge of the lower incisor relative to the A-Pog line. Positioning too far forward of A-Pog line makes a protrusive lower lip, and too far backward makes a retrusive lower lip. To create well-balanced lips, the optimum position is on or near the A-Pog line.

Saxby and Freer(1985), considered that the angulation of the lower incisor does not necessarily reflect its anteroposterior spatial position. However, the linear distance of the lower incisor from the A-Pog line was highly correlated with some of the soft tissue variables. The angulation of the upper incisors was better correlated with soft tissue variables such as, morphology, thickness, than was the angulation of lower incisors.

1.5.2. Skeletal Analysis.

Downs(1948), classified facial types according to the degree
of retrusion or protrusion of the mandible. As this attribute of facial form is determined by a skeletal foundation, it would obviously be an advantage to classify skeletal pattern in a manner consistent with facial type as this is appraised by examination of the individuals or their photographs. So far, it has been found that this can best be accomplished by relating certain planes representing the skeletal pattern to the Frankfort horizontal plane.

The facial angle is an expression of the degree of retrusion or protrusion of the chin, and is determined by intersection of Nasion-Pogonion line with the Frankfort horizontal plane. The mean value was 87.8 degrees and the range was 82 degrees as a retrusive chin, to 95 degrees showing a protrusive chin. The angle of convexity, is a measure of the protrusion of the maxillary part of the face to the total profile. The angle is formed by the two lines, one from Nasion and the other from Pogonion, and both meeting at A point. The mean was 0 degree. If the point A fell posterior to the facial plane, the angle formed was read in minus degrees, and if anterior, in plus degrees. The range was found to be +10 degrees giving a convex profile, to -8.5 degrees giving a concave profile, while at 0 degree representing a straight profile.

In evaluating the relationship of the jaws, attention has been centered almost exclusively on the anteroposterior or horizontal relationships, or specifically, there seems to be
a tendency to forget the influence of the vertical relationships of the jaws on the facial profile. Some measures that may be of assistance in the evaluation of vertical relations are the proportional relationship of the upper facial height to the total facial height, the inclination or steepness of the mandibular plane and the freeway space. An upper facial height (Nasion-Anterior Nasal Spine) that is approximately 43% of the total facial height (Nasion-Menton) is fairly acceptable and this indicates a good vertical relationship of the facial skeletal profile. Brodie (1946) and Christie (1977) found the lower face height was 47%.

1.5.3. Soft Tissue Analysis.

1.5.3.1. Soft tissue profile changes due to growth.

Hellman (1927), stated that in its transition from infancy to senility the face goes through several stages of development, which once attained become characteristic for a certain period of life. These developmental stages are brought by increase in size, increase in complexity of structure and form.

Hellman (1932), showed sex differences, that the face of the female is relatively longer and that of the male is relatively broader and deeper, and that the female jaw bones and dental arches are relatively more prognathous than those of the male.

Krogman (1939), found that normal growth is continuous but
not uniform, there are spurts of activity. Furthermore, the growth of different parts in the same plane or the same part in different planes alternates in velocity and intensity.

Baum (1951), compared the skeletal pattern denture of 31 boys and 31 girls age between 11-14 years old. Comparison of the skeletal pattern of the male to that of the female in this group showed that angle of the convexity of the male was higher than that of the female. In a comparison of the denture patterns, there showed no significant differences. The angle of convexity can be shown to be significantly larger in the young group.

Bjork (1947), found that an increased prognathism of both jaws characteristic of profile changes with age and that the increase is greater in the mandible than in the maxilla.

Brodie (1953), stated that from the sample composed of cephalometric x-rays of 21 white males he found that the late stages of growth have been shown to be accompanied by a continuation of forward and downward movement of the Anterior Nasal Spine and of Pogonion, while the dental arch and its supporting bone tends to move more slowly and thus drop behind.

This decreases the prominence of the denture. At the same time, however, such behaviour is not necessarily accompanied by a more upright position of the position of the incisors. These teeth may become less prominent or may remain at the original axial inclination.
Downs (1956), gave evidence that in normal growth the lower face or mandible moves forward at a greater rate than the maxilla, thus increasing the facial angle from 82 degrees to 88 degrees and decreasing the angle of convexity from +10 degrees to 0 degree. Vertical growth is greater in the area of the ramus than at the profile, thus decreasing the mandibular plane angle from 28 degrees to 22 degrees. Furthermore, on sex differences he showed that females have minimum facial change in size or proportion after 14-15 years old. Males, on the other hand, consistently continue growth and development until twenty years old.

Stoner and Lindquist (1956), found that the soft tissue changes which occurred during treatment were:

1. a downward movement of the chin pad to about the same degree as the hard tissue,
2. a downward movement of the upper lip in the majority of cases.

The soft tissue improvements were produced by four principal changes:

1. a reduction in the prominence of the lips,
2. a reduction of the curl in the lower lip,
3. vertical opening at the chin,
4. some forward positioning of the chin.
Reidel (1964), concluded that the hard and soft tissue profiles of the face undergo alterations in size and proportions as a direct result of growth and development, as well as orthodontic treatment. Linear changes in prominence of the nose and chin are no less than those of lip relation which result from orthodontic movement of the incisor teeth, so that the resulting facial changes arise from both contributing factors.

Subtelny (1961), Chaconas and Bartroff (1975) showed that the convexity of the face decreases with increase in age, irrespective of the type of malocclusion present.

1.5.3.2. Soft tissue profile changes due to treatment.

Reidel (1957), considered that the soft-tissue profile is closely related to the skeletal and dental structures that comprise the bony profile.

Subtelny (1959), observed as well the tendency for the integumental chin to closely follow the degree of the prognathism of the underlying skeletal framework and that the same pattern of change was evident in both the skeletal and soft tissue measurement.

King (1960), stated that for each millimeter of distal movement of the incisors the prominence of the upper lip decreased by about 0.5 mm.

Branoff (1971), found from cephalometric evaluation of 30
orthodontically treated patients, that the changes in soft-tissue thickness and lip length were correlated with movement of hard structures during treatment.

Angelle (1973), found that there was a marked tendency for the upper lip to be retruded following the retraction of the upper anterior teeth.

Waldman (1982), found a significant correlation between retraction of the upper incisor and soft-tissue at labii superius. The lip retraction was 1.0 mm with an average retraction of incisor of 3.8 mm.

Lo (1982), found the mean ratio between retraction of upper incisor and change in labii superius was 2.5 to 1. That is for every 2.5 mm retraction of upper incisor, the labii superius will move by 1 mm in the same direction; and it is similar to what Roos (1977), found.

The previous review of literature relating the soft-tissue response to tooth movement indicated a strong correlation between movement of the two tissues system, during orthodontic treatment.

The following literature review represents contrary opinion from that just mentioned.

Negers' (1959) study indicated that a proportionate change or improvement of the soft-tissue profile does not necessarily accompany extensive dentition changes, and that, therefore, one can no longer rely entirely on a dentoskeletal analysis for accurate information on the soft-tissue facial profile
changes which have occurred during orthodontic treatment.

Burstone (1967), stated that no simple formula can be given for predicting the amount of lip displacement following retraction of the incisors.

Hershey (1972), from his 36 females sample, aged over 16 years, found that tooth movement may not always mean marked reduction of the profile contour and that the lip position is not highly correlated with incisor tooth movement. An attempt was made to localize the factors responsible for the lip not following the lingual movement of tooth, but it was an actual increase in the lip thickness or creation of a void between lip and tooth.
CHAPTER 2.

THE SIGNIFICANCE OF LIP PROFILE (L.P.).

2.1. Component parts recognized in Lip Profile outline are as follows:

1. Superior Labial Sulcus (SLS): The deepest point of the concavity between the upper lip and nose.

2. Labrale Superius (LS): The most anterior point on the convexity of the upper lip.

3. Labrale Inferius (LI): The most anterior point on the convexity of the lower lip.


Figure 1:
(From: Mink, 1969).

2.2. Esthetics.

Stricker, Clifford, Cohen, Giddon, Meskin, Evans (1979) claimed that concern for physical attractiveness begins early in childhood. In this context a number of orofacial
characteristic such as lips, chin, jaw and mouth were mentioned. Deviation of the tooth alignment, except in extreme malocclusions were ranked nearly at the bottom. Weakness of the orofacial musculature, flaccid lips, mentalis bulk, and a deep mentolabial crease were regarded, as being of the highest importance as unattractive attributes.

Simon (1923), wrote "It is well known that many patients, perhaps the majority, apply for the correction of their dental anomalies for none other than cosmetic reason" quoted by Wood, 1968.

Herzberg (1952), concluded that the majority of patients desire orthodontic service for two reasons: namely, the presence of facial disharmony or facial deformity and malalignment of the teeth, or both. Patients are little interested in the bony changes or the angulation of the teeth shown in a cephalometric radiograph. A patient is interested in seeing an important reduction in the protrusion of the lips, the cure or, in other words, improvement of the soft tissue profile. The effect of the need to appear physically attractive has spread from emphasis on cosmetics, clothing and jewelry to medicine and dentistry. Public demand has increased the scope of these professions to include the alteration of otherwise functionally normal but unattractive body features to make them esthetically more flattering. Faces are lifted, wrinkles are removed, teeth are crowned, straightened or
replaced, jaws are reshaped, noses are altered, fat removed, hair transplanted— all in the quest to appear physically more "attractive", (Jacobson,1984).
CHAPTER 3.

THE MORPHOLOGICAL BACKGROUND TO LIP PROFILE.

3.1. INTERNAL STRUCTURE.

One of the muscles of facial expression is the orbicularis oris. The orbicularis oris muscle is a muscle which can be divided into the pars peripheralis as a main part, and a smaller part, the pars marginalis. The fibres from right and left sides meet in the midline, literally the fibres run into the modiolus, (Lightoller, 1926).

The modiolus is the muscular mass formed lateral to the angle of the mouth by the meeting of muscles surrounding and directed towards the rima oris.
The pars peripheralis of the orbicularis oris forms the bulk of the muscle, thickest at the rima oris and extending as far as the septum, above, in the maxilla and the sulcus mentolabialis, below, in the mandible. The pars marginalis fibres lie in a plane anterior to the pars peripheralis. The pars marginalis takes origin in the deepest portion of the modiolus, adjacent to the mucous membrane and deep to the pars peripheralis. The muscles close and protrude the lips and shapes them during lip activity.

3.2. LIP PROFILE SUPPORT.

The lip profile is determined both by the underlying hard-tissues and the morphology of the lip itself,
(Burstone, 1959). Wisth (1974), showed that the position and morphology of the upper and lower lips are dependent on tooth position. However, there are variations in the findings on the amount of change in position of the upper lip relative to the corresponding changes in the incisor position.

Ricketts (1960), found that the upper lip follows the upper teeth in the ratio 1 to 3 in linear change while Wisth’s group with a large overjet showed the same ratio. However, the overjet group had a ratio of 1 to 2. Anderson (1973), found the ratio to be 1 to 1.5. It is logical that when the incisors are retracted the lip tonicity is decreased and the lip becomes thicker, both being related to the hard tissue change. Soft tissue change is not easy to measure and because of individual variations in lip morphology and tonicity, even when the incisor positions may be alike, the appearance and measurements can be different, (Koch, Gonzales, Witt, 1979). However, prediction of vertical changes of soft tissue has not been established widely compared to horizontal changes.

Jacobs (1978), from his study of 11 males and 9 females, treated orthodontically with extraction of four first premolars, found that closure of the interlabial gaps occurs predictably when correlated with both horizontal and vertical movement of the maxillary incisors. The interlabial gap closure vertically at a ratio of approximately 1 mm from every 2 mm of horizontal retraction of maxillary incisors if
neither extrusion nor intrusion occurs during the retraction administered.

3.3. POSITION OR POSTURE.

3.3.1. Competency.

The lip position or posture has usually been classified in two main types, the competent and incompetent lips, Jackson (1962).

3.3.1.1. The competent lip posture is that in which the lips form an anterior seal when the mandible is in a physiological rest position, without any active contraction of orofacial musculature.

3.3.1.2. The incompetent lip posture is that in which the lips do not form an anterior seal under the same conditions. According to a strict definition of incompetent lip postures, the lips when at rest may be as little as 1 mm or as much as 10 mm apart, (Jackson, 1962). He also stated that those lips which are kept apart by dental obstruction, but said to be adequate anatomically have been classified as "incompetent but potentially competent".

It is important to recognize that incompetent lips cannot be made competent by exercise; exercise does not lengthen muscles. However, as a child matures, he is more likely to keep his lips together by a subconscious muscular effort provided that the degree of incompetence is not too
great, (Houston, 1983).

Ingervall and Eliasson (1982), studied the effect of a simple lip exercise on incompetent lips. The subjects were twenty-five children, age range 9.2 - 13.4 years, 15 in the lip-training group and 10 in a control group. In the lip-training group the height of both lips increased significantly and the interlabial gap decreased, after following an exercise for 11 - 14 months. The thickness of the upper lip decreased and in most cases the lower lip covered the incisal edge of the upper incisor. In control group, no increase in lip height was found, but the interlabial gap and the thickness of the upper lip increased significantly.

Harrington and Breinholt (1963), also found that lip training can affect lip morphology.

Burstone (1967), defined the factors that govern lip incompetence, i.e.

a. differences of length of either or both lips;

b. variation in skeletal height in the anterior portion of the face.

Simpson (1976), from his electromyographic study of a group of 21 patients, 17 females and 4 males with incompetent lips found that lip incompetence measured electromyographically was related to horizontal but not vertical skeletal factor.

Backlund (1963), found that the degree of incompetence varies
directly with the lower face height, but lip length did not vary with face height.
The orthodontic importance of lip incompetence is that the lower lip plays a major role in controlling the upper incisor position. The lower lip should cover the incisal third of the labial surface of the upper incisors, (Subtelny, 1961); where this is not the case because the lips are habitually parted, the upper incisors may be proclined. Before reduction of an overjet it is necessary to assess whether the patient is likely to maintain a lip seal after treatment, if this does not happen the overjet will increase again after appliances are discarded.

Children with incompetent lips were found by Gustafsson and Ahlgren (1975) to have a greater anterior facial height, especially in the lower face, than children with competent lips. They also found that children with incompetent lips, swallowed and chewed with significantly more activity of the upper lip than children with competent lips.

3.3.2. Habitual Position.

The lips may be habitually parted where, for example, the patient breathes through his mouth due to nasal obstruction or where severely prominent upper incisors prevent the lips from coming together. But it must not be assumed that such an individual with parted lips is a mouth breather. In some cases where the lips are only mildly incompetent and there is a slight increase in overjet, the mandible will be habitually postured forwards so that a lip seal can be
obtained with less total muscular effort, (Houston, 1983).

3.4. LIP MORPHOLOGY RELATED TO ACTIVITY.

3.4.1. Activity.

Orton (1966) described lip activity as follows:

3.4.1.1. Speech:
During speech there is relatively little contact of the upper incisors by the lower lip, although separation may be small in the case of the labio-dental fricative sounds, "f" and "v", (Bashir and Schult, 1978).

3.4.1.2. Expressive behaviour, e.g. smiling and laughing:
During smiling the lower lip is contracted below the tips of the upper incisors.

3.4.1.3. Swallowing and Mastication.
During swallowing and mastication the inner surface of the lower lip can be seen flowing over the tip and the labial surface of the upper incisor. The path of movement is dependent on the path of closure of the mandible. The duration of the lip contact with the upper incisor is far longer during swallowing than in speech.

3.4.1.4. Habitual Resting Posture.
In habitual resting posture, the inner surface of the lower
lip covers the incisal third of the upper incisor, (Subtelny, 1961). In competent lips, the upper and lower lips will lightly touch and conversely in incompetent lips, there is an inter-labial gap. Only the last two, i.e. swallowing and the habitual resting posture of the lips, have the role in the control of the upper incisor by the lower lip.

Burstone (1967), stated that two postural position of the lips can be observed, the relaxed and the closed-lip position.

In the relaxed-lip position, the lips are relaxed, apart, and hanging loosely with no effort made at lip contraction.

In the closed lip-position, the lips are lightly touching in order to produce an anterior seal of the oral cavity. The closed-lip position is characterized by minimal contraction in the effort to effect this anterior closure.

In vertical dimension, in relaxed-lip position, there is normally a space between the upper and the lower lips, this space is called the inter-labial gap. The average is 1.8 mm in centric occlusion, and 3.7 mm in rest position of the mandible, with standard deviation 1.2 mm and 1.6 mm respectively, (Burstone, 1967).

Inadequacy of lip length relative to vertical dimension of the lower face is characterized by large interlabial gap, which is the "incompetent lip" state.

In contrast if the lips are long in relation to the vertical dimension of the lower part of the face, the lips are in
contact and become bulged forward away from the teeth.
It has been shown that the activity of the orbicularis oris
muscle reaches a minimum when the mandible is in the
habitual rest position, (Tulley, 1953).

According to Beresford, Clinch, Halden, Hovell, Kettle, Reitan,
Tulley and Walther (ed by Walther 1966, p154) normal resting
lip position is with lips in contact, the lower lip covering
the lower quarter to one-third of the crowns of the upper
incisor teeth.
3.5. LIP LENGTH.

According to Burstone (1967), if one wants to evaluate the relative length of the upper and lower lips, it is better to divide the lower face into two portions. The upper portion, representing the upper lip, is measured from subnasale (the deepest point of profile convexity between base of nose and upper lip) to stomion. The lower portion, is measured from stomion (the highest point on the upper lip) to gnathion (the lowest point on the chin).

Figure 2: (from Burstone, 1967)

Fig. 4. Vertical measurements of lip. Upper lip length (subnasale-stomion) and lower lip length (stomion-gnathion).
From his study it was found that the mean length of the upper lip was 23.8 mm for boys and 20.1 mm for girls, and the lower lip length was 49.9 mm for boys and 46.4 mm for girls.

Atherton (1964), investigated 3 groups of children.

Group I, with deep overbite, 23 children with competent lips and 7 children with incompetent lips.

Group II, with normal overbite, 13 children have competent lips and 17 have incompetent lips.

Group III, with anterior open bite, 3 children have competent lips and 27 have incompetent lips.

He found that there was no statistically significant difference between the lip length between groups at the 5% level using an analysis of variance. It seems that the lip length does not accommodate itself to the lower face height. Patient with deep bite and reduced lower face height have a characteristic a wrinkle above the chin, which is probably caused by accommodation of normal amount of lip to a small face height.

The length of the upper lip was measured from the base of the columella to the vermilion border and the lower lip from the vermilion border to the point of greatest convexity.
3.6. LIP THICKNESS.

Riedel (1957), from his study with the Seafair girls, found the soft-tissue thickness labial to the maxillary incisor to have a mean of 10.75 and range from 5 to 14.5 mm.

The soft-tissue thickness labial to the mandibular incisors was found to have a mean of 12.98 mm and a range from 10.5 mm to 16 mm.

Schwarz (1961), stated that the thickness of soft-tissue, is an essential requisite for determining the profile curve. The thickness of soft-tissue varies in areas of the profile. The thickness of the soft-tissue covering the lower face such as from subnasale to point A is 12 mm in children and 14-16 mm in adults.

The upper lip is 12 mm, the lower lip is 12 mm, the average chin cushion is 10 mm and the soft-tissue thickness at gnathion is 6 mm.

3.7. LIP GROWTH.

Vig (1979), investigated cephalometric lateral skull - radiographs at annual intervals from age of 3 or 4 years. Fifty persons who had been followed up to the age of 20 years were used in his study. He discovered that the mean increment was 4.5 mm for the upper lip and 9.9 mm for the lower lip (at 17, 18, 19 years).

It can be seen that the lower lip growth exceeds the upper. He demonstrated marked growth changes in the lip between ages of 9 and 11 years and there is a reduction in lip
separation. The age interval during which the most marked changes occur in lip separation is between 9 and 13 years.

Myofunctional therapists have claimed that the muscle exercises are able to improve deficiencies of lip tissue and lip seal. But Vig's study shows that such improvement might occur with growth.

Forsberg (1979), indicated in antero-posterior direction continued forward growth of the nose and retraction of the lips from 21-34 years of age in males and females. The sum of these changes has a definite effect on the soft-tissue profile.

Subtelny (1959), showed that lip growth, both upper and lower is continuous to about the age of eighteen years for boys and girls. He also demonstrated there is a definite thickening of the upper lip in vermilion portion, slightly greater in boys than girls.

Mamandras (1984), in his longitudinal study on growth of the lips from 8-18 years of age, indicated that the lip area is increasing in size with advancement of age. During this period the most marked increase occurred between the ages of 12 and 14 years. The mean percentage increase of the maxillary and mandibular lip areas from 8-18 years was 59.0 and 57.9 for the males and 27.1 and 39.7 for the females.

3.8. LIP POSITION AND INCISOR RELATIONSHIP.

It has been noticed that competent and incompetent lips of
varying degree of severity can be associated with any type of incisor relationship, whether it is Class I, Class II division 1, or Class II division 2 malocclusion, (Jackson, 1962).

In normal occlusion or in a malocclusion of a local nature, the lower lip will be found to rise above the level of the incisal margins of the maxillary central incisors to a height of 3-7 mm. The height of lower lip in actual contact with the labial surfaces of the central incisors is less than this. The actual amount of lower lip in contact with the upper incisors will depend on the shape of the inner surface, both in convexity and in the shape of the junction of the upper and lower lip, the lip line, (Nicol, 1955).

There is an association between incisal overbite and lip position. As the overbite increases there is less coverage of the upper central incisor teeth by the upper lip and a greater coverage by the lower lip. Although the degree of overbite does not influence the number of competent or incompetent lip postures. There was no sex difference in the distribution of lip position, (Jackson, 1962).
3.9. COMPARISON STUDY BASED ON DIFFERENT RACIAL BACKGROUND.

3.9.1. Comparison of Cephalofacial Relationship of Different Races.

3.9.1.1. Downs (1956) compared measurements of 4 different ethnical background done by graduate students at different universities, based on normal occlusion of the following groups:

1. Cotton (1951), University of California, 20 Negros age 11-24 years.


3. Wong (1950), University of California, 20 American-born Chinese, age 11-16 years.

4. Craven (1952), University of Illinois, 20 Australian aboriginies exact age unknown, but thought to be teenage and young adults.

The first three were divided equally as to sex, the Australian were unknown sex. All cases were selected on the basis of excellent occlusion and good physiological facial harmony. The finding showed differences in patterns which are significant. The important difference appears in the greater facial convexity.
As all of the material in these studies was selected and checked by a group of professionals, Downs concluded that prognathism and dental protrusion are normal patterns for each ethnic group.

3.9.1.2. Altemus (1960) using Downs, Steiner analysis, compared Takano's, Wong's, Cotton's, Howard, Down's sample and came to a conclusion that the skeletal patterns, in profile, of the Negro and Caucasian seem to be similar. The differences in the craniofaciodental complex between Negroes, Caucasian and other racial groups have been pointed out and analysis of these differences seems to indicate that norms and standards of one racial group can not be used without modification for another racial group.

3.9.2. Comparison of Integumental Relationship of Different Races.

Altemus'(1963), study compared the soft tissue mass of the profile of two groups of:

1. 37 North American Caucasian Children, 11 males and 26 females aged 13.4-15.6 years.

2. 50 North American Negro-children, 25 males and 25 females, aged 12-16 years. Both have acceptable facial form, the North American Negro children had normal occlusion as well.
The rontgenograms were traced, and measurements were made from the soft tissue to adjacent hard tissue using the nasal floor plane as reference plane.

Findings (in millimeters):

<table>
<thead>
<tr>
<th>Integumental</th>
<th>males</th>
<th>females</th>
</tr>
</thead>
<tbody>
<tr>
<td>thickness</td>
<td>Burstone - Howard</td>
<td>Burstone - Howard</td>
</tr>
<tr>
<td>at</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subnasale</td>
<td>18.7±2.33 16.3±2.10 16.9±1.45</td>
<td>19.6±1.73</td>
</tr>
<tr>
<td>Sup.labial sulcus</td>
<td>16.2±1.61 17.8±2.49 14.7±1.88</td>
<td>16.5±2.11</td>
</tr>
<tr>
<td>Labrale superius</td>
<td>15.5±1.88 16.4±3.04 12.1±1.83</td>
<td>14.2±2.43</td>
</tr>
<tr>
<td>Labrale inferius</td>
<td>16.1±1.54 17.1±2.57 13.4±1.29</td>
<td>14.5±1.97</td>
</tr>
<tr>
<td>Inf.Labial sulcus</td>
<td>12.9±2.20 15.1±3.11 11.6±1.31</td>
<td>13.0±1.01</td>
</tr>
<tr>
<td>Menton</td>
<td>12.8±2.19 12.7±3.67 12.2±1.85</td>
<td>12.6±2.77</td>
</tr>
</tbody>
</table>
The table shows that the means for the Howard group were larger except for subnasale. The Howard group besides having acceptable facial also had normal occlusion. However, this group has shown a protrusiveness of hard and soft tissues to be normal when compared with a standard prepared for North American Caucasian children. Their protrusiveness is acceptable and does not require reduction as a criterion for successful orthodontic treatment.

3.10. METHODS OF SOFT-TISSUE MEASUREMENTS.

In considering soft tissue, a number of approaches are possible. Methods of measuring superficial facial contour and establishment of standard. The standards derived from these methods will be reviewed and compared with the author's methods and findings.


The study used 2 groups of sample which possessed good or excellent facial profile, which were selected from photographs and judged by a panel of artists. The criteria for selection were, caucasian race, age and facial form. The younger sample consisted of 11 males and 26 females, age ranged from 13.4 to 15.6. This includes an age range at which orthodontic treatment is terminated in many instances.
The young adult sample comprised of 15 males and 25 females ranged from 16.5 to 36.3 years. This group included the post retention period. Since the soft tissue of the face is quite irregular and variable and does not readily suggest a plane of reference within the soft-tissue itself, therefore skeletal landmarks were utilized. The reference plane used by Burstone was Nasal floor.

Some of the landmarks he used which were relevant to the author's study were:

1. Superior labial sulcus: The deepest point on the upper lip as determined by a horizontal (parallel to nasal floor) line drawn from subnasale to a vertical tangent to the deepest part of the sulcus profile.

2. Labrale superius: The most prominent point on the upper lip as measured from a perpendicular tangent to nasal floor.

3. Labrale inferius: The most prominent point on the lower lip as determined by a perpendicular tangent from nasal floor.

4. Inferior labial sulcus: The most concave point as measured by a line tangent to menton and labrale inferius.
The values of acceptable profiles in millimeters:

<table>
<thead>
<tr>
<th>Extension</th>
<th>males</th>
<th>females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior labial sulcus</td>
<td>16.2±1.61</td>
<td>14.7±1.88</td>
</tr>
<tr>
<td>Labrale superius</td>
<td>15.5±1.88</td>
<td>12.1±1.83</td>
</tr>
<tr>
<td>Labrale inferius</td>
<td>16.1±1.54</td>
<td>13.4±1.29</td>
</tr>
<tr>
<td>Inferior labial sulcus</td>
<td>12.9±2.2</td>
<td>11.6±1.31</td>
</tr>
</tbody>
</table>

According to Burstone (1959), since these measurements do not exactly reflect "thickness" and "length" he used the term horizontal and vertical extension. The soft tissue mass of all area from subnasale to menton are thicker in the males, especially horizontal values in the upper lip.

The study was comprised of 14 girls and boys, age 11 years, selected in part from the contest in a Smile Contest in Indianapolis.

The criteria were as follows:

1. The first permanent molars and central incisors had to be erupted,

2. A class I relationship of the primary cuspid,

3. Well positioned anterior teeth,

4. A maximum of 40% overbite.

3.10.2.1. Lip length:
The upperlip was measured from subnasale to a line parallel to the nasal floor and that passed through the lowest point of the lip profile. The lower lip was measured from the highest point of the lip-profile to soft-tissue gnathion. The interlabial gap was measured while the lips were in rest-position.

3.10.2.2. Lip Thickness:
The maxillary lip thickness was measured at two places:

a. From subnasale to a line perpendicular to the nasal floor through the bony subspinale.

b. From labrale superius to line perpendicular to the nasal floor through incision superius.
The mandibular lip thickness was measured from:

a. Labrale inferius to a line perpendicular to the nasal floor through incision inferius and,

b. From menton to a line perpendicular to the nasal floor through supramentale.

Figure 5:
(From: Mink, 1963).

His findings were:


<table>
<thead>
<tr>
<th></th>
<th>boys</th>
<th>girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper lip</td>
<td>19.8±1.5</td>
<td>23.8±1.5</td>
</tr>
<tr>
<td>Lower lip</td>
<td>41.3±2.4</td>
<td>49.9±4.5</td>
</tr>
<tr>
<td>Upper lip</td>
<td>18.7±2.4</td>
<td>20.1±1.9</td>
</tr>
<tr>
<td>Lower lip</td>
<td>40.1±2.4</td>
<td>46.4±3.4</td>
</tr>
</tbody>
</table>

mixed dentition
mixed dentition and adolescent
2. Lip thickness, (in millimeter).

<table>
<thead>
<tr>
<th></th>
<th>boys</th>
<th>girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subnasale</td>
<td>14.8±2.4</td>
<td>13.5±1.7</td>
</tr>
<tr>
<td>Upperlip</td>
<td>15.1±1.3</td>
<td>12.2±1.2</td>
</tr>
<tr>
<td>Lowerlip</td>
<td>15.3±1.0</td>
<td>13.3±1.2</td>
</tr>
<tr>
<td>Pogonion</td>
<td>12.1±2.0</td>
<td>10.5±1.5</td>
</tr>
</tbody>
</table>

Subnasal 14.8±2.4 18.6±2.6
Upperlip 15.1±1.3 16.1±2.2
Lowerlip 15.3±1.6 16.9±1.6
Pogonion 12.1±2.0 13.4±3.0

3.10.3. Vig's (1979) Study.

Vig studied the lip growth from serial radiographs records of untreated subjects. Cephalometric radiographs were taken at annual intervals from age 3-4 years and had been followed up to the age of 20 years. The subjects were residing in London area. The upper and lower lip height/length were recorded as the lengths of perpendicul ars from the maxillary and mandibular planes to the crest of upper and lower lips.
Lip height

at 13 yrs age  24.68±2.77  43.54±4.41
14 yrs age    25.52±2.97  44.56±4.88
15 yrs age    25.92±3.98  44.07±4.23
16 yrs age    26.64±3.05  45.06±3.26

Figure 6:
(from Vig, 1979).

3.10.4. Cox and Van der Linden's (1971) Study.

They studied facial harmony using 72 lateral rontgenograph which divided into 4 groups as follows:

1. Group M+ 18 males with the best facial harmony.
2. Group M− 18 males with the poorest facial harmony.
3. Group F+ 18 females with the best facial harmony.
4. Group F− 18 females with the poorest facial harmony.
The bony and soft tissue landmarks which they used for their study are shown on the figure below. The coordinates of each landmark were established in relation to the Y axis (facial plane or N - Pog) and X axis from Nasion perpendicular to Y axis.

Figure 7:
(From Cox and v.d.Linden, 1971).

Some of the values which have relation with lip profile were cited,(in millimeters).

Lip thickness

<table>
<thead>
<tr>
<th>at:</th>
<th>M+</th>
<th>M-</th>
<th>F+</th>
<th>F-</th>
</tr>
</thead>
<tbody>
<tr>
<td>a to Y axis</td>
<td>16.1+1.7</td>
<td>18.7+3.3</td>
<td>14.6+2.6</td>
<td>16.9+3.3</td>
</tr>
<tr>
<td>LS to Y axis</td>
<td>19.4+2.3</td>
<td>22.7+3.7</td>
<td>17.3+2.6</td>
<td>16.9+3.6</td>
</tr>
<tr>
<td>St to Y axis</td>
<td>11.5+2.5</td>
<td>14.6+3.7</td>
<td>10.4+2.4</td>
<td>12.8+3.4</td>
</tr>
<tr>
<td>Li to Y axis</td>
<td>16.2+2.6</td>
<td>19.2+4.4</td>
<td>15.4+2.2</td>
<td>17.7+3.3</td>
</tr>
<tr>
<td>b to Y axis</td>
<td>7.5+1.9</td>
<td>9.6+2.3</td>
<td>8.0+1.4</td>
<td>9.6+2.4</td>
</tr>
</tbody>
</table>
It can be concluded that in both sexes from the analysis of the soft-tissue and skeletal measurements of the lateral head films that persons with poor facial balance have more convex faces. A number of faces with good facial harmony were found to be associated with malocclusion.

3.10.5. Hillesund, Pjeld and Zachrisson’s (1978) Study.

They studied reliability of soft-tissue profile. They used 2 group of samples.

First group, termed as an overjet group, consisted of 16 males and 19 females, age 9 to 14 years, with criteria overjet at least 8 mm.

The second group, termed as normal group consisted of 15 males and 17 females, age 10 to 14 years, the criteria for this group was having normal incisor relationship (overjet and overbite between 1-3 mm). All children were of Norwegian origin.

They were called in twice and each time, two different cephalograms were taken. The first radiograph was taken with the teeth in centric occlusion and the lip in light contact, and the second was taken with the teeth in occlusion and the lips relaxed.

All registration were made according to x and y coordinate system. A y axis was drawn from N to Pog (facial plane) and x axis was established from the incisal edge of upper
incisor perpendicular to the hard tissue facial plane (N-Pog).

Eight reference points of soft-tissue profile were registered, shown on the figure, some which have relevance with the author's study quoted:

All measurements were from soft-tissue profile point to their hard-tissue analogues.

A-points-(TLS): lip thickness at sulcus superior.

Upper lip (TLS): lip thickness at labrale superius.

Lower lip (TLI): lip thickness at labrale inferius.

B-point (TSM): lip thickness at sulcus inferior.

Figure 8:
(From Hillesund et al, 1978.)
The values of the lip thickness for the normal group were:

Lip thickness (in millimeters),

<table>
<thead>
<tr>
<th>at</th>
<th>Closed lips</th>
<th>Relaxed lips</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Point</td>
<td>14.4 ± 1.4</td>
<td>14.6 ± 1.5</td>
</tr>
<tr>
<td>Upper lip</td>
<td>13.0 ± 1.6</td>
<td>14.0 ± 1.9</td>
</tr>
<tr>
<td>Lower lip</td>
<td>13.4 ± 1.9</td>
<td>14.9 ± 2.1</td>
</tr>
<tr>
<td>B point</td>
<td>10.7 ± 1.0</td>
<td>10.5 ± 1.0</td>
</tr>
</tbody>
</table>

The interlabial gap in the relaxed position in the normal group was 1.0 ± 1.4 mm and for the overjet group was 5.0 ± 2.2 mm.
PART II: ORIGINAL WORK.

CHAPTER IV.

4.1. STATEMENT OF OBJECTIVE.

In order to define what the average class I malocclusion lip profile looks like as the aim of the study, 37 Cephalometric radiographs of class I malocclusion were measured to determine statistical parameters for measureable components of lip profile among a local (Sydney) adolescent population.

Subjects with malocclusion were selected according to criteria recorded below (4.2.1.1), because the rigorously pursued requirements for human ethical review in research no longer permit use of x-rays merely for research purposes. For this reason, cephalometric study using 'normal control' samples can no longer be ethically justified, (Godfrey, 1986).

4.2. MATERIALS:

4.2.1. The Nature of Sample Cephalometric Radiographs.

4.2.1.1. Records available:

The lateral cephalometric radiographs used in the present study were collected from the Orthodontic Department of The United Dental Hospital.

4.2.1.2. Cephalograph exposure:

The cephalographs were taken on a Siemens Orthopantomograph.
5 apparatus.
The time exposure was at average 1.2 second with an apparatus setting of 70 KV and 15 mA.
The focus to film distance was 5 feet (152.5 cm) and the distance from the midsagittal plane to the film was at average 15 cm. This gives a linear enlargement of 9%, which was not corrected in the study. An aluminium wedge was placed between the soft tissue parts of the profile and the film in order to give an optimal x-ray film exposure of soft tissue contour. All cephalograms were taken with the teeth in occlusion, with the lips in a relaxed position, primarily by diverting each subject's focus of attention away from both the lips and the requirement of relaxation.

4.2.1.3.Selection criteria of the sample:
The following selection criteria were considered to be sufficiently definitive to be employed as "quasi-normal" according to accepted clinically accepted norms.

Sample selection was based on the cephalometric radiograph having the following criteria.

- Skeletal:

1. Class I skeletal, with ANB angle range 2 – 4 degrees.

2. Wits appraisal range from -3 mm to + 3.5 mm.

- Dental:

1. Class I molar relationship.
2. Class I Incisor relationship.

3. Upper incisor to lower incisor angle minimum 120 degrees.

- Lips:

1. Maximum interlabial gaps 4 mm.

4.2.1.4. Subjects.

The subjects selected for the sample were male and female patients at The Department of Orthodontics of The United Dental Hospital.

At first, sixty pretreatment cephalometric radiographs were selected, traced and examined by the author. These cephalometric radiographs were scrutinized and 23 subjects were discarded as being unsuitable for the study. Finally, the remainder 37 subjects were used in the study.

The subjects were comprised of 22 females and 15 males, age between 10.8 years and 17.4 years, with the average age was 13.8 years.

4.2.2. Study Rationale.

Inability to obtain records for a "normal" or "acceptable" group because of ethical limitation in use of x-ray to establish a lip profile standard.

Riedel (1957) demonstrated that "pleasing" soft tissue profiles matched with good bony profiles, i.e. those bony
profiles with small (normal) skeletal differences between angles SNA and SNB.

In Cox and Van der Linden's (1971) study, a remarkable agreement was found among and between the subjective selections of the two groups of judges. An objective cephalometric analysis revealed that persons considered to have poor facial balance generally had more convex faces. Peck and Peck (1970), evaluated standardized orthodontic records of two popular black celebrities. Their analysis showed that neither women exhibited the anthropologic characteristic of her race but, instead, had many Caucasian like features.

By choosing the samples under such criteria mentioned previously, hopefully the samples could fulfill or nearly represent as a "normal" group or "acceptable" group. The subject consists of mixed ethinical background but predominantly Caucasian.

The ANB angle, the "Wits" appraisal and the interlabial figures used for the criteria in the study were chosen by the author as closest as possible to the normal standard, but still within the normal limits. The molar and incisors relationship were also in Class I Angle.

Although the subjects were selected from the pretreatment orthodontic patients they were all judged as Class I skeletal and dental malocclusion. These criteria are in accord with the aim of study that is to define the average
class I malocclusion lip profile.

4.3. METHOD OF ASSESSMENT OF LIP PROFILE.

4.3.1. Cephalometric Tracing.

All radiographs were traced on "Unitek" acetate tracing paper, size 8"x10".
A 2H Lead pencil was used for tracing; the tracing was carried out on the transluminating tracing table.

4.3.2. Measurements:

Both angular and linear measurements were made of the tracings from the radiographs. Both hard tissue angular and linear measurements were measured to the nearest 0.5 degree and to the nearest 0.5 mm respectively, except for the lip profile area measurements were measured to 0.10 mm with a Helios sliding caliper.

4.3.3. Measurement Check:

Each radiograph was traced and measured twice within 2 months interval. The first and second measurements were tabulated. The mean differences and the standard deviations of each measurements were calculated. Student "t" test were calculated and a "t" table used to determine the significance of the differences between the two tracings as a test of measurement reliability.

The difference counted as significant as the P value was equal or less than 0.05.
4.3.4. Method of Measurements Used in the Study.

The A-P plane:

1. The distance of upper incisor to A-P plane, is measured from the upper incisal edge perpendicular to the A-P plane. (As employed in University of Sydney, Orthodontic analysis).

2. The distance of lower incisor to A-P plane, is measured from lower incisal edge perpendicular to A-P plane. The A-P plane is established from point A to point Pogonion, Williams(1969) measured only the lower incisor.


Wits appraisal, is the distance measured from the projection of point A and point B to the occlusal plane.

If the projection of point A fell distal to the projection of point B the reading was negative.

When the projection of point A fell mesial to the projection of point B the reading was positive.

4. Point A to N-Pog distant, (Holdaway, 1983).

The distance is achieved by measuring from point A perpendicular to line N-Pog.


The H angle is established by connecting from the most anterior of the upper lip to soft tissue pogonion and crosses the soft tissue profile line.

The soft tissue line is constructed by connecting soft tissue Nasion to soft tissue pogonion.
The "E" plane, (Ricketts, 1957):

The distance of upper lip and lower lip to "E" plane. The Ricketts "E" plane was established by connecting a line from the most prominent part of the chin to the nose.

6. The upper lip distance to E plane was measured from the most protruding point of the upper lip perpendicular to E plane.

7. The lower lip distance to E plane was measured from the most protruding point of the lower lip perpendicular to E plane. Ricketts measured only the lower lip to E plane.

Lip part measurements:

Since the measurement of the lip parts following the Hillesund et al (1978) method, therefore, all vertical and horizontal lip measurement in the study were measured to the x and y coordinates.

The y axis is established from point A to point Pog. The axis is established from the lowest tip of the upper incisor perpendicular to y axis, Hillesund et al, 1978).

8. The upper lip height was measured between the perpendicular projections onto this y axis of sulcus superior and the lowest part of the upper lip.

9. The lower lip height was measured between the perpendicular projection onto the y axis of sulcus inferior and the highest point of the lower lip.
The author used different way to measure the lower lip height, because the author wanted to exclude the chin part that some other investigators included to their measurement and in order to use the same soft tissue points sulcus superior and sulcus inferior.

Lip thickness at:

10. Sulcus superior was measured from the most concave point between the upper lip and the base of the nose perpendicular to y axis.

11. Labrale superius was measured from the most anterior point on the convexity of the upper lip perpendicular to y axis.

12. Labrale inferius was measured from the most anterior point on the convexity of the lower lip perpendicular to y axis.

13. Sulcus inferius was measured from the most concave point between the lower lip and the chin.
Figure 9  Cephalometric measurements

FH plane

occl plane

E plane

AP plane
Figure 10  Lip part measurements

All measurements were from soft-tissue profile point to their hard-tissue analogues.
CHAPTER 5
RESULT AND DISCUSSION

5.1. RESULT.

1. Reliability test.

From all thirteen measurements of the first and the second tracing were found as not statistically significant. Therefore, either the first or the second measurement can be used. The first measurement was used for this study. The result of the reliability test are shown on Table 1.

2. The result of the thirteen measurements of this study shown on the Table 2.

3. The correlation of A to N-Pog and the H angle is shown on Table 3.

4. Comparison of other studies to present study is recorded in Table 4 and will be discussed subsequently.
Table 2
Result of tests for reliability of measurement of 37 subjects

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mean</th>
<th>SD</th>
<th>t value</th>
<th>P value</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 U L - AP</td>
<td>0.0811</td>
<td>0.5591</td>
<td>0.6823</td>
<td>0.4</td>
<td>N.S.</td>
</tr>
<tr>
<td>2 L L - AP</td>
<td>0.0810</td>
<td>0.6719</td>
<td>0.7341</td>
<td>0.5</td>
<td>N.S.</td>
</tr>
<tr>
<td>3 Wits</td>
<td>0.2432</td>
<td>1.5393</td>
<td>0.9610</td>
<td>0.2</td>
<td>N.S.</td>
</tr>
<tr>
<td>4 A - NPog</td>
<td>0</td>
<td>0.6236</td>
<td>0</td>
<td>-</td>
<td>N.S.</td>
</tr>
<tr>
<td>5 H angle</td>
<td>0.0945</td>
<td>1.0661</td>
<td>0.5391</td>
<td>0.5</td>
<td>N.S.</td>
</tr>
<tr>
<td>6 U L - E pl</td>
<td>0.1081</td>
<td>1.4392</td>
<td>0.4568</td>
<td>0.5</td>
<td>N.S.</td>
</tr>
<tr>
<td>7 L L - E pl</td>
<td>0.0810</td>
<td>0.5834</td>
<td>0.8455</td>
<td>0.4</td>
<td>N.S.</td>
</tr>
<tr>
<td>8 U L height</td>
<td>0.1540</td>
<td>0.7030</td>
<td>1.3324</td>
<td>0.5</td>
<td>N.S.</td>
</tr>
<tr>
<td>9 L L height</td>
<td>0.2972</td>
<td>1.7759</td>
<td>0.1079</td>
<td>0.2</td>
<td>N.S.</td>
</tr>
<tr>
<td>10 S S</td>
<td>0</td>
<td>0.6940</td>
<td>0</td>
<td>-</td>
<td>N.S.</td>
</tr>
<tr>
<td>11 L S</td>
<td>0.0891</td>
<td>0.4363</td>
<td>1.2421</td>
<td>0.4</td>
<td>N.S.</td>
</tr>
<tr>
<td>12 L L I</td>
<td>0.0108</td>
<td>0.3611</td>
<td>0.1819</td>
<td>0.1</td>
<td>N.S.</td>
</tr>
<tr>
<td>13 S I</td>
<td>0.0621</td>
<td>0.2841</td>
<td>1.3295</td>
<td>0.2</td>
<td>N.S.</td>
</tr>
</tbody>
</table>

The difference was counted as significant as the P value was equal or less than 0.05.

Table 3
Result of present study measurements of 37 subjects

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 U L - AP</td>
<td>4.23</td>
<td>2.36</td>
<td>-1 to 9</td>
</tr>
<tr>
<td>2 L L - AP</td>
<td>0.49</td>
<td>2.30</td>
<td>-5 to 7</td>
</tr>
<tr>
<td>3 Wits</td>
<td>0</td>
<td>1.5</td>
<td>-3 to 3.5</td>
</tr>
<tr>
<td>4 A - NPog</td>
<td>0.96</td>
<td>1.36</td>
<td>-1.5 to 3</td>
</tr>
<tr>
<td>5 H angle</td>
<td>9.39°</td>
<td>4.38</td>
<td>0° to 16°</td>
</tr>
<tr>
<td>6 U L - E pl</td>
<td>-3.91</td>
<td>3.5</td>
<td>-12 to 4</td>
</tr>
<tr>
<td>7 L L - E pl</td>
<td>-3.01</td>
<td>3.08</td>
<td>-10 to 3</td>
</tr>
<tr>
<td>8 U L height</td>
<td>15.75</td>
<td>2.6</td>
<td>9.4 to 21.8</td>
</tr>
<tr>
<td>9 L L height</td>
<td>17.96</td>
<td>3.08</td>
<td>11.5 to 26.5</td>
</tr>
<tr>
<td>10 S S</td>
<td>14.56</td>
<td>1.51</td>
<td>11.4 to 17.3</td>
</tr>
<tr>
<td>11 L S</td>
<td>15.05</td>
<td>2.26</td>
<td>10.6 to 19.7</td>
</tr>
<tr>
<td>12 L L I</td>
<td>16.03</td>
<td>1.89</td>
<td>12.0 to 20.1</td>
</tr>
<tr>
<td>13 S I</td>
<td>11.7</td>
<td>1.27</td>
<td>9.8 to 15.6</td>
</tr>
</tbody>
</table>

All measurement are in millimeter except for H angle measured in degrees.
Table 4
Correlation between A - NPog and H angle for 37 subjects

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mean</th>
<th>SD</th>
<th>&quot;r&quot; value</th>
<th>&quot;r&quot; value at 5%</th>
<th>&quot;r&quot; value at 1%</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - NPog</td>
<td>0.959</td>
<td>1.355</td>
<td>0.548</td>
<td>0.325</td>
<td>0.418</td>
<td>S</td>
</tr>
<tr>
<td>H angle</td>
<td>9.378</td>
<td>4.381</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table showed that there was a strong correlation between A - NPog and the H angle.

Table 5
Some of the present study findings were compared statistically with others

<table>
<thead>
<tr>
<th>Measurement</th>
<th>study compared to</th>
<th>their mean</th>
<th>present mean</th>
<th>t value</th>
<th>P value</th>
<th>Sig</th>
<th>their n</th>
</tr>
</thead>
<tbody>
<tr>
<td>U 1 - AP</td>
<td>Patrick(1977)</td>
<td>4.23</td>
<td>4.22</td>
<td>0.065</td>
<td>0.5</td>
<td>n.s</td>
<td>28</td>
</tr>
<tr>
<td>L 1 - AP</td>
<td>Patrick(1977)</td>
<td>1.57</td>
<td>0.48</td>
<td>0.063</td>
<td>0.5</td>
<td>n.s</td>
<td>28</td>
</tr>
<tr>
<td>Wits</td>
<td>Patrick(1977)</td>
<td>0.66</td>
<td>0.67</td>
<td>1.186</td>
<td>0.2</td>
<td>n.s</td>
<td>28</td>
</tr>
<tr>
<td>U L--E p1</td>
<td>Centofante(1982)</td>
<td>-3.6</td>
<td>-3.93</td>
<td>0.293</td>
<td>0.5</td>
<td>n.s</td>
<td>11</td>
</tr>
<tr>
<td>L L--E p1</td>
<td>Centofante(1982)</td>
<td>-3.5</td>
<td>-3.01</td>
<td>0.506</td>
<td>0.5</td>
<td>n.s</td>
<td>11</td>
</tr>
<tr>
<td>S S</td>
<td>Hillesund(1978)</td>
<td>14.6</td>
<td>14.56</td>
<td>0.1100</td>
<td>0.2</td>
<td>n.s</td>
<td>32</td>
</tr>
<tr>
<td>L S</td>
<td>Hillesund(1978)</td>
<td>14.0</td>
<td>15.04</td>
<td>2.0846  &gt;0.05</td>
<td>s</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>L I</td>
<td>Hillesund(1978)</td>
<td>14.9</td>
<td>15.90</td>
<td>2.1356  &gt;0.05</td>
<td>s</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>S I</td>
<td>Hillesund(1978)</td>
<td>10.5</td>
<td>11.84</td>
<td>5.0973  &gt;0.05</td>
<td>s</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

The difference is counted significant as the P value is equal or less than 0.05.
5.2. DISCUSSION.

The results of the present study are compared with other studies:

1. Upper incisor A-P distance.

Despite Patrick's (1977) sample comparing young adult males with acceptable occlusion there was no significant difference compared with the present younger aged sample. Likewise the present study mean value and range matched the norms of Downs (1948) and Riedel (1957).

2. Lower Incisor to A-P distance.

Again the present study sample gave similar mean value to Patrick and Downs. There was also agreement with Williams (1969) who suggested a mean value of 0.0 mm.

3. Wits appraisal.

Present study mean is 0 ± 1.5 mm range from -3 to 3.5 mm.

Roth's (1980) longitudinal study of 25 boys and 25 girls aged between 10 and 14 years showed that Wits appraisal is not constant in time, but increases with growth. At ten years of age the mean was about 1 mm.

Jacobson (1975), found that the Wits appraisal was 0 mm for males on the basis of excellent occlusion.
Patrick (1977) found the mean was 0.66 mm ± 2.18 and ranged from - 2.5 to 4 mm. All these separate finding are closely comparable.

4. A to N-Pog.

Present study mean is 0.96 mm ± 1.36, range from - 1.5 to 3 mm.

5. H angle.

Present study mean is 9.37 ± 4.38 degrees, range from 0 to 16 degrees.

Statistically there is a close relationships between the A - NPog and the H angle.

Holdaway (1983) found that if the skeletal convexity increases, the H angle also increase.

The present study (result in Table 3) is in agreement with Holdaway's findings.

Upper Lip and Lower Lip to E Plane:

6. Upper lip to E plane.

Present finding mean is - 3.91 ± 3.5 mm, range from - 12 to 4 mm and,

7. Lower lip to E plane.

Present findings mean is - 3.01 ± 3.08 mm, range from - 10 to 3 mm.
Centofante et al (1982), using two groups of subjects:

In group 1: 7 females and 4 males with no anterior malocclusion.

In group 2: 19 females and 17 males with malocclusion.

Both groups aged between 11-15 years. The value of the upper lip to E plane was $-3.6 \pm 0.7$ mm for group 1 and $-3.6 \pm 0.3$ mm for group 2.

The value for the lower lip to E plane was $-3.5 \pm 0.9$ mm for group 1 and $1.6 \pm 0.5$ mm for group 2.

Ricketts (1957), proposed the distance for upper lip should lie $4$ mm and the lower lip $2$ mm behind the E plane.

The present study generally agrees with the findings of these authors.

**Upper and Lower Lip Height:**

8. Upper lip height.

Present study mean is $15.75 \pm 2.6$ mm, range from $9.4$ to $21.8$ mm, and

9. Lower lip height.

Present study mean is $17.96 \pm 3.08$ mm, range from $11.5$ to $26.5$ mm.

The measurements, as noted earlier (method Section 4.3.4.8) are new to this study and cannot be compared with Mink (1963), Vig (1979). The reason for using a different
method was explained previously.

**Lip Thickness:**

10. At Sulcus superius, present finding mean is $14.56 \pm 1.51$ mm, range from 11.40 to 17.30 mm.

11. At Labrale superius mean is $15.05 \pm 2.26$ mm, range from 10.60 to 19.70 mm.

12. At Labrale inferius mean is $16.03 \pm 1.89$ mm, range from 12 to 20.10 mm.

13. At Sulcus inferius mean is $11.71 \pm 1.27$ mm, range from 9.80 to 15.60 mm.

Cox and V.d. Linden (1971), measured lip thickness. They used x and y coordinates. Soft tissue landmarks were measured from soft tissue landmark to y axis.

The present study followed the system of Hillesund et al (1978). Their values for the lip thickness with the lips in a relaxed lip position were:

- at Sulcus superius: $14.6 \pm 1.5$ mm,

- at Labrale superius: $14.0 \pm 1.9$ mm,

- at Labrale inferius: $14.9 \pm 2.1$ mm,

- at Sulcus inferius: $10.5 \pm 1.0$ mm.

The present study values showed that these are larger than Hillesund's et al findings.
The lip thickness at Sulcus superius, Labrale superius and Labrale inferius were relatively similar; but, the thickness at Sulcus Inferius was 4 mm thinner than the other three.
CHAPTER 6
SUMMARY AND CONCLUSION

1. A Cephalometric radiographic study of lip profile was undertaken, by using 37 pretreatment true lateral Cephalometric radiographs collected from The Department of Orthodontic in the United Dental Hospital. The patients comprised of 22 females and 15 males. The mean age of the patient was 13 years and ranged from 11 to 17.5 years.

The criteria for selecting the sample were:

a. Skeletal:

- Class I type with ANB range from 2 to 4 degrees.
- The "Wits" appraisal range from -3 to + 3.5 mm.

b. Dental:

- Class I Molar relationship,
- Class I Incisor relationship,
- Upper Incisor to lower Incisor angle minimum 120 degrees.

c. Lips:

- With maximum interlabial gap of 4 mm.

3. The tracing and measurement of angular and linear measurement were tabulated, the mean, SD were calculated.

4. Statistical analysis was carried for the double tracings and measurements and there were no statistical significant difference between the first and the second measurements.
5. The result were also compared with other finding carried out previously.

6. Although the sample used for the study was mixed in the ethnic background, and some measurements were larger values in some instances but overall they are still matched normals of the other studies.

7. This was undertaken to develop an "Australian Standard" for the lip profile on the ground that the "Australian" group is heterogenous, consisting of different racial/ethnic groups but predominantly are Caucasian. It is not practical to establish one standard for each ethnic group.

8. The author initiated this study because of growing concerns about assessment of soft-tissues related to orthodontic diagnosis and treatment. There is a need for follow-up study using the same or similar sample in a post treatment evaluation.

9. It was noted that ethical considerations have precluded selecting and assessing a "normal group" not requiring orthodontic treatment.
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<td>201.52</td>
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* Parts of this table are reprinted by permission from R. A. Fisher's *Statistical Methods for Research Workers*, published by Oliver and Boyd, Edinburgh (1935–1950); from Maxine Merrington's "Table of Percentage Points of the t-Distribution," *Biometrika*, 32:300 (1942); and from Bernard Ostle's *Statistics in Research*, Iowa State University Press (1954).

*From SNEDECOR GW., COCHRAN WG., 1967*
Correlation Table

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<th>Degrees of Freedom</th>
<th>5(%)</th>
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<th>Degrees of Freedom</th>
<th>5(%)</th>
<th>1(%)</th>
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Portions of this table were taken from Table VA in *Statistical Methods for Research Workers* by permission of Professor R. A. Fisher and his publishers, Oliver and Boyd.

(From SNEDECOR GW, COCHRAN WG, 1967).
Appendix : 5

Formula

Test of Significance

\[ t = \left( \bar{x}_1 - \bar{x}_2 \right) \sqrt{\frac{n_1 n_2 (n_1 + n_2 - 2)}{(n_1 + n_2)(E_{x_1}^2 + E_{x_2}^2)}} \]

From : Goulden , 1960 , p 56

Measurement of Correlation

\[ r = \frac{E (x_1 x_2)(n - 1)}{S_1 S_2} \]

\[ S_1 = \sqrt{E x_1^2} \quad ; \quad S_2 = \sqrt{E x_2^2} \]

From : Goulden , 1960 , p 125
Cephalometric Analysis Form

**CEPHALOMETRIC ANALYSIS**

**Patient:**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Norm</th>
<th>1st Ceph. Date</th>
<th>2nd Ceph. Date</th>
<th>3rd Ceph. Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNA*</td>
<td>87 + 4°</td>
<td>deg</td>
<td>deg</td>
<td>deg</td>
</tr>
<tr>
<td>SNB*</td>
<td>79 + 3°</td>
<td>deg</td>
<td>deg</td>
<td>deg</td>
</tr>
<tr>
<td>ANB*</td>
<td>3 + 2°</td>
<td>deg</td>
<td>deg</td>
<td>deg</td>
</tr>
<tr>
<td>Y axis to NS</td>
<td>66 + 3</td>
<td>deg</td>
<td>deg</td>
<td>deg</td>
</tr>
<tr>
<td>M - F to NS</td>
<td>32 + 4</td>
<td>deg</td>
<td>deg</td>
<td>deg</td>
</tr>
<tr>
<td>WITI: Appraisal</td>
<td>0 + 1</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>A to N pog</td>
<td></td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
</tr>
</tbody>
</table>

**DENTAL:**

| /A to AP    | 3.5 +3mm | mm             | mm             | mm             |
| /A to AP    | 0.5 +1.0mm | mm             | mm             | mm             |
| /A to M PI  | 91 + 4°  | deg            | deg            | deg            |
| /A to /L    | 130 + 9° | deg            | deg            | deg            |
| /L to SN    | 103 + 5° | deg            | deg            | deg            |
| O PI to M PI| 16 + 5°  | deg            | deg            | deg            |

**SOFT TISSUE**

Holdaway angle: degrees

Upper lip to E plane: mm  Upper lip height: mm

Lower lip to E plane: mm  Lower lip height: mm

Lip Thickness at:
- Sulcus superior: mm  Labrale inferior: mm
- Labrale inferior: mm  Sulcus inferior: mm