Preoperative Computer Simulation for Asian Rhinoplasty Patients: Analysis of Accuracy and Patient Preference

Myeong Sang Yu, MD, PhD; and Yong Ju Jang, MD, PhD

Abstract

Background: Preoperative computer simulation (PCS) is a tool for demonstrating potential rhinoplasty results to patients and determining the patient's preferred external nasal appearance.

Objectives: The authors evaluated the effectiveness of PCS in Asian rhinoplasty patients.

Methods: The records of 224 patients who underwent rhinoplasty were reviewed. Sixty-eight (30.4%) of these patients had received PCS. To evaluate the accuracy of PCS in predicting postoperative results, postoperative photographs and PCS images were graded on a 4-point scale by a panel of 3 otolaryngologists. Postoperative patient satisfaction was compared between the PCS and non-PCS groups. Aesthetic parameters were assessed in the PCS images to determine the patient's preferred external nasal appearance.

Results: The mean overall accuracy of PCS was 86.0% according to the otolaryngologist panel's ratings: 41.2% of the surgical results were rated as identical, 44.1% as similar, 13.2% as approximate, and 1.5% as poor. There were no significant differences between the PCS and non-PCS groups in terms of patient satisfaction or revision rates \( P > .05 \). The most favored nasal appearances were straight dorsum (63.2%), straight columella (50.0%), and convergent alar axis (64.7%). The mean (± standard deviation) preferred nasofrontal and nasolabial angles were 137.5° ± 6.9° and 97.3° ± 8.6°, respectively.

Conclusions: Preoperative computer simulation is an accurate tool for assessing preferred external nasal appearance and can be a reliable predictor of postoperative rhinoplasty results in Asian patients.

Level of Evidence: 3

Keywords

rhinoplasty, computer simulation, patient satisfaction, patient preference

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It is important that rhinoplasty patients have realistic expectations, maintain effective communication with their surgeon, and share a mutual understanding of desired surgical results.\(^1,2\) Most patients cannot visualize their postoperative appearance before surgery.\(^3,4\) Since the development of inexpensive, rapid, high-resolution digital photography and image manipulation software, preoperative computer simulation (PCS) has been widely employed in the planning of rhinoplasty procedures.\(^4,5\) Preoperative computer simulation improves communication between the surgeon and patient and allows the patient to participate actively in the surgical planning process.\(^6\) It also helps to foster realistic expectations, minimize anxiety, reconcile the patient’s preferences and the surgeon’s aesthetic goals.

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and eliminate unrealistic expectations.\textsuperscript{5,7-11} Moreover, PCS facilitates the training of residents\textsuperscript{12} and can be an effective and objective tool for determining the patient’s preferred external nasal appearance.\textsuperscript{4} Despite these advantages, many surgeons are reluctant to adopt PCS in practice. In addition to equipment costs, the learning curve, and the extra time required during consultation, potential medico-legal implications must be considered, such as final outcomes that fall short of the predictions. These issues limit the general acceptance of this tool.\textsuperscript{5}

The roles and benefits of PCS in rhinoplasty consultation are debatable. Some authors noted improved patient-physician communication and greater physician confidence after incorporating PCS into their consultations.\textsuperscript{2,3} Others reported no significant differences in overall satisfaction levels between rhinoplasty patients who received PCS during preoperative consultation and patients who did not.\textsuperscript{9}

Applying PCS to Asian patients could yield different efficacy results from those in Caucasian patients because of inherent differences between Asian and Caucasian noses. Most published studies of PCS efficacy have been conducted with Caucasian patients.\textsuperscript{2-5,8-12} To our knowledge, there has been no such study in Asian rhinoplasty patients.

The present study was designed to assess the accuracy of PCS for predicting actual rhinoplasty results in Asian patients. The utility of PCS for determining patients’ preferred external nasal appearance also is discussed.

\section*{METHODS}

The records of 224 consecutive patients who underwent rhinoplasty between November 2007 and December 2008 were reviewed. The study was approved by the Institutional Review Board of Asan Medical Center (Seoul, South Korea). All rhinoplasties were performed by a single surgeon (Y.J.J.) through the open approach. Sixty-eight (30.4\%) of these patients received PCS as part of their preoperative consultation (PCS group), and 156 patients did not (non-PCS group). Preoperative computer simulation was performed if requested by the patient.

\section*{Preoperative Computer Simulation}

The preoperative rhinoplasty consultation consisted of an introduction, medical history review, discussion of patient concerns, physical examination, and obtaining standard 6-view digital photographs (frontal, left and right lateral, left and right oblique, and basal views). Images were obtained with a Canon (Lake Success, New York) D70 camera equipped with a double slave flash. Preoperative computer simulation images were taken from the profile, frontal, and basal views, with the patient interacting to simulate proposed operative changes (Syncromax version 3.0; DreamWizard, Seoul, South Korea). Patient expectations were informed by each patient’s anatomy, the surgically achievable changes, and the surgeon’s professional advice. The mutually agreed-on final versions of the simulations were referenced in planning each surgical procedure.

\section*{Objective and Subjective Outcome Assessments}

Surgical outcomes were assessed by 3 independent otolaryngologists who are rhinoplasty experts. To maintain objectivity, the selected panelists had no personal or financial relationship with the authors and were assured that their responses would remain anonymous. The quality of the match between PCS images and postoperative results was assessed by consensus of 3 panelists on a scale of 1 to 4 (1 = identical, 2 = similar, 3 = approximate, and 4 = poor). Patient satisfaction was assessed by a face-to-face interview/survey conducted at the 6-month follow-up visit, in which an independent otolaryngologist questioned patients regarding overall contentment with outcomes. Patients also rated their satisfaction on a scale of 1 (dissatisfaction) to 4 (satisfaction).

\section*{Preferred Nasal Appearance}

The PCS images were reviewed by each patient to determine the external nasal appearance most preferred by our rhinoplasty patients (Figure 1). The shape of the dorsum and columella limb was classified as straight, concave, or convex. The nasolabial angle was measured at the intercept of the line extending from the subnasale to columellar point and the line from the subnasale to labrale superiorus. The nasofrontal angle was measured at the intercept of the line extending from glabella to nasion and the line extending from nasion to tip.\textsuperscript{11} The alar axis was classified as divergent, straight, or convergent according to the criteria of Brissett and Sherris.\textsuperscript{13}

\section*{Statistical Analysis}

All analyses were performed using the Statistical Package for the Social Sciences, version 12.0 for Windows (SPSS, Inc, an IBM Company, Chicago, Illinois). Differences in patient satisfaction were compared between the PCS and non-PCS groups by Fisher exact test and $t$ test. Intra- and interrater reliability was assessed by intraclass coefficient (ICC). The ICCs between 0.60 and 0.80 were considered substantial; ICCs above 0.80 were regarded as excellent (near perfect).

Statistical significance was defined as $P < .05$. 

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Of the 224 patients, 127 were men and 97 were women. The mean age was 27.5 years (range, 16-61 years), and the mean follow-up period was 20.1 months (range, 13-43 months). The PCS group (n = 68) comprised 38 men and 30 women, with a mean age (± standard deviation [SD]) of 28.3 ± 8.4 years (range, 17-55 years). The non-PCS group (n = 156) comprised 91 men and 65 women, with a mean age of 26.9 ± 7.3 years (range, 16-61 years).

Most patients in the PCS group had multiple reasons for seeking rhinoplasty, including a desire to increase tip projection (n = 45; 66.2%), increase rotation (n = 19; 27.9%), narrow a wide bulbous tip (n = 10; 14.7%), and correct asymmetry (n = 7; 10.3%). Dorsal deformities included flat nose (n = 33; 48.5%), deviated nose (n = 25; 36.8%), hump (n = 22; 32.4%), and cleft lip (n = 2; 2.9%). Five patients (7.4%) had undergone rhinoplasty previously.

All operations in the PCS group were performed through an open approach. Forty-nine patients (72.1%) who desired significant improvement of the nasal dorsum underwent dorsal augmentation incorporating Tutoplast-processed fascia lata (Tutogen Medical, Neunkirchen am Brand, Germany): as graft material in 23 patients (33.8% of all PCS patients), as a combination of Tutoplast-processed fascia lata and autologous cartilage in 19 (27.9%), and as autologous cartilage alone in 7 (10.3%). With respect to nasal tip surgery in the PCS group, most patients (n = 58) received septal cartilage as the graft material: shield graft in 26 patients (38.2%), caudal septal extension graft in 21 (30.9%), columella strut in 15 (22.1%), and onlay graft in 11 (16.2%). Upper-third deformities were corrected in 45 PCS patients (66.2%): medial or lateral osteotomies in 29 patients (42.6%), spreader graft in 20 (29.4%), and hump resection in 16 (23.5%). Six patients (8.8%) underwent alar base surgery to correct flaring and/or wide nostrils.

According to the panel of 3 otolaryngologists, PCS images vs outcomes were rated as identical for 28 patients (41.2%), similar for 30 patients (44.1%), approximate for 9 patients (13.2%), and poor for 1 patient (1.5%) (Table 1). The ICCs for intra- and interrater reliability were 0.950 (95% confidence interval [CI], 0.930-0.975) and 0.815 (95% CI, 0.675-0.905), respectively. Both intra- and interrater reliability were regarded as excellent. Representative cases and the corresponding panel ratings are shown in Figures 2 to 5.

Mean (± SD) patient satisfaction on a scale of 1 to 4 was 3.41 ± 0.91 for the PCS group and 3.37 ± 0.79 for the non-PCS group. There were no significant differences in patient satisfaction between the 2 groups ($P > 0.05$). Two patients (2.9%) in the PCS group and 4 (2.6%) in the non-PCS group requested revisional rhinoplasty. There were no significant differences in revision rates between the groups ($P > 0.05$; Table 1).

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**Table 1. Accuracy Ratings, Patient Satisfaction Scores, and Revision Rates for the PCS and Non-PCS Groups**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>PCS Group (n = 68)</th>
<th>Non-PCS Group (n = 156)</th>
<th>$P$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy of PCS images, No. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identical</td>
<td>28 (41.2)</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Similar</td>
<td>30 (44.1)</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Approximate</td>
<td>9 (13.2)</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>1 (1.5)</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Patient satisfaction, mean ± SD</td>
<td>3.41 ± 0.91</td>
<td>3.37 ± 0.79</td>
<td>NS</td>
</tr>
<tr>
<td>Revision rate, No. (%)</td>
<td>2 (2.9)</td>
<td>4 (2.6)</td>
<td>NS</td>
</tr>
</tbody>
</table>

There were no significant differences between the study groups. NA, not applicable; NS, not significant; PCS, preoperative computer simulation; SD, standard deviation.

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**Figure 1.** Measurement parameters for identifying patient preference were (A) the nasofrontal angle, (B) the shape of the dorsum, (C) the shape of the columella limb, and (D) the nasolabial angle.
Most patients in the PCS group (63.2%) preferred a straight dorsum over a mildly concave dorsum (33.8%) or mildly convex dorsum (2.9%; Table 2 and Figure 6). Fifty percent of patients preferred a straight columella limb, 44.1% favored a mildly concave columella limb, and 5.9% desired a mildly convex columella limb (Table 2 and Figure 7). The most preferred type of alar axis was convergent (64.7%), followed by straight (22.1%) and divergent (13.2%) (Table 2 and Figure 8). Opinions of PCS images demonstrated that the mean preferred nasofrontal and nasolabial angles were 137.5° ± 6.9° and 97.3° ± 8.6°, respectively. The difference between the percentage of men (81.6%) vs women (40.0%) who preferred a straight dorsum was statistically significant ($P = .001$; Table 2). There was also a significant sex difference in regard to the nasofrontal angle ($P < .001$; Table 2).

**DISCUSSION**

The objective ratings of our otolaryngologist panel and the subjective patient satisfaction outcomes indicate that PCS can be a viable predictor of postoperative rhinoplasty.
results in Asian patients, demonstrating results similar to those for Caucasian patients.\textsuperscript{8-11} To our knowledge, this is the first study in which PCS was evaluated with Asian rhinoplasty patients.

There are many differences between Asian and Caucasian noses. Asian noses tend to have thicker skin, a more depressed dorsum, shorter length, wider nasal tip, and rounder nostrils.\textsuperscript{1,14} Therefore, rhinoplasty operations performed on Asian patients differ from those typically performed on Caucasians. Caucasian patients usually require reductive rhinoplasty, whereas Asian patients typically undergo augmentation rhinoplasty to enlarge parts of the nose such as the tip and nasal bridge. Accordingly, simulations of dorsal and tip augmentation are often provided to Asian patients who desire rhinoplasty.

The accuracy between PCS images and postoperative rhinoplasty results has been examined in several studies. Sharp et al\textsuperscript{9} reported that 68% of rhinoplasty patients felt their postoperative results were either as expected or better than expected based on PCS images. In a study by Muhlbauer

Figure 3. A 21-year-old woman with dorsal hump and tip ptosis. (A, D) Preoperative photographs. (B, E) Preoperative computer simulation images. (C, F) Twenty-eight months after dorsal reduction and tip surgery. The result was rated as similar by the panel of independent otolaryngologists.
and Holm, 78.3% of rhinoplasty patients rated their overall aesthetic results as identical or similar to PCS images. Vuyk et al. reported 80% agreement between PCS images and the postoperative results of several facial plastic surgery procedures. Results of these studies are similar to those of our study, in which the mean overall accuracy was 86.0% according to our panel. We believe that applying this technology can improve surgical results, regardless of actual accuracy, by facilitating the physician-patient relationship and communication.

Despite the fact that aesthetic perceptions of the nose differ between Asians and Caucasians, most published studies have relied on Western standards of nasal aesthetics. In fact, the application of these principles has essentially “Westernized” Asian perceptions of facial structures. The preferred shape of the nose can differ between cultures and may vary according to race, sex, individual preferences, and other factors. Therefore, it is essential that rhinoplasty surgeons understand the preferred shape of the Asian nose. Preoperative computer simulation has enabled surgeons to

Figure 4. A 55-year-old woman with a short nose and cephalic rotated tip. (A, D) Preoperative photographs. (B, E) Preoperative computer simulation images. (C, F) Twelve months after dorsal augmentation and tip surgery. The result was rated as approximate by the panel of independent otolaryngologists.
Despite the lack of a unifying concept of the ideal nose, there is sufficient evidence that specific populations have predictable aesthetic goals.15 Wang et al16 reported that Koreans generally have lower dorsal and radix height and a more acute nasolabial angle than Caucasians. The mean nasolabial and nasofrontal angles in test ideal models of the nose.4 Despite the lack of a unifying concept of the ideal nose, there is sufficient evidence that specific populations have predictable aesthetic goals.15

Table 2. Preferred Nasal Appearance in the PCS Group

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Men (n = 35)</th>
<th>Women (n = 30)</th>
<th>Total (n = 68)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape of dorsum, No. (%)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Straight</td>
<td>31 (81.6)</td>
<td>12 (40.0)</td>
<td>43 (63.2)</td>
<td>.001*</td>
</tr>
<tr>
<td>Mild concave</td>
<td>5 (13.2)</td>
<td>18 (60.0)</td>
<td>23 (33.8)</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Mild convex</td>
<td>2 (5.2)</td>
<td>0 (0.0)</td>
<td>2 (2.9)</td>
<td>NS</td>
</tr>
<tr>
<td>Shape of columella limb, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Straight</td>
<td>21 (55.3)</td>
<td>13 (43.3)</td>
<td>34 (50.0)</td>
<td>NS</td>
</tr>
<tr>
<td>Mild concave</td>
<td>16 (42.1)</td>
<td>14 (46.7)</td>
<td>30 (44.1)</td>
<td>NS</td>
</tr>
<tr>
<td>Mild convex</td>
<td>1 (2.6)</td>
<td>3 (10)</td>
<td>4 (5.9)</td>
<td>NS</td>
</tr>
<tr>
<td>Alar axis, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convergent</td>
<td>24 (63.2)</td>
<td>20 (66.7)</td>
<td>44 (64.7)</td>
<td>NS</td>
</tr>
<tr>
<td>Straight</td>
<td>10 (26.3)</td>
<td>5 (16.7)</td>
<td>15 (22.1)</td>
<td>NS</td>
</tr>
<tr>
<td>Divergent</td>
<td>4 (10.5)</td>
<td>5 (16.7)</td>
<td>9 (13.2)</td>
<td>NS</td>
</tr>
<tr>
<td>Nasofrontal angle (degrees), mean ± SD</td>
<td>134.3 ± 7.3</td>
<td>141.1 ± 6.1</td>
<td>137.5 ± 6.9</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Nasolabial angle (degrees), mean ± SD</td>
<td>97.4 ± 9.8</td>
<td>97.1 ± 8.9</td>
<td>97.3 ± 8.6</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS, not significant; PCS, preoperative computer simulation.

*Significant difference between men and women by Fisher exact test.

*Significant difference between men and women by t test.
In their study were 78.5° and 82.7° (respectively) in young Korean men and 126.0° and 133.6° in young Korean women. In the present study, patient opinions of PCS images demonstrated that Korean men prefer wider nasofrontal and nasolabial angles. In contrast, a study by Daniel17 of Caucasian patients showed that a straight dorsum (63.2%), smooth concave columella (46.7%), and straight alar axis (83.4%) are the most favored features. These findings coupled with ours clearly demonstrate that the preferred shapes of the columella and alar axis differ between Caucasians and Koreans.

Responsible application of PCS requires diligence on the surgeon's part. Although PCS can be utilized efficiently to evaluate the patient's profile, the frontal view is not as representative as the profile view because the photo is 2-dimensional. Erroneous morphing may alter the appearance of the patient's eyes, eyebrows, and cheeks. Moreover, small differences might be difficult to distinguish on frontal images.8 In addition, surgeons could unintentionally and yet legally bind themselves to achieving the surgical results shown by PCS.12 Therefore, it is especially important that surgeons perform PCS in a responsible manner and generate realistic and surgically achievable images. Computer imaging assessment is only as effective as the surgeon's ability to deliver the predictive result. It should be made clear to patients that the images do not guarantee final results but rather should be interpreted as a possible result. Therefore, it is important to obtain a signed statement from patients indicating that they are aware that the final outcome may not match the simulation images. Ethical considerations, such as manipulating photographs to encourage patient consent, are also a concern.8 Because the computer simulation method is not fixed, the experience of the surgeon who generates the images is germane to the quality of the simulations. As the surgeon becomes familiar with the simulation tools and gains experience, simulation results should improve.

At the time of this study, most Korean rhinoplasty patients did not request computer simulation, and we did not actively persuade them to undergo it. Recently, as medical information has become more accessible through the Internet and mass media, more rhinoplasty patients have become aware of computer simulation and have requested it during preoperative consultation.

The expectations of each patient in our study (PCS and non-PCS) were adjusted according to individual anatomy,
Figure 7. Preoperative computer simulation images of the columella limb. Its shape was classified as straight (A; 29-year-old man), concave (B; 23-year-old woman), or convex (C; 48-year-old man).

Figure 8. Preoperative computer simulation images of the alar axis. The axis was classified as convergent (A; 25-year-old man), straight (B; 21-year-old woman), or divergent (C; 31-year-old man).
surgically achievable goals, and the surgeon’s professional advice. Therefore, we believe that there was no significant difference in expectations between the PCS and non-PCS groups.

Limitations of the current study include its relatively small sample size and nonrandomized design. Under optimal conditions, determining PCS efficacy would require randomization of all patients to the PCS and non-PCS groups and matching for age and sex. Actually, this point was considered when designing this study, but we realized PCS is a critical process for rhinoplasty patients. Therefore, we could not exclude the patients asking for PCS from participation in our study. The expert panel’s assessment of the quality of the match between PCS images and postoperative results was essentially subjective; employing anthropometric measurements would produce more objective analyses. Large randomized studies are needed to further assess the role of PCS in consultation with Asian rhinoplasty patients and to determine the most preferred external appearance.

CONCLUSIONS

Preoperative computer simulation can be a reliable predictor of postoperative results in Asian rhinoplasty patients. Approximately 86% of surgical results were rated as identical or similar to the PCS images. Preoperative computer simulation is an accurate tool for determining Asian patients’ preferences for external nasal appearance. We recommend that surgeons consider incorporating PCS into their preoperative consultations with Asian rhinoplasty patients.

Disclosures

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REFERENCES