Precise Anatomical Study of Rhinoplasty
Description of a Novel Method and Application to the Lateral Crural Steal

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IMPORTANCE The prediction of nasal tip position in terms of projection, rotation, and length is a major challenge in rhinoplasty. Studies using preoperative and postoperative photographs lack accuracy owing to variable position, and computer-simulated models lack clinical applicability.

OBJECTIVES (1) To describe an accurate and reproducible technique to study the effect of surgical manipulations on the nasal tip; and (2) to describe the effect on the nasal tip cartilages of the lateral crural steal (LCS).

DESIGN, SETTING, AND PARTICIPANTS Cadaveric study in a tertiary hospital center using 10 cadaveric specimens.

INTERVENTIONS Heads were placed in a Mayfield head holder, and a 12.2-megapixel camera was fixed on a tripod in a perfectly still position and focused on the surgical field during all surgical manipulations. An external rhinoplasty approach was performed for all specimens, and a 4-mm LCS was achieved.

MAIN OUTCOMES AND MEASURES Measures include tip projection, tip rotation, and nasal length using preoperative and postoperative photographs.

RESULTS Our method was successfully performed on all specimens: LCS resulted in a significant mean increase in projection using the Goode ratio (mean, 0.05; \( P = .005 \)) and rotation (mean, 13.2°; \( P = .005 \)). However, absolute tip projection variation was inconsistent, ranging from −1.0 mm to 0.6 mm. Nasal length was significantly shortened in all cases (mean, 1.3 mm, \( P = .005 \)).

CONCLUSIONS AND RELEVANCE We describe the first technique for precise anatomical study of tip position in rhinoplasty on cadaveric specimens. This technique was successfully applied to 10 consecutive nasal tips. We have shown a significant increase in projection using the Goode ratio and rotation with LCS. However, the effect on absolute projection is inconsistent.

LEVEL OF EVIDENCE NA.
Nasal tip modification is considered by many to be the most challenging aspect of rhinoplasty.1 This challenge lies in the prediction of results with regard to projection, rotation, and definition.1 Several theoretical models have been developed to predict nasal tip projection and rotation, such as the tripod2 and the M-arch.3 To supplement these models and to help predict postoperative results, studies have attempted to measure tip position on preoperative and postoperative photographs4 or using computer programs such as the Tip-Plasty Simulator.3 However, accuracy is an inherent weakness in studies where measures are based on photographs because the position of the head is not necessarily identical in the preoperative and postoperative images, and the location of the camera from the head may vary.6 Studies based on computer simulations provide a purely conceptual model with a weaker clinical correlation than human or cadaveric studies.

Our aim is to describe an accurate and easily reproducible technique to study the effect of surgical manipulations on the nasal tip cartilages. To our knowledge, such a technique has never been described in the literature. Using this technique, we will show the effect on the nasal tip of the lateral crural steal (LCS), a cartilage-sparing tip-modifying technique used to increase tip projection and rotation.7 To our knowledge, the LCS has never been evaluated in a purely anatomical study.

Methods

We conducted a dissection study on 10 fresh cadaveric heads of patients having provided informed consent to postmortem research. We excluded heads with nasal deformity or previous nasal surgery. Institutional review board approval was obtained.

Setup

The operative setup is shown in Figure 1. The head was placed in the supine position in an Integra Mayfield Triad Skull Clamp (Integra LifeSciences Corporation) using 3 skull pins. A 12.2-megapixel EOS Rebel XSi camera (Canon) was placed on a camera tripod approximately 75 cm lateral to the cadaveric head. The camera was centered on the nasion as a fixed point that would not move during all manipulations. This setup remained perfectly and completely still during all surgical manipulations. Preoperative and postoperative photographs were taken with maximum resolution.

Operative Technique

To allow maximal appraisal of the cartilaginous framework of the nasal tip, and to be able to modify the cartilage under direct vision, an external rhinoplasty approach was used for all cadaveric specimens. An inverted-V transcolumellar incision was connected to bilateral alar marginal incisions. The columellar skin flap was elevated off the medial crura in the plane superficial to the perichondrium until reaching the nasal bone. The dissection was then completed subperiosteally to the nasion. The vestibular skin was undermined completely under the lower lateral cartilage to allow lateral crural mobilization. We ensured that the lateral crural attachments were not severed to maintain the adequacy of the tripod model.

A conservative cephalic trim was practiced, leaving an intact strip of at least 6 mm. This was done to allow a similar width of domal cartilage before and after LCS to decrease confounding variables. With the caliper, a line was drawn at 4 mm from the tip-defining points bilaterally. The lateral crus was then advanced medially in a curvilinear fashion onto the medial crus until the drawn lines became the new tip-defining points, as discussed by Kridel et al.7 The cartilage was fixed using 5-0 Prolene mattress sutures (Ethicon Endo-Surgery Inc) just below the new dome on each side. A schematic representation is shown in Figure 2. An interdomal suture of 5-0 Prolene at the level of the tip-defining point was also added to recreate tip architecture. In our technique, the skin was not re-draped, thus allowing us to study the effect of the manipulations solely on the cartilage and to eliminate the confounding factor of overlying skin.

Measurement of Outcomes

To ensure reproducible outcomes between the preoperative and postoperative images, we conducted all measurements in the same standard fashion using identical technique in each case. The photographs were taken without any displacement of the operative setup between the preoperative and postoperative photograph. Using Photoshop CS5 software (Adobe Systems Incorporated), we analyzed the photographs using cephalometric reference points.

Definitions

Nasal length is the distance between the nasion and the tip-defining point (Figure 3A).7 Absolute projection is the perpendicular distance between the tip-defining point and a line passing through the nasion and alar crease (Figure 3B). The
Figure 2. Schematic Illustration of the Preoperative (A) and Postoperative (B) Nasal Tip

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Figure 3. Measurement of Length (A), Projection (B), and Rotation (C)

TDP indicates tip-defining point.
Goode ratio to measure projection is the perpendicular distance between the tip-defining point and a line passing through the nasion and alar crease divided by nasal length. The Goode ratio evaluates relative projection, since it relates tip projection to other tip variables such as nasal length and rotation. Rotation is the angle between the facial plane (line between glabella and pogonion) and a line passing through the tip-defining point and subnasale (Figure 3C). All measures were made in triplicate by the same observer, and the mean of the 3 measures was used.

### Table. Change Between Preoperative and Postoperative Nasal Tip Projection, Rotation, and Length After the Lateral Crural Steal Modification

<table>
<thead>
<tr>
<th>Cadaveric Head (N = 10)</th>
<th>Projection, mm</th>
<th>Length, mm</th>
<th>Goode Ratio</th>
<th>Rotation, °</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Change</td>
<td>Pre</td>
</tr>
<tr>
<td>1</td>
<td>12.31</td>
<td>11.28</td>
<td>−1.03</td>
<td>17.69</td>
</tr>
<tr>
<td>2</td>
<td>15.22</td>
<td>15.78</td>
<td>0.56</td>
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<td>13.89</td>
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<td>5</td>
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<td>10.38</td>
<td>0.02</td>
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<tr>
<td>6</td>
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<td>11.13</td>
<td>0.43</td>
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</tr>
<tr>
<td>7</td>
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<td>−0.3</td>
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<tr>
<td>8</td>
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<td>9.88</td>
<td>−0.42</td>
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</tr>
<tr>
<td>9</td>
<td>9.53</td>
<td>9.01</td>
<td>−0.52</td>
<td>15.13</td>
</tr>
<tr>
<td>10</td>
<td>9.39</td>
<td>9.94</td>
<td>0.55</td>
<td>16.28</td>
</tr>
<tr>
<td>Mean (95% CI)</td>
<td>NA</td>
<td>NA</td>
<td>−0.08 (−0.47 to 0.30)</td>
<td>NA</td>
</tr>
</tbody>
</table>

| P value            | NA | NA | .92 | NA | NA | .005* | NA | NA | .005* | NA | NA | .005* |

Abbreviations: NA, not applicable; pre, preoperative measurement; post, postoperative measurement.

*P < .05 on the Wilcoxon signed-rank test is considered statistically significant.

**Figure 4. Image Superimposition of the Preoperative and Postoperative Profiles of All 10 Heads**

In each panel, 1 indicates the preoperative position, and 2 indicates the postoperative position.
Statistical Analysis
All statistical analyses were executed using IBM SPSS Statistics 19 software. The Wilcoxon signed-rank test was used to compare the difference between preoperative and postoperative findings for each measurement. Statistical significance was defined as $P < .05$.

Results
We successfully performed the operative technique on 10 specimens without any displacement of the operative setup. The Table lists the results for change in the values of projection, rotation, and length between baseline and LCS with 95% confidence intervals. A statistically significant difference was found for tip rotation, nasal length, and the Goode ratio measure of projection.

Using Adobe Photoshop, we removed the background from the preoperative and postoperative photographs, and only the profile was preserved. To better demonstrate the change of position in the nasal tip, the postoperative image was superimposed on the preoperative image with 50% transparency to demonstrate the mobilization of the tip (Figure 4). All points in the profile were perfectly superimposed to allow precise observation of the change in position of the nasal tip. Changes in projection and rotation are graphed in Figure 5, with corresponding $P$ values from the Wilcoxon signed-rank test.

Discussion
We have developed a novel method to evaluate tip modification in cadaveric studies of rhinoplasty. To our knowledge, this is the first description of such a technique in the literature. We have successfully applied this method to 10 consecutive cadaveric specimens to study LCS.

Two important advantages of this technique are its simple methodology and its minimal requirement of specialized equipment; the setup is readily available in any university hospital setting. It also provides the operator with accurate preoperative and postoperative measurements and is easily reproducible. Another notable advantage is the ability to create superimposition of the preoperative and postoperative photographs, as demonstrated in Figure 4. When the profile is perfectly superimposed, we can directly appreciate the change in the position of the nasal tip.

Measuring projection, rotation, and length directly on the cartilage modifies the original definitions of these variables. However, this permits accurate evaluation of the isolated effect that each modification has on the cartilaginous nasal tip.

Using the classic definition of rotation, we have shown a consistent increase using the LCS technique, which was an expected result concordant with previously described clinical experience.

However, there is great variation in the literature in the methods used to assess nasal tip projection. The Goode ratio is one of the most commonly used methods. The ideal Goode ratio, between 0.55 and 0.60, has been shown to correlate most with facial attractiveness. The Goode ratio evaluates relative projection, since it relates projection to other tip variables such as nasal length and rotation. However, to evaluate absolute projection of the tip, we also used the perpendicular distance (in millimeters) between the tip-defining point and the plane passing through the nasion and alar crease.

Our results were interesting. As expected, the LCS increased the Goode ratio in a statistically significant manner. A 4-mm LCS increased the Goode ratio by 0.05 on average ($P = .005$). However, to our surprise, the increase in absolute

Figure 5. Graphic Representation of Changes in Nasal Tip Position Between Baseline and Post-LCS

A. Projection, in millimeters; B, length, as a Goode ratio; C, Rotation, in degrees. LCS indicates lateral crural steal procedure.
projection (in millimeters) was inconsistent. Half of the cartilaginous tips increased in projection, and half decreased (Table). We were unable to consistently demonstrate an increase in absolute projection with the LCS technique in our cadaveric specimens, but neither were we able to demonstrate its opposite. In accordance with the tripod model, the lateral crura are fixed at their lateral extremities, and the medial crura are fixed at their medial extremities. By stealing from the lateral crura, we lengthen the medial crura. The reason this lengthening does not always translate into an increase in absolute projection resides partly in the characteristics of the existing tripod model that vary between individual cadavers, namely, the configuration, shape, and resiliency of individual cartilaginous frameworks. Figure 6 illustrates well the decrease in millimeters in post-LCS projection despite an increase in Goode ratio.

A great advantage of our technique is the ability to perfectly superimpose images, arising from the immobility of the setup. Our results with the LCS are similar to those reported by Foda and Kridel in 1999 in a clinical study using preoperative and postoperative photographs, although they used an LCS of 5 mm instead of the 4 mm we used in our study. In both studies, the tip rotation was significantly increased, and the nasal length was significantly shortened. The relative tip projection was increased in both studies, confirmed by Goode ratio, but the absolute projection of the nasal tip from the facial plane was inconsistent.

In conclusion, we describe the first technique to our knowledge for precise anatomical study of tip cartilage position in rhinoplasty on cadaveric specimens. This technique was successfully applied to 10 consecutive nasal tips. We evaluated the effect of LCS and confirmed an increase in rotation and relative projection of the nasal tip cartilages previously described in other clinical studies. Future directions for research include using this technique to evaluate other nasal tip-plasty maneuvers to help with preoperative planning in rhinoplasty.

**REFERENCES**