ORIGINAL ARTICLE

Objective Assessment of Tip Projection and the Nasolabial Angle in Rhinoplasty

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Objective: To provide an objective method to measure the extent of nasal tip projection and the nasolabial angle.

Design: We retrospectively studied preoperative and postoperative images using a novel approach. The constant position of the cornea in lateral views and the diameter of the iris in frontal views were used to standardize and compare digitalized images of patients before and after surgery. We tested this objective assessment technique using the digitized slides of patients with saddle nose deformities and measured changes in their nasal tip projection and nasolabial angle. We included 63 patients who had undergone an open rhinoplasty with the I-beam technique by the same surgeon over a 7-year period. We tested the reproducibility of these measurements with 10 independent investigators. We also determined whether the measurements using this objective technique correlated with the surgeon's or patients' subjective assessments of the outcome.

Results: We were able to use the objective measurement technique in 42 patients (67%). It was not possible to use the technique in 21 patients (33%) because the photographic conditions had not been fulfilled. The measurement variability of 10 different investigators expressed as standard deviations in percentage of the mean value was 6.7% for nasal tip projection and 1.3% for the nasolabial angle. The surgeon's subjective assessment of the outcome correlated with the objective changes of nasal tip projection ($P = .045$) and the nasolabial angle ($P = .045$). There was no correlation between the patients' assessments and the objective measurements.

Conclusions: The objective measurements tested were easy to use and investigator independent. They also correlated with the surgeon's assessment of outcome.

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ACCURATE PREOPERATIVE and postoperative analysis and evaluation of the anatomy and appearance of the nose are essential for assessing the efficacy of surgical techniques, as well as for modifying surgical procedures based on their long-term outcome.[1-9] Photographs,[3,4] cephalometric radiographs,[1] and direct clinical measurements[5,6] are the primary means by which the nasal tip has been assessed, but few studies have addressed quantitative changes in nasal tip projection[7,8] and the nasolabial angle. A universally accepted method of assessing nasal tip projection and the nasolabial angle has not been described, to our knowledge. The measuring techniques described to date are laborious and often dependent on the patient's compliance, and they do not make use of modern computer technology, eg, measurements from life-size projections of slides,[8,9] or tools such as the nasal projectometer.[5,9]

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Our aim was to establish an objective, practical, easy-to-use, computer-assisted rhinoplasty assessment technique for measuring the extent of nasal tip projection and the nasolabial angle based on an iris-dependent calibration of existing profile photographs (if they fulfill minimal photographic conditions).

METHODS

The photographs of 63 patients with saddle nose deformities were used to study the rhinoplasty assessment technique. All patients had changes in the degree of nasal tip projection and the nasolabial angle after an open rhinoplasty with an I-beam transplantation performed by the same surgeon over a 7-year period. I-beam transplantation is a surgical technique that is used to increase nasal tip support and projection. There were 31 men (49%) and 32 women (51%), with a mean ± SD age of 40.1 ± 13.5 years (age range, 15-64 years). All patients were white. Follow-up ranged from 1 to 24 months. During the follow-up period, photographs of

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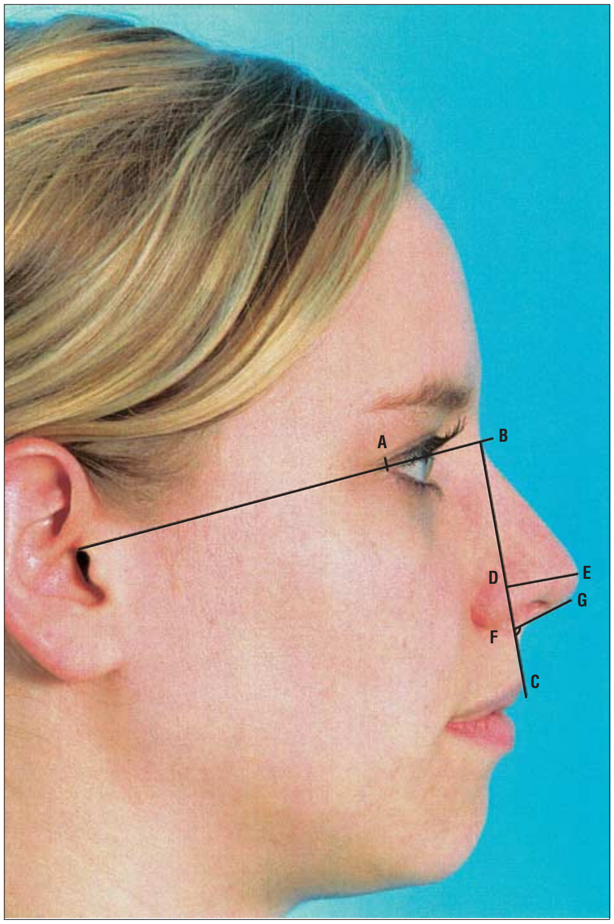

Figure 1. Lateral view. Rhinoplasty assessment technique and photographic conditions illustrated by 4 lines superimposed on the face. A indicates the lateral canthus; B, the nasal frontal angle defined by a line from the superior aspect of the tragus through point A extended on to the nasal root; C, the vermillion cutaneous junction of the upper lip; D-E, the line that is perpendicular to B-C, extending to the most projecting part of the nasal tip; and F-G, the line that follows the columella. The length of D to E is used as a determinant for nasal tip projection. The angle between lines B to C and F to G determines the nasolabial angle.

the right and left profiles and a frontal view were taken 1 to 4 times.

The measurements were performed on retrospectively digitized preoperative and postoperative right profile slides of nonsmiling patients. We used commercially available software (ImageAccess; PIC Systems AG, Glattbrugg, Switzerland). On preoperative and postoperative digitized slides, the degree of nasal tip projection and the nasolabial angle were analyzed objectively using 4 defined lines superimposed on the face (**Figure 1** and **Figure 2**). One line, which was drawn from the superior aspect of the tragus through the lateral canthus (Figure 1, point A), extending over the nasal root, was used to define the nasal frontal angle (Figure 1, point B), which is often difficult to locate in a reproducible fashion. The measurement of the distance from A to B was used to define changes in the nasal frontal angle between the preoperative and postoperative photographs. A second line was drawn from the nasal frontal angle (Figure 1, point B) to the vermillion cutaneous junction of the upper lip (Figure 1, point C). A third line, perpendicular to the second, meets the most projecting part of the nasal tip (Figure 1, point E). The length of this third line (Figure 1, D-E) in millimeters was used as a determinant of nasal tip projection. The angle between the second line (Figure 1, B-C) and the fourth line (Figure 1, F-G), following the columella, was used to measure the nasolabial angle. The calibration was performed using the mean ± SD diameter of the iris and cornea, which is consistently 11.5 ± 0.6 mm in adults. After calibration, the values were recalculated to life-size.

The photographic conditions require a full-profile photograph, with no rotation of a nonsmiling patient's head. The patient's eyes should be wide open, with a straight gaze, for exact calibration, and the superior aspect of the tragus, the lateral canthus, and the vermillion-cutaneous junction of the upper lip should be visible.

To evaluate investigator-dependent variability, 10 randomly chosen adult individuals were instructed regarding the aforementioned criteria and taught how to use the computer software to magnify or reduce the images, allowing them to standardize the images before they did the measurements. Questions were answered on demand.

To compare objective measurements with subjective assessment, the patients and the surgeon were asked whether the outcome of the operation was successful. The 2 groups were classified as successful or unsuccessful, and each of the patient's and the surgeon's results were compared using the Mann-Whitney rank-sum test. Statistical significance was defined by $P<.05$.

RESULTS

Changes in nasal tip projection and the nasolabial angle could be quantified in 42 patients (67%). Figure 2 shows a representative example of these measurements with preoperative and postoperative measurements. An increase in nasal tip projection and nasolabial angle was noted in 31 (74%) and 33 (79%) patients, respectively, while a decrease occurred in 11 (26%) and 9 (21%) patients.

We were unable to use the rhinoplasty assessment technique in 21 patients (33%). The pictures of 12 patients (19%) failed to show the ears; therefore, the necessary landmarks were lacking. Calibration was not possible in 1 case because the patient's closed eyes were closed and therefore his irises were hidden. The preoperative pictures of 5 patients (8%) and the preoperative and postoperative pictures of 2 patients (3%) were missing. In the preoperative picture of 1 patient, the profile was rotated.

The measurement variability of 10 different investigators is summarized in the **Table**. According to the surgeon's assessment, the measurements in the group in which surgery was successful (n = 34) differed significantly from those in the group in which surgery was unsuccessful (n = 8) ($P=.045$ for both nasal tip projection and nasolabial angle). There were no significant differences regarding nasal tip projection ($P=.18$) or nasolabial angle ($P=.08$) between the 2 groups (38 successful outcomes vs 4 unsuccessful outcomes) when the measurements were assessed by the patients.

COMMENT

We have developed and tested an objective computer-assisted technique to assess nasal tip projection and the nasolabial angle with the use of an iris-dependent calibration, which is possible because the diameter of the iris in adults is 11.5 ± 0.6 mm, showing an extraordinary constancy, and any divergence from these measurements is pathological.[10] With the use of this technique, differ-

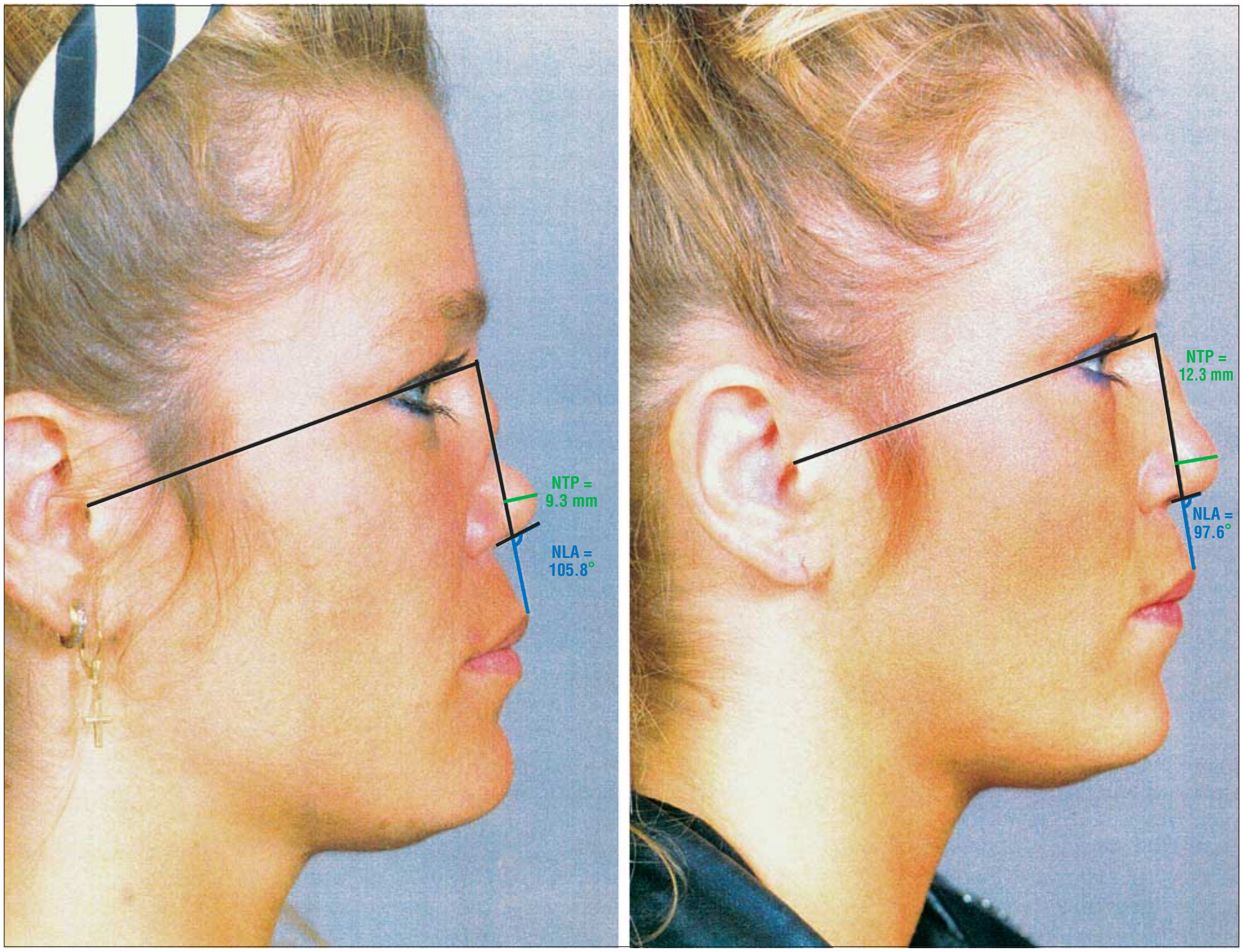

Figure 2. A, The right profile of a patient before rhinoplasty, with 4 lines and the resulting values of the preoperative nasal tip projection (NTP) (9.3 mm) and the nasolabial angle (NLA) (105.8°) superimposed. B, The same patient after rhinoplasty, with changes in the NTP (12.3 mm) and the NLA (97.6°). The computer-assisted calibration defines the radius of the iris as 5.75 mm in each picture, ensuring standardization of the patients' photographs.

ences in photograph size do not affect the measurements, as every distance is standardized. The technique is easy to use and can be applied to most existing photographs that fulfill limited photographic criteria. Using computer technology is preferable to using manual measurements with callipers and rulers (eg, nasal tip projectometer[5]) or measurements taken from the life-size projection of slides[7] because the results are more reproducible. Given the current excellent image quality and ongoing refinements in digital photography, converting to digital photography is fast and cost-effective,[11] especially when the cost of digital photography is compared with the cost of serial cephalometric studies. Furthermore, cephalometric studies are laborious and are associated with radiation exposure.[1]

Instead of nasal tip projection being expressed as a ratio of midface length,[4,12,13] the technique described herein expresses measurements in absolute values based on iris-dependent calibration, which allows a more accurate comparison for future studies.

We analyzed interinvestigator variability, and although the different investigators were only briefly introduced to the technique, the interinvestigator variability was less than 10%. We conclude that this method is easy to learn and provides reproducible results. The objective values correlate with the subjective assessment of the experienced surgeon; therefore, the technique can also be used to rate the success of rhinoplasty. To our knowledge, this correlation has not been demonstrated with any

Interinvestigator Variability of the Rhinoplasty Assessment Technique

Investigator No.*	Age, y†	Profession	Nasal Tip Projection, mm‡	Nasolabial Angle, Degrees§
1	41	Physician	18.40	99.91
2	39	Photographer	19.06	99.29
3	25	Secretary	18.28	98.73
4	23	Secretary	17.12	97.26
5	39	Secretary	16.80	99.17
6	36	Nurse	17.95	101.40
7	28	Nurse	20.07	101.20
8	26	Nurse assistant	19.58	100.20
9	42	Nurse	20.47	100.45
10	33	Physician	17.55	101.18

*All 10 investigators were female.
†Mean, 26.
‡Mean ± SD, 18.53 ± 1.24; SD%, 6.7.
§Mean ± SD, 99.88 ± 1.30, SD%, 1.3.

other measuring technique. The surgeon's assessment did not correlate with the patients' assessment probably because of the small number of patients involved and because patients are usually satisfied more easily than surgeons.[2]

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