A Comparative Study of Two Methods of Quantifying the Soft Tissue Profile

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Abstract: One of the most important components of orthodontic diagnosis is the evaluation of the patient's soft tissue profile. There have been many attempts to quantify the soft tissue profile based on the lateral cephalogram. Yet, the methodology used to evaluate the profile varies widely among studies, and there has been no consistency in the way straight lines are constructed in the analysis of the soft tissue contours. The purpose of the current study was to compare the values obtained by 2 drawing methods (tangent line and anatomic points) of constructing angles, and to assess the intraobserver and interobserver reproducibility for both methods. There were statistically significant differences between the 2 methods for 9 of the 10 measurements evaluated. In the comparison of reproducibility assessed by Pearson correlation analysis, both methods showed statistically significant correlations between repeated measurements. The anatomic point method, however, showed greater reproducibility by means of a paired *t*-test. In the analysis of intraobserver reproducibility, 2 measurements showed significant differences with the anatomic point method and 4 measurements demonstrated significant differences when the tangent line method was used. In the analysis of interobserver reproducibility, 5 measurements showed significant differences in the anatomic point method, while 6 measurements represented significant differences in the tangent line method. Our results indicate that a precise description of the methodology used in the analysis of the soft tissue must be provided because of the differences between methods. In the analysis of soft tissue contours, the construction of lines with the anatomic point method is more reproducible than the tangent line method. (*Angle Orthod* 2000;70:200–207.)

Key Words: Soft tissue profile; Drawing method; Reproducibility; Cephalometry

INTRODUCTION

One of the most important components of orthodontic diagnosis and treatment planning is the evaluation of the

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patient's soft tissue.[1,2] Subtelny,[3] Burstone,[4] and Bowker et al[5] have recommended that the analysis of the soft tissue should be taken into consideration for the proper evaluation of an underlying skeletal discrepancy because of individual differences in soft tissue thickness. Investigators[6–9] have developed numerous analyses to interpret the diagnostic information that the lateral cephalogram provides.

The analysis of the hard tissue structures of the face, as seen in the lateral cephalogram, is relatively straightforward. Landmarks are identified to represent various skeletal and dental structures; distances, angles, and ratios are calculated according to the requirements of the specific cephalometric analysis selected by the clinician. To quantify the profile, however, curved surfaces of the soft tissue also must be reduced to distances, angles, and ratios—a procedure that is much less precise than simply connecting hard tissue landmarks.

For the measurement of an angle in the analysis of a soft tissue contour, the construction of 2 straight lines is needed. Those lines can be drawn in several ways, including the connecting of landmarks identified along the soft tissue contour (anatomic point method), constructing straight lines

TABLE 1. Definition of Nasolabial Angle According to the Authors

Author	Definition	Mean Value (degrees)
Lusterman[10]	Angular relationship of the extremity of the upper lip to the inferior border of the nose	No data on white patients
Scheideman et al[11]	Columella tangent and upper lip tangent	111.4 (M), 111.9 (F)
Legan and Burstone[12]	Cm-Sn-Ls	102
Park and Burstone[13]	Pn-Sn-Ls	116.7
Genecov et al[14]	Not mentioned	109.8 (M), 108.3 (F)
Nanda et al[15]	Cm-Sn-Ls	105.8 (M), 110.7 (F)
Fitzgerald et al[16]	Anteroinferior angle formed by the intersection of PCm tangent and the PCm-Ls line	113.6 (M), 116.2 (F)
Zylinski et al[17]	Tangent to columella of nose-Sn-Ls	110.8
McNamara et al[2]	Intersection of the tangent to the inferior aspect of the nose to the upper lip	102.4 (M), 102.2 (F)
Formby et al[18]	Cm-Sn-Ls	118.7 (M), 114.0 (F)
Margolis[19]	Angle formed by a line tangent to the columella of the nose and another line tangent to the philtrum of the upper lip	Approximately 100

tangent to the curved surfaces (tangent line method), or a combination of the 2 techniques. The quantification of a specific soft-tissue contour may vary according to the method used in the analysis.

A review of the literature demonstrates that there has been no consistency in the construction of lines for the analysis of soft tissue contours. The nasolabial angle, for example, is one of the most important soft tissue measurements. [2,10–19] For the measurement of this angle, the construction of 2 lines along the inferior contour of nose and upper lip is needed. There is much variation, however, in the definition and drawing method of the nasolabial angle, with some authors[12,13,15,18] using anatomic landmarks, some[2,11,19] using tangent lines, and others[16,17] using both (Table 1). The values of the nasolabial angle reported vary among studies, in part because of the specific measurement technique used.

The purpose of the present study is to compare the measurements obtained from 2 methods of soft tissue analysis: one based on the use of anatomic points and the other on the use of tangent lines in the construction of angles. We assess the intraobserver and interobserver reproducibility for both methods.

MATERIALS AND METHODS

Forty normal occlusion individuals were used as subjects in this study. These individuals possessed ideal facial esthetics and Class I occlusal relationships. None of these individuals had a history of orthodontic treatment. The average age of the 20 males in this study was 18 years and 9 months; the average age of the 20 females was 18 years and 8 months.

The lateral cephalograms were traced by 1 investigator (Dr Kim) on acetate paper using a pencil with a 0.3 mm diameter lead. Each tracing was photocopied twice; once for the anatomic point method and the other for the tangent line method. Ten variables were selected to quantify the

TABLE 2. Definition of 10 Angular Measurements and Drawing Method in Each Group[a]

Variable	Anatomic Point Group	Tangent Line Group
FHA	NP-OG′	NP–forehead tangent
FNA	O-G′-N′	Forehead tangent–subglabellar tangent
NDA	G′-N′-Prn	Subglabellar tangent–nose dorsum tangent
D-NP	N′Prn-NP	Nose dorsum tangent–NP
NTA	N′-Prn-Sn	Nose dorsum tangent–inferior contour tangent of nose
NLA	Cm-Sn-Ls	Inferior contour tangent of nose–upper lip tangent
UL-NP	SnLs-NP	Upper lip tangent–NP
LL-NP	LiSm-NP	Lower lip tangent-NP
MLA	Li-Sm-Pog′	Inferior contour tangent of lower lip-Anterior contour tangent of chin
PMA	SmPog′– ThMe′	Anterior contour tangent of chin-Inferior contour tangent of chin

[a] FHA indicates forehead angle; FNA, frontonasal angle; NDA, nasal depth angle; D-NP, dorsum-nasion perpendicular; NTA, nasal tip angle; NLA, nasolabial angle; UL-NP, upper lip-nasion perpendicular; LL-NP, lower lip-nasion perpendicular; MLA, mentolabial angle; PMA, pogonion-menton angle.

contour of the facial region according to the method described previously by McNamara et al.[2] The following regions were analyzed: forehead angle (FHA), frontonasal angle (FNA), nasal depth angle (NDA), dorsum-nasion perpendicular (dorsum-NP), nasal tip angle (NTA), nasolabial angle (NLA), upper lip-nasion perpendicular (UL-NP), lower lip-nasion perpendicular (LL-NP), mentolabial angle (MLA), and pogonion-menton angle (PMA).

To construct the above angles using the anatomic point method, the following landmarks were selected, and each angle was drawn according to the definition in Table 2 (Figure 1).

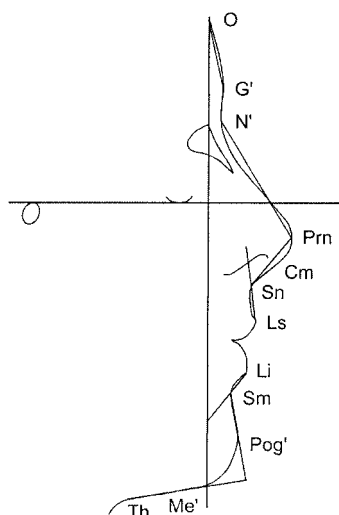O: Intersection of the nasion perpendicular[2] with the forehead

FIGURE 1. Construction of angles using anatomic points.

G′ (soft tissue glabella): The most prominent point in the
  midsagittal plane of the forehead
N′ (soft tissue nasion): The most concave point in the
  tissue overlying the area of the frontonasal suture
Prn (pronasale): The most prominent point of the nose
Cm (columella): The most anterior soft tissue point on
  the columella (nasal septum) of the nose
Sn (subnasale): The point at which the columella merges
  with the upper lip in the midsagittal plane
Ls (labrale superius): The most anterior point on the up-
  per lip
Li (labrale inferius): The most anterior point on the lower
  lip
Sm (supramentale): The point of greatest concavity in
  the midline of the lower lip between labrale inferius
  and soft tissue pogonion
Pog′ (soft tissue pogonion): The most anterior point on
  the soft tissue chin
Me′ (soft tissue menton): The most inferior point on the
  soft tissue chin
Th (throat): The intersection between the submental area
  and the tangent line of the neck.

To construct the same 10 angles using the tangent line
method, tangential lines were drawn to the soft tissue con-
tour in each region according to the method of McNamara
et al[2] as follows (Table 2; Figure 2).

Forehead tangent
Subglabellar tangent
Nose dorsum tangent
Inferior contour tangent of nose
Upper lip tangent
Lower lip tangent
Anterior contour tangent of chin
Inferior contour tangent of chin

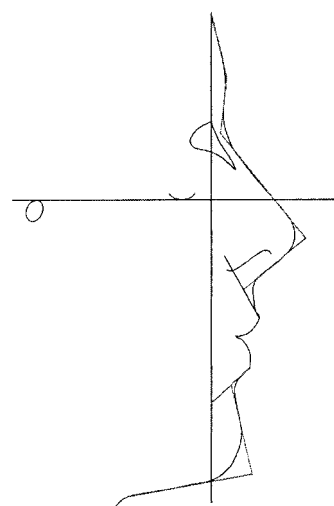Each tracing was digitized using a computer program

FIGURE 2. Construction of angles using tangent lines.

Quick Ceph Image Pro (Orthodontic Processing, Coronado,
CA) and 10 angular measurements were computed in each
tracing. To assess the intraobserver reproducibility, the
drawings were executed a second time by 1 examiner. The
corresponding drawing was executed after a 2-week inter-
val. To assess interobserver reproducibility, immediately
following the initial procedure, a second examiner indepen-
dently constructed each drawing using either the anatomic
point or the tangent line method.

The repeated measurements by the primary examiner
were used to assess intraobserver reproducibility. The
means of the difference between the first and second mea-
surements were calculated for both methods, and a paired
t-test and Pearson correlation were used to assess intraob-
server reproducibility.

The measurements obtained by 2 examiners were used
to assess interobserver reproducibility. Means of difference
between both measurements were calculated for both meth-
ods, and a paired *t*-test and Pearson correlation were com-
puted.

RESULTS

Comparison of the measurements between methods

The means and standard deviations for the 2 methods are
listed in Table 3. All variables except for the forehead angle
showed significant differences between the 2 drawing meth-
ods. There were major differences for the nasal tip and
nasolabial angles, 31.5° and 31.2° respectively. The differ-
ence for upper lip-NP and mentolabial angle also showed
differences of over 20° (Table 3). All variables had statis-
tically significant correlation coefficients (Table 4).

Intraobserver reproducibility

The results of paired *t*-test showed statistically significant
differences ($P < .01$) between the first and second mea-

TABLE 3. Comparison of Measurements According to the Drawing Method Between Anatomic Point and Tangent Line Groups[a]

Variable	Anatomic Point		Tangent Line		Signi-ficance
	Mean	SD	Mean	SD	
FHA	14.55	3.28	14.40	6.56	NS
FNA	155.42	5.79	151.21	9.99	*
NDA	141.60	5.40	130.06	7.37	***
D-NP	28.38	2.85	35.64	4.47	***
NTA	104.06	4.66	72.57	7.15	***
NLA	93.45	8.49	62.25	9.99	***
UL-NP	19.79	7.40	45.78	7.27	***
LL-NP	50.62	10.46	68.43	9.78	***
MLA	127.49	11.14	105.71	12.64	***
PMA	93.32	8.04	85.30	9.05	***

[a] FHA indicates forehead angle; FNA, frontonasal angle; NDA, nasal depth angle; D-NP, dorsum-nasion perpendicular; NTA, nasal tip angle; NLA, nasolabial angle; UL-NP, upper lip-nasion perpendicular; LL-NP, lower lip-nasion perpendicular; MLA, mentolabial angle; PMA, pogonion-menton angle; mean, mean of measurements in each group; SD, standard deviation; and NS, not significant.
* $P < .05$.
*** $P < .001$.

TABLE 4. Pearson Correlation Coefficients Between Anatomic Point and Tangent Line Groups[a]

Variable	r	Significance
FHA	0.93	***
FNA	0.95	***
NDA	0.91	***
D-NP	0.86	***
NTA	0.51	***
NLA	0.87	***
UL-NP	0.55	***
LL-NP	0.76	***
MLA	0.82	***
PMA	0.94	***

[a] FHA indicates forehead angle; FNA, frontonasal angle; NDA, nasal depth angle; D-NP, dorsum-nasion perpendicular; NTA, nasal tip angle; NLA, nasolabial angle; UL-NP, upper lip-nasion perpendicular; LL-NP, lower lip-nasion perpendicular; MLA, mentolabial angle; and PMA, pogonion-menton angle.
*** $P < .001$.

surements in 2 variables (dorsum-NP and pogonion-menton angles) when the anatomic point method was used. When the tangent line method was used, 4 variables (dorsum-NP, nasolabial, upper lip-NP, and pogonion-menton angles) showed significant differences ($P < .05$) (Table 5). Significant correlations were found between the first and second measurements for both methods. Their values ranged from 0.95 to 0.99 in the anatomic point method, and from 0.85 to 0.98 in the tangent line method (Table 6).

Interobserver reproducibility

Table 5 also gives the results of the *t*-test between the 2 types of measurements made by the 2 examiners. Five of the 10 variables demonstrated statistically significant dif-

ferences ($P < .05$) with the anatomic point method, whereas 6 variables showed significant differences ($P < .01$) with the tangent line method (Table 5). Significant correlations were found between the 2 types of measurements made by the 2 examiners. Their values ranged from 0.95 to 0.99 with the anatomic point method and from 0.84 to 0.97 with the tangent line method. The anatomic point method, generally, had a higher degree of agreement between replicates than did the tangent line method (Table 6).

DISCUSSION

Producing a change in the soft tissue profile through treatment often is one of the primary concerns of the orthodontic patient. While the perception of beauty varies widely among individuals and among racial and ethnic groups, many investigators[7,9,11,20] have sought to quantify objectively their clinical impressions of the soft tissue profile. Yet, the quantification of the soft tissue profile is not a simple matter because the profile, as observed in the lateral headfilm, consists of many curved lines. The curved lines usually are converted to straight lines to quantify the soft tissue contours and then these straight lines are compared to so-called ''normal values''. Questions may be raised as to whether the converted straight lines accurately depict the original curvature and if the construction of the straight line is consistent. The construction of the lines should be reproducible over time and should be independent of the specific person performing the analysis.

When comparing the accuracy of the measurements obtained by using the 2 methods, the data in this study showed that 9 of the 10 variables generated by the 2 methods differed significantly from one another. Specifically, the nasal tip angle and the nasolabial angle presented difference of more than 30°, and the upper lip-NP and mentolabial angles showed the difference of greater than 20°. The results of the present study strongly indicate that a precise description of the definition of the methodology used is imperative when evaluating a soft tissue variable. On the other hand, the forehead angle did not demonstrate a significant difference between the 2 drawing methods. The lack of difference in this measure apparently is related to the proximity of soft tissue glabella to the tangent drawn along the forehead.

When evaluating intraobserver reproducibility, 2 variables in the anatomic point method and 4 of 10 variables in the tangent line method presented significant differences between the first and second measurements. Thus, the use of the anatomic point method resulted in greater intraobserver reproducibility than did the use of the tangent line method. Whereas the dorsum-NP angle and the pogonion-menton angle showed low reproducibility when the anatomic point method was used, this lack of reproducibility may be related to errors in landmark identification. Figure 3A shows scattergrams illustrating intraobserver reproducibili-

TABLE 5. Comparison and Differences Between First and Second Drawing in Each Group (Intraobserver Reproducibility) and Between 2 Drawers (Interobserver Reproducibility)[a]

| | Intraobserver Reproducibility | | | | | | Interobserver Reproducibility | | | | | |
| | Anatomic Point | | | Tangent line | | | Anatomic Point | | | Tangent Line | | |
Variable	Difference[b]	SD	Significance	Difference[b]	SD	Significance	Difference[c]	SD	Significance	Difference[c]	SD	Significance
FHA	0.51	0.51	NS	2.00	2.94	NS	0.43	0.37	**	1.60	3.05	NS
FNA	0.85	0.80	NS	2.53	2.86	NS	0.81	0.56	NS	2.13	2.95	NS
NDA	0.75	0.63	NS	1.17	1.37	NS	0.87	0.56	NS	1.46	1.40	**
D-NP	0.47	0.32	***	0.73	0.89	**	0.43	0.35	**	1.51	1.41	***
NTA	1.19	0.88	NS	1.54	1.27	NS	1.10	0.86	*	2.51	1.71	***
NLA	2.23	1.71	NS	3.04	2.68	**	2.56	1.71	**	2.28	2.09	***
UL-NP	1.36	1.01	NS	2.42	2.23	***	1.30	1.11	NS	1.87	1.79	NS
LL-NP	2.30	1.68	NS	2.34	2.78	NS	1.98	1.52	NS	3.07	3.23	***
MLA	2.75	2.11	NS	3.50	3.56	NS	2.60	1.88	NS	4.12	4.07	***
PMA	1.90	1.54	**	2.40	2.43	*	1.63	1.14	*	2.26	2.79	NS

[a] FHA indicates forehead angle; FNA, frontonasal angle; NDA, nasal depth angle; D-NP, dorsum-nasion perpendicular; NTA, nasal tip angle; NLA, nasolabial angle; UL-NP, upper lip-nasion perpendicular; LL-NP, lower lip-nasion perpendicular; MLA, mentolabial angle; PMA, pogonion-menton angle; SD, standard deviation; and NS, not significant.

[b] Mean of absolute value of differences between first and second measurements.

[c] Mean of absolute value of difference between drawers.

* $P < .05$.

** $P < .01$.

*** $P < .001$.

TABLE 6. Pearson Correlation Coefficients Between First and Second Drawing in Each Group (Intraobserver Reproducibility) and Between 2 Drawers (Interobserver Reproducibility)[a]

| | Intraobserver Reproducibility | | Interobserver Reproducibility | |
Variable	Anatomic Point	Tangent Line	Anatomic Point	Tangent Line
FHA	0.98	0.85	0.99	0.84**
FNA	0.98	0.93	0.99	0.92
NDA	0.99	0.97	0.98	0.97
D-NP	0.99	0.98	0.98	0.95
NTA	0.95	0.96	0.95	0.93
NLA	0.95	0.94	0.95	0.96
UL-NP	0.98	0.95	0.97	0.95
LL-NP	0.96	0.93	0.97	0.93
MLA	0.96	0.93	0.96	0.93
PMA	0.97	0.94	0.98	0.93

[a] FHA indicates forehead angle; FNA, frontonasal angle; NDA, nasal depth angle; D-NP, dorsum-nasion perpenpicular; NTA, nasal tip angle; NLA, nasolabial angle; UL-NP, upper lip-nasion perpendicular; LL-NP, lower lip-nasion perpendicular; MLA, mentolabial angle; PMA, pogonion-menton angle. All measurements showed a statistically significant correlation at $P < .001$ except FHA.

** $P < .01$.

ty of the anatomic points. Inconsistency in locating pronasale, particularly in the vertical dimension, can account for the low reproducibility of the dorsum-NP angle, and the variability of the throat point seems to be related to the low reproducibility of the pogonion-menton angle.

As mentioned, the tangent line method presented significant differences in 4 of 10 variables (dorsum-NP, nasolabial, upper lip-NP, and pogonion-menton angles). Whereas

there was no significant difference in the anatomic point method, the nasolabial angle showed low reproducibility when the tangent line method was used. The shape of inferior aspect of nose can account for such a difference. When the inferior aspect of nose has an ''S'' shape, there often can be an inconsistency in the construction of a tangential line. Similarly, the variability in drawing a line tangent to the upper lip also contributes to low reproducibility of nasolabial angle when the tangent line method is used.

In addition to the nasolabial angle, the pogonion-menton angle is an important variable in the diagnosis of the sagittal relationship of the chin. This angle also showed a significant difference between the first and second measurements by means of the tangent line method, but not with the anatomic method. It is likely that the shape of the inferior contour of the chin, particularly an ''S'' shape, contributes to inconsistency of pogonion-menton angle. Figure 4A shows the difference between the 2 measurements for each tangent line used to construct angles in this study. This figure should be helpful in understanding the source of error for each angular measurement.

In the comparison of intraobserver reproducibility by way of the Pearson correlation analysis, both methods showed high correlations between the first and second measurements. In general, however, the anatomic point method showed a higher degree of agreement than did the tangent line method.

One of the basic steps in diagnosis is to obtain a series of cephalometric measurements of a patient and compare these measures with published average or normal values. For the proper comparison, the lines used to obtain a mea-
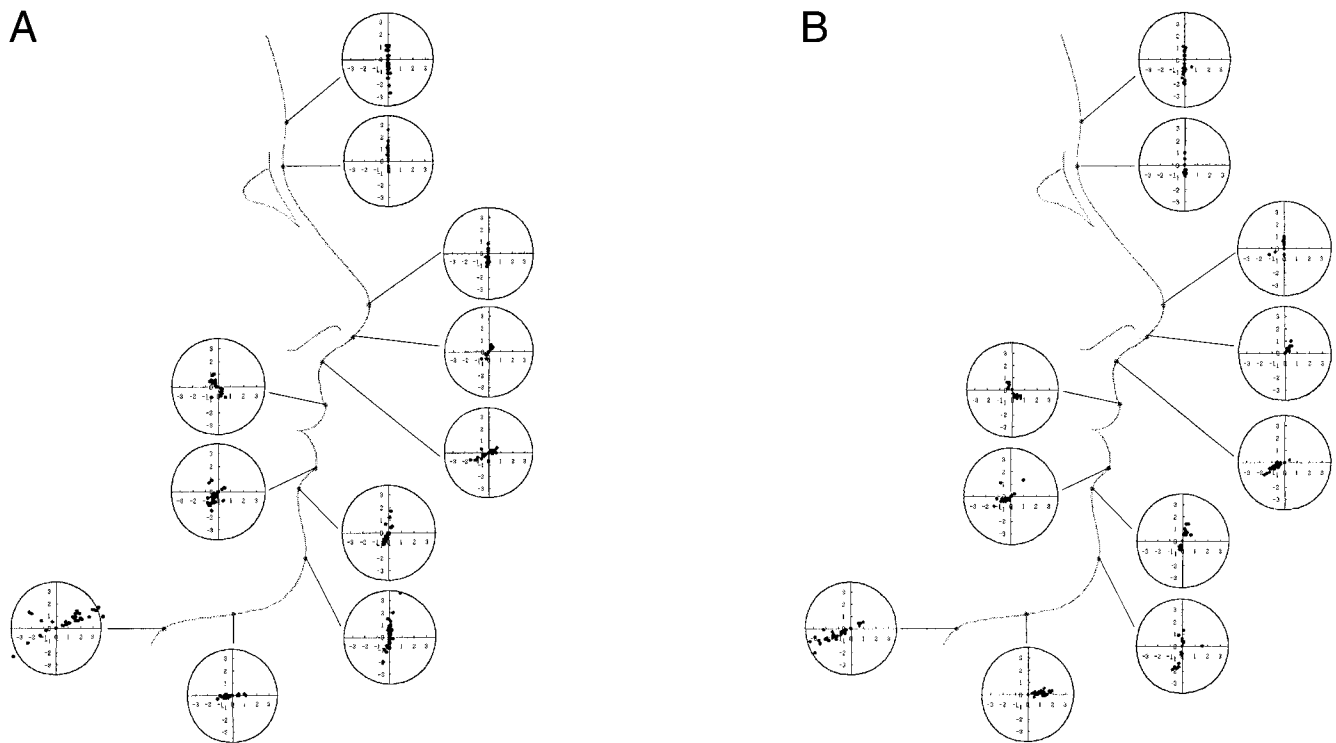
A

B

FIGURE 3. Scattergrams illustrating the reproducibility of each anatomic point. (A) Difference between the first and second measurements or intraobserver difference, (B) Difference between 2 measurements made by 2 operators or interobserver difference. Each dot indicates the difference between 2 measurements. This figure illustrates which landmark contributes to an inconsistency of an angular measurement when the anatomic point method is used.

surement should be drawn exactly the same way, regardless of the operator or the time interval between tracings. According to the results of the interobserver study, 5 of the 10 variables in the anatomic point method and 6 of the 10 variables in the tangent line method showed statistically significant differences. These findings indicate that there appears to be no major difference in interobserver reproducibility between the 2 methods. It should be noted, however, that the values of the differences with the tangent line method were greater than were those with the anatomic point method. All variables obtained with the tangent line method presented differences of more than 1°, whereas few variables showed the difference greater than 1° with the anatomic point method. Considering that a discrepancy of less than 1°, in general, would not result in a different clinical decision, it can be stated that measuring with the anatomic point method has greater interobserver reproducibility than does the tangent line method.

Unlike in the intraobserver study, the nasolabial angle constructed by anatomic point method demonstrated significant difference between examiners. It is likely that this finding is associated with the difference between examiners in columella point identification (Figure 3B). As mentioned, the tangent line method showed significant differences between examiners in 6 of 10 variables. The reason the variables with the tangent line method showed differences between examiners is similar to that seen in intraobserver

study. Particularly, the dorsum-NP angle is associated with the shape of the nasal dorsum. Some of subjects have an ''S'' or ''hump of camel'' shape, and this dorsal hump may contribute to diversity in construction of tangent line to the dorsal aspect of the nose. The diversity in the nasolabial angle may be associated with the shape of inferior aspect of the nose. It is likely that the construction of tangent line on lower lip is much more inconsistent than on the upper lip. This variation contributes to the difference between drawings of lower lip-NP and mentolabial angles (Figure 4B). Also, in the comparison of interobserver reproducibility through Pearson correlation analysis, the anatomic point method had slightly higher agreement than did the tangent line method.

While this study found that the anatomic point method has superior reproducibility than the tangent line method, this does not mean that soft tissue measurements should be obtained only by the anatomic point method. Another important issue in soft tissue analysis is whether the converted straight lines accurately depict the original curvature because most of these lines are used as components of angles to express the degree of convexity or concavity. Such an issue is beyond the scope of the present study.

CONCLUSIONS

The present study showed significant differences between the measurements with the anatomic point method and
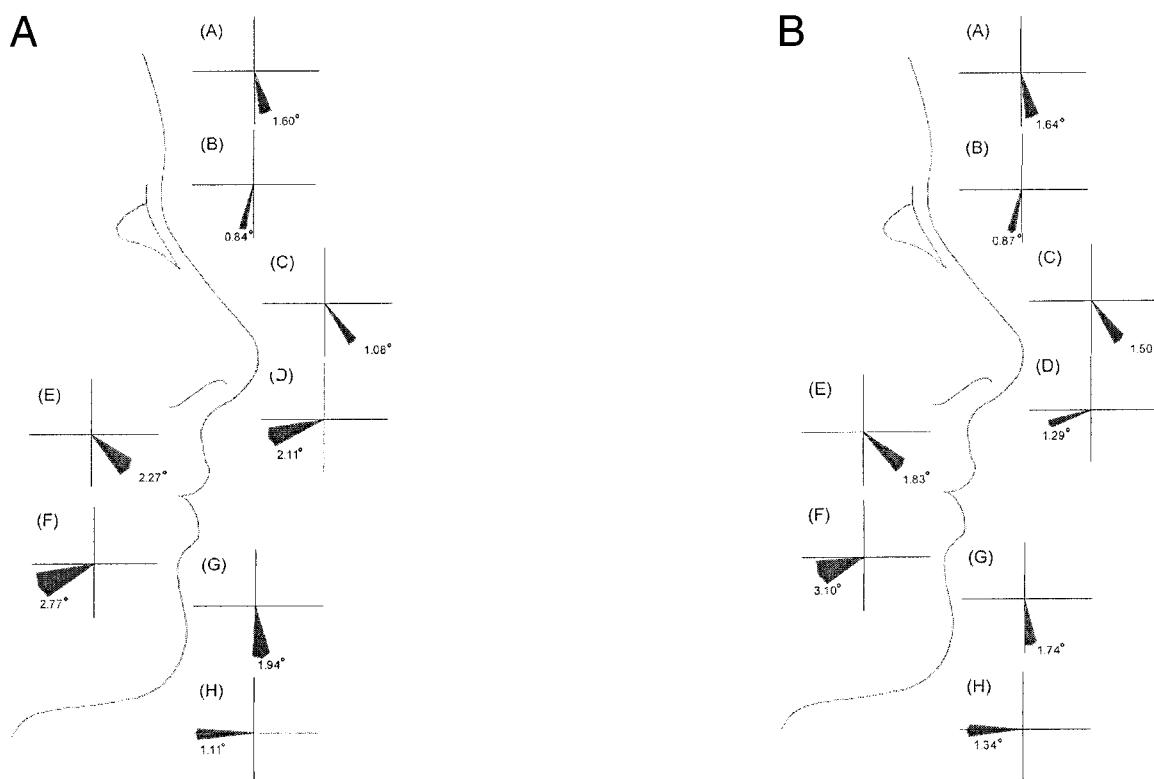
FIGURE 4. Graphic presentation of reproducibility of each tangent line. (A) Difference between the first and second measurements or intraob-server difference, (B) Difference between 2 measurements made by 2 operators or interobserver difference. An angle was constructed between the nasion perpendicular and each tangent line. The direction of each arrow represents the mean of 2 measurements. The width of the arrow and the value in the figure indicate the mean of difference between the 2 measurements. This figure illustrates which tangent line contributes to an inconsistency of an angular measurement when the tangent line method is used. A, Forehead tangent; B, Subglabellar tangent; C, Nose dorsum tangent; D, Inferior contour tangent of nose; E, Upper lip tangent; F, Lower lip tangent; G, Anterior contour tangent of chin; H, Inferior contour tangent of chin.

those with the tangent line method. These findings indicate that the value of a soft tissue measurement may be different depending on the method used. It is evident that a precise description of the methodology used in the analysis of the soft tissue must be provided because of the differences between drawing methods. On the other hand, the present study compared the reproducibility between 2 drawing methods: the anatomic point method and the tangent line method. This study found that anatomic point method has greater reproducibility in either intraobserver or interobserver comparison than the tangent line method.

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