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Metrics of Nasal Tip Rotation: A Comparative Analysis

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Objective: **We introduce a new metric for measuring nasal tip rotation, the "columellar facial angle." The present study aimed to determine the degree of correlation of the nasolabial angle, the nostril axis, and the columellar–facial angle as metrics of nasal tip rotation in healthy volunteers. The study also aimed to identify any nasal or facial features unrelated to tip position, which consistently altered these values.** ***Methods:*** **Lateral photographs in the Frankfort horizontal plane were taken of 100 volunteers. Measurements of tip rotation were then calculated for each model using three different methods: nasolabial angle, nostril axis, and columellar–facial angle. Data were analyzed for degree of correlation of the three values for all models. Facial features in those subjects with low correlation between measurement methods were analyzed.** ***Results:*** **For all grouped data, both the nasolabial angle and the nostril axis showed moderate correlations with columellar facial angle but no correlation with each other. Individual subjects whose measurements did not correlate tended to display certain anatomic features: premaxillary deficiency, premaxillary excess, sloped upper lips, or vertical malposition of the nostrils.** ***Conclusions:*** **No one method of measurement of nasal tip rotation is reliable for all patients. Certain nasal and facial features are likely to alter these values. Of the three measurement methods presented, the columellar–facial angle is most likely to yield consistent measurements of nasal tip rotation.** ***Key Words:*** **Nasolabial angle, facial analysis, nostril axis, facial columellar angle.**

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INTRODUCTION

The assessment of nasal tip position is critical in rhinoplasty analysis, planning, and follow up. Although tip projection is a straightforward, easily attainable value (the distance from the nasofacial junction to the tip defining point), nasal tip rotation is not measurable in a manner that is consistent across different individuals with variable facial anatomy.

Nasal tip rotation reflects the position of the nasal tip along an arc with the radius maintained from the facial plane. There historically have been two methods of measuring nasal tip rotation: the nasolabial angle (NLA)[1] and the nostril axis (NA).[2,3] NLA is measured as the angle between the line drawn from the anterior columella to the subnasale and the line from the subnasale to the labrale superius. NA is measured as the angle between the line drawn through the midpoint of the nostril opening and the line exactly perpendicular to the Frankfort horizontal (the line that intersects the superior tragus or external ear canal and inferior orbital rim). At present, NLA is the most commonly used metric. Most normative guidelines for "ideal" nasal tip rotation are expressed in terms of NLA.

In essence, these metrics use neighboring anatomic landmarks to approximate the degree of rotation of the nasal tip. However, as a result of variant anatomy of facial features that impact the anatomic reference points used to make these measurements, these metrics may be misleading in certain individual cases (see Fig. 1).

We introduce a new method of measurement of nasal tip rotation, the columellar–facial angle (CFA). CFA is measured as the angle formed between the line drawn from the anterior columellar to the subnasale and the line perpendicular to the Frankfort horizontal. The present study aimed to determine the degree of correlation of NLA, NA, and CFA in healthy volunteers. The study also aimed to identify any nasal or facial features that consistently altered these values.

MATERIALS AND METHODS

Lateral photographs in the Frankfort horizontal plane were taken of 100 healthy volunteers (60 female and 40 male). Measurements of tip rotation were then calculated for each model using NLA, NA, and CFA.

The image analysis was performed using a computer software program (Mirror Suite; Canfield Scientific, Fairfield, NJ). Basic demographic information was recorded for each model. Data were analyzed for degree of correlation of the three values for all models. Two measurements were used to analyze the data. Each of the three measurements was rank-ordered for all subjects. For example, the subject with the largest NLA was ranked

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TABLE I.
Descriptive Data for All Metrics.

	Average Nasolabial Angle	Average Nostril Axis	Average Columellar–Facial Angle
Female	102.72 (SD 13.47)	105.79 (SD 9.01)	107.95 (SD 8.74)
Male	98.83 (SD 14.11)	105.57 (SD 9.39)	104.18 (SD 10.17)

SD = standard deviation.

one for that measurement method, the second largest was ranked two, and so on. The biggest difference between the pairs of ranks for each subject was noted and expressed as a rank-difference value. Subsequently, each value for each measurement method in each subject was converted to a Z-score by subtracting the value from the mean value for that measurement and dividing by the standard deviation (SD) within genders. A Z-difference score was then generated by computing the largest difference between Z scores. Nasal and facial features in those subjects with low correlation between measurement methods were analyzed.

RESULTS

For female subjects, the average NLA was 102.72° with a SD of 13.47, the average NA angle was 105.79° with a SD of 9.01, and the average "columellar–facial angle" was 107.95° with a SD of 8.74. In males, the average NLA was 98.83 with a SD of 14.11, the average NA angle was 105.57 with a SD of 9.39, and the average "columellar–facial angle" was 104.18 with a SD of 10.17 (see Table I).

The columellar–facial angle showed moderate correlation to the NLA (Pearson coefficient 0.57, $P < .0001$) and the NA (Pearson coefficient 0.43, $P < .0001$). No correlation was found between the NA and NLA (Pearson coefficient 0.016, $P = .87$). Similar results were found when the data were separately by gender (see Table II and Fig. 2).

In nearly every case, the largest differences in rank order occurred between the NLA and the NA, the two metrics that were found to show poor overall correlation to each other. Subjects were then placed in descending order of rank difference, generating a list of subjects from least to most consistent with regard to how the different measurements correlated (if the different measurements treated a subject consistently, they should all rank that subject about the same). When Z-scores were analyzed, once again the largest difference occurred between the NLA and the NA. Using rank difference and z-difference led to very similar results with a correlation of 0.78 for males and 0.89 for females.

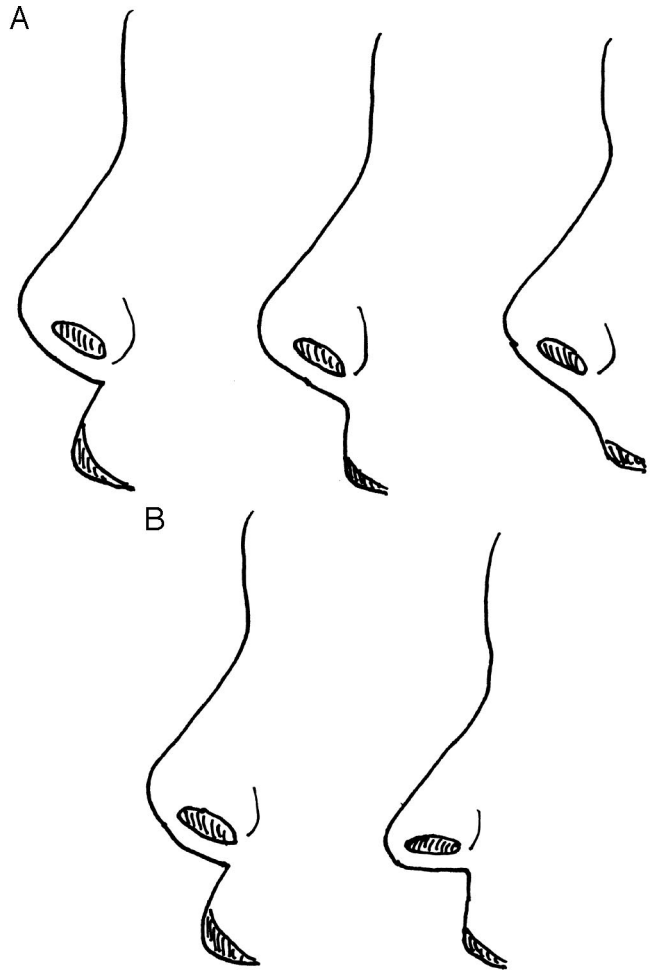

Fig. 1. (A) Three noses with equivalent nasal tip rotational position will yield very different nasolabial angle values because of different upper lip slopes. (B) Two noses with the same nasolabial angle with different nasal tip rotational positions.

The subjects with the biggest difference between the pairs of ranks and Z-scores were analyzed as to what facial features accounted for this difference. It was discovered that subjects whose values showed poor correlation displayed physical attributes that affected the placement of the reference points for measurement. Premaxillary deficiency, premaxillary excess, sloped upper lips, and divergence between the NA and columella were found to be features associated with poor correlation between mea-

TABLE II.
Analysis of Correlation of Measurements.*

Variable 1	Variable 2	n	Pearson Correlation	Pearson *P* value	Pearson 95% Confidence Interval Lower	Pearson 95% Confidence Interval Upper
Nasolabial angle	Columellar–facial angle	100	0.565	0.0000	0.415	0.685
Nasolabial angle	Nostril axis	100	0.016	0.8712	−0.181	0.212
Nostril axis	Columellar–facial angle	100	0.430	0.0000	0.256	0.578

*Columellar–facial angle showed moderate correlation to nasolabial angle and nostril axis. No correlation was found between nostril axis and nasolabial angle.

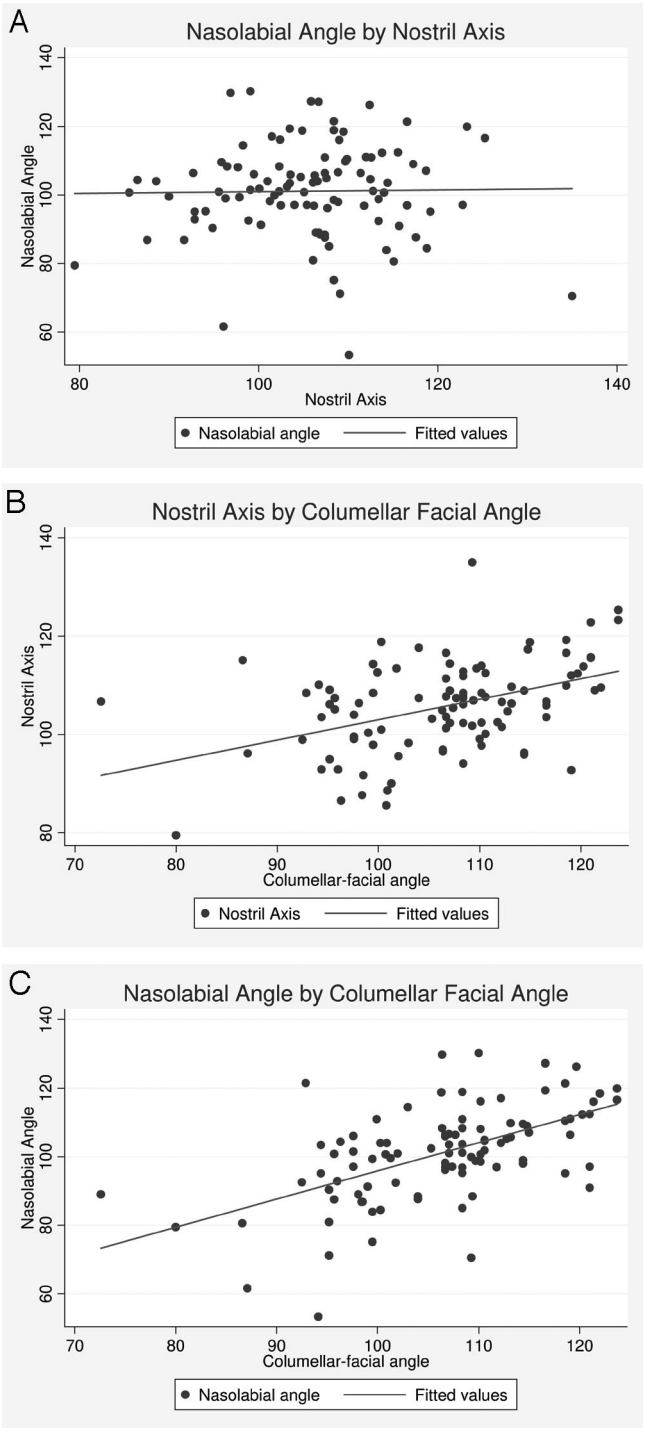

Fig. 2. (A) Nasolabial angle versus columellar–facial angle. Moderate correlation (Pearson coefficient 0.57, $P < .0001$). (B) Nostril axis versus columellar–facial angle. Moderate correlation (Pearson coefficient 0.43, $P < .0001$). (C) Nasolabial angle versus nostril axis. No correlation (Pearson coefficient 0.016, $P = .87$).

surement methods. Subjects with the lowest difference between pairs of ranks and Z-scores were noted to have vertical upper lips and parallel relationships between the columella and the NA (see Fig. 3).

The degree of upper lip sloping was computed for each individual by subtracting the NLA from the CFA. A positive value indicated an upper lip that sloped posteriorly toward the nose. A negative value indicated an upper lip that sloped anteriorly toward the nose. The highest value was 40.7 and the lowest -28.6. For all subjects, the mean slope was positive 5.27 (SD 11.6), indicating that on average most upper lips tended to slope slightly posteriorly toward the nose. The mean of the absolute values of these differences was 9.77 (SD 8.2). This value represented the average divergence from the vertical plane of the upper lip slope (irrespective of anterior or posterior trajectory). Similar values were obtained when computed separately by gender. Overall, 75 of the 100 subjects had upper lips that sloped posteriorly toward the nose; the upper lip sloped anteriorly in 25 subjects (Table III).

DISCUSSION

The assessment of nasal tip rotation is critical in presurgical planning and postoperative monitoring. The expression of tip rotation in a quantitative manner allows for objective comparison between patients and the establishment of specific surgical goals. However, the different methods used in these evaluations may result in divergent values in some instances. Complicating this dilemma is the fact that there is no quantitative gold standard to which each individual measurement method may be compared. Each of these methods uses inconstant reference points to generate two lines. One line approximates the axis of the nasal tip. The other line serves as a vertical reference. The angle formed between these lines is then used to estimate the rotational position of the nasal tip. However, because all of the landmarks used to create these lines are inconstant and may vary independently from variations in nasal tip position, the various measurement techniques may yield values that do not accurately reflect true tip rotation.

NLA is currently the most commonly used metric for nasal tip rotation. Esthetic parameters for an ideal nose are typically expressed in terms of the NLA and range from 95° to 105° for females and 90° to 95° for males. As evidenced by the large range of angles considered ideal, there is considerable variation in the preferences of different practitioners. Additionally, authors in recent years have advocated adjusting these values when they are applied to patients of certain ethnic backgrounds to account for anatomic differences.

The NLA is problematic when the trajectory of the upper lip is significantly sloped. In these situations, the variant position of the lip changes the vertical reference line, thus changing the overall angle value. Two different noses with similar rotational nasal tip positions may therefore have very divergent nasolabial angles because of different slopes of the upper lip. A large nasal spine, a tension nose deformity, or a highly projected nasal tip may lead to an upper lip that slopes anteriorly toward the nose. This will lead to a larger nasolabial angle. In contrast, a patient with significant premaxillary deficiency or a hypoplastic midface may have an upper lip that slopes posteriorly as it approaches the nose, leading to a more acute NLA. In addition, variation of the soft tissue of the lip may create different slopes of the upper lip independent of the underlying skeletal framework. The position of the upper

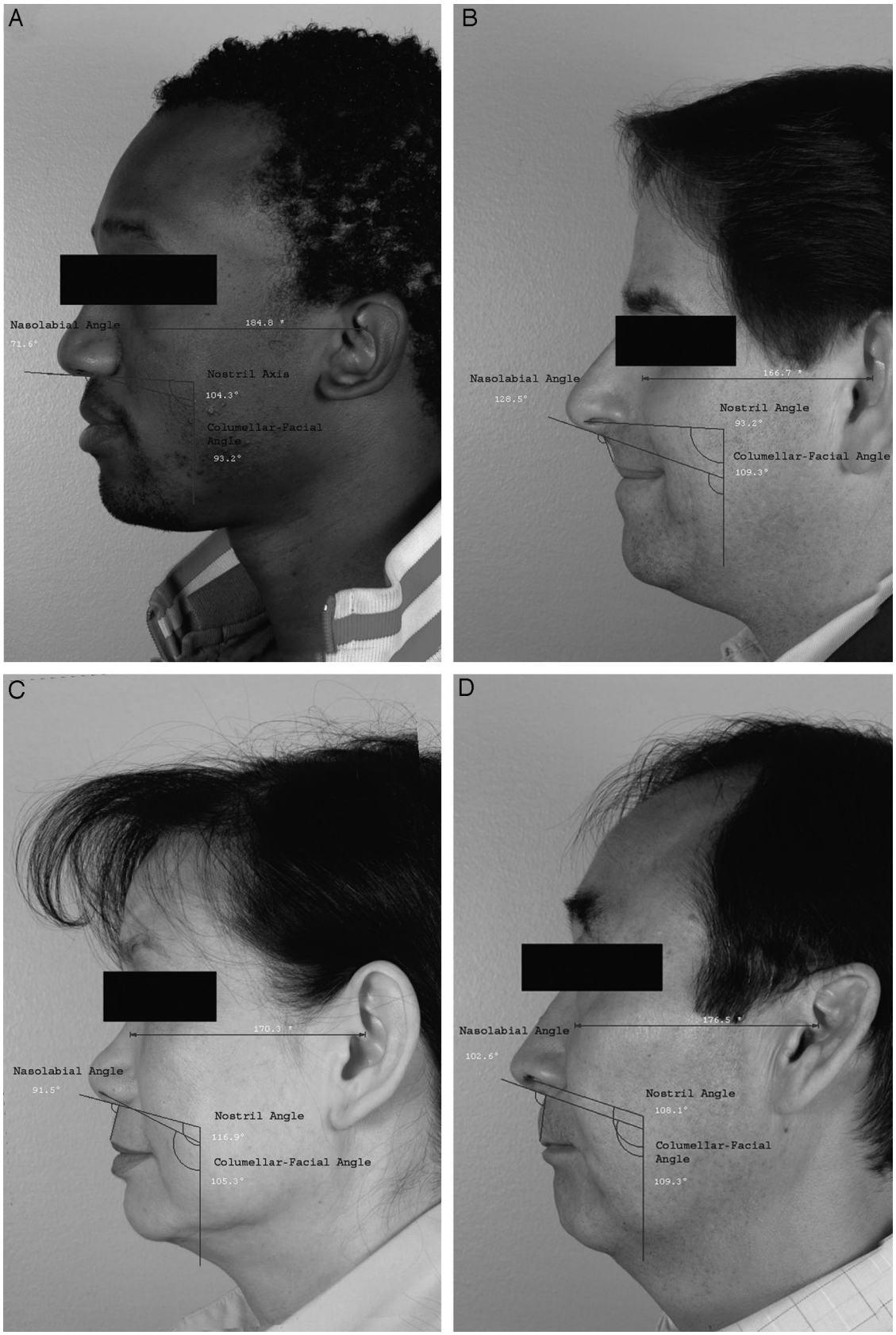

Fig. 3. (A) Upper lip slopes posteriorly toward the nose. Poor consistency between nasolabial angle (NLA) and columellar–facial angle (CFA) or nostril axis (NA). (B) Upper lip slopes anteriorly toward the nose. Poor consistency between NLA and CFA or NA. (C) Upper lip slopes posteriorly toward the nose and nostril axis "off-axis" from columella. Poor consistency among NLA, NA, and CFA. (D) Vertical orientation of the upper lip and parallel relationship between the columella and nostril axis. High consistency among NLA, CFA, and NA.

TABLE III.
Subjects as Separated by the Difference Between Columellar–Facial Angle and Nasolabial Angle.*

Columellar–Facial Angle Minus Nasolabial Angle	No. of Subjects (total 100)
Greater than 30	3
20 to 30	7
10 to 20	19
0 to 10	49
-10 to 0	15
-20 to -10	7
Less than -20	3

*These values represent the divergence of the slope of the upper lip from the vertical plane (perpendicular to the Frankfort horizontal). Positive values indicate upper lip slope posteriorly toward the nose. Negative values indicate upper lip slope anteriorly toward the nose.

lip may also vary depending on facial animation during assessment or photography (smiling, mouth open or closed, and so on) (see Fig. 4). Thus, two individuals with a similar rotational position of the nose may have vastly different NL angles depending on lip position. Similarly, two individuals with the same NL angle may have very different degrees of tip rotation (see Fig. 1).

Another limitation of the NLA is that the columellar trajectory may not reflect the rotational position of the nasal tip. Vertical malposition of the columella (hanging columella or retracted columella) may affect the position of the reference line, altering the angle value. Leach pointed to the interference of a protruding maxillae or procumbent incisors as features, which skew the position of the columella and upper lip and thus the nasolabial angle.[4] Because of this problem, Leach and others favor using the NA to determine tip rotation. Essentially, the axis of the nostrils replaces the columellar line and a line that is perpendicular to the Frankfort horizontal replaces the upper lip as the vertical reference. The main problem of this metric is that in some individuals, the nostril trajectory is "off axis" from the overall direction of the nasal tip (Fig. 3).

We introduce CFA as an alternative measurement method. The CFA is the angle formed between a line from the mid-columella to the subnasale and a line perpendicular to the Frankfort horizontal. The advantages of this method of measurement include the use of an objective vertical reference line, which does not change with varia-

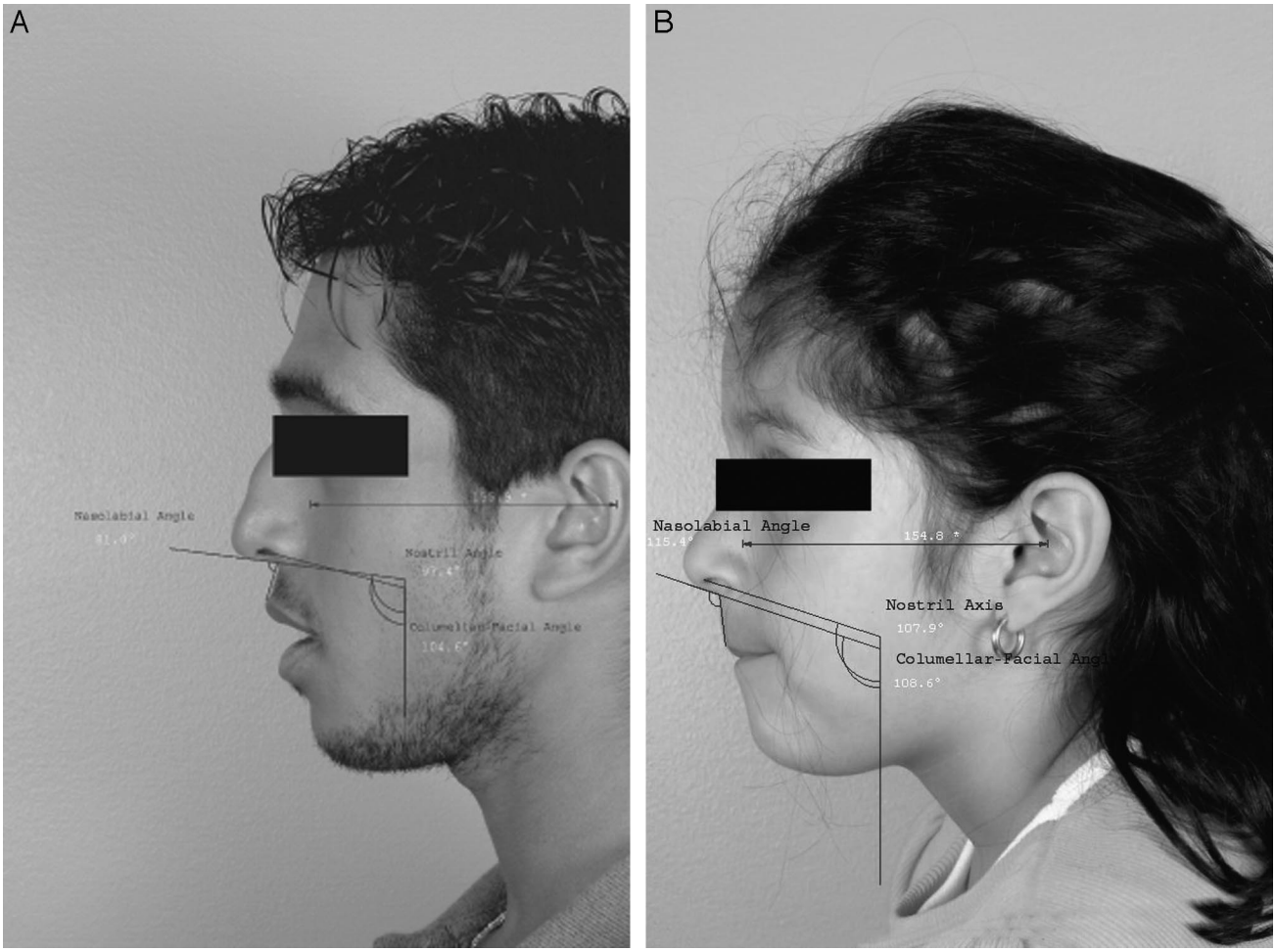

Fig. 4. (A) Open mouth alters upper lip position and skews nasolabial angle. (B) Upper lip in animation skews nasolabial angle.

tions of the local anatomy, particularly the upper lip. Although the columellar line may vary somewhat independent of nasal tip position, it is our opinion that these variations occur less frequently than do variations of the NA.

In the present study, CFA was shown to have moderate correlation to NLA and NA. No correlation was found between NLA and NA. Although this finding does not prove that columellar–facial angle is the most accurate metric for assessing tip rotation, it does suggest that this metric is most likely to display agreement with other metrics. These findings are not surprising when one considers that the CFA measurement shares one reference line with each of the other measurement methods. That is, both CFA and NA use the same vertical reference line; CFA and NLA both use the same horizontal line. Because NA and NLA use two different lines, it follows that there should be the least agreement between these two metrics.

Analysis of the individual subjects who displayed the highest difference in ranked pairs or Z-scores revealed certain anatomic features. Most commonly, a severely sloping upper lip (posteriorly toward the nose) skewed the NLA measurement toward smaller values with no effect on the other two measurement types. Premaxillary deficiency and/or fullness of the upper lip vermillion contributed to this type of variant. Many of the patients of Asian or African descent displayed these features. Conversely, subjects in whom the upper lip sloped anteriorly toward the nose tended to have larger NLA values as compared with the values generated by the other measurement methods. These individuals tended to exhibit premaxillary fullness, a prominent nasal spine, or a highly projecting nose causing webbing at the nasolabial angle. Facial animation also affected the position of the upper lip and therefore skewed the NLA in a few subjects.

In other subjects, there was a distinct mismatch of the vectors of the NA and the columella. Although not assessed quantitatively, it seemed the NA was deviant from the overall direction of the nasal tip in most of these instances (Fig. 3).

The nasolabial angles of 90° to 95° for males and 95° to 105° for females have been advocated as ideal.[5] The mean value for males in our study was a NLA of 98.83, and in females it was 102.72. However, given that the slope of the upper lips varied significantly, it is difficult to interpret this data. Based on the high variation of the upper lip slope, we advocate that the NLA not be used in measuring the nasal tip rotation. Using a standardized vertical reference line perpendicular to the Frankfort horizontal eliminates the inconsistency created by variations of the upper lip. Thus, either the NA or the CFA should be used. The decision to use one of these methods over the other may vary for different subjects and may come down to which landmark—the columella or NA—best seems to represent nasal tip position. Based on a subjective review of this patient population, it seems the NA is less likely than the columella to reflect the position of the tip. Because there is no other reliable standard of tip rotation to which these references could be gauged, an objective comparison could not be accomplished. Nonetheless, it is our recommendation that if a single method is to be used to measure tip rotation, the columellar–facial angle is best.

CONCLUSIONS

No one method of measurement of nasal tip rotation is reliable for all patients. Certain nasal and facial features are more likely to alter these values. Surgeons must bear in mind the differences among these measuring techniques when using them in presurgical planning. For patients in whom premaxillary deficiency, premaxillary excess, nasal tip overprojection, and vertical malpositions of the columella are found, these measurements may not correlate. We advocate abandoning the use of the NLA as a result of high variation in the slope of the upper lip—a feature that alters the computed value. We recommend instead that the CFA be used in measurement of nasal tip rotation.

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BIBLIOGRAPHY

1. Powell N, Humpherys B. *Proportions of the Aesthetic Face.* New York: Thieme-Stratton; 1984.
2. Sheen JH, Sheen AP. *Aesthetic Rhinoplasty,* 2nd ed. St. Louis: Mosby; 1987:25–45.
3. Daniel RK. The nasal tip: anatomy and aesthetics. *Plast Reconstr Surg* 1992;89:216.
4. Leach J. Aesthetics and the Hispanic rhinoplasty. *Laryngoscope* 2002;112:1903–1916.
5. Toruimi DM, Becker DG. *Rhinoplasty Dissection Manual.* Baltimore: Lippincott Williams & Wilkins; 1999:15.