Computer Imaging Software for Profile Photograph Analysis

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Objectives: To describe a novel calibration technique for photographs of different sizes and to test a new method of chin evaluation in relation to established analysis measurements.

Design: A photograph analysis and medical record review of 14 patients who underwent combined rhinoplasty and chin correction at an academic center. Patients undergoing concurrent orthognathic surgery, rhytidectomy, or submental liposuction were excluded. Preoperative and postoperative digital photographs were analyzed using computer imaging software with a new method, the soft tissue porion to pogonion distance, and with established measurements, including the cervico-mental angle, the mentocervical angle, and the facial convexity angle.

Results: The porion to pogonion distance consistently increased after the chin correction procedure (more in the osseous group). All photograph angle measurements changed toward the established normal range postoperatively.

Conclusions: Surgery for facial disharmony requires artistic judgment and objective evaluation. Although 3-dimensional video analysis of the face seems promising, its clinical use is limited by cost. For surgeons who use computer imaging software, analysis of profile photographs is the most valuable tool. Even when preoperative and postoperative photographs are of different sizes, relative distance comparisons are possible with a new calibration technique using the constant facial landmarks, the porion and the pupil. The porion-pogonion distance is a simple reproducible measurement that can be used along with established soft tissue measurements as a guide for profile facial analysis.

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scribes a novel calibration technique for photographs of different sizes.

**METHODS**

**COMPUTER IMAGING ANALYSIS**

Preoperative and postoperative standardized profile photographs of 14 patients were analyzed by 1 blinded investigator (T.T.T.) using computer software (Marketwise Hi-Res 7.0 software; United Imaging, Winston-Salem, NC). The measurement variability was not significant when measured 3 separate times. Two study groups were chosen (osseous genioplasty and chin correction surgery by one of us (J.M.S.) and the anteriormost midpupil were chosen because of the consistency of these 2 points on the profile view, even after genioplasty, rhinoplasty, or other procedures. The distance between the Po’ and the pupil (Pup) was calibrated using the “calibrate” feature on the imaging software (Figure 1). The chosen distance between the points is calibrated to 10 U. (This feature of the software was used for the patient to hold a 10-cm ruler on the photograph.) By setting the Po’-Pup distance at 10 U, the Po’-Pog’ distance was measured as a function of the Po’-Pup distance. Therefore, the results are only comparable between the same patient’s preoperative and postoperative photographs.

**ANGLE MEASUREMENTS**

Three facial angles were measured on matched preoperative and postoperative profile photographs. Soft tissue points are illustrated in Figure 2A. Their definitions are as follows: (1) glabella, most prominent anterior point of the forehead; (2) orbitale, lowest point on the inferior orbital rim; (3) menton, lowest point on the chin; (4) Pog’, most prominent point on the chin; (5) Po’, superiormost external auditory canal; (6) pronasale, anteriormost point of the nose (tip); (7) subcervicale, innermost point between the submentum and the neck; and (8) subnasale, point at which the columella meets the upper lip. The menton, Pog’, Po’, and subnasale were the soft tissue counterparts to cephalometric points.

By using the measurement feature of the software, first the distal point of the angle is chosen and, while holding the right click button down, a line is drawn to the midpoint of the angle where the mouse button is released. The second line is drawn by moving the mouse to the third point, and the angle measurement appears on the screen. The cervicomental angle (CMA) is formed by a line tangent to the submentum and the neck tangent intersecting at the subcervicale, the innermost point between the submental area and the neck (Figure 2B). The men-tocervical angle (MCA) is defined by a line from the pronasale-nasal tip to the Pog’ as it intersects with the submental tangent (Figure 2C). The facial convexity angle (FCA) is defined as the intersection of a line from the glabella to the subnasale, with a line from the subnasale to the Pog’ (Figure 2D).

This study was approved by the University of California, Davis, institutional review board. Statistical analysis was performed using SAS statistical software (SAS Institute Inc, Cary, NC), by the University of California, Davis, Statistical Laboratory using paired t-tests on the preoperative and postoperative results and analysis of variance to test differences in the study groups. Results were considered significant if P<.05.

**RESULTS**

**MEDICAL RECORD REVIEW**

Fourteen patients who underwent concurrent rhinoplasty and chin correction surgery by one of us (J.M.S.) between November 9, 1999, and February 16, 2004, were identified. The 2 study groups included 6 patients in the implant group and 8 in the osseous group (Table). The mean age was 32 years (range, 14-49 years), with 12 females and 2 males. The mean follow-up was 9 months (range, 3-37 months). No complications, such as infection, mentalis dysfunction, tooth damage, or implant extrusion, were identified.

Technical aspects of the procedures were reviewed for chin correction methods. Osseous genioplasty was per-
formed in the standard intraoral fashion with bone fixation using a titanium plate and screws (Paulus; Stryker Leibinger Inc, Kalamazoo, Mich), as previously described. The mean plate size (horizontal advancement) was 6 mm (range, 4-8 mm). The mean horizontal advancement was 4.8 mm (range, 3-8 mm). The mean vertical shortening (n=4) was 3 mm (range, 1-7 mm), while the mean vertical lengthening (n=4) was 3.6 mm (range, 2-6 mm).

A standard submental approach was used to place anatomical chin implants (Implantech Associates Inc, Ventura, Calif). Three patients underwent implantation with a medium implant (8 mm of anterior projection/1.2 mm). Three patients had small implants (6.0 mm/1.2 mm), and no large implants (10.0 mm/1.2 mm) were used.

PHOTOGRAPH ANALYSIS

The preoperative findings for each measurement in the 2 study groups were not significantly different (P>.05). If the angles were different at the outset, then a greater or lesser change may have been identified, not because of the difference in the operations, but because of an inadvertent selection bias of using 1 procedure for a different subset of patients.

PO’ TO POG’ DISTANCE

In all patients (N=14), the ratio of the Po’-Pog’ distance–Po’-Pup distance increased (mean±SD, from 1.28±0.06 preoperatively to 1.33±0.07 postoperatively; P<.01) (Figure 3A). In the implant group, the mean±SD Po’-Pog’ distance increased from 1.27±0.08 to 1.30±0.08 (P<.02). The mean±SD Po’-Pog’ distance in the sliding osseous group increased from 1.28±0.05 to 1.35±0.05 (P<.01). The postoperative change was greater for the osseous genioplasty group (P=.03) (Figure 3B).

CERVICOMENTAL ANGLE

All patients had a decrease in the CMA (mean±SD, from 127°±14° preoperatively to 124°±13° postoperatively; P<.01), as shown in Figure 4. Separately, the mean±SD CMA decreased in the implant group (n=6) (mean±SD, from 132°±15° preoperatively to 127°±15° postoperatively; P<.01) and the osseous group (n=8) (mean±SD, from 124°±13° preoperatively to 121°±11° postoperatively; P<.03). There was no significant difference in the postoperative CMA change between the 2 groups (P=.41).

MENTOCERVICAL ANGLE

In all patients, the MCA decreased (mean±SD, from 120°±9° preoperatively to 111°±9° postoperatively; P<.01) (Figure 5). The mean±SD MCA decreased in the implant group (from 125°±10° preoperatively to 119°±9° postoperatively; P<.01) and the osseous group (from 116°±5° preoperatively to 106°±4° postoperatively).
In this study, changes in profile photographs after concurrent rhinoplasty and chin surgery are represented by positional changes in the soft tissue landmarks that are measured by a variety of angles and distances. No facial feature can be properly analyzed without considering the relationship of the surrounding structures. The complex concept of balanced facial proportions is similar to the words of Epstein,7 “to be established by comparisons, by shifting shades of difference, turned over and teased out, and after all that what one comes up with might still not feel altogether right and precise.” That feeling is the artistic aspect that should be considered, even after the objective analysis is completed.

Profile photograph analysis has many limitations. A favorable profile view can be seen after genioplasty, but the chin, when viewed from the front, may seem unnaturally narrow. Dynamic changes after surgery, such as lip position with smiling or mentalis dysfunction, are also not readily identifiable on static photographs. Although this study deals with 2-dimensional analysis and the limitations therein, the future of facial analysis using 3-dimensional photography and videography will allow the surgeon to quantify changes by adjusting the viewpoint.8 The major drawback of this technology for an individual surgeon’s practice remains costly (approximate price, $68 000).9

Adherence to the principles of standardized photography is essential to accurate analysis.10 One of the major limitations of the photographs in this study was size differences between the preoperative and postoperative images. Photographs taken with a ruler next to the chin (Figure 6K) or life-size photographs are ideal for a comparative study; however, when this is not used, the Po’-Pup distance calibration is introduced as a method to allow relative comparisons between preoperative and postoperative images. The Po’-Pup distance was chosen because of the constant position of the ear canal and Pup regardless of surgery. By using computer imaging software, the photograph size is made equal based on the Po’-Pup distance on preoperative and postoperative views. The relative values of change, such as the Po’-Pog’ distance, can then be measured. One limitation of this technique is that this new value, Po’-Pog’, must be compared with other patients as a ratio of Po’-Pog’/Po’-Pup. Therefore, the Po’-Pog’ distance cannot be compared with the millimeters of chin advance-

### Figure 3
The preoperative and postoperative porion (Po’)-pogonion (Pog’)-Po’-pupil (Pup) ratios in patients in the osseous group and the implant group (the osseous group showed a greater increase \( P = .03 \) than the implant group) (A); and the change in the Po’-Pog’-Po’-Pup ratio between the implant and osseous study groups (the osseous group had a greater postoperative change \( P < .05 \)) (B).

### Figure 4
The preoperative and postoperative cervicomental angle measurements in patients in the osseous group (patients 1-8) and the implant group (patients 9-14). The horizontal shaded area represents the normal reported range.

### Table

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ment unless a ruler is present in the photographs. Since
the completion of this study, a new technique to cali-
brate existing profile photographs using the diameter
of the iris (mean ± SD, 11.5 ± 0.6 mm) as a constant has
been described by Sporri et al11 for use in measuring
nasal tip projection. Absolute measurements of the Po'
-Pog' distance can be obtained using this constant in
future studies.

All patients in this study exhibited a change in the mea-
sured angles toward the established normal ranges. The
only significantly different postoperative change be-
tween the implant and osseous groups was in the in-
creased Po'-Pog' distance. Several aspects could account
for the difference. The soft tissue response to a chin im-
plant is reported as only 60% (1:0.6), while an osseous ge-
nioplasty can result in a 1:1 advancement for up to 8 mm
of bone movement.4,12 The reason for this disparity is likely
related to the contraction of the soft tissue capsule that
surrounds a polymeric silicone (Silastic) implant and re-
sorption of up to 5 mm of mandible.13 The following will
relate how the change in measurements correlates to
changes in soft tissue landmarks after either chin implant-
tion with an alloplast or osseous genioplasty.

CERVICOMENTAL ANGLE

The results of this study support the concept that chin
augmentation procedures can create aesthetic im-
provement in the CMA. The normal CMA has been described
for males (121°) and females (126°).14 After surgery, all
patients in this study showed improvement (less ob-
tuse) in the CMA. Although Guyuron and Raszewski15(p199)
have reported that “the cervicomental angle im-
proved more for osteoplastic genioplasty” when compared
with chin implantation in a series of 76 patients, there
was no difference in the 2 groups in this study. Obvi-
ously, the most improvement in neck contour is seen
when chin surgery is combined with rhytidectomy or sub-
mental liposuction.

MENTOCERVICAL ANGLE

The MCA has been defined in 2 different ways. Powell
and Humphreys10 defined the MCA as the junction of a
line from the glabella to the Pog’ with the submental
tangent (menton to subcervicale). The MCA is useful in
soft tissue analysis because it integrates features of the
nasal tip projection (pronasale), neck position (sub-
mental tangent), and chin projection (Pog’).11 Although
changes in tip projection were not measured in this
study, the MCA will be increased with increasing nasal
tip projection and decreased with deprojection. One
notable difference between the 2 groups is that most of
the implant group (5 of 6 patients) were within the
MCA’s normal range (110°–120°) postoperatively, while
only 2 patients in the osseous group remained in the
normal range (Figure 7). As anticipated, the 3 largest
decreases in the MCA (15°, 15°, and 17°) were observed
in patients who underwent the largest movements dur-
ing osseous genioplasty.

Although the ultimate surgical change is at the discre-
tion of the surgeon’s aesthetic judgment, several standard
proportions of the soft tissue profile view have been sug-
gested for preoperative assessment. One of the lines of
the MCA is the “E line” (esthetic plane) that extends from the
pronasale and the Pog’ (Figure 5B). By using this line as a
reference, Ricketts18 suggested that the upper lip should be
4 mm posterior, while the lower lip is 2 mm posterior to
this line; however, he recognized that considerable vari-
a tion exists for lip positioning. The Gonzales-Ulloa “zero-
meridian line” can be created by drawing a line from the
nasal that is perpendicular to the Frankfort horizontal
plane on a profile photograph. The anteriormost chin point
(soft tissue Pog’) is suggested to ideally touch this line17;
however, some researchers believe that this represents chin
overprojection (Figure 7). Others1 suggest that the Pog’
should be 4 (±2) mm posterior to a line that is perpendicu-
lar to the Frankfort horizontal plane that extends down
through the subnasale.

Figure 5. The preoperative and postoperative mentocervical angle (MCA) measurements in patients in the osseous group (patients 1-8) and the implant group
(patients 9-14) (A); preoperative profile photograph of patient 11, illustrating a large MCA (B); and postoperative profile photograph of the same patient 4 months
after “small” chin implant placement and rhinoplasty (a reduction in tip projection during rhinoplasty decreases the MCA) (C). In A, the gray shaded area
represents the normal reported range. All patients had a decrease in the MCA (P<.05). There was no difference in the postoperative change between the study
groups.

Figure 7

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FACIAL CONVEXITY ANGLE

Downs described the FCA by using bony landmarks on cephalograms. The soft tissue equivalent of this angle has a reported normal mean±SD of 168°±4°. Because nasal tip projection is not represented in this angle, the effect of genioplasty on chin projection, irrespective of nasal tip surgery, can be evaluated with the FCA. An FCA that is closer to 180° suggests an overprojected chin, but could involve dentofacial malocclusion or maxillary retrusion.

Figure 6. The preoperative and postoperative facial convexity angle (FCA) measurements in patients in the osseous group (patients 1-8) and the implant group (patients 9-14) (A); preoperative profile photograph of a 35-year-old patient (patient 8) demonstrating an acute FCA (160°) and a mentocervical angle (MCA) (120°) that is in the upper normal range (normal range, 110°-120°) (B); profile photograph 6 months after rhinoplasty with sliding osseous genioplasty (6 mm of horizontal advancement and slight vertical recession) (C); frontal preoperative view (D); frontal postoperative view (E); left oblique preoperative view (F); left oblique postoperative view (G); right oblique preoperative view (H); right oblique postoperative view (I); left profile preoperative view (J); and left profile postoperative view with ruler in photograph (K). In A, 5 patients in the osseous group and 1 in the implant group had a postoperative FCA greater than the normal range (mean±SD, 168°±4°). As the FCA approaches 180°, a flattening of the profile and masculinization of a female profile occurs and should be avoided by selecting the proper implant size or osseous advancement. In C, the measured MCA decreased by 15°, while the FCA increased into the normal range (168°). There was a change in the competence of the lips when compared with the preoperative photograph.
tion. On the other hand, an FCA that is less than normal could suggest a horizontally deficient chin and/or maxillary protrusion. Excellent aesthetic results in both groups were reflected by increased FCAs. The postoperative FCAs in the osseous group were outside the reported normal range in 6 of the 8 patients (Figure 6). Aesthetic judgment must include avoidance of chin overprojection. Too much osseous advancement, or an improperly selected implant, can result in masculinization of the female profile.

In conclusion, computer imaging software is a simple and reliable tool that is useful for analyzing photographs in patient education, surgical planning, and postoperative review. Each facial measurement and angle should be used as a guide in combination with other analysis tools and clinical judgment. As 3-dimensional photographic analysis becomes more affordable and available, comparison of preoperative and postoperative results will include spatial relationships and dynamic components of facial structures.

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