

Validation of a Photonumeric Assessment Scale for Grading the Slope of the Asian Forehead

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BACKGROUND As the number of aesthetic treatments has grown, so have the number of photonumeric assessment scales used to compare the effectiveness of these aesthetic treatments in specific anatomical areas; however, these are primarily based on Caucasian features.

OBJECTIVE To assess the validity of the first aesthetic scale for assessing the slope of the Asian forehead. A secondary objective was to correlate this scale with subject demographics and baseline characteristics.

METHODS During 2 validation sessions, 13 raters assessed full frontal and lateral facial images of female ($n = 28$; 56.0%) and male ($n = 22$; 44%) subjects. For each subject, the severity of forehead sloping was graded from 0 (convex forehead, optimal forehead volume) to 4 (concave forehead, very severe sloping). Raters also assessed the age of each subject and the estimated aesthetic treatment effort required to treat each subject.

RESULTS Inter-rater reliability was “substantial” with scores of 0.67 and 0.68 for the first and second validation sessions, indicating high reliability. BMI showed the highest correlation with the scale and was a significant predictor in the final regression model.

CONCLUSION This photonumeric assessment scale will be useful for assessing the slope of the Asian forehead in both clinical and research settings.

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The growing number of aesthetic treatments available for enhancing the appearance of aging skin has greatly increased their popularity. These include toxins, fillers, and numerous energy-based treatments. A growing number of photonumeric assessment scales have also been developed and validated by Merz Pharmaceuticals to compare the

relative efficacy of different aesthetic treatments and techniques. These rating scales have been developed to objectively assess changes in age-related changes and treatment-related improvements in the upper face,¹ midface,² lower face,³ global face,⁴ platysma,⁵ neck volume,⁶ and décolleté.⁷ These scales are designed to be used alone to evaluate changes in specific

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anatomical areas or used together to assess more global changes in appearance.

To date, aesthetic assessment scales have been designed primarily for use within the Caucasian population; however, there is growing interest for aesthetic treatments among other racial and ethnic groups.^{8,9} Among Asians, for example, one must consider differences in structural facial anatomy, the signs and rates of skin aging,¹⁰ and differences in aesthetic preferences.^{11,12} A systematic review of the literature revealed significant differences in the perception of facial attractiveness between Asian and Caucasian women.¹³ Because of these differences, new guidelines have been developed specifically for treating the Asian face with toxins,^{14,15} fillers,¹⁶ and vertical lifting.^{17,18}

The primary objective of this validation study was to determine the reliability of the first aesthetic scale for assessing the slope of the Asian forehead. A secondary objective was to test the validity of the scales by correlating them with subject demographics and baseline characteristics.

Methods

Subject Selection

Participating subjects were young Asian women and men, 18 to 39 years old with all degrees of forehead contour from a very flat forehead to a very optimal

forehead slope. Subjects from South-Korea, China, and Japan were of primary interest, but subjects from Indonesia, Vietnam, Taiwan, and Thailand were also included. Subjects with scarring, skin disease, irregular skin tone, or tattoos in the target area were excluded.

Each subject provided informed consent before participation. Demographic information, baseline characteristics, and risk factors were collected before enrollment.

Standardized Photography

Two-dimensional color photographs were obtained using professional, high-resolution photography equipment. Subjects were photographed in highly standardized positions and always with the same angles and standardized background and lighting conditions. Raw image files were converted to high-resolution JPEG files for use in the photographic database.

Scale Creation

The process of scale creation generally followed the method described elsewhere for creating other Merz Aesthetics Scales.¹⁻⁶ Briefly, subjects were screened by an experienced medical team, and 1 subject was selected whose image was representative of general forehead appearance. Additional images were then selected from the photographic database to superimpose varying degrees of forehead appearance onto the base image to create composite computer-generated

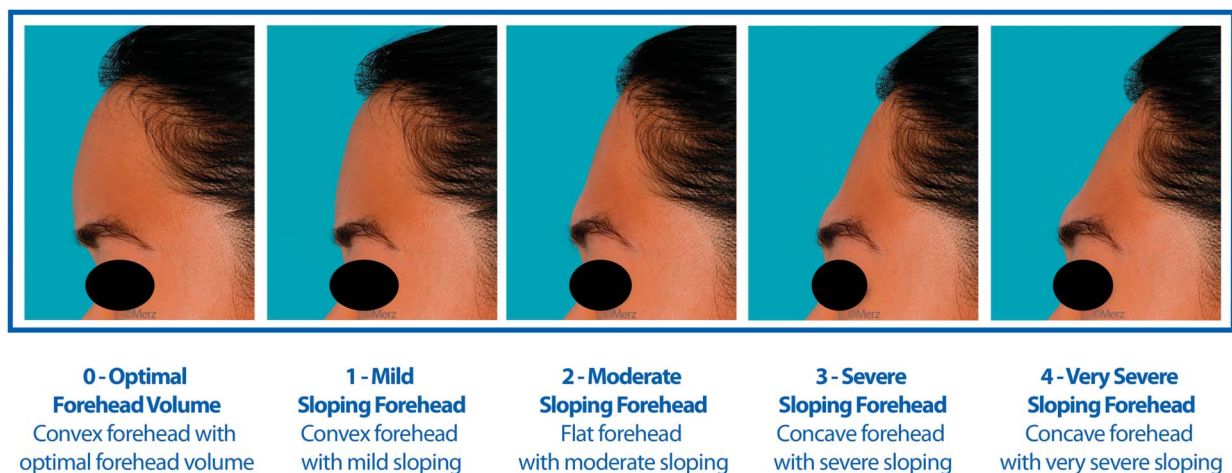


Figure 1. Final scale for the sloping forehead assessment.

images for the forehead scale (Figure 1). Photographs of subjects used as base images were not used again in the scale validation process. Each forehead image was rated on a scale ranging from 0 (convex forehead with optimal forehead volume) to 4 (concave forehead with very severe sloping).

Procedure

Dermatologists, plastic surgeons, and other qualified physicians with experience in aesthetic medicine participated as raters in 2 validation sessions performed 4 weeks apart. During each session, raters were provided with booklets containing images of 50 subjects. For each subject, the first page showed a full frontal face view, and the second page showed a lateral view including the forehead. Raters were asked to score the forehead (0–4) and assess the age of each subject and the estimated aesthetic treatment effort required for each subject.

Raters generally completed their booklets at home and were blinded with respect to any subject identifiers or characteristics. Booklets with 2 randomization sequences were used for the 2 validation sessions.

Statistical Analysis

Categorical data were described by their absolute and relative frequencies. Scale ratings (range, 0–4) and metric data were summarized by the total number (*n*), arithmetic mean, SD, median, 25% and 75% quantile, minimum, and maximum. Validation session and rater, subject, sex, and ethnicity were summarized. Estimated effort of aesthetic treatment was summarized with absolute and relative frequencies by the validation sessions and by the subjects and validation sessions. Estimated aesthetic treatment effort and estimated age were further summarized by *n*, arithmetic mean, SD, median, 25% and 75% quantile, minimum and maximum by the validation sessions and by the subjects and validation sessions.

Inter-rater reliability was assessed by using the intraclass correlation coefficient (ICC 2, 1) of Shrout and Fleiss¹⁹ and the weighted kappa values using Fleiss–Cohen weights.²⁰ The following ranges of ICC 2, 1 were

used for interpretation of results, with “substantial” regarded as the minimum score to achieve^{21,22}:

- (1) 0.00 to 0.20, slight
- (2) 0.21 to 0.40, fair
- (3) 0.41 to 0.60, moderate

TABLE 1. Demographics and Baseline Characteristics

	(N = 50)
Mean age, yrs (SD)	26.5 (3.7)
Age range, yrs	21–37
Sex, <i>n</i> (%)	
Male	22 (44.0)
Female	28 (56.0)
Mean BMI, kg/m ² (SD)	21.7 (3.4)
Median BMI, kg/m ² (min, max)	21.3 (16, 31)
Race, <i>n</i> (%)	
Asian	50 (100.0)
Country of origin	
China	14 (28.0)
Hong Kong	3 (6.0)
Korea	2 (4.0)
South Korea	5 (10.0)
Taiwan	2 (4.0)
USA	24 (48.0)
Ethnicity	
Chinese	30 (60.0)
Korean	7 (14.0)
South Korean	5 (10.0)
Taiwanese	5 (10.0)
Taiwanese/Chinese	1 (2.0)
Vietnamese	1 (2.0)
Korean/Vietnamese/Chinese	1 (2.0)
Smoker status	
Nonsmoker	46 (92.0)
Past smoker	4 (8.0)
Mean life-years smoking (SD)	6.3 (5.6)
Median life-years smoking (min, max)	6.0 (1, 12)
Sunlight exposure, <i>n</i> (%)	
Never	0
Rarely	3 (6.0)
Sometimes	28 (56.0)
Often	19 (38.0)
Very often	0
Fitzpatrick skin type, <i>n</i> (%)	
I	1 (2.0)
II	10 (20.0)
III	22 (44.0)
IV	17 (34.0)

BMI, body mass index.

TABLE 2. Sloping Forehead Scale Ratings by Validation Sessions

Scale Score, n (%)	Session 1, (n = 650)	Session 2, (n = 650)
0, optimal	102 (15.7)	103 (15.8)
1, mild	218 (33.5)	204 (31.4)
2, moderate	222 (34.2)	198 (30.5)
3, severe	88 (13.5)	123 (18.9)
4, very severe	20 (3.1)	22 (3.4)

(4) 0.61 to 0.80, substantial

(5) ≥ 0.81 , almost perfect

Intra-rater reliability was also evaluated using the weighted ICC 2, 1. Statistics were calculated for each rater and pooled. For the pooled ICC 2, 1, the 2 identifiers for subjects and raters were first combined into 1 single subject-rater identifier. The intra-rater ICC 2, 1 was then calculated as the ratio of the between-subject/rater variance and the total variance. The same ICC 2, 1 ranges were used for interpreting the results.

To validate the assessment scale, correlations between the scale and subject demographic variables were performed (Pearson and Spearman correlation) using data from the first validation session. The first validation session was preferred as it reflects an initial unbiased use of the scale. For interpretation of the Pearson and Spearman coefficients, a mean coefficient >0.6 was considered high.

An additional mixed-effect regression model was implemented for the scale with an additional question as dependent variables and subject demographic variables as possible predictors. Subject and rater were considered as random effects, and all

other possible predictors as fixed effects. Model selection was based on stepwise backward selection with a p -value of .3 required for a variable to stay in the model.

Results

Raters consisted of male ($n = 7$) and female ($n = 6$) individuals who were dermatologists ($n = 9$), plastic surgeons ($n = 2$), and other physicians ($n = 2$). There were 650 planned ratings (13 raters \times 50 subjects) during each validation session. Among the 50 rated subjects, 28 (56.0%) were women, 22 (44.0%) were men with a mean (SD) age of 26.5 (3.7) years (range, 21–37 years). Other demographic information and baseline characteristics are shown in Table 1.

Sloping Forehead Scale

The scores for the Sloping Forehead Scale are summarized in Table 2. Most subjects had a score of 0 to 2 in Session 1 (83%) and Session 2 (78%), whereas a few subjects had a score of 4 in Session 1 (3.1%) and Session 2 (3.4%). The overall mean (SD) rating was 1.55 (1.01) for the first validation session and 1.63 (1.07) for the second session. Summary statistics for Sloping Forehead Scale scores by treatment sessions are summarized in Table 3.

TABLE 3. Sloping Forehead Scale Ratings by Validation Sessions

Session	Statistic	Sloping Forehead Validation Scale
1, N = 650	Mean (SD)	1.55 (1.01)
	Median (min, max)	2.0 (0, 4)
	Q25, Q75	1.0, 2.0
2, N = 650	Mean (SD)	1.63 (1.07)
	Median (min, max)	2.0 (0, 4)
	Q25, Q75	1.0, 2.0

TABLE 4. Estimated Effort of Aesthetic Treatment and Estimated Age

Session	Statistic	Aesthetic Treatment Effort	Estimated Age
1, N = 650	Mean (SD)	4.48 (2.00)*	30.36 (6.18)
	Median (min, max)	4.0 (0, 10)	30.0 (18, 50)
	Q25, Q75	3.0, 6.0	26.0, 35.0
2, N = 650	Mean (SD)	4.74 (1.88)†	29.52 (5.65)‡
	Median (min, max)	5.0 (3.0, 0, 10)	29.0 (18, 52)
	Q25, Q75	3.0, 6.0	25.0, 33.0

*N = 648.
 †N = 646.
 ‡N = 649.

Estimated Effort of Aesthetic Treatment & Estimated Age

The mean (SD) estimated aesthetic treatment effort rating was 4.48 (2.00) for Session 1 and 4.74 (1.88) for Session 2. The mean estimated age was 30.36 (6.18) years for the first session and 29.52 (5.65) years for the second session (the actual mean age was 26.5 [3.7] years) (Table 4).

Inter-Rater Reliability

The ICC and weighted kappa coefficients for inter-rater reliability of the Sloping Forehead Scale are provided in Table 5. Inter-rater reliability based on ICC for Sloping Forehead Scale was “substantial” with scores being ≥ 0.61 . Reliability for the estimated treatment effort was “slight” for both sessions. The estimated age was “slight” for Session 1 and “fair” for Session 2. The mean kappa values with Fleiss–Cohen weights were similar to the ICC values for inter-rater reliability.

Intra-Rater Reliability

The ICC and kappa estimates for intra-rater reliability of the Sloping Forehead Scale are provided in Table 6. Intra-rater reliability based on ICC was “almost perfect” (≥ 0.81) for the Sloping Forehead Scale and “substantial” (≥ 0.61) for the Estimated Age and Estimated Treatment Effort. The mean weighted kappa values were considerably lower than the corresponding ICC values for the estimated treatment effort and estimated age. A bubble plot, visualizing the frequency of rating combinations of validation Session 1 and 2, is shown in Figure 2.

Validity of Scales

The Pearson and Spearman correlation coefficients were similar and showed only small differences. Spearman correlation coefficients from Session 1 are shown in Table 7. The final model of the stepwise regression for the Sloping Forehead Scale from validation Session 1 is shown in Table 8. There was no relationship between the estimated and actual age of the

TABLE 5. Inter-Rater Reliability by Validation Sessions

	ICC (2,1)	Mean Weighted Kappa (CI) Fleiss–Cohen
Validation Session 1		
Sloping forehead	0.67 (substantial)	0.66 (0.62–0.70)
Estimated age	0.19 (slight)	0.23 (0.20–0.26)
Estimated treatment effort	0.13 (slight)	0.13 (0.09–0.17)
Validation Session 2		
Sloping forehead	0.68 (substantial)	0.67 (0.63–0.72)
Estimated age	0.22 (fair)	0.25 (0.22–0.28)
Estimated treatment effort	0.17 (slight)	0.17 (0.11–0.22)

CI, confidence interval; ICC, intraclass correlation coefficient.

TABLE 6. Intra-Rater Reliability: ICC 2, 1 and Kappa Values for the Forehead Scale

Scale	ICC 2, 1	Mean Weighted Kappa (CI) Fleiss-Cohen
Sloping forehead	0.84 (almost perfect)	0.82 (0.78–0.87)
Estimated age	0.76 (substantial)	0.56 (0.49–0.63)
Estimated effort of treatment	0.69 (substantial)	0.49 (0.35–0.62)

CI, confidence interval; ICC, intraclass correlation coefficient.

subjects or actual age and the estimated treatment effort. Body mass index (BMI) showed the highest correlation with the Forehead Scale and was also a significant predictor in the final regression model. It should be noted that there is an effect of rater sex on the ratings, meaning that there was a difference in the review between the 2 sexes.

Discussion

Forehead contour is an important element for establishing attractiveness of the Asian face.^{23–27} Conse-

quently, treatments for treating the Asian forehead have been developed, such as augmentation with fillers;^{16,27,28} however, there has been no means for assessing aesthetic outcomes after corrective procedures. Most available scales are based on the appearance of Caucasian features. Therefore, the objective of this study was to develop and validate a new Merz photonumeric scale for objectively assessing forehead slope in Asian men and women and to validate its use for clinical and research settings. This scale is valid for use on standardized photographs and not for live clinical assessments.

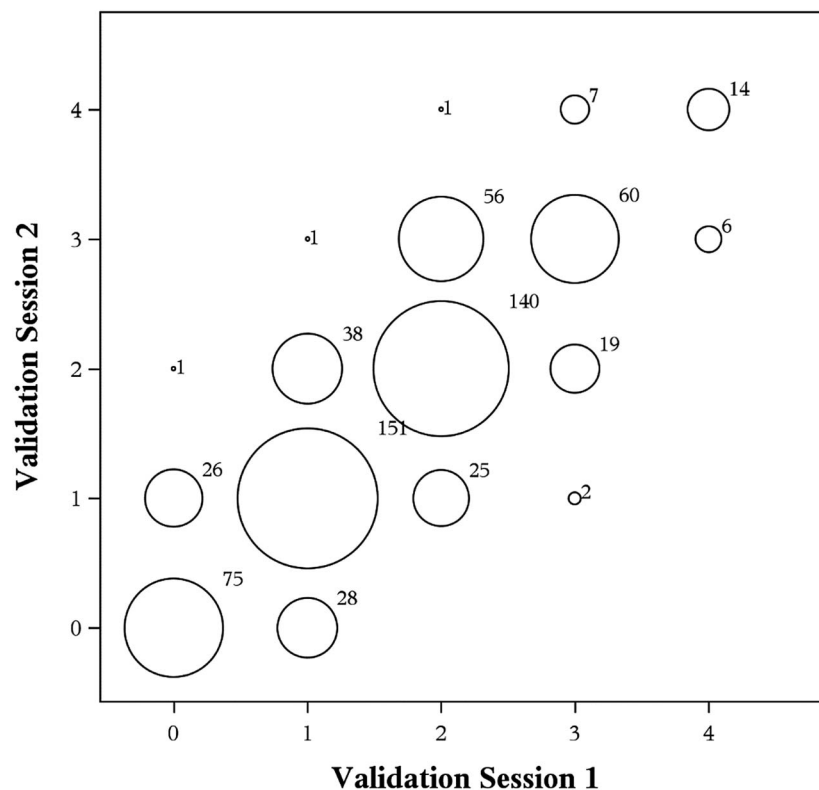


Figure 2. A bubble plot for rating combinations between the first and second validation session cycles for the sloping forehead assessment scale. The rating scores from the first and second session are plotted using proportional circles to represent the frequencies of rating combinations (13 raters \times 50 subjects = 650 scores). As high reliability is evident when the bubbles are located along the diagonal line, the plots illustrate high intra-rater reliability. The scale from 0 to 4 on both axes represents the severity grades of the scales.

TABLE 7. Spearman Correlation Coefficient for Sloping Forehead Scale Data

	<i>Forehead Scale</i>	<i>Estimated Age</i>	<i>Estimated Treatment Effort</i>	<i>BMI</i>
Forehead scale	1	—	—	—
Estimated age	0.14	1	—	—
Estimated treatment effort	0.28	0.08	1	—
BMI	0.54	0.13	0.18	1
Age	0.09	0.27	0.07	0.25

BMI, body mass index.

During the 2 validation sessions, evaluated subjects presented with Sloping Forehead Scale Ratings of optimal to mild (47.2%–49.2%), moderate (30.5%–34.2%), or severe to very severe (16.6%–22.3%). Thus, subjects with a range of forehead slope severity were represented.

The inter-rater reliability of the Sloping Forehead Scale was “substantial” with ICC estimates ≥ 0.60 for both sessions. Inter-rater reliability was also demonstrated by the bubble plot for rating the first and second validation sessions. Intra-rater reliability was “almost perfect” with an ICC = 0.84 across raters. There was a moderate correlation between scale ratings and BMI, which was determined to be a significant predictor in the regression model. Thus, subjects with a higher BMI had a more severely sloping forehead look.

The mean estimated esthetic treatment effort rating was very similar between validation sessions (4.48 and 4.74), and the mean estimated age was (30.36–29.52 years) similar to the actual mean age of 26.5 years; however, there was no relationship between the estimated and actual age of the subjects or actual age and the estimated treatment effort. BMI showed the high-

est correlation with the Forehead Scale and was also a significant predictor in the final regression model.

Among the available photonumeric scales available for measuring aesthetic changes, most are based on Caucasian features despite differences in the perception of facial beauty across races and cultures. One study recently demonstrated differences in facial configuration between attractive Caucasian and attractive Asian faces.²⁹ Although there were some common features in facial beauty perception, some beauty standards differed with race and ethnicity, and some conventional beliefs about ideal facial attractiveness were found to be inappropriate for some racial groups.

Thus, as the number of Asian patients seeking aesthetic enhancement seems to be growing, this novel 5-point assessment scale will be an important tool for use in the clinical and research setting for assessing changes in the appearance on the Asian forehead.

Conclusion

This study has demonstrated the value of a new photonumeric assessment scale for assessing forehead slope on young Asian men and women. This assessment scale is an important addition to the existing validated aesthetic scales used to grade other anatomical areas. This new scale will provide a standardized measure of forehead appearance in Asian patients.

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TABLE 8. Final Model of Stepwise Mixed-Effects Regression for the Sloping Forehead Scale

<i>Covariate</i>	<i>Category</i>	<i>Regression Coefficient</i>	<i>p</i>
Intercept	—	–1.626	.017
BMI	—	0.143	<.001
Rater sex	Female	0.171	.075
	Male	0.000	—

BMI, body mass index.

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