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Assessment of the anteroposterior soft-tissue contour of the lower facial third in the ideal young adult

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An evaluation of the normal anteroposterior positions of five soft-tissue points inferior to the nose was undertaken for a selected sample of twenty-five male and twenty-five female young adults exhibiting pleasing (good) facial profiles and normal sagittal and vertical skeletal relationships. The subjects were selected from dental, dental hygiene, and graduate students at Baylor College of Dentistry by three members of the graduate orthodontic faculty and two members of the oral surgery faculty of the dental college. Cephalograms were taken with the subjects in natural head position, thus establishing a true extracranial horizontal reference plane. A true vertical reference plane was constructed perpendicular to the true horizontal, through subnasale. The five soft-tissue points were measured linearly relative to this subnasale vertical plane. Means, standard deviations, and standard errors were calculated for the five points. In addition, the same soft-tissue points were analyzed relative to the Frankfort horizontal and to a nasion vertical perpendicular to the true horizontal and the Frankfort horizontal. The use of the subnasale vertical perpendicular to the true horizontal was shown to have the smallest standard deviation of the four methods.

Key words: Anteroposterior, Profile, Subnasale, Vertical, Perpendicular

Orthodontists for years have studied the soft-tissue contour of facial profiles in patients and realized the significance of changes in that contour induced by tooth movement.[1-4] In the past, facial profile esthetics were described very subjectively.[5-7] More recently, various methods of soft-tissue assessment have evolved,[8-24] and many studies have been published as to how movements of teeth and supporting bone may affect the position of the facial soft tissues. However, no method has been reported which ade-

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quately describes the face without depending upon anatomically variable intracranial landmarks as reference points or upon the facial soft tissues themselves, such as nose, lips, and chin.

In 1952 Herzberg[8] described the profiles of three subjects which he considered to be "in balance." Using photographs, he stated that the chin, upper lip, and lower lip fell on a vertical line through subnasion or subnasale. However, he made no mention of any horizontal planes or the method by which the vertical reference line was constructed on the photographs. Stoner[11] and later Peck and Peck[22] studied acceptable profiles on photographs using a vertical plane tangent to soft-tissue nasion and pogonion. From this plane sagittal positions for the upper lip, lower lip, and chin were assessed on the basis of angular measurements.

The use of the esthetic plane, a line tangent to the tip of the nose and soft-tissue pogonion, was introduced by Ricketts.[12] He suggested that in adult females the lower lip was ideally located 2 mm. posterior to the line and the upper lip 4 mm. posterior to the line. In adult males, the lips were slightly more retracted. Riedel[13] concluded that in many cases of facial beauty, a straight line could be drawn tangent to the upper lip, lower lip, and chin.

Merrifield[19] analyzed soft-tissue profiles with a line tangent to soft-tissue pogonion and the most procumbent lip extending superiorly to intercept the Frankfort horizontal. The inferoposterior angle formed by the intersection of this profile line and the Frankfort horizontal was called the "z angle." Its value gave some indication of the sagittal position of the lips and chin.

Burstone[20] used a plane through subnasale and tangent to soft-tissue pogonion and stated that this plane has minimal variation in nongrowing patients. He established linear measurements perpendicular to this plane for the normal positions of the most prominent points of the upper and lower lips.

Gonzales-Ulloa and Stevens[21] constructed a vertical plane through soft-tissue nasion and perpendicular to the Frankfort horizontal. They stated that in most faces considered to be "beautiful" the soft-tissue chin fell on this vertical plane.

Finally, Holdaway[24] stated that the "H line," a tangent to the chin and upper lip, should ideally fall 3 to 7 mm. anterior to soft-tissue point A, or the superior labial sulcus, and that the lower lip should fall approximately 0.5 mm. anterior to this plane.

The orthodontic literature, as exemplified by the preceding brief review, includes an abundance of studies of the human soft-tissue facial profile which use intracranial landmarks or soft-tissue points, such as the tip of the nose, nasion, or chin, to establish reference planes. However, the locations of such intracranial landmarks may be quite variable,[25] and the positions of such soft-tissue reference points will also be variable, abnormally influenced or greatly changed by growth or surgical procedures. Therefore, it seems less than ideal to construct reference planes for soft-tissue evaluation with such volatile points. Such an approach tends to bias the practitioner toward masking skeletal discrepancies and simply establishing treatment objectives aimed at making a less than ideal face *proportionately* less than ideal. Certainly, with the orthopedic (growing patients) and surgical (nongrowing patients) means of treatment available to the orthodontist today, a uniform method of evaluating anteroposterior discrepancies in soft-tissue profiles is warranted.

Jacobson[23] used an extracranial true vertical reference plane obtained from natural

Fig. 1. Cephalometric radiograph depicting exposure of the true vertical reference plane.

head position and suggested this as being the most accurate method of assessing the profile from a lateral cephalogram. However, he mainly studied sagittal jaw discrepancies and not linear or angular soft-tissue relationships to the true vertical.

The purpose of this study was to assess normal means, standard deviations, and ranges for the anteroposterior positions of five soft-tissue profile landmarks inferior to the nose in young adults exhibiting pleasing (good) facial profiles and normal sagittal and vertical skeletal relationships, using linear measurements from four different vertical reference planes—subnasale verticals perpendicular to a true horizontal and to Frankfort horizontal and nasion verticals perpendicular to true horizontal and to Frankfort horizontal. Possible application for these data in the orthodontic diagnosis of dentofacial deformities in the sagittal dimension and treatment planning for their correction will be presented.

Methods and Materials

An initial sample was obtained from screening approximately 500 dental, dental hygiene, and graduate students at Baylor College of Dentistry in Dallas, Texas. The criteria for preliminary selection included age (young adults with ages ranging from 19 to 32), Caucasian race, good (esthetic) soft-tissue profile, Class I occlusion, and normal overbite-overjet relationships. Prospective subjects numbered approximately 80 males and 60 females after this initial screening. Lateral cephalometric radiographs were taken of all these persons in natural head position[25] with the lips in repose. A plumb line, constructed by suspending a 1 kg. weight from a wire 0.012 inch in diameter, was allowed to hang freely in front of the film cassette and grid and anterior to the subjects' soft-tissue profiles.

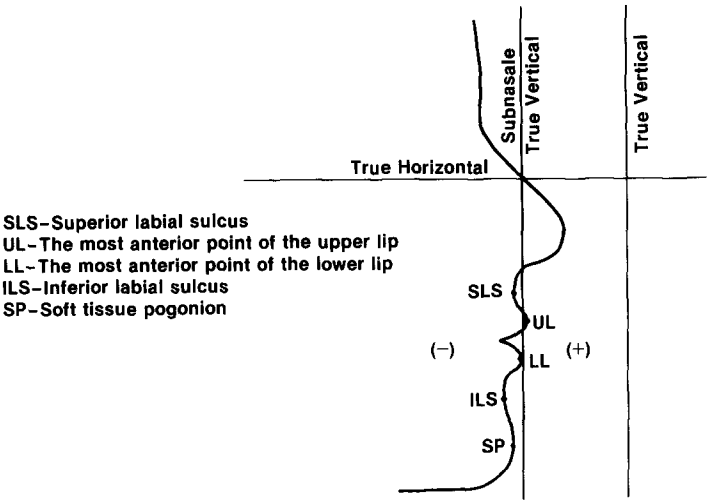

Fig. 2. Method and soft-tissue points used in measuring anteroposterior profile contour relative to the subnasale vertical perpendicular to the true horizontal.

On the lateral cephalograms the wire appeared as a radiopacity and, since the radiographs were exposed in natural head position, represented a true vertical extracranial reference plane (Fig. 1).

All cephalograms obtained from the initial sample were traced and measured to determine if each subject exhibited sagittal skeletal relationships and a ratio of middle to lower anterior vertical facial heights within normal limits.[31, 32] An ANB angle of from 0 to 4 degrees was considered to represent a normal sagittal skeletal relationship when the vertical dimension was also considered normal. Maxillary depth and facial angle were measured, and a "Wits" analysis was also performed on all cephalograms to further assure normality of sagittal skeletal dimensions. The vertical dimension was analyzed by measuring the middle anterior facial height (soft-tissue glabella to subnasale) and the lower anterior facial height (subnasale to soft-tissue menton). Ideally, these measurements should be approximately equal. If, however, the facial heights were within 15 percent of one another, they were considered acceptable. Subjects who did not fall within these normal limits in the sagittal and vertical dimensions were discarded from the sample.

The profiles of the remaining forty-nine males and forty-eight females were traced from the cephalograms onto separate sheets of white paper. Subjective evaluations of these profile tracings were then made individually and separately by three members of the graduate orthodontic faculty and two members of the oral surgery faculty at Baylor College of Dentistry. They were asked separately to analyze the profiles according to male and female divisions and to select only those which they believed to be esthetically pleasing or "normal." If at least four of the five members selected the profile as being "normal," it was used in the final sample. The number of subjects selected for investigation was finally set at twenty-five males and twenty-five females.

A fine pencil line was constructed directly on each cephalogram perpendicular to the true vertical. This line represented a true horizontal reference plane. Then a line was drawn perpendicular to the true horizontal through soft-tissue point subnasale. The plane

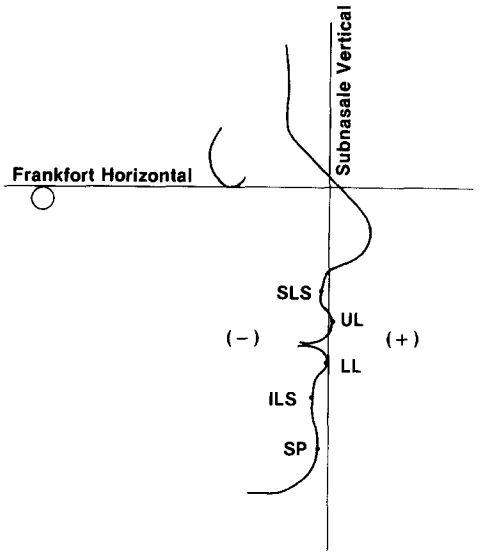

Fig. 3. Method and soft-tissue points used in measuring anteroposterior profile contour relative to the subnasale vertical perpendicular to the Frankfort horizontal.

was called the subnasale vertical (Fig. 2). Subnasale was located by bisecting the angle formed by the columella of the nose and the drape of the upper lip. Millimeter measurements perpendicular to the subnasale vertical were obtained with calipers for the anteroposterior positions of the following soft-tissue points: superior labial sulcus (SLS); the most anterior point of the upper lip (UL); the most anterior point of the lower lip (LL); inferior labial sulcus (ILS); and soft-tissue pogonion (SP). If a soft-tissue point was located anterior to the subnasale vertical, a positive value was assigned, while a point posterior to the plane was assigned a negative value. If a soft-tissue point was tangent to the vertical, zero was assigned. All measurements were read to the nearest 0.5 mm. Means, standard deviations, and standard errors were calculated for the anteroposterior locations of the five soft-tissue points relative to the subnasale vertical in both the male and female groups.

Similarly, the five soft-tissue points were analyzed by three other methods (Figs. 3, 4, and 5). The subnasale vertical was drawn perpendicular to the Frankfort horizontal instead of the true horizontal, and the anteroposterior positions of the points were again measured. Also, a nasion vertical was constructed by drawing a vertical line through soft-tissue nasion which was defined as the deepest concavity at the bridge of the nose. The soft-tissue points were analyzed relative to this vertical constructed perpendicular to the true horizontal and perpendicular to the Frankfort horizontal.

Results

Means and standard deviations for the location of all soft-tissue points by all methods of measurement are listed in Tables I and II. Relative to the subnasale vertical constructed from the Frankfort horizontal, the mean position of all soft-tissue points was very similar to those obtained relative to the subnasale vertical perpendicular to the true horizontal in

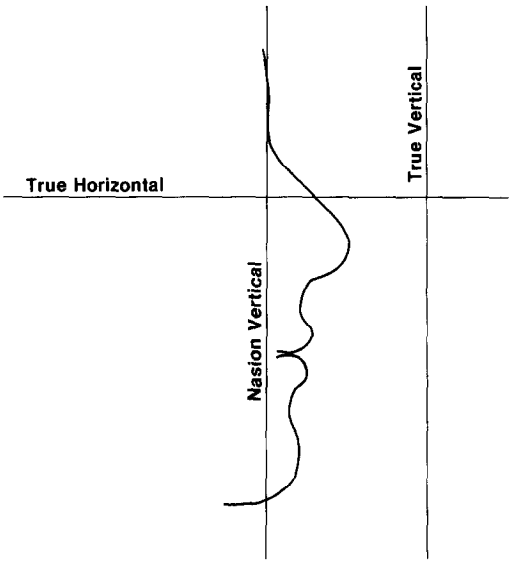

Fig. 4. Method and soft-tissue points used in measuring anteroposterior profile contour relative to the nasion vertical perpendicular to the true horizontal.

both male and female populations. However, the standard deviations for all measurements were slightly higher with the Frankfort horizontal method.

Using the nasion vertical and the true horizontal, as well as the nasion vertical and the Frankfort horizontal, it was found that the means for the positions of all soft-tissue points were similar and, as expected, located well anterior to the vertical reference plane. Although the same basic anteroposterior relationships were exhibited in the male and female samples as when the subnasale vertical was used, the standard deviations for all measurements were substantially higher.

For all four methods used, the standard deviations became progressively larger from superior labial sulcus to soft-tissue pogonion. The values obtained from the subnasale vertical constructed perpendicular to the true horizontal had the smallest standard deviations when compared to the values obtained from the three other methods.

Discussion

The esthetic criteria for sample selection were subjective. The consensus was shared by five independent professionals on the "idealness" of the face. Since these professionals make diagnoses and plan treatment for the public, it was not deemed essential, in this study, for a lay person to be consulted. Because of his training, the professional is more cognizant of facial proportion. It is implied that these mean measurements with the standard deviations provide a range of suggested normals for use by each practitioner as it fits his individual eye for beauty. He may use this as a tool to provide treatment for the total population of young adults seeking orthodontic/orthognathic corrections.

The subnasale vertical constructed from the true horizontal may be a good tool for assessing anteroposterior contour of soft-tissue profiles. In both the male and female samples, the results obtained were different from those of Herzberg.[8] Whereas he de-

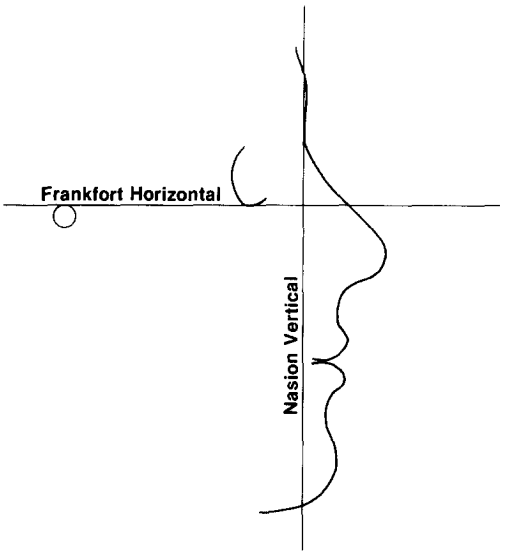

Fig. 5. Method and soft-tissue points used in measuring anteroposterior profile contour relative to the nasion vertical perpendicular to Frankfort horizontal.

scribed the lips and chin falling on the vertical, this was not found to be true in this study. The superior labial sulcus was located posterior to, and the upper lip anterior to, the subnasale vertical in both male and female groups. Both the superior labial sulcus and the upper lip were located about 0.5 mm. more anteriorly in the females than in the males. In the male group the lower lip fell slightly posterior to the vertical, whereas in the female group it was located slightly anterior to the vertical. This supports a previous report that females are naturally more protrusive in the lip region than males.[12] The inferior labial sulcus was posterior to the subnasale vertical in both male and female groups, with the sulcus of the females being located about 2.0 mm. more anteriorly than that of the males. In both sexes the soft-tissue pogonion was posterior to the vertical, with the male pogonion about 0.5 mm. posterior to that of the females. From the preceding comparisons, it may be suggested that females, in general, have slightly fuller lip regions and shallower labial sulci than males and chins that are at least as relatively prominent as those of males. The observation of the female chins being as relatively prominent as the chins of males is certainly contrary to current clinical thinking. However, this study tends to support a hypothesis that, in general, male chins are not actually more prominent than females' but only *appear* to be more prominent because the lips are not as full and the labial sulci are more pronounced. Stated conversely, the female chins do not appear to be as prominent as the males' because the lips of the females are more protrusive and the labial sulci are shallower or less pronounced. When comparing the means using the subnasale vertical perpendicular to the Frankfort horizontal, it was observed that the results are very similar. Differences range from 0.02 mm. for the lower lip of the males to 0.3 mm. for the soft-tissue pogonion of the females. However, the standard deviations and standard errors were larger with the use of the Frankfort horizontal for all of the soft-tissue points in both sexes, with the exception of the upper lip in the females. Therefore, this specific sample

Table I. Summary of means and standard deviations for anteroposterior positions of five soft-tissue points in male subjects measured by all four methods used

	Subnasale vertical		*Nasion vertical*	
Soft-tissue point	*True horizontal*	*Frankfort horizontal*	*True horizontal*	*Frankfort horizontal*
Superior labial sulcus	$\bar{x}$ = (−)1.72 s = 0.78	$\bar{x}$ = (−)1.76 s = 0.79	$\bar{x}$ = (+)7.80 s = 3.14	$\bar{x}$ = (+)7.94 s = 3.34
Upper lip	$\bar{x}$ = (+)1.60 s = 1.68	$\bar{x}$ = (+)1.58 s = 1.72	$\bar{x}$ = (+)11.12 s = 3.45	$\bar{x}$ = (+)11.34 s = 3.53
Lower lip	$\bar{x}$ = (−)0.22 s = 1.92	$\bar{x}$ = (−)0.20 s = 2.07	$\bar{x}$ = (+)9.30 s = 4.10	$\bar{x}$ = (+)9.52 s = 4.40
Inferior labial sulcus	$\bar{x}$ = (−)7.94 s = 2.14	$\bar{x}$ = (−)7.86 s = 2.43	$\bar{x}$ = (+)1.50 s = 4.41	$\bar{x}$ = (+)1.84 s = 4.77
Soft-tissue pogonion	$\bar{x}$ = (−)3.48 s = 2.80	$\bar{x}$ = (−)3.38 s = 3.64	$\bar{x}$ = (+)5.98 s = 4.45	$\bar{x}$ = (+)6.48 s = 5.44

$\bar{x}$ = Mean.
s = Standard deviation.

Table II. Summary of means and standard deviations for anteroposterior positions of five soft-tissue points in female subjects measured by all four methods used

	Subnasale vertical		*Nasion vertical*	
Soft-tissue point	*True horizontal*	*Frankfort horizontal*	*True horizontal*	*Frankfort horizontal*
Superior labial sulcus	$\bar{x}$ = (−)1.22 s = 0.72	$\bar{x}$ = (−)1.16 s = 0.77	$\bar{x}$ = (+)8.46 s = 2.93	$\bar{x}$ = (+)8.70 s = 2.80
Upper lip	$\bar{x}$ = (+)2.10 s = 1.25	$\bar{x}$ = (+)2.24 s = 1.20	$\bar{x}$ = (+)11.94 s = 3.32	$\bar{x}$ = (−)12.22 s = 2.99
Lower lip	$\bar{x}$ = (+)0.42 s = 1.64	$\bar{x}$ = (+)0.56 s = 1.69	$\bar{x}$ = (+)10.14 s = 3.37	$\bar{x}$ = (+)10.48 s = 3.26
Inferior labial sulcus	$\bar{x}$ = (−)6.04 s = 2.09	$\bar{x}$ = (−)5.84 s = 2.41	$\bar{x}$ = (+)3.52 s = 3.26	$\bar{x}$ = (+)3.92 s = 3.55
Soft-tissue pogonion	$\bar{x}$ = (−)2.90 s = 1.85	$\bar{x}$ = (−)2.60 s = 2.75	$\bar{x}$ = (+)6.72 s = 3.19	$\bar{x}$ = (+)7.16 s = 4.11

$\bar{x}$ = Mean.
s = Standard deviation.

suggests that the use of the true horizontal is slightly more accurate, with smaller standard deviations, than the use of the Frankfort horizontal.

The data gathered using the nasion vertical also supported the finding that females have slightly fuller lips and shallower labial sulci than males and chins that are as relatively prominent as those of males. However, the standard deviations and standard errors were much larger than those obtained when the subnasale vertical was used. This may be the consequence of more variation between individuals in the anteroposterior location of soft-tissue nasion than that of subnasale. It should be noted that soft-tissue pogonion was located 6 to 7 mm. anterior to the nasion vertical, whereas Gonzales-Ulloa and Stevens[21] had previously reported that it was tangent to the vertical in pleasing

profiles. This conflict in results could be attributed to differences in the respective nationalities studied, mean age, and/or subjective selection of the sample.

The subnasale vertical perpendicular to the true horizontal seems to be as reliable as the other methods investigated since the smallest standard deviations were obtained with this model. This method of sagittal soft-tissue assessment may be applied to the diagnosis and treatment planning of orthodontic and orthognathic surgery cases. In diagnosis, the orthodontist or the oral surgeon may assess maxillary protrusion or retrusion, mandibular protrusion or retrusion, or combinations of these problems by using the subnasale vertical to determine the anteroposterior position of salient soft-tissue points which reflect the underlying sagittal position of skeletal and dental structures. In treatment planning, the orthodontist may incorporate the vertical plane into a visualized treatment objective in order to obtain esthetically pleasing results, since there is considerable knowledge of the variability of soft-tissue response to tooth movement.[1-3, 24, 26] It should be recognized that this method of sagittal soft-tissue assessment does not depend on the position of the chin, as do the esthetic plane of Ricketts and the H line of Holdaway. By using only these methods of treatment planning, the orthodontist could retract maxillary anterior teeth to a deficient mandible, concomitantly producing an unacceptable facial profile. In orthognathic surgical treatment planning, the subnasale vertical may be a very helpful tool in determining where to position skeletal structures in the sagittal dimension for an "ideal" esthetic result. A visualized treatment objective on presurgical cephalograms can be accomplished using data reported on soft-tissue response to various orthognathic surgical procedures.[27-30]

Finally, the subnasale vertical may provide a useful tool for future research on soft-tissue changes associated with both orthodontic and orthognathic surgical treatment.

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