Impact of Rhinoplasty on Objective Measurement and Psychophysical Appreciation of Facial Symmetry

S. A. Reza Nouraei, MRCS; Maria A. Pulido, MD; Hesham A. Saleh, FRCS(ORL-HNS)

Objectives: To determine the impact of rhinoplasty on the objective measurement and subjective appreciation of facial symmetry and to investigate whether perceptual shifts are correlated with objective changes in facial proportions.

Design: Frontal view photographs were used to measure bilateral symmetry ratios of the medial and lateral canthi, tragus, ala, and oral commissure in 100 patients before and 6 months after rhinoplasty. Gestalt dichotomous impressions of facial symmetry were also obtained in all cases. Paired t tests and χ² tests were used to compare facial proportions and the proportion of faces perceived as symmetrical, respectively, before and after surgery. The receiver operating characteristic and analysis of variance were used to assess whether perceptual shifts in symmetry could be correlated with objectively measurable changes in facial proportion.

Results: The number of faces perceived as symmetrical increased from 42 to 62 after rhinoplasty (P < .001, χ² test). Objectively, midline-to-ala symmetry increased from an average of 91.1% (5.5%) (mean [SD]) to 93.8% (4.5%) after rhinoplasty (P < .001, paired t test). Other facial proportions did not change significantly (P > .10). The degree of change in midline-to-ala symmetry was the only objective measure that was significantly associated with the subjective perception of the face as symmetrical or asymmetrical (P < .01, 1-way analysis of variance). Most positive perceptual shifts were associated with an objective improvement in nasal symmetry that was greater than 2%. Conversely, most negative perceptual shifts were associated with minimal postoperative improvement or loss of nasal symmetry.

Conclusion: Rhinoplasty leads to objectively measurable changes in nasal symmetry that correspond with psychophysical modifications in the perception of a face as symmetrical or asymmetrical.

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Facial symmetry is an important determinant of the perception of a person as healthy and attractive and plays an important, if mostly subconscious, part in social interactions and mate selection.1-3 The nose is the central feature of the face, and its dimensions and proportions, whose imperfections rhinoplasty aims to correct,4-6 play an important role in the overall perception of facial symmetry. We have previously shown that in patients requesting aesthetic rhinoplasty the degree of midline-to-ala asymmetry is an independent predictor of the perception of the face as symmetrical or asymmetrical by independent observers.7 The goals of the present study were to objectively assess changes in facial proportion after rhinoplasty and to determine whether and how these changes relate to shifts in the perception of facial symmetry.

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sible to wholly eliminate an element of random error resulting from subtle axial rotations. Anthropometric measurements were obtained based on facial soft-tissue landmarks.\textsuperscript{9,11} Measurement was initiated with the selection of an imaginary sagittal line that started in the hairline and then crossed the central point above the bridge of the nose, the central portion of Cupid’s bow, and the chin. Because inherent facial asymmetries exist in every face, these points were not always in a perfectly straight line, in which case the midline was drawn as the line of best fit. Because Cupid’s bow was the most constant of the 4 landmarks, the line of best fit always passed through it. The distance from this line to the medial and lateral canthi, tragus, lateral alar margin, and oral commissure was measured, and bilateral symmetry was determined as the ratio of the lesser to the greater distance and expressed as a percentage (\textit{Figure 1}).

\textbf{PERCEPTUAL ANALYSIS}

Preoperative and postoperative photographs were shown to 10 independent observers, none of whom were aware of the premise of the study. The photographs were loaded onto a PowerPoint presentation (Microsoft Corp, Redmond, Washington) and shown sequentially to each observer. A period of 3 seconds was allowed for viewing, followed by a 3.5-second window during which the observer was asked to express an opinion on whether the face looked symmetrical or asymmetrical. A 1-minute break was introduced after every 20 viewings. The brief viewing time was deliberately chosen to optimize the chances of obtaining a Gestalt view of facial symmetry. A special consideration involved the possibility of “perceptual contamination” given that the same observers were being asked to rate both the preoperative and the postoperative photographs of the same patient. This possibility was addressed by randomly dividing the picture set into 2 parts using a random sequence generator (\texttt{www.random.org}), each consisting of preoperative and postoperative pictures of 50 patients (50%). The same observers were asked to rate these 2 picture sets at 2 different sittings 4 months apart. The alternative approach would have been to ask different observers to rate preoperative and postoperative pictures of the same patient, which would have introduced an inescapable element of interobserver variability. A face was considered symmetrical if more than 50% of the viewers considered it so.\textsuperscript{7} Patients were classified into 4 perceptual groups: (1) patients whose faces were preoperatively and postoperatively perceived as symmetrical (S-S); (2) patients whose faces were preoperatively and postoperatively perceived as asymmetrical (A-A); (3) patients whose faces were preoperatively perceived as asymmetrical but were postoperatively judged to be symmetrical (A-S); and (4) patients whose faces were preoperatively perceived to be symmetrical but were postoperatively judged to be asymmetrical (S-A).

\textbf{STATISTICAL ANALYSIS}

Distributional normality of data was tested using the Anderson-Darling test. Changes in the degree of facial symmetry in different facial regions within subjects after rhinoplasty were assessed using paired \(t\) tests. The proportion of faces considered symmetrical before and after rhinoplasty were compared using \(\chi^2\) tests. Changes in facial symmetry were calculated by subtracting the postoperative bilateral symmetry ratio from the preoperative value. One-way analysis of variance was used to explore the relationship between objective changes in facial proportions and subjective perceptions of symmetry. Two receiver operating characteristic studies were performed to assess the ability of objective changes in facial symmetry to differentiate between patients in the A-S and the S-A groups from the rest. This was carried out to investigate whether perceptual shift could be correlated with “thresholds” of facial symmetry change.

There were 61 women and 39 men in the study, and the majority of the patients (\(n=54\)) were of Northern European descent. There were no significant differences between the sexes or the races with respect to preoperative and postoperative degrees of facial symmetry (\textbf{Table}). Overall, the ratio of midline to lateral alar margin increased from an average of 91.1% (5.5%) (mean [SD]) before surgery to 93.8% (4.5%) after surgery (\(P<.001\), paired \(t\) test). Other facial proportions did not change significantly (\(P>.10\)) (\textbf{Figure 2}). Before surgery, 42 patients were considered to have a symmetrical face, and this number increased to 62 after surgery (\(P=.001\), \(\chi^2\) test). Thirty-four of the 42 patients whose faces were perceived to be symmetrical before surgery were also perceived to have symmetrical faces based on their postoperative photographs (S-S), while the remaining 8 patients were considered to have asymmetrical faces after rhinoplasty (S-A). Of the 58 patients whose faces were perceived to be asymmetrical based on their preoperative photographs, 30 were still perceived to have asymmetrical faces after surgery (A-A), while 28 faces were perceived to have attained facial symmetry after surgery (A-S). There was a significant difference in the degree of change in fa-
cial symmetry (postoperative symmetry ratio–preoperative symmetry ratio) in the midline to lateral alar margin measurement between these 4 perceptual groups ($P < .05$, 1-way analysis of variance). None of the other facial measurements showed this pattern (Figure 3). This observation was further explored using receiver operating characteristic statistics. We hypothesized that perceptual shifts were likely to be attributable, at least in part, to objectively measurable changes in facial proportion, and if so, the degree of change in facial symmetry after surgery could be a perceptual shift discriminator. Figure 4 shows 2 receiver operating characteristic curves relating to S-A (Figure 4A) and A-S (Figure 4B) groups. A greater area under the curve (0.78) was observed for loss of perception of symmetry than was seen for achieving facial symmetry (area under the curve, 0.64). Seven of 8 patients with a negative perceptual shift had improvements of less than 2% in the midline to lateral alar margin, and 63% of them experienced a postoperative deterioration in nasal symmetry. Conversely, 68% of pa-

Table. Degree of Facial Symmetry Between Men and Women and Between Different Ethnic Groups Before and After Rhinoplasty

<table>
<thead>
<tr>
<th>Variable</th>
<th>Male (n = 39)</th>
<th>Female (n = 61)</th>
<th>Middle Eastern (n = 21)</th>
<th>Asian (n = 11)</th>
<th>Latino (n = 6)</th>
<th>Far-Eastern (n = 4)</th>
<th>Afro-Caribbean (n = 4)</th>
</tr>
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<tbody>
<tr>
<td>Before rhinoplasty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>RMLTr</td>
<td>94.1 (4.2)</td>
<td>94.2 (4.0)</td>
<td>94.0 (4.3)</td>
<td>96.0 (5.3)</td>
<td>96.0 (1.2)</td>
<td>97.3 (1.7)</td>
<td>91.4 (4.9)</td>
</tr>
<tr>
<td>RMLLC</td>
<td>95.8 (4.5)</td>
<td>95.6 (3.5)</td>
<td>95.0 (5.2)</td>
<td>97.0 (2.5)</td>
<td>94.8 (4.9)</td>
<td>96.6 (3.8)</td>
<td>94.3 (3.2)</td>
</tr>
<tr>
<td>RMLMC</td>
<td>91.5 (5.7)</td>
<td>90.6 (5.1)</td>
<td>91.8 (6.6)</td>
<td>92.6 (4.1)</td>
<td>92.3 (7.6)</td>
<td>93.4 (2.3)</td>
<td>89.7 (6.2)</td>
</tr>
<tr>
<td>RMLLAM</td>
<td>90.0 (5.5)</td>
<td>90.9 (5.5)</td>
<td>92.1 (5.4)</td>
<td>92.6 (4.1)</td>
<td>92.3 (7.0)</td>
<td>97.6 (1.8)</td>
<td>92.7 (4.4)</td>
</tr>
<tr>
<td>RMLLOC</td>
<td>94.4 (4.1)</td>
<td>93.6 (4.7)</td>
<td>93.7 (4.8)</td>
<td>92.1 (4.5)</td>
<td>91.7 (5.4)</td>
<td>94.2 (3.6)</td>
<td>91.4 (7.1)</td>
</tr>
<tr>
<td>After rhinoplasty</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMLTr</td>
<td>94.5 (3.4)</td>
<td>94.4 (3.5)</td>
<td>94.2 (3.7)</td>
<td>96.7 (3.7)</td>
<td>97.2 (1.8)</td>
<td>96.9 (3.3)</td>
<td>94.3 (3.9)</td>
</tr>
<tr>
<td>RMLLC</td>
<td>95.7 (3.3)</td>
<td>95.8 (3.1)</td>
<td>95.2 (3.7)</td>
<td>97.2 (1.8)</td>
<td>94.8 (4.9)</td>
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<tr>
<td>RMLMC</td>
<td>91.9 (5.4)</td>
<td>92.1 (5.4)</td>
<td>91.2 (5.2)</td>
<td>91.7 (6.0)</td>
<td>91.4 (4.4)</td>
<td>94.4 (4.4)</td>
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<td>RMLLAM</td>
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<td>92.3 (7.0)</td>
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<td>RMLLOC</td>
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</tbody>
</table>

Abbreviations: ML-LAM, midline to lateral alar margin; ML-LC, midline to lateral canthus; ML-MC, midline to medial canthus; ML-OC, midline to oral commissure; ML-Tr, midline to tragus; R, ratio.
patients with a positive perceptual shift had improvements in nasal symmetry that was greater than 2%. None of the other facial ratios influenced perception.

**COMMENT**

We studied the nature and extent of changes in objective anthropometric measurements of facial proportion resulting from aesthetic rhinoplasty and correlated these measurements with Gestalt changes in the perception of the face as symmetrical or asymmetrical. Our findings show that rhinoplasty is objectively associated with a statistically significant improvement in the degree of nasal symmetry but not in other anthropometric facial measurements (P < .001). Subjectively, before rhinoplasty the majority of the faces were perceived as asymmetrical, whereas after rhinoplasty most faces were perceived as symmetrical. The degree of nasal symmetry has previously been associated with the perception of the face as symmetrical or asymmetrical in patients requesting aesthetic rhinoplasty, and the present study not only extends these findings but also links shifts in the perception of the face as symmetrical or asymmetrical with the attainment or loss of nasal symmetry after rhinoplasty.

Most patients who experienced a positive perceptual shift had improvements in the degree of nasal symmetry that exceeded 2%. Conversely, 87.5% of patients who experienced a negative perceptual shift had improvements in nasal symmetry that were less than 2%; indeed, the majority of them, in fact, experienced loss of nasal symmetry after rhinoplasty. Loss of nasal symmetry after rhinoplasty therefore exerted a greater negative influence on perception when compared with the positive influence of attaining nasal symmetry in causing a positive perceptual shift. This is an important observation and needs to be taken into account when the relative risks and benefits of offering different surgical approaches to correct a nasal deformity are being considered.

The findings of the present study have significant implications for the practice of evidence-based facial plastic surgery. Facial symmetry has long been recognized as central to the perception of an individual as healthy and attractive, and the present study suggests that achievement of better, more subtle nasal symmetry after...
rhinoplasty leads to considerable improvement in the overall perception of the face as symmetrical. Therefore, this study could be a preoperative step toward introducing a scientific evidence-based approach to assessing outcome in rhinoplasty surgery, although more studies are needed to correlate objective anthropometric facial proportions with psychophysical facial perception. The midline to lateral alar margin provides 1 objective nasal measure, and while we have shown that it correlates with changes in perception before and after rhinoplasty, it is not a full description of the nasal form and cannot, therefore, in isolation, describe the full range of subtle changes that occur after rhinoplasty. Another limitation of the present study, and indeed any study of this kind, is the small but unavoidable possibility of perceptual contamination; ie, by asking the same observers to rate the same patient before and after rhinoplasty, there is a risk that their initial rating of the patient may influence their subsequent assessment of the face. This problem could be addressed in 2 ways: Different observers could be asked to rate preoperative and postoperative pictures. We piloted this approach, and 2 groups of observers were asked to rate the same images. We found interobserver concordance generally to be poor. The alternative approach, which we took, was to ask the same observers to rate the data set in 2 separate installments some months apart. We accept the fact that this method cannot wholly eliminate the possibility of perceptual contamination, but a comparative study of preoperative and postoperative photographs of the same patient cannot conceptually be undertaken except by 1 of these 2 ways.

In conclusion, our study demonstrates that objective changes in nasal symmetry are significantly associated with changes in the perception of the face as symmetrical or asymmetrical and that loss of nasal symmetry has a greater influence in causing a negative perceptual shift than attainment of facial symmetry has in causing a positive shift in perception. Rhinoplasty aims to improve facial aesthetics by improving the dimensions and symmetry of the nose, and objective measurement of facial dimensions could, in time, form part of an evidence-based approach to evaluating patients who are undergoing rhinoplasty. This study takes a step toward achieving this goal, but it must be borne in mind that improvements in the dimensions and proportions of the nose are in fact aimed at enhancing the perception of the facial form in much the same way, for example, that reductions in the air-bone gap in middle ear surgery are aimed at improving hearing. We do not therefore believe that anthropometric facial proportions should, without perceptual correlation, be used for outcome assessment in facial plastic surgery, but we do believe that they need to be clearly studied and mathematically modeled and that their variance should be correlated against variance in facial perception. Only after objective measures have been shown to be able to explain the majority of the variance in perception could they themselves be used as outcome measures in facial plastic surgery.

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REFERENCES


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