Comparison of preferences in lip position using computer animated imaging

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Abstract: The objectives of this study were to examine the esthetic preferences of lip position in males and females, and to compare them with each other and with a common orthodontic standard using a custom computer animation program. The sample consisted of 53 young adult subjects, 25 males and 28 females. The sample was divided into orthodontically treated and untreated subjects. ANOVA and Scheffé tests were carried out to determine differences between the responses of the various groups. Also, *t*-tests were used to compare subjects' responses to a commonly used orthodontic standard (Ricketts' E-line). The results indicated a sex-effect, with females preferring fuller lips than males. Significant differences were also found between orthodontically treated subjects and untreated subjects, with untreated subjects preferring fuller lips. Differences were significant at $p < 0.05$. Furthermore, both males and females preferred lip fullness greater than the Ricketts' values.

Key Words: Cephalometrics, Facial profile, Beauty, Computer imaging, Orthodontics

Numerous authors have described the importance of physical attractiveness,[1-3] and others have discussed the primary role of the face in overall physical attractiveness.[4,5] Within the face, the mouth is a highly influential characteristic of attractiveness ratings.[6-9] Some authors have attempted to answer the question of what constitutes facial attractiveness.[10,11] Although averageness[10] and neotony[11] have been correlated with increased facial attractiveness, the exact relationship between specific anatomic dimensions within the face and subjective esthetic evaluations of these features, such as lips, has not been adequately measured.

Historically, orthodontists have focused on the horizontal lip position as an important feature in determining beauty.[12,13] The orthodontic standards used today, which are often referred to as "norms" or the "average of the population," are more accurately the anatomic norms for the very specific populations upon which they were based. Most studies based averages on occlusions and faces that were "satisfactory" to "excellent," not "average." In fact, Ricketts' E-line[13] appears to be based on clinical experience, as no documented sample is given. Furthermore, Steiner's sample[12] was chosen by orthodontists on the basis of good facial esthetics and occlusions.[14]

It seems that the standards orthodontists use may be inadequate since they (1) incompletely and often only crudely capture overall facial appearance, (2) seldom recognize sex differences in esthetic criteria, (3) often rely too heavily on hard tissue analyses, (4) tend to focus predominantly or exclusively on lateral perspectives (i.e., profile), and (5) are not based on socially defined esthetic standards.[4] Reference lines developed 30 to 40 years ago provided the orthodontic specialty with standards to follow in treatment planning, but standards of the public appear to differ and may well vary with time.

Giddon[15] stated that most people want to look like those whom they identify as having enhanced self-esteem or high professional stature—movie or television actors, fashion models, or attractive celebrities, for example. According to Giddon, orthodontists must establish esthetic

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Figure 1A

Figure 1B

Figure 1A-B
Series of female and male images (5 out of 29 frames for each sex; frames -14, -7, 0, +7, +14)

goals that are coincident with the public's standards of the time. Numerous authors have recently described a trend toward fuller lips, specifically among male and female models, suggesting that facial preferences have indeed changed over the years.[16-18] The question thus becomes whether present orthodontic standards are an adequate reflection of today's facial esthetic preferences.

The purpose of this study was to examine the esthetic preferences for lip position in males and females and to compare them with a common orthodontic standard. The specific aims of this study were to determine (1) whether sex differences exist in preferences for lip position, (2) if these preferences differ from Ricketts' E-line,[13] and (3) the magnitude of physical change in anatomical position of the lips associated with an acceptable profile. These questions were addressed using custom computer animation software.[19-21]

Materials and methods

Stimulus faces

Using a 35 mm Nikon 6006 camera, color profile photographs were taken of a 28-year-old Caucasian male in natural head position. A calibration ruler was held anterior to the face at a standardized distance of 5 feet from the camera. The subject was instructed to display a relaxed facial expression with his lips closed and at rest. Lighting consisted of overhead fluorescent lights, the camera flash, and a Morris mini-slave flash II.

A 4 x 6-inch color print was then scanned into a computer using a Hewlett Packard Scan Jet II CX (Hewlett-Packard Corp, San Diego, Calif) to create the initial template. Corel Photo Paint 5.0 (Corel Corp, Ottawa, Ontario, Canada) and Adobe Photoshop 3.0 (Adobe Systems Inc, Mountain View, Calif) were used to transform the male figure into a female. This was done by pasting selected female characteristics, such as long hair and earrings, onto the male image. In addition, characteristically male features, such as facial stubble and thick eyebrows, were minimized or eliminated from the altered image.

As the first step in creating average male and female faces, the faces were modified to fit male and female mesh diagrams,[22] respectively. The male and female images were then manipulated to fit the average anthropometric facial profile proportions and angular profile measurements of Farkas et al.[23,24]

Using the warp function of Morph software (Windows version 2.5, Gryphon Software Corporation, San Diego, Calif), the extreme retrusive and protrusive positions of the upper and lower lips of the unaltered male and female images were created. These extreme positions were created by distorting the lips horizontally from the unaltered images to the most protrusive position, and an equal distance to the most retrusive position. The warped area included the upper lip (subnasale to the interlabial gap) and the lower lip (interlabial gap to supramentale). The distortions were adjusted slightly to maintain the continuity of the soft tissue drape, then they were saved as a series of images or frames (examples in Figure 1). Fourteen images were cre-

ated in the protrusive direction, initiating from the start image, and 14 images were created in the retrusive direction, for a total of 29 frames. The color images were subsequently spliced together using a custom computer animation program to form a movie, as specified by Kitay.[19]

To control for habituation, fatigue, and other order effects, the lips were presented in counterbalanced order three times from extreme retrusive to extreme protrusive positiona (R→P), and three times from extreme protrusive to extreme retrusive positions (P→R) at a speed of 3.4 frames per second (i.e., R→P, P→R, P→R, R→P, R→P, P→R) in accordance with Giddon et al.[25] Although the unaltered image was not necessarily equidistant from the extreme retrusive and protrusive positions within each sequence, previous research has shown that there is little likelihood of bias or artifact due to symmetrical oscillation around the most pleasing image.[26] Previous studies have demonstrated high reproducibility of repeated observations.[19,20,21]

Table 1
Analysis of variance for the protrusive lip position

Source	DF	Sum of squares	Mean square	F	*p*	Scheffé
Group[a]	3	16.04	5.35	2.63	0.0543	-
Face[b]	1	0.01	0.01	0.00	0.9529	-
Group x face	3	1.02	0.34	0.17	0.9183	-
Error	98	199.14	2.03			
Total	105	216.21				
Sex[c]	1	3.80	3.80	1.83	0.1793	-
Face[b]	1	0.01	0.01	0.00	0.9534	-
Sex x face	1	0.50	0.50	0.24	0.6251	-
Error	102	211.90	2.08			
Total	105	216.21				
Treatment[d]	1	10.83	10.83	5.39	0.0223*	1-2
Face[b]	1	0.01	0.01	0.00	0.9526	-
Treatment x face	1	0.34	0.34	0.17	0.6824	-
Error	102	205.03	2.01			
Total	105	216.21				

*Significant at $p<0.05$

[a] Judge groups: 1 = male treated; 2 = female treated; 3 = male untreated; 4 = female untreated

[b] Face: 1 = male; 2 = female

[c] Sex: 1 = male; 2 = female

[d] Treatment: 1 = treated; 2 = untreated

Judges

In order to determine the sample size needed to identify a significant difference, a power analysis was carried out before beginning the study. It was calculated that 12 subjects were needed in each group to have a 0.9 probability of detecting a clinically significant difference (1 mm), if one existed. Twenty-eight female and 25 male Caucasian volunteers from the University of Illinois at Chicago, ranging in age from 17 to 30 years (mean age 21.6 ± 3.4 years) served as judges. Subjects were recruited from students at the University of Illinois at Chicago Circle Center. Of the 25 males, 12 had received previous orthodontic treatment and 13 had not. Sixteen of the 28 females had been treated orthodontically and 12 had not.

Procedure

After a practice trial, each judge was asked to complete two tasks. In the first task, the judge was instructed to respond to the overall profile by pressing the left mouse button when the lip position became acceptable, and releasing the button when the position became unacceptable. An acceptance range or zone of acceptability (ZA) for each judge could then be established from the mean retrusive and protrusive trials.

In the second task, the judge was asked to indicate the most pleasing lip position (MP) by pressing once on the mouse button when the lips looked most pleasing as they moved in counterbalanced order three times from each direction between the retrusive and protrusive extremes. The responses were stored separately for each judge as log files upon completion of the survey. Upon completion of these tasks, the judges were also asked to rate the attractiveness of their own face on a 5-point scale for correlation with their esthetic judgments of the stimulus photos.

Data and analysis

The images moved from the retrusive to the protrusive position three times and from the protrusive to the retrusive position three times for a total of six responses. The responses were recorded as frame numbers, which were then converted to millimeter measurements as follows: The male face with the most retruded lip position was superimposed on the male face with the most protruded lip position and the distance between the most protrusive points of the two lip positions was measured in millimeters (10.1 mm). Given the difference between the computer image and life size (61%), the corrected distance between the two lip extremes (16.6 mm) was divided by the total number of frames (29), resulting in a millimeter per frame (0.57 mm/frame) measurement. The same procedure

was repeated for the female face and, as expected, resulted in the same computation.

Averages for the six R and six P responses were then obtained from the millimeter data. The difference between these mean boundaries ($\bar{X}_P - \bar{X}_R$) determined each judge's range or ZA. The midpoint for the ZA (the midpoint of acceptability, or MA), was defined as: [($\bar{X}_P - \bar{X}_R$) / 2 + $\bar{X}_R$]. The MP response for each judge was similarly determined from the mean of 3R→P + 3P→R trials/6.

Using ANOVA followed by the conservative Scheffé test, the orthodontically treated groups (male = group 1; female = group 2) were compared with the untreated groups (male = group 3; female = group 4). In addition, ANOVA was used to analyze the differences between the male and female judge's responses to the male and female profiles, and treated and untreated judges' responses to male and female faces. Using *t*-tests, the preferred lip positions, MP and MA, were then compared with Ricketts' E-line.

Results

Tables 1 through 3 describe ANOVAs for lip position. Significance was established at $\alpha = 0.05$. No significant differences were found for the retrusive lip position. As shown in Table 1, significant main effects were found among treatment groups using ANOVA. The orthodontically treated group of judges preferred a mean protrusive lip position of 1.4 ± 1.0 mm anterior to the unaltered image, whereas the untreated group preferred a mean protrusive lip position of 2.0 ± 1.7 mm. In Table 2, the ANOVA for MA of lip position was also significant. Groups 1 and 4 showed significant differences in their evaluation of the midpoint. Male orthodontically treated judges (group 1) indicated a preference for

Table 2
Analysis of variance and the Scheffé test for the midpoint lip position

Source	DF	Sum of squares	Mean square	F	*p*	Scheffé
Group[a]	3	15.32	5.11	2.87	0.0405*	1-4[a]
Face[b]	1	0.36	0.36	0.20	0.6525	-
Group x face	3	0.69	0.23	0.13	0.9426	-
Error	98	174.60	1.78			
Total	105	190.98				
Sex[c]	1	3.89	3.89	2.13	0.1478	-
Face[b]	1	0.36	0.36	0.20	0.6567	-
Sex x Face	1	0.13	0.13	0.07	0.7926	-
Error	102	186.59	1.83			
Total	105	190.98				
Treatment[d]	1	10.10	10.10	5.72	0.0186*	1-2
Face[b]	1	0.36	0.36	0.21	0.6510	-
Treatment x face	1	0.41	0.41	0.23	0.6291	-
Error	102	180.10	1.77			
Total	105	190.98				

*Significant at $p<0.05$

[a] Judge groups: 1 = male treated; 2 = female treated; 3 = male untreated; 4 = female untreated

[b] Face: 1 = male; 2 = female

[c] Sex: 1 = male; 2 = female

[d] Treatment: 1 = treated; 2 = untreated

Table 3
Analysis of variance and the Scheffé test for the most pleasing lip position

Source	DF	Sum of squares	Mean square	F	*p*	Scheffé
Group[a]	3	26.60	8.87	4.28	0.0070*	1-4
Face[b]	1	1.34	1.34	0.65	0.4226	-
Group x face	3	0.62	0.21	0.10	0.9597	-
Error	98	202.97	2.07			
Total	105	231.53				
Sex[c]	1	13.82	13.82	6.52	0.0122*	1-2
Face[b]	1	1.34	1.34	0.63	0.4280	-
Gender x face	1	0.07	0.07	0.03	0.8581	-
Error	102	216.30	2.12			
Total	105	231.53				
Treatment[d]	1	9.98	9.98	4.63	0.0339*	1-2
Face[b]	1	1.34	1.34	0.62	0.4321	-
Treatment x face	1	0.05	0.05	0.02	0.8776	-
Error	102	220.15	2.16			
Total	105	231.53				

*Significant at $p<0.05$

[a] Judge groups: 1 = male treated; 2 = female treated; 3 = male untreated; 4 = female untreated

[b] Face: 1 = male; 2 = female

[c] Sex: 1 = male; 2 = female

[d] Treatment: 1 = treated; 2 = untreated

a mean midpoint lip position of -0.8 ± 1.0 mm, which was 1.0 mm behind the lip position of the unaltered image. Untreated females (group 4) chose a more protruded mean midpoint lip position of 0.29 ± 1.86 mm. Also, orthodontically treated judges differed significantly from the untreated judges in their response for the mean midpoint lip position. The treated group chose a mean midpoint lip position of -0.58 ± 1.00 mm, compared with the untreated group's preference for a more protrusive lip midpoint of acceptability (0.04 ± 1.60 mm).

As Table 3 shows, the analysis of variance and Scheffé test indicate that the orthodontically treated male judges (group 1) preferred an MP lip position of -0.57 ± 1.21 mm, whereas untreated females (group 4) preferred an MP lip position of 0.90 ± 1.80 mm, reflecting a statistically significant difference. Furthermore, significant differences existed between male and female responses. Males preferred an MP lip position of -0.28 ± 1.34 mm, while females chose a MP lip position of 0.44 ± 1.54 mm. Also, orthodontically treated judges' responses differed significantly from untreated judges' responses. The treated judges chose an MP lip position of -0.19 ± 1.25 mm, compared with the untreated judges' preference for an MP lip position of 0.43 ± 1.66 mm.

Table 4
Most pleasing upper lip position for the male face, measured to Ricketts' E-line in millimeters

Subjects	Most pleasing upper lip position	S.D.	Difference	*t*
Male treated	-2.98	1.46	0.02	0.05
Male unreated	-2.33	1.21	0.67	1.99
Female treated	-2.24	1.32	0.76	2.30*
Female untreated	-1.61	2.03	1.39	2.37*
All males	-2.64	1.35	0.36	1.33
All females	-1.97	1.66	1.03	3.43*
Treated males and females	-2.56	1.40	0.44	1.66
Unreated males and females	-1.98	1.66	1.02	3.07*

*Significant at $p<0.05$

Table 5
Most pleasing lower lip position for the male face, measured to Ricketts' E-line in millimeters

Subjects	Most pleasing lower lip position	S.D.	Difference	*t*
Male treated	-1.68	1.46	0.32	0.76
Male untreated	-1.03	1.21	0.97	2.89*
Female treated	-0.94	1.32	1.06	3.20*
Female untreated	-0.31	2.03	1.69	2.88*
All Males	-1.34	1.35	0.66	2.44*
All Females	-0.67	1.66	1.33	4.43*
Treated males and females	-1.26	1.40	0.74	2.80*
Unreated males and females	-0.68	1.66	1.32	3.98*

*Significant at $p<0.05$

Judges' responses in comparison with Ricketts' E-line

The E-line is defined as a line joining the tip of the nose (pronasale) to the chin (soft tissue pogonion). The values for MP lip positions were measured from the most protrusive point on the lip to the E-line, as prescribed by Ricketts. The value given by Ricketts for the upper lip to E-line for Caucasians is -3 ± 2 mm, and the value for the lower lip is -2 ± 2 mm. The apparent standard deviations for the upper and lower lip measurements to the E-line should be referred to as clinical deviations, as they were based on clinical observations (Ricketts, personal communication). The differences between the study groups and Ricketts' standards (Tables 4 through 7) were statistically significant using a *t*-test, indicating a preference for fuller lips than indicated by the E-line.

Self-ratings

In rating their own attractiveness, 33 judges (62.3%) thought of themselves as average, while 16 (30.2%) said they were attractive. Three (5.7%) perceived their faces as very attractive, and one (1.9%) indicated that she thought her face was unattractive. Correlation coefficients revealed that judges who rated their faces as attractive or very attractive evaluated the four lip positions similarly to those judges who rated their own faces as average. However, as Figure 2 shows, judges who rated their faces as average had a significantly smaller zone of acceptability (ZA) than the judges who rated their faces as attractive (Figure 2), based on a *t*-test. No significant differences in ZA were found for sex or orthodontic treatment.

Discussion

The initial hypothesis that the preferred lip fullness for males differs from that for females was supported by the fact that females reported a preference for fuller lips for the most pleasing lip position. These findings are in agreement with Czarnecki et al.[16] and Nguyen and Turley.[17] Thus, a treating orthodon-

tist may feel more comfortable leaving a female patient with slightly fuller lips than a comparable male patient.

The demonstration that the untreated group preferred a fuller profile than did the treated group should caution clinicians about orthodontic or surgical therapy that results in flattening of the patient's profile. When a treatment plan includes the extraction of four first premolars, for example, anterior teeth are often retracted, at least partially, into the extraction spaces, resulting in a variable amount of lip retraction.[27,28] Results from this study indicate that orthodontically treated judges prefer lip positions within the profile closer to that seen in orthodontically treated subjects (i.e., a more retrusive lip position). Untreated judges, however, were significantly more variable in their responses to the preferred lip position than treated judges. It seems as if orthodontically treated judges' ideational representation of their esthetic preferences is more consistent than that of untreated judges.

Although the results of this study cannot be generalized to the population as a whole, these findings agree with those of Alley and Hildebrandt,[4] which indicate that the standard orthodontists use is not based on current socially defined esthetic standards. Therefore, standards such as Ricketts' E-line should be used only as a guide for orthodontic treatment planning, keeping in mind more modern esthetic preferences. Rather than an upper lip position of -3 ± 2 mm, a more protrusive location would be desirable, specifically -2 ± 1.5 mm. Similarly, the preferred location for the lower lip is -1 ± 1.5 mm, rather than Ricketts' value of -2 ± 2 mm. There is no doubt that the trend in today's fashion magazines is to portray models with lips that are more full. If most people want to look like others with whom they wish to identify, such as fashion models and attractive celebrities,[15] health professionals such as orthodontists, oral surgeons, and plastic surgeons owe it to their patients to at least be aware of such trends.[29-32]

Table 6
Most pleasing upper lip position for the female face, measured to Ricketts' E-line in millimeters

Subjects	Most pleasing upper lip position	S.D.	Difference	*t*
Male treated	-2.66	0.97	0.34	1.21
Male unreated	-2.20	1.62	0.80	1.78
Female treated	-2.07	1.13	0.93	3.32*
Female untreated	-1.08	1.64	1.92	4.09*
All males	-2.41	1.34	0.59	2.19*
All females	-1.65	1.43	1.35	5.00*
Treated males and females	-2.32	1.09	0.68	3.24*
Untreated males and females	-1.66	1.69	1.34	3.94*

*Significant at $p<0.05$

Table 7
Most pleasing lower lip position for the female face, measured to Ricketts' E-line in millimeters

Subjects	Most pleasing lower lip position	S.D.	Difference	*t*
Male treated	-1.66	0.97	0.34	1.21
Male untreated	-1.20	1.62	0.80	1.78
Female treated	-1.07	1.13	0.93	3.32*
Female untreated	-0.08	1.64	1.92	4.09*
All males	-1.41	1.34	0.59	2.19*
All females	-0.65	1.43	1.35	5.00*
Treated males and females	-1.32	1.09	0.68	3.24*
Untreated males and females	-0.66	1.69	1.34	3.94*

*Significant at $p<0.05$

The finding that judges who rated their own faces as average had a smaller range of acceptability (ZA) than the judges who rated their faces as attractive may be explained by more attractive judges having greater tolerance than average judges, as shown in Figure 2.

Although several recent studies have addressed the topic of lip position within the profile,[16,17] these studies used photographs or androgynous facial silhouettes to depict male and female profiles. Newer video imaging techniques have enhanced the ability to portray realistic profile images. Furthermore, assessment of profile preferences by the method described in this paper appears to be extremely sensitive, as indicated by the judges' aggregate ability to differentiate < 1 mm of change in soft tissue change. In addition to a single most pleasing image, a range of preferences becomes available.

Conclusions

The conclusions of this study are as follows:

1. Females prefer a fuller lip position than males for both female and male stimulus faces.
2. Untreated judges prefer a fuller lip position than orthodontically treated judges.
3. Both males and females prefer a lip position that is more protrusive than Ricketts' standard.

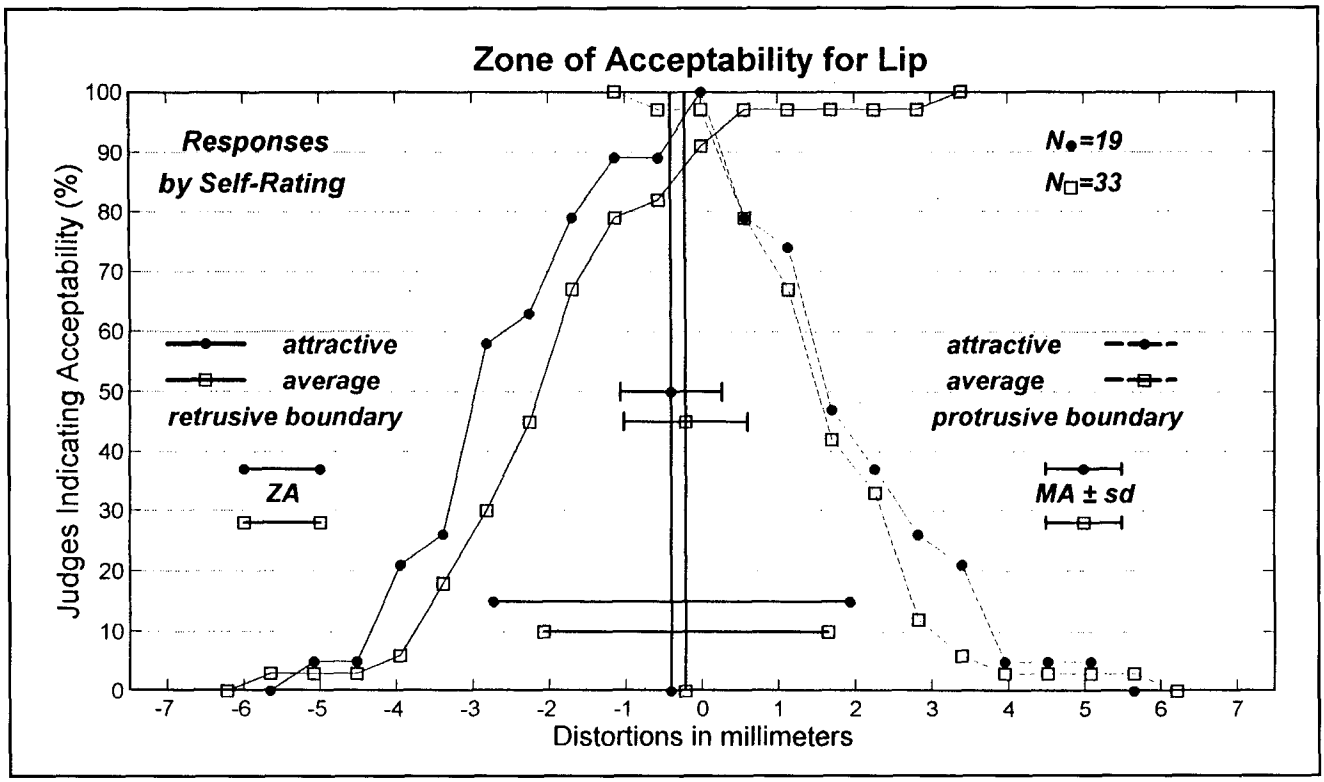

Figure 2
Zones of acceptability for lip position based on judges' self-ratings of attractiveness

4. Judges who rated their own faces as average had a smaller zone of acceptability than those who rated their faces as attractive.

A major advantage of using the computer software and video imaging described in this study is that the subject can respond objectively to the display of realistic profile images. Furthermore, this methodology permits the esthetic preference of the subject to be expressed as a range of acceptability as well as a single most pleasing lip morphology.

In order to provide orthodontic standards or norms for non-Caucasians,[5] future studies should include faces and judges from diverse social and cultural backgrounds. Also, future applications of morphing technology should involve comparison of male and female images that differ both in their physical dimensions as well as in the interaction among simultaneously changing features.

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Disclosures

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