Change in Columellar–Philtral and Nasolabial Angles Over Time Following Rhinoplasty

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Abstract

Preoperative analyses of the columellar–philtral and nasolabial angles (CPA and NLA) are important considerations for the rhinoplasty surgeon. This study aims to quantify and compare the degree of change in nasal tip rotation as measured by CPA and NLA over time following rhinoplasty and to identify surgical maneuvers or patient characteristics that may affect nasal tip rotation. Prospective analysis of CPA and NLA in 111 consecutive, consenting cosmetic, and/or functional rhinoplasty patients of the senior author over a 1-year time period was performed. Angles were analyzed before surgery, immediately after surgery, and at 1 week, 1 month, 6 months, and 1 year following surgery. Subgroup analyses based on surgical maneuvers and other covariates were performed. The greatest change to CPA and NLA in the upright position was 11.8 degrees (95% confidence interval [CI]: 9.8–13.7, $p < 0.001$) and 9.3 degrees (95% CI: 7.9–10.7, $p < 0.001$) of elevation 1 week after surgery, respectively. The mean CPA was not significantly different than preoperative measures 6 months after surgery; however, the NLA remained 4.94 degrees (95% CI: 2.1–8.4, $p = 0.001$) elevated. Females showed approximately 10 degrees more elevated CPA than males in pre- and postoperative time points; however, the NLA did not discriminate between sexes. Transfixion incisions appears to cause a significant decrease in postoperative NLA compared with patient who did not undergo transfixion incisions. Measurements for nasal tip rotation are variable and inconsistent throughout the literature. This study shows that rhinoplasty may have a greater effect on nasal tip rotation as measured by NLA and that the effects of NLA and CPA are independent, signifying that a standardized measurement for nasal tip rotation is warranted.

Keywords

- nasolabial angle
- rhinoplasty
- columellar–philtral angle

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Preoperative (PreOP) analysis of the nasal tip is crucial to the rhinoplasty surgeon.[1,2] One of these considerations is nasal tip position and degree of rotation from the lateral view. There are various methods used to measure the degree of nasal tip rotation including the columellar–philtral angle (CPA) and the nasolabial angle (NLA). The CPA is the angle between the base of the columella as it joins the skin of the philtrum.[1] It is easily identified and can be marked out clearly on photographs. The NLA is defined as the angle between a line bisecting the midpoint of the nostril aperture and a line drawn perpendicular to the Frankfort horizontal while intersecting the subnasale. The nasal spine, caudal septum, medial crura, and skin of the upper lip and columella contribute to the framework of the CPA and NLA.[1,2]

The "ideal" CPA and NLA have not been universally established, and many surgeons use the terms interchangeably.[3] Older references cite a broad range for the CPA, between 90° to 120°, while more recent literature acknowledges gender-related differences in this "ideal" angle with females tolerating more nasal rotation than males (100°–110° vs. 95°–100°). Differences in "aesthetic ideals" or preferences across ethnicities, however, are not often taken into account.[4–11] Regardless of the "ideal" nasal rotation, the effects of rhinoplasty on the CPA and NLA are equally important to the surgeon and patient. Surgical maneuvers, grafts, and patient characteristics may have opposed or additive effects on the postoperative nasal tip rotation. As such, understanding which variables have more influence allows surgeons to meet and set patient expectations.

The aim of our study is to examine and quantify the degree and direction of change in the NLA and CPA over time following rhinoplasty. The secondary aim is to determine which surgical maneuvers, techniques, or grafts have a greater influence on nasal tip rotation. By analyzing data from consecutive patients who underwent rhinoplasty by a single surgeon, this report reflects our efforts to better understand these changes over a 1-year time period. This goal was generated from a desire to define how much the nose will "drop" over time after rhinoplasty, how long it will take to do so, and how surgical techniques affect these changes. This knowledge is helpful to rhinoplasty surgeons when counseling patients, individualizing surgical treatment plans, and when "setting the nasal tip" on the operative table, considering an anticipated degree of change over time.

Materials and Methods

Patients

After Institutional Review Board approval by the North Shore-Long Island Jewish Health System Human Research Protection Program, we prospectively collected photographs over a 1-year span on 111 consecutive human subjects who underwent rhinoplasty at the practice of our principal investigator (S.J. P.). All volunteers consented to enrollment in the study, to have their pre- and postoperative photographs taken, and to allow such photographs to be analyzed for change to the CPA and related angles. Only volunteers at least 18 years of age were enrolled. Photographs and measurements were collected for 6 months and up to 1 year on patients undergoing primary, revision, open, or closed rhinoplasty. Patient characteristics such as age, gender, and race were also retrospectively collected and surgical techniques including incisions used, maneuvers performed, and grafts utilized were noted.

CPA and NLA Photographs and Measurements

All photographs were captured from the right lateral view. PreOP upright photographs were captured at the patient's consultation visit. The PreOP supine photographs were taken in the operating room, after the patient had been sedated but before surgery had commenced. Immediately following surgery, and just prior to placement of the nasal cast, photographs were taken with the patient on the operative table in the supine position, (EndOP; ►**Fig. 1**). We did not take immediate postoperative (EndOP) photos in the upright position. Photographs were again taken in the upright and supine lateral positions on the day of cast removal, approximately 1 week after surgery. From then on, only upright photographs were captured at 1 month, 6 months, and 1 year follow-up intervals (►**Fig. 2**). We measured all CPAs and NLAs using the angle tool in the Mirror medical imaging software program (Canfield Scientific, Parsippany, NJ) for each time point to compare values and analyze changes over time.

Statistical Analysis

Frequencies and percentages were calculated for patients by subgroups based on demographics and rhinoplasty procedures. Continuous variables were summarized with means and standard deviations. Nonparametric Wilcoxon rank sum

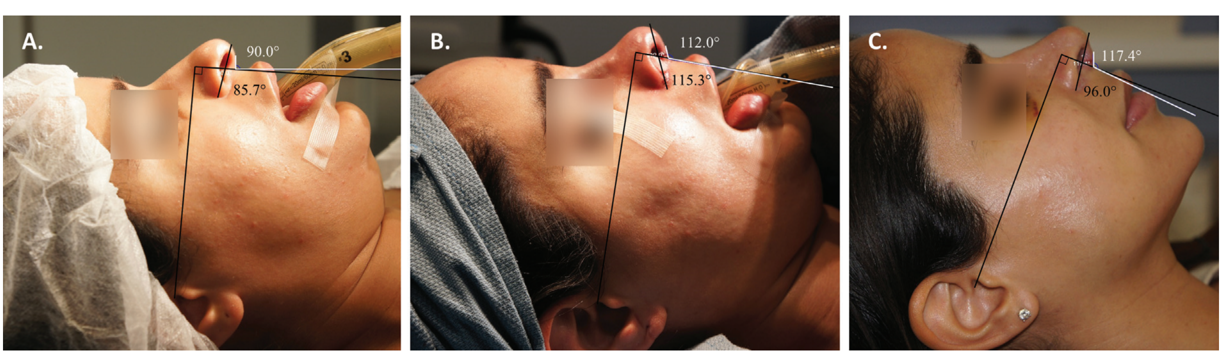

Fig. 1 Illustration of the CPA (*white line*) and NLA (*black line*) from the right lateral supine position (**A**) preoperatively on the surgical table but prior to incision, (**B**) immediately after surgery (EndOP), and (**C**) 1 week postoperatively. CPA, columellar–philtral angle; NLA, nasolabial angle.

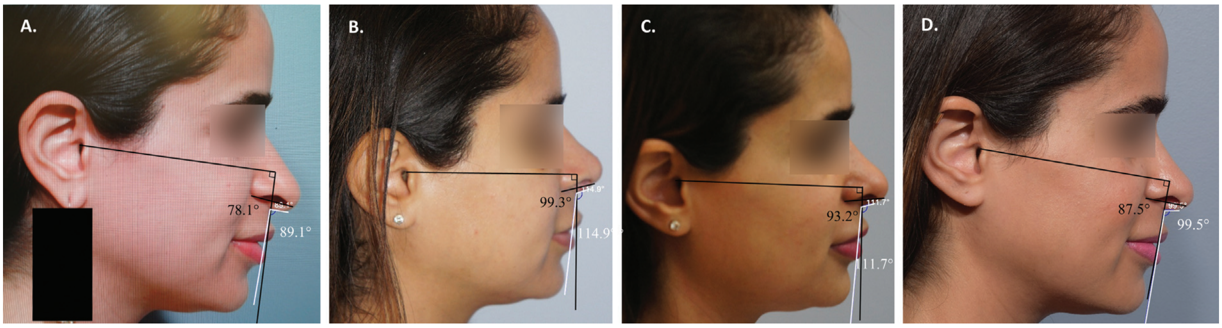

Fig. 2 Illustration of the CPA (*white line*) and NLA (*black line*) in upright (**A**) preoperative consultation, (**B**) 1 week, (**C**) 1 month, and (**D**) 6 months postoperatively. CPA, columellar–philtral angle; NLA, nasolabial angle.

tests and Kruskal–Wallis tests were used to compare age and angles by patient subgroups. To analyze the effects of gravity on the CPA and NLA, we compared the PreOP supine to the PreOP upright angles using paired *t*-tests. Longitudinal measures of CPA and NLA were analyzed using mixed model regression to account for repeated measures. In addition to effects of time, we added covariates to the models to test whether changes in angles were affected by surgical maneuvers, grafts, or incisions and to test whether trajectories of angles over time were modified by the covariate (covariate × time interaction test). Custom contrasts and least-squares adjusted means were used to efficiently extract between-time comparisons within subgroups and between-group comparisons within time periods from a single model. Mixed model analyses make use of all data and, compared with complete case analysis, are robust to missing data if missing is at random or if missingness depends on observable covariates. Point estimates for means and differences of means and 95% confidence intervals (CIs) were used to summarize effect sizes. We used $\alpha = 0.05$ for statistical significance levels and did not adjust α for testing multiple covariates. However, we did use Sidak's correction to adjust significance for multiple tests among time periods and subgroups for each covariate analyzed.

Table 1 Descriptive analysis of patients included in this case series

	N	%
All	109	
Gender		
Female	76	70
Male	26	24
NA	7	6
Race		
African	1	1
African-American	3	3
Asian	1	1
Caucasian	46	42
Greek	1	1
Hispanic	5	5
Indian	6	6
Mediterranean	1	1
Non-Caucasian	1	1
Saudi	1	1
NA	43	39

Abbreviation: NA, not applicable.

Results

Descriptive Analysis

There were 111 patients seen over the course of 1 year for rhinoplasty surgery; however, only 109 patients met the inclusion criteria. In this case series, there were more females (70%) than males and the majority self-identified as Caucasian (42%), ►**Table 1**. The average age was 31 years, the youngest patient was 18, and the oldest was 57 years of age. Of the 109 patients with NLA and CPA measurements, 68 had complete information on surgical technique and grafts utilized. A majority of the surgeries performed were primary rhinoplasty (71%) and a little more than half (57%) of the patients in this case series underwent closed rather than open rhinoplasty, (►**Table 2**). Younger patients were more likely to undergo primary and closed rhinoplasty, while older patients underwent open revision rhinoplasty. The most commonly performed surgical maneuvers were dorsum/supra tip reductions (82%) and osteotomies (68%), while the most commonly implored grafts were spreader grafts (74%) and columellar strut grafts (CSGs) (34%; ►**Table 3**).

CPA and NLA Overtime Following Rhinoplasty

To analyze the effects of gravity on the CPA and NLA, we compared the PreOP supine to the PreOP upright photographs. Both the CPA and NLA were significantly greater in

Table 2 The number and percentage of patients who underwent open, closed, primary, and revision rhinoplasty

N (%)	*Open*	*Closed*	
Primary	10 (15)	38 (56)	48(71)
Revision	19 (28)	1 (1)	20 (29)
	29 (43)	39 (57)	

Table 3 Surgical maneuvers, grafts utilized, and incisions made

	N	%
All	68	100
Maneuvers:		
Base reduction	7	10
Caudal septum shortening	18	26
Caudal septum fixation to spine/midline	15	22
Dome sutures	43	63
Dorsum/supratip reduction	56	82
Footplate sutures	5	7
LCO	6	9
LCS	7	10
LLC cephalic trim	29	43
Maxillary crest removed/reduced	10	15
MCO	7	10
Medial crural footplate shortening	4	6
Osteotomy	46	68
Resection of the depressor septi muscle	20	29
Repositioning of LLC	3	4
ULC reduced	5	7
VDD	2	3
Grafts:		
Alar rim grafts	11	16
Batten underlay	3	4
CSEG	11	16
CSG	23	34
Dorsum onlay/radix graft	10	15
ESG	6	9
LCSG	18	26
Shield/tip graft	23	34
Spreader grafts	50	74
Incisions:		
Hemi-transfixion	7	10
Intercartilaginous	36	53
Marginal	61	90
Transfixion	33	49

Abbreviations: CSG, crural strut graft; CSEG, caudal septum extension graft; ESG, extended spreader graft; LCO, lateral crural overlay; LCS, lateral crural steal; LCSG, lateral crural strut graft; LLC, lower lateral cartilages; MCO, medial crural overlay; ULC, upper lateral cartilage; VDD, vertical dome division.

the supine when compared with the upright position but the effects of gravity appear to have a more clinically significant change on the CPA measurement (►**Table 4**).

The greatest change in the CPA and NLA was a positive nasal tip rotation of 17.8° (95% CI: 14.6°–21.0°) and 14.9° (95% CI: 11.2°–18.4°), respectively, which was observed in the supine position between the PreOP and immediate postoperative time point after closure of the incision (EndOP: ►**Fig. 3**). In the upright position, the greatest change in rotation for CPA and NLA was an increase of 11.8° (95% CI: 9.8°–13.7°, $p < 0.001$) and 9.3° (95% CI: 7.9°–10.7°, $p < 0.001$), which was seen at the first postoperative visit, approximately 1 week after surgery (►**Fig. 4**). From this point forward, both the CPA and NLA began to decrease overtime. The CPA decreased more rapidly than NLA and, by 6 months, was not significantly different from PreOP values (0.7° difference, 95% CI: 2.5°–3.0°, $p = 0.673$). The NLA, on the other hand, remained elevated and was positively rotated by 4.94° (95% CI: 2.1°–8.4°, $p = 0.001$) compared with the PreOP values at 6 months. Our case series experienced incomplete follow-up of patients. The dropout was <10% at 6 days and less than 20% at 1 month (►**Table 5**).

Table 4 A paired *t*-test analysis to assess the effects of gravity on CPA and NLA; CPA appears to be more affected by gravity than NLA and was approximately 5 degrees more obtuse in the supine position

Angle	*N*	*Mean difference [95% CI]*	*SD*	*p-Value*
CPA	97	4.89 [2.82–6.96]	10.3	<0.001
NLA	86	0.99 [0.29–1.69]	3.27	0.006

Abbreviations: CPA, columellar–philtral angle; NLA, nasolabial angle; SD, standard deviation.

Multivariable Analysis

To determine which maneuvers or patient characteristics had a greater effect on the NLA and CPA overtime, additional repeated measures analyses were performed on 68 patients with complete information on surgical maneuvers, grafts utilized, and incisions made (►**Table 6**). Comparisons at 1-year follow-up were not performed due to high rates of loss to follow-up. The results showed that, on average, the CPA was approximately 9.64° (95% CI: 3.89°–15.39°, $p < 0.01$) more elevated in females compared with males at the PreOP consultation and this difference did not vary significantly in the postoperative periods. The NLA, however, was not significantly different between genders in pre- or postoperative time points. Patients who underwent revision rhinoplasty had significantly more acute NLA (−5.08°; 95% CI: −8.85° to −1.30, $p < 0.05$) than patients undergoing primary rhinoplasty in the PreOP consultation, but this difference was lost in the postoperative time periods. On the contrary, revision rhinoplasty patients experienced a more obtuse CPA 1 month after surgery, 9.27° (95% CI: 3.37°–15.17°, $p < 0.001$), compared with primary rhinoplasty patients. Transfixion incisions significantly reduced the NLA relative to PreOP values at 1 week and 1 month postoperatively, with a drop of 2.8° ($p = 0.036$) and 3.06° ($p = 0.032$) respectively. Although patients who underwent maxillary crest removal had a significantly more acute NLA than patient who did not undergo maxillary crest removal at 1 and 6 months postoperatively, this difference relative to PreOP values was not significantly different. In this

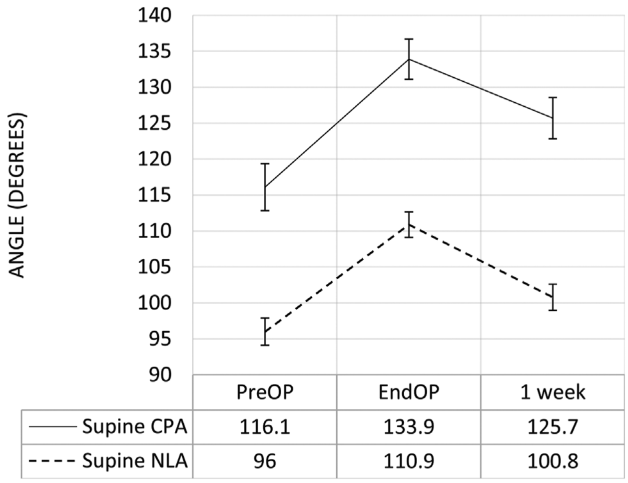

Fig. 3 Graph depicting the change in CPA and NLA in the supine position. CI, confidence interval; CPA, columellar–philtral angle; NLA, nasolabial angle.

case series, differences in the PreOP consultation were too significant to compare postoperative values in the CPA for open versus closed, use of transfixion incisions, and CSG. For the NLA, perioperative values were too different to draw conclusions on postoperative values for maneuvers including caudal septum shortening and dorsum/supratip reduction.

Table 5 Loss to follow-up was less than 20% at 1 month follow-up

		% Lost to follow-up	
		NLA	CPA
Supine	PreOP	15.7	11.8
	EndOP	3.9	0.0
	6 days	6.9	7.3
Upright	PreOP	0.0	0.0
	6 days	6.9	9.1
	1 month	17.6	18.2
	6 months	37.3	43.6
	1 year	50.0	90.0

Discussion

The results of this study show that the greatest change in CPA and NLA was an increase by approximately 18° and 15° from beginning to end of surgery as measured on the operative table. The nose then quickly dropped between the completion of surgery and 1 month postoperatively. Although the upright CPA reverted back to PreOP measurements by 6 months, the average NLA remained 5° elevated, suggesting that postoperative soft tissue swelling has a greater effect on the CPA and that

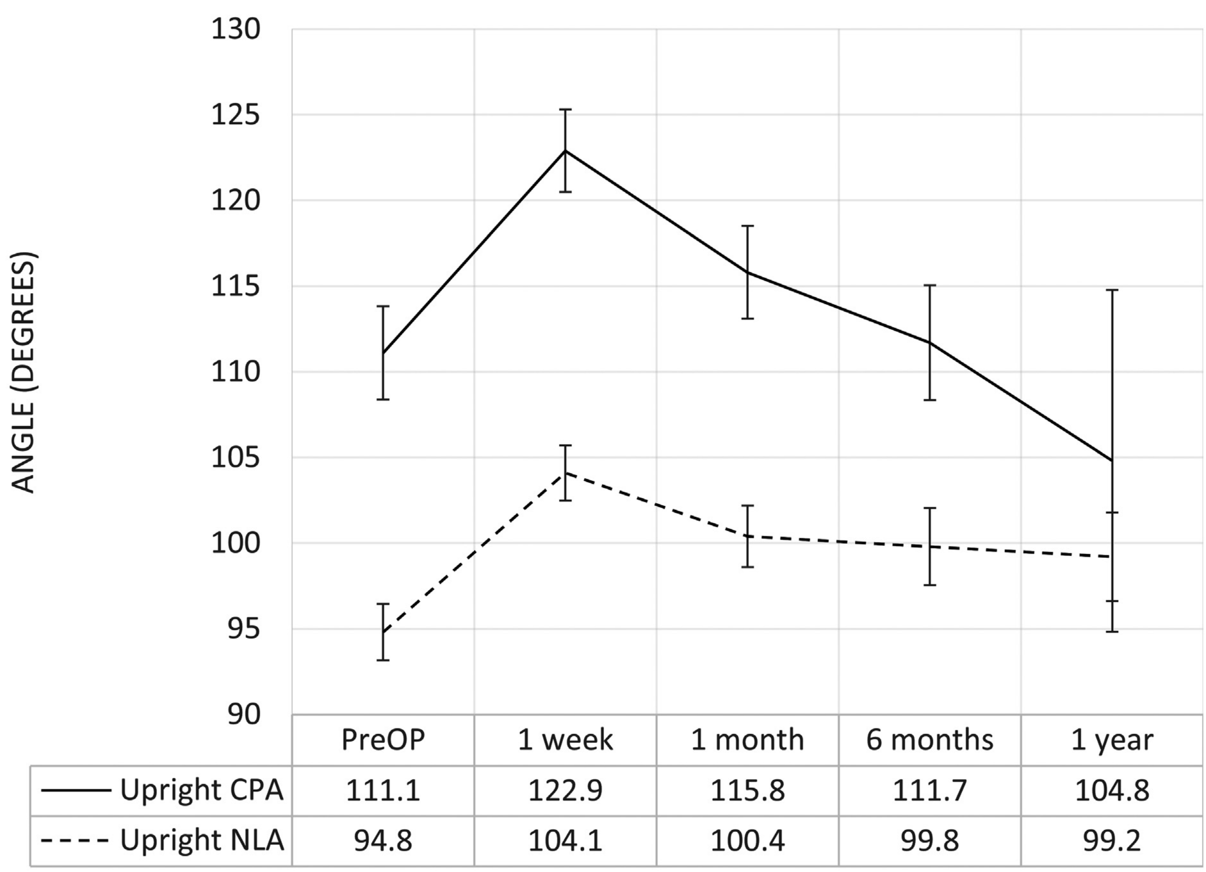

Fig. 4 Graph depicting the change in CPA and NLA in the upright position. CI, confidence interval; CPA, columellar–philtral angle; NLA, nasolabial angle.

Table 6 Repeated measures analysis of selected covariate effects on NLA and CPA over time; covariate × time *p*-value tests whether the time trajectories for covariate subgroups are parallel

			Upright NLA		*Covariate × Time p-value*	*Upright CPA*		*Covariate × Time p-value*
Covariate	*Referent*	*Days*	*Average Difference (degrees)*	*(95% CI)*		*Average difference (degrees)*	*(95% CI)*	
Gender	Male	PreOP	0.51	(−3.41, 4.43)	0.350	9.64	(3.89, 15.39)**	0.678
		1 week	1.42	(−2.53, 5.37)		11.53	(5.69, 17.37)***	
		1 month	2.45	(−1.55, 6.44)		9.00	(3.06, 14.94)**	
		6 months	2.92	(−1.38, 7.22)		9.12	(2.54, 15.70)**	
Primary vs. revision	Primary	PreOP	−5.08	(−8.85, −1.30) **	0.025	5.69	(−0.01, 11.40)	0.419
		1 week	−2.50	(−6.30, 1.31)		7.56	(1.78, 13.34)*	
		1 month	−1.62	(−5.50, 2.26)		9.27	(3.37, 15.17)**	
		6 months	−1.65	(−5.66, 2.35)		7.83	(1.49, 14.17)*	
Open vs. closed	Open	PreOP	−2.34	(−5.80, 1.11)	0.960	5.97	(0.86, 11.08)*	0.255
		1 week	−2.50	(−5.99, 0.98)		8.68	(3.49, 13.87)**	
		1 month	−2.01	(−5.56, 1.55)		9.11	(3.82, 14.41)***	
		6 months	−1.86	(−5.58, 1.86)		9.68	(3.96, 15.40)**	
Transfixion incision	No	PreOP	−2.02	(−5.99, 1.94)	0.093	10.92	(4.38, 17.45)**	0.515
		1 week	−4.82	(−8.83, −0.80)*		9.91	(3.25, 16.56)**	
		1 month	−5.08	(−9.22, −0.95)*		12.29	(5.53, 19.05)***	
		6 months	−3.31	(−7.67, 1.06)		13.81	(6.51, 21.11)***	
Cephalic trim	No	PreOP	−0.52	(−4.65, 3.61)	0.772	7.63	(0.67, 14.58)*	0.837
		1 week	−1.39	(−5.57, 2.79)		6.34	(−0.74, 13.43)	
		1 month	−1.16	(−5.45, 3.13)		6.74	(−0.41, 13.90)	
		6 months	0.20	(−4.32, 4.72)		5.28	(−2.34, 12.89)	
Caudal septum shortening	No	PreOP	−5.22	(−9.93, −0.51)*	0.156	5.36	(−2.63, 13.35)	0.123
		1 week	−2.26	(−7.01, 2.50)		6.27	(−1.89, 14.43)	
		1 month	−3.60	(−8.68, 1.48)		8.47	(0.15, 16.79)*	
		6 months	−1.77	(−6.84, 3.30)		1.36	(−7.15, 9.86)	
Dorsum/ supratip reduction	No	PreOP	−8.75	(−13.87, −3.63)**	0.138	0.07	(−9.44, 9.59)	0.375
		1 week	−4.68	(−9.89, 0.52)		3.13	(−6.51, 12.77)	
		1 month	−7.75	(−12.99, −2.52)**		5.26	(−4.40, 14.92)	
		6 months	−6.98	(−12.74, −1.23)*		2.68	(−7.98, 13.33)	
Max crest removal/ reduced	No	PreOP	−4.91	(−10.65, 0.84)	0.341	9.27	(−0.55, 19.09)	0.136
		1 week	−5.41	(−11.16, 0.34)		4.50	(−5.57, 14.57)	
		1 month	−6.66	(−12.54, −0.78)*		2.61	(−7.36, 12.58)	
		6 months	−8.78	(−14.98, −2.57)**		3.36	(−7.21, 13.92)	
CSG	No	PreOP	2.04	(−2.11, 6.19)	0.977	−11.71	(−18.06, −5.35)***	0.849
		1 week	2.16	(−2.04, 6.36)		−13.11	(−19.60, −6.62)***	
		1 month	2.57	(−1.76, 6.89)		−13.30	(−19.82, −6.77)***	
		6 months	2.63	(−1.88, 7.14)		−13.67	(−20.65, −6.69)***	
CSEG	No	PreOP	2.65	(−2.87, 8.17)	0.682	−6.81	(−16.12, 2.51)	0.587
		1 week	4.33	(−1.20, 9.86)		−6.25	(−15.60, 3.09)	
		1 month	3.66	(−1.96, 9.29)		−9.76	(−19.22, −0.30)*	
		6 months	2.12	(−3.65, 7.89)		−9.50	(−19.49, 0.48)	

Abbreviations: CPA, columellar–philtral angle; CSG, crural strut graft; CSEG, caudal septum extension graft; NLA, nasolabial angle.

Note: Significance of the between-subgroup comparisons indicated by $^{*}< 0.05$ $^{**}< 0.01$ $^{***}< 0.001$. $N = 68$. The average difference was calculated by subtracting the NLA and CPA of the alternative from the referent covariate.

rhinoplasty surgery has a greater effect on nasal tip rotation as measured by the NLA. The CPA was more affected by gravity and was approximately 5° more obtuse in the supine position. This may be due to the fact that the measurements for CPA incorporate two soft tissue landmarks, while the NLA is defined by more rigid skeletal and cartilaginous landmarks.

The multivariable analysis showed that the CPA was approximately 10° more elevated in females, which is representative of the current literature. On the other hand, there was no difference in NLA between genders. This finding suggests that gender differences are focused on the aesthetics created by the philtrum and cutaneous lip. Revision rhinoplasty appears to have a greater effect on CPA than primary rhinoplasty. The revision rhinoplasty group experienced a more elevated CPA at 1- and 6-months postoperative time points. It may be that soft tissue swelling takes more time to decrease after revision rhinoplasty and more long-term data is required for patients undergoing revision rhinoplasty. In this case series, the group of patients with transfixion incisions experienced a significant decrease in NLA at 1 week and 1 month postoperatively both compared with PreOP values and with patients who did not have transfixion incisions. This may be explained by retraction of the medial crura of the lower lateral cartilages (LLCs) caused by a full incision between its attachment to the membranous septum. Patients who underwent maxillary spine removal had a significantly more acute postoperative NLA at 6 months compared with those who did not. Although this difference was not statistically significant from PreOP values, the sample of patients who underwent maxillary crest removal (10%) may have been too small to show true changes. Nonetheless, the nasal spine is an important contributor to tip rotation as it is the base upon which the components of the NLA rest.[1] In this case series, changes in the NLA or CPA were not appreciated with dorsal hump reduction, caudal septal shortening, or the utilization of CSG/CSEG, which is consistent with other studies.[12,13] Although cephalic trim may be associated with an increase in the NLA, our study did not show any difference.[13] However, the degree of nasal tip rotation may be directly proportional to the amount of trimming, a variable that we did not account for in this study.[14] Other variables not accounted for in this study are columellar show or degree of repositioning of the LLC, which may have a more significant effects on NLA. Whether a change in NLA and CPA was the intention of the rhinoplasty surgeon was also not noted.

This study shows that different measurements of nasal tip rotation, such as NLA and CPA, are affected independently by rhinoplasty surgery. Although other studies have quantified the changes in nasal tip projection and rotation following rhinoplasty, the definitions for nasal tip rotation are inconsistent.[13] Harris et al identified four different measurements for nasal tip rotation and described how each may be affected differently by patient characteristics and surgical maneuvers. Honrado and Pearlman emphasize the significance of augmentation and reduction of the nasal spine on the NLA and the effects of a pushing philtrum on the CPA. The results of this study support these claims and show that rhinoplasty may cause independent and contrary effects on the rotation as measured by the NLA and CPA. This is important to consider when comparing studies and begs us to establish more standard measurements and definitions for nasal tip rotation.

This study differs from other studies in that two different measurements for nasal tip rotation were compared and a multivariable, rather than a *t*-test analysis, was performed to determine the effects of patients and rhinoplasty variables on the CPA and NLA over time. The group of patients included in this case series were consecutive (consenting) rhinoplasty patients from a single surgeon over the span of 1 year. This methodology helps reduce the risk of bias from differences in the performance of surgical techniques.

A significant limitation to this study was the high loss to follow-up rate at 6 months and 1 year. Therefore, interpretations at these time points should be considered with care as the small sample size may not be large enough to capture true differences. Incorporating more patients in the study would have increased the power needed to make more meaningful comparisons between NLA and CPA at 6 months to 1 year follow-up. Future studies may use this methodology, especially when accounting for the multiple variables that may affect the final result in rhinoplasty surgery.

Conclusion

This study confirms the anecdotal practice among rhinoplasty surgeons when examining and counseling rhinoplasty patients: that it takes time for the tip of the nose to drop after surgery. Initial consternation on the part of both patients and sometimes surgeons is now supported by data that significant changes in both the CPA and NLA occur during healing and may take up to 6 months, or longer in revision cases, to reach their final position. This parallels the known paradigm that the most dramatic changes occur during the first 6 to 12 weeks following rhinoplasty surgery after which there are still significant changes, albeit at a slower rate, until the 6 months of follow-up appointment. In this study, the effects of rhinoplasty on the measured CPA and NLA differed. Since these measurements are used interchangeably within the literature, differences across studies are difficult to interpret and a more universal definition for nasal tip rotation must be considered. Although the CPA is more easily identifiable, it appears to be more affected by postoperative swelling and the NLA, which incorporates rigid landmarks, may be a more reliable objective measure for nasal tip rotation following rhinoplasty.

Conflict of Interest
None declared.

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