The Effect of Nasal Tip Rotation on Upper Lip Length

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Abstract
Background: Increasing the nasolabial angle (NLA) with tip rotation generates the appearance of a lengthened lower facial third. In particular, the upper lip show seems increased following elevation of the nasal tip.

Objectives: The purpose of this study is to quantify the impact of tip rotation on upper lip length (ULL), and to establish a predictable correlation between the two.

Methods: A retrospective cohort study of rhinoplasty patients with increased tip rotation, using either caudal septal extension graft (CSEG) or columellar strut graft (CS), was performed. Three-dimensional photos were obtained and analyzed anthropometrically and used to measure the ULL and NLA. The deltas between NLA and ULL at the various time points, was then compared using linear regression with \( P < 0.05 \) recognized as statistically significant.

Results: One-hundred and fifty patients were identified and 88 patients met inclusion criteria. CS and CSEG were used in 40% \((n=36)\), and 60% \((n=52)\), respectively. Three-dimensional assessment showed that as the NLA positively correlated with the ULL in both cohorts. The CSEG group created a greater NLA and ULL compared to the CS cohort. Both NLA and ULL decreased over time, but remained statistically increased as compared with preoperative measurements. For every one degree of NLA increase, the ULL increases by 0.05 mm.

Conclusions: Increasing nasal tip rotation in rhinoplasty results in greater upper lip show. Both CS and CSEG can effectively increase tip rotation and ULL. A predictable correlation of nearly 0.05 mm of ULL for every 1 degree of tip rotation is shown.

Level of Evidence: 4

Rhinoplasty can address both nasal aesthetics, and improve overall facial balance.\(^1\) A major component of a rhinoplasty relates to the nasal tip, where the shape, projection, and rotation must be controlled.\(^2,5\) In the setting of an under-rotated or droopy tip, the nose can enshroud the upper lip resulting in an elongated middle third that creates facial disharmony.

Various operative techniques exist to cephalically elevate (rotate) the tip.\(^8,9\) An underemphasized benefit of cephalic tip positioning is the impact on facial harmony by increasing the show of upper lip length.\(^10\) Maliniak highlighted that a decreased nasolabial angle (NLA) will diminish the “beauty the mouth possesses,” further emphasizing the profound impact of tip rotation on facial appearance.\(^11\)

Both caudal septal extension graft (CSEG) and columellar strut (CS) affect tip rotation.\(^5,10,12-14\) The extent to which each type of graft can rotate the tip cephalically, increase the ULL, and maintain this rotation have not been previously investigated. The purpose of this study is to quantify the effect of tip rotation on upper lip length (ULL) by correlating the degree of tip rotation to resultant...
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Lip show. Specifically, the study sets to derive a predictable algorithm to define how each degree increase in NLA relates to each millimeter of ULL. Additionally, we assess for differences between CSEG and CS in maintaining tip rotation using NLA as proxy, and ULL over time.

METHODS

This study was IRB approved by Yale University (1101007932). A retrospective cohort study was performed using 3D photogrammetry of rhinoplasty patients between 2013 and 2015 who had a CSEG or CS for tip rotation (Figures 1 and 2), without direct tip graft. Patients undergoing secondary rhinoplasty, those with a history of cleft nasal deformity, and those undergoing any other simultaneous procedures were excluded from consideration.

Each patient underwent an open rhinoplasty. Their anterior nasal spine (ANS) or columella was not augmented in any case. A judicious cephalic trim was performed. All included patients underwent tip rotation. In the CS cohort, this graft was placed toward the cephalic margin of the medial crus near the caudal septum, and oriented for cephalic rotation. In the CSEG group, the graft was placed to not lengthen the septum caudally near the base, but rather, to extend at or above the anterior septal angle. It was placed dorsally and cephalically to provide an anchorage point for the domes and medial crura, thereby achieving tip rotation.

Three-dimensional photos (Vectra, Canfield, Parsippany, NJ) were obtained. All photographs were taken with specific instruction given to patients regarding posture and positioning, in an attempt to standardize positioning. Patients were asked to relax and look at the mirror, and the photographer ensured the patients were not smiling or animating during photo capture. Photos were analyzed anthropometrically at three time points: preoperatively (t1), postoperatively at or less than 3 months (t2), and postoperatively at greater than 4 months (t3). The analysis was performed in a blinded fashion by two separate observers (KRP, AP). The ULL measurement was measured from subnasale to lowest point of Cupid’s bow, on frontal and lateral views (Figure 3). The points were determined based on Farkas anthropometric studies. Prior to performing the actual study, the raters placed the points on a series of 3D photos and confirmed the position and its reproducibility.

The NLA was derived from three points (infra-lobular tip point, subnasale, and lip Cupid’s bow), on lateral view (Figure 3). It was measured at the same points as the ULL. The delta between NLA and ULL was then compared between the two groups. The tip rotation (degrees), as defined by the NLA, was then correlated to the increase in ULL (millimeters).

Comparisons between both surgical subgroups (CSEG and CS) were made using independent t test, and comparisons within a surgical subgroup at various time points were made using a paired-wise t test. In order to determine the correlation between NLA and ULL, deltas between t2 and t1 were analyzed using linear regression analysis. Linear regression analysis was conducted to correlate the change in ULL on frontal view to the degree change in the NLA on lateral view for the two surgical groups using the delta derived from t2 and t1. All statistical analysis were carried out using IBM SPSS Statistics.

RESULTS

The study identified 150 patients during the time period with 88 meeting inclusion criteria.

Fifty-two patients (37 female, 15 male) underwent CSEG and 36 patients (21 female, 15 male) underwent CS. The average age was 34 years (range, 16-71 years) in the CSEG group and 35 years (range, 17-75 years) in the CS group (Table 1). The mean follow-up was 6.5 months (range, 3-27 months).

Figure 1. Intraoperative photograph of a 16-year-old female patient demonstrating the columellar strut graft. The arrow points to the graft.

Figure 2. Intraoperative photograph of a 16-year-old female patient demonstrating the caudal septal extension graft. The arrow points to the graft.
The ULL increased to 18.36 mm (from a preoperative of 16.78 mm) with increased tip rotation, and fell to 17.72 mm by t3. In the CSEG, the ULL were 16.9 mm, 18.4 mm, and 18.2 mm at t1, t2, and t3, respectively; in the CS group, the ULL were 16.6 mm, 17.4 mm, and 17.0 mm at t1, t2, and t3, respectively (Table 1). These data indicate that the ULL remained increased in both groups, but fell with time an average of 3% in the CS group, but only 1.1% in the CSEG group.

Analysis using linear regression, showed that, for CSEG group, every one degree change in NLA correlates to a 0.05 mm change in ULL ($P < 0.05$); for CS group, every one degree change in NLA correlates to a 0.04 mm change in ULL ($P < 0.058$) (Figures 4-6).

For the entire cohort, linear regression demonstrated for every one-degree change in NLA correlates to 0.048 mm change in ULL ($P < 0.05$).

**Discussion**

The under-rotated or droopy nasal tip can be considered unaesthetic and is associated with the appearance of a long nose and middle facial third with a short upper lip. The masked upper lip and philtrum is an underemphasized consequence of the derotated tip. The nasolabial angle is a function of tip rotation, with idealized norms depending on gender and preference. Kosins et al highlight the illusion created by a downward rotated nasal tip. Specifically, the authors demonstrated in 25 patients that the more acute (downward rotated) the nasal tip, the more susceptible it will be to the optical illusion of a “plunging” nasal tip upon smile. This is explicated because the alar-cheek junction rises above the nasal tip in patients whose nasal tips are downward rotated often in repose and certainly on smile. Clinically, as the nasal tip comes to be rotated closer to the nasal ideal, the illusion of a plunging tip will be decreased. As such, increasing tip rotation is a frequent rhinoplasty maneuver, to impart a normal NLA with beneficial impact on nasal aesthetics. Our findings indicate that nasal tip rotation has a powerful impact on the upper lip show. Cephalically rotating the droopy tip will unveil an otherwise “hidden” smile and restore the facial thirds. See Figure 7 and Supplemental Figure 1 for representative examples.

Both the CS, and, the CSEG have been described to control tip position and may be used to increase tip rotation. The secondary impact of this is a more balanced and harmonious face, due to the increased upper lip show. The normal upper lip length, to the inferior aspect of the visible vermilion-mucosal border has been described as 22.5 mm and 20.2 mm for males and female, respectively. The normal upper lip length to the vermilion border has been described between 19 and 22 mm. Norms, obviously, vary based on age, gender, and race.

In this study, we sought to quantify the effect of tip rotation on ULL, while assessing for changes over time.
We also investigated the impact of CSEG vs CS on NLA and ULL and its stability over time. Using this information, we endeavored to develop a calculation to predictably determine how ULL responds per degree of increased tip rotation as measured by NLA. We also wanted to determine if the apparent increase in upper lip length is an objective increase in actual measurement vs an illusory increase, as the lip becomes less enshrouded by the tip. Our suspicions center around the fact that the pivot point for tip rotation is actually not right at the skin, but deeper by several millimeters — closer to the posterior septal angle and anterior nasal spine. By the time one is near the skin surface (at the labial-columellar point), this point has moved cephalically.  

Our overall cohort of patients underwent tip rotation causing an increase in NLA. The results showed that the NLA was increased postoperatively (t2), but fell in the longer postoperative time-point (t3). This finding was expected as both tip rotation and projection settle (or fall) with time, from edema resolution and scar contracture. The tip rotation at t3 remained greater than preoperatively (t1), and the amount by which it fell (from t2 to t3) was less in the CSEG group. The likely reason is that this graft is fixated to the caudal septum and should theoretically be more stable and less prone to soft tissue forces with healing and contracture of the soft tissue envelope.  

As a proxy to NLA change, and increased rotation, the ULL also increased postoperatively, and was greater at t2 vs t3. Similarly, in the CSEG group compared to CS, the ULL remained longer (18.2 vs 17 mm), and fell less with time (1.1% vs 3%), which was statistically different. Again, the better maintenance of the ULL with the CSEG is explained anatomically, where the medial crura and domal elements are fixed to a more rigid/stable construct, compared to a floating CS. In both cases though it was quantitatively confirmed that cephalic tip positioning (nasal tip rotation) results in an increased ULL, and that the immediate postoperative position (t2) (overcorrection) stabilizes, or falls with time (t3).  

In addition to confirming that nasal tip rotation, corresponding to an increase in NLA, and directly lengthens the upper lip, we endeavored to objectively define that relationship. That is, in order to exhibit correlation of planned to actual results, a precise description of the upper lip change, per degree of tip rotation, would be beneficial. In all patients, the amount of lip increase was 0.048 mm per degree of tip rotation. The CSEG group showed slightly greater rotation and ULL (0.05 mm), while the CS group showed slightly less (0.04).  

These are very small millimeter correlations, and one could argue that 0.05 mm is within the margin of error of point placement on our 3D analysis software. However, the statistical analysis demonstrates a tight correlation, and small standard deviation; making the findings...
unlikely due to chance. Additionally, we measured only the cutaneous portion of the upper lip, to the bottom portion of Cupid’s bow at the white roll. We chose this as a more reproducible landmark, and less apt to be altered with lip position compared with the inferior aspect of the red lip. However, a correlation to Farkas’ upper lip norms is not possible, as he measured to the bottom of the shown vermillion-mucosal border. Our calculation indicates that a change in tip rotation of 5 degrees (ie, 90-95 degrees), results in an increase in the cutaneous upper lip of a 0.25 mm. Considering the entire upper lip (to the red border) this absolute metric increase would be even greater.

One may argue that many maneuvers can result in tip rotation cephalically during rhinoplasty. No doubt the interplay of the lip length and position to nasal tip and base position is complex. Alterations in projection, rotation, columellar show, and base will all impact the lip

Figure 7. (A, C) Preoperative and (B, D) postoperative photographs taken at 12 months of a 28-year-old woman who underwent tip rotation using a caudal septal extension graft. The patient presented with the following complaints: difficulty breathing, columellar show, dorsal hump, and an overall improvement to the appearance of her nose. She underwent open rhinoplasty.
length. Although tip projection is intimately related to tip rotation as delineated by the tripod concept, the authors believe it is the rotation that is more applicable to lip length than rotation. First, anterior or posterior positioning of the angle should not change the length of the base of the angle measurement. And any change in rotation as it relates to projection is still ultimately a change in rotation – this will subsequently affect upper length measurement. In each case the medial crural footplates and the intervening ligaments were separated/divided. So the increase in projection and rotation would not draw up the upper lip skin to alter position. Rather, we believe it is the unshrouding of the upper lip, and to some extent the cephalic pivot of the medial crural footplates that result in the increase in upper lip length. Further confounders include decreased columellar show (medial crura cephalic positioning), modification of the posterior septal angle (anterior nasal spine region), and potential for subtle point differences in landmark placement. In this study, we limited the confounding variables by including a large cohort of patients, and focused on patients who underwent tip rotation as the primary maneuver. The 3D assessment allows for these objective comparisons and relationships. In addition to the above listed concerns, the relatively short duration of average follow-up (6.5 months) is another limitation of the manuscript.

Tip rotation was further limited to two groups of patients: 1. CS oriented with cephalic rotation, and 2. CSEG that was fixed extending past the anterior septal angle. Most of the rotation occurred midway up the medial crura at the infralobule and the domes themselves. Cephalic repositioning of the medial crura near or onto the caudal septum and/or thin cephalic septum trim could also contribute to added ULL (moving the columellar-labial junction point more cephalic). However, in our cohort, the principal maneuver was tip rotation occurring mostly at the infralobule and tip. We believe that increasing tip rotation and reducing columellar length (on lateral view) had the most profound impact on upper lip length. One may further argue that columellar strut or caudal septal extension grafting creates a wider base near the posterior septal angle, which can push the nasolabial angle caudal and anterior shortening creates the upper lip. While it is still possible that we excessively bulked the tissue/columella near the ANS, our goal was to rotate cephalically and therefore intentionally pivoted from the ANS/posterior septal angle cephalically. We did not observe any situations in this cohort where the ULL shortened.

Certainly tip rotation alone is not the only variable impacting ULL, following rhinoplasty. We have shown before that decreasing columellar show via the tongue-in-groove technique, also results in an increased ULL. This mechanism may contribute as well when using a CSEG to increase tip rotation. The CSEG is typically placed parallel to the caudal border of the septum (from a caudal-cephalic dimension), and secured to the septum with non-absorbing sutures. The medial crus are then brought cephalically and secured to the CSEG and CSEG-caudal septal complex in several locations. This helps achieve both tip rotation and reduced columellar show on lateral view – both of which increase ULL. In contrast, the CS is typically placed caudally to the caudal end of the septum, and is not fixed to the septum. Therefore, even though the medial crus are sutured to the CS, there is less rigidity of the system, and columellar show also cannot be significantly reduced without a caudal septal trim. In those cases with a CS, however, there was no augmentation of the ANS region, and the CS was placed at the cephalic margin of the medial crus.

The advent of 3D photogrammetry has made the objective analysis of our study possible. Such an accurate frame of reference, and analysis tools, are not predictable or available for traditional 2D photographs. The 3D manipulations in our study permitted evaluating point placement from many angles and correlating a variable obtained on lateral view (NLA), with a measure seen on frontal (ULL). These correlations from the same photographic rendering are not possible in two dimensions. A myriad of literature now exists utilizing 3D analysis to draw meaningful conclusions from objective comparisons. Although preoperative and postoperative photographs of the patients from multiple angles (frontal, lateral, oblique, and/or basal) were available, as obtained from a 3D camera, the authors chose the representative images to clearly demonstrate how the lip appears longer following the increased tip rotation.

Our study enhances the knowledge base by objectively documenting that increased tip rotation (NLA), results in increased ULL. We further were able to derive a calculation of tip rotation to ULL increase, and discern anthropometric differences when comparing 2 distinct graft techniques to achieve tip rotation in rhinoplasty (CS vs CSEG). None of these comparisons would be possible without 3D photography and analysis.

**CONCLUSIONS**

Increasing nasal tip rotation in rhinoplasty (NLA) results in greater ULL, with beneficial aesthetic effect. Both CS and CSEG can enable increased tip rotation and ULL, which are greatest immediately postoperative and falls with time. In this series the CSEG maintained the ULL more robustly with time. Additionally, our data indicate that for every 1 degree of tip rotation, the cutaneous upper length increases by about 0.05 mm.

**Supplementary Material**

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