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Beyond the 21-cm Notch-to-nipple Myth: Golden Proportions in Breast Aesthetics

Lars Johan Sandberg, MD, FACS, FEBOPRAS*
Kim Alexander Tønseth, MD, PhD*
Kristine Kloster-Jensen, MD, PhD*
Jun Liu, PhD†
Gregory Reece, MD†
Martin Halle, MD, PhD‡
Åsa Edsander-Nord, MD, PhD‡
Anna Höckerstedt, MD§
Susanna Kauhanen, MD, PhD§
Tyge Tind Tindholdt, MD, PhD¶
Gudjon Leifur Gunnarsson, MD||
Jesse Creed Selber, MD, MPH, FACS†

Background: The 21-cm notch-to-nipple distance has been accepted without academic scrutiny as a key measure in breast aesthetics. The Fibonacci sequence and phi ratio occur frequently in nature. They have previously been used to assess aesthetics of the face, but not the breast. This study aims to assess if the static 21-cm measure or the proportional phi ratio is associated with ideal breast aesthetics.

Method: Subclavicular-breast height and breast width were used to calculate the aesthetic ratio. Subjects were subsequently aesthetically rated. A one-sample t-test was used to determine if the ratio for each breast differed from phi. Breast scores with one, both, or no breasts were compared with an optimal phi ratio. Analysis of variance was performed. Tukey–Kramer adjustment for multiple comparisons was used when pairwise comparisons were conducted.

Results: Five subjects (14%) had bilateral optimal phi ratio breasts. Four subjects (11%) had one breast with an optimal phi ratio. Subjects with bilateral optimal phi ratios had significantly higher overall breast scores than those with only one optimal breast ($\Delta = 0.86$, $P = 0.025$) or no optimal breast ($\Delta = 0.73$, $P = 0.008$). Distance from optimal Fibonacci nipple position was moderately to strongly correlated with aesthetic score (−0.630, $P = 0.016$). No correlation was found between 21-cm notch-to-nipple distance and aesthetic score.

Conclusion: The bilateral optimal phi ratio is correlated with high overall aesthetic scores, as is the optimal Fibonacci nipple position. No correlation was found between 21-cm notch-to-nipple distance and overall aesthetic score. *(Plast Reconstr Surg Glob Open 2021;9:e3826; doi: 10.1097/GOX.0000000000003826; Published online 25 October 2021.)*

INTRODUCTION

The Fibonacci series, the Fibonacci spiral, the phi ratio, "the golden ratio," "the golden angle," or "the golden section" are all closely related concepts that have been extensively studied in art, biochemistry, biology, botany, anatomy, and architecture over time.[1–5] The concept is ancient and has captured the imagination of mathematicians, scientists, and artists alike for centuries. It was first published by mathematician Fibonacci in 1202. The series represents a mathematical sequence where each number is the sum of the two preceding numbers starting with numbers 0 and 1 (0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144…). When extrapolated, the ratio between two successive numbers, called phi, approximates 1.618. Phi was later referred to by Fra Luca Pacioli as the divine proportion associating phi with beauty.[6] The book *Divina Proportione* was illustrated by Leonardo Da Vinci; he later called phi the section aurae—the golden section. The golden section is illustrated by a line that is sectioned in portions where the line itself and also the two segments each relate to each other by the factor phi (Fig. 1).[2]

The spiral shape associated with the Fibonacci series has been shown to be ubiquitous in nature, from universal phenomena such as the structure of DNA[7] and the shape of galaxies, to everyday phenomena like snail shells

*From the *Department of Plastic Surgery Oslo University Hospital, University of Oslo Norway, Oslo, Norway; †Department of Plastic Surgery University of Texas, MD Anderson Cancer Center, Houston Tex.; ‡Karolinska University Hospital, Stockholm, Sweden; §University of Helsinki, Helsinki, Finland; ¶Aleris Healthcare, Malmö, Sweden; and ||Department of Plastic Surgery Sørlandet Hospital Trust, Arendal, Norway.*

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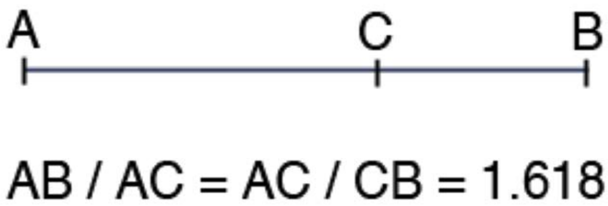

Fig. 1. The golden section.

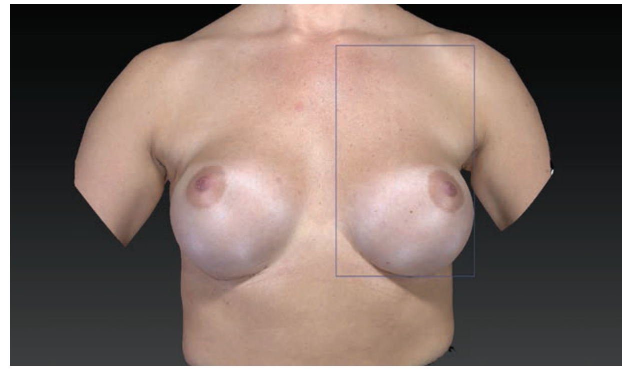

Fig. 2. Illustration of the outlines of a Fibonacci rectangle based on a subject ranked number 24 of 37.

and the growth pattern in sunflower florets.[2] It has been proposed that the Fibonacci spirals and the Fibonacci sequence allow cellular units to form in a spiral pattern that does not create gaps when they grow symmetrically in a coordinated stereotactic pattern.[2]

The golden ratio has previously been applied to facial aesthetics—the golden mask was developed by Marquardt[8] and Kim,[9] but the mask remains controversial and is not straight-forward to apply clinically.[10] Illustrations of the Fibonacci spirals applied to breasts are common on the internet, but no previous academic studies dealing with this subject are known to us.

Static measures of the breast with the 21-cm notch-to-nipple distance were introduced by Penn[11] in 1955 to find optimal measures for breast reduction. This measure was later accepted and has been used as an aesthetic indicator in breast surgery with little to no validation.

The aims of this article are to critically evaluate the correlation between the phi ratio proportion and aesthetics of the breast and compare it to the 21-cm notch-to-nipple distance and aesthetics.

METHOD

The breasts of 32 volunteer nursing-student subjects were 3D scanned using the Vectra system (Canfield Scientific Inc Parsippany, N.J.). Five additional virtual subjects were based on real subjects. These subjects were chosen based on small breast volumes that could tolerate virtual augmentation with natural results.[12] Inclusion criteria were female gender and age between 18 and 35 years. Exclusion criteria were congenital or acquired deformity of the breast or prior surgery of the breast. Prior cosmetic surgery of the breast was allowed. All ethnicities, bra sizes, body weights, and BMIs were allowed. Demographics of the 32 subjects were previously described by Sandberg et al.[12] Ten plastic surgeons rated the 3D scans of the breasts and subjects aesthetically on a 1–5 Likert scale based on their individual professional opinion using a validated scoring system.[12]

The golden rectangle with a long axis to short axis ratio of 1.618 is the Fibonacci ideal[9] (Fig. 2). This rectangle is a two-dimensional measuring tool. A phi ratio of 1.618 ± 0.05 was defined as optimal. To obtain the measures for calculating the phi ratio for a breast, a two-dimensional image of the frontal view was created using the Vectra system based on the three-dimensional scan. A rectangular box encompassing the complete visible breast was designed. A horizontal line was drawn in a frontal view at the most inferior point of the sternal notch and continued below the clavicle bilaterally and symmetrically. A parallel horizontal line was drawn marking the lowest visible point of the breast seen in the scanned images. In the case of ptosis, this meant that the lowest visible part of the breast was not the inferior mammary fold. The most medial and lateral point of the breast were used to draw parallel lines at 90-degree angles to the horizontal markings. The rectangle that is created around the breast creates a Fibonacci box. An example of such a rectangle or box is seen in Figure 2. All the marked rectangles were then measured, and finally, all the ratios between height and width were calculated.

For those breasts that were considered phi ratio optimal, further analysis was performed using the previously illustrated method using the Fibonacci spiral to evaluate optimal nipple position (Fig. 3A–G). The golden rectangle, illustrated in Figure 2, is used. The dimensions of the rectangle are then scaled down by the factor phi and it is rotated into position by 90-degree increments with the long axis first rotated to assume the most inferior position of the original rectangle, then laterally, and then superiorly in a serial fashion (Fig. 3A–G). Finally, the Fibonacci spiral was used (Figs. 3H and 4) to identify the optimal nipple position. The difference from the actual nipple position from this optimal position was measured in millimeters and assessed for "overall aesthetic score" for each individual breast and for "overall aesthetic score" for the paired bilateral breasts. Notch-to-nipple distance was measured using Vectra 3D software in a three-dimensional format.

Statistics

Data were collected and analysis was performed for breasts both as separate units and as pairs. A total of 74 breasts were analyzed. Pearson's r, Spearman's rho, and Kendall's tau were used to evaluate the strength of the relationship between specific measurements and overall breast score.

A phi ratio based on measurements encompassing the breast in a frontal view was calculated for the right and left breasts individually in the 37 subjects. The optimal phi ratio was defined as 1.618. We considered the breasts that were less than 0.05 from the optimal phi ratio within the optimal range. Subjects were categorized into three

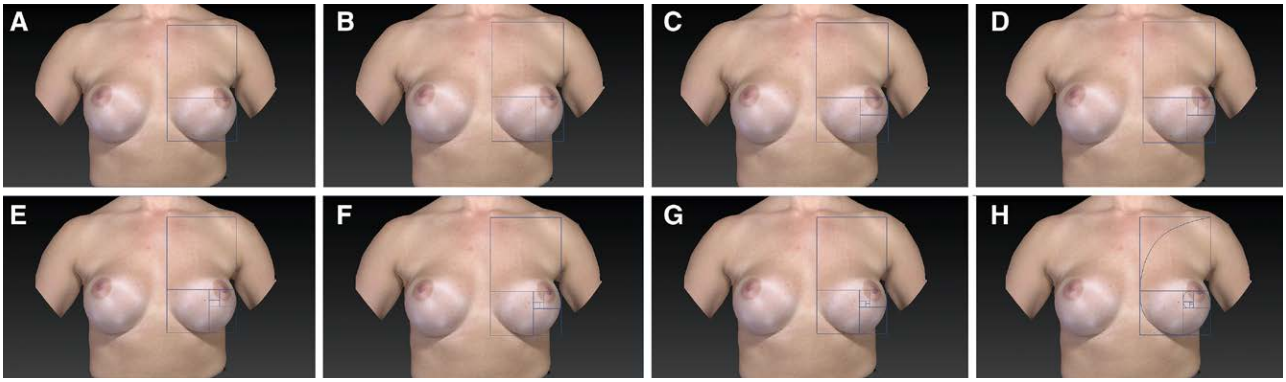

Fig. 3. Illustration of the Fibonacci spiral sequence to determine optimal NAC position. A, Step 1: the next sequential rectangle following Figure 2 is decreased by a factor 1.618 (phi) and rotated counter-clockwise for the left breast. For the right breast the rotation would be clockwise. B-G, Steps 2-7: further counter-clockwise rotation of the following sequential rectangles. H, Step 8: Fibonacci spiral sequence. A spiral based on the serial rectangles is drawn.

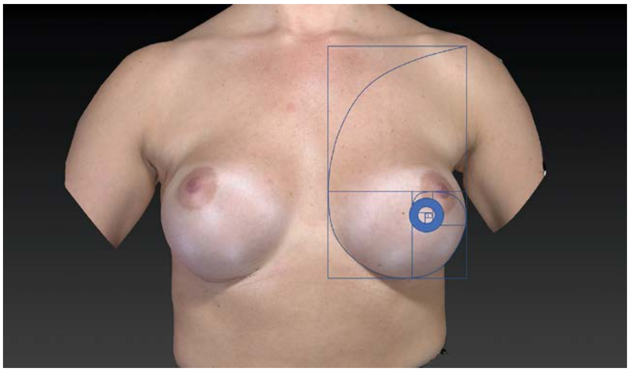

Fig. 4. Fibonacci spiral. Optimal NAC placement based on the Fibonacci spiral.

groups defined by whether they had one, both, or no breasts with a phi ratio in the optimal range. The optimal static notch-to-nipple distance was defined as 21 cm. We considered the breast to be of optimal notch-to-nipple distance if the distance was between 20 and 22 cm (21 cm ± 4.8%). Similarly, we categorized subjects into three groups: no breast, unilateral, and bilateral optimal notch-to-nipple distance.

Descriptive statistics such as means, SDs, median, and range were used to summarize the phi ratio. The distribution of the phi ratio and static notch-to-nipple distance was studied using histograms and Shapiro–Wilk tests to evaluate normality. A one-sample t-test was used to compare the mean phi ratio or notch-to-nipple distance to the optimal ratio/distance. Frequencies and percentages were used to summarize breasts with no, unilateral and bilateral optimal ratio/distance. A comparison of the mean overall breast scores among optimal groups was performed using Analysis of Variance (ANOVA). Pairwise post-hoc tests were performed using the Tukey–Kramer method to adjust for multiple comparisons. All analyses were performed using SAS 9.4.

RESULTS

The subjects' average age was 22.1 (±2.5) years, ranging from 19 to 29. Average BMI was 22.8 (±3.1) with a range from 16.9 to 30.9. A wide range of brassiere sizes were used by the population.[12] The phi ratio was normally distributed for the left, right, and all breasts regardless of laterality. The average phi ratio was 1.596 ± 0.173 (95% confidence interval [CI] = [1.538, 1.653]) for the right breast and 1.594 ± 0.197 (95% CI = [1.529, 1.660]) for the left breast. The mean phi ratio was not significantly different from the optimal ratio of 1.618 (right: P = 0.44; left: P = 0.47). For all individual breasts, the mean phi ratio was 1.595 (95% CI = [1.552, 1.638]), which also was not significantly different from the optimal ratio of 1.618 (P = 0.286) (Table 1).

Optimal phi ratio range (1.618 ± 0.05) was found in both breasts in five (14%) subjects. Four subjects (11%) had one breast with an optimal phi ratio. Neither breast was considered optimal for 28 (76%) subjects. The breasts with optimal ratios have a significantly higher overall breast aesthetic score (4.07 versus 3.47, P < 0.001). Subjects who had both breasts with optimal phi ratios had significantly higher overall breast score than subjects who had only one (Δ = 0.86, P = 0.025) or no phi optimal breast (Δ = 0.73,

Table 1. Summary of Phi Ratio Measurement

	N	Mean ± SD	95% CI	Range of Phi Ratio	P (H_0: μ = 1.618)
Right breast	37	1.596 ± 0.173	(1.538, 1.653)	1.17, 1.90	0.436
Left breast	37	1.594 ± 0.197	(1.529, 1.660)	1.13, 2.08	0.471
All breasts	74	1.595 ± 0.184	(1.552, 1.638)	1.13, 2.08	0.286

P = 0.008). The overall breast score was not significantly different between subjects with only one optimal or no optimal breast (Tables 2–4). Subjects with an optimal phi ratio also had aesthetic ratings of height and width that were significantly better than those with suboptimal phi ratios (Table 5).

Furthermore, the difference in millimeters between the optimal Fibonacci nipple position and actual nipple position for the 14 breasts with an optimal phi ratio had a significant moderate to strong negative correlation between optimal distance, and aesthetic score was −0.630 (P = 0.016) using Spearman's test. That is, the shorter the distance between optimal and actual nipple positions, the higher the overall aesthetic breast score (Table 6).

Optimal static distance from notch to nipple (21 cm ± 1) was found in both breasts in six (16.2%) subjects (Table 7). No significant correlation was found between 21 ± 1 cm distance and overall aesthetic score whether breasts were considered as a pair or as individual units (Tables 7 and 8). When optimal distance from notch to nipple in both breasts was more strictly set at 21 cm ± 0.5, only two subjects had both breasts in the optimal range. A slight difference was seen in aesthetic scores for subjects with bilateral optimal static distance (21 cm ± 0.5) 3.9 (±0) compared to 3.5 (±0.6) for one optimal breast and 3.5 (±0.5) for neither breast being optimal. However, this slight difference was not significant, with a high p value (P = 0.398). No significant difference in scores was seen when each breast was analyzed as an individual unit with the narrower limit.

The highest ranked of all the 37 subjects was a virtual subject with an average overall bilateral aesthetics score of 4.50. This subject had two phi ratios that were regarded as optimal (1.57 right and 1.607 left) and also a small deviance from the Fibonacci-based nipple position (difference of 11.2 mm right and 9.4 mm left).

DISCUSSION

We have performed a cross-sectional study on 37 female subjects and 74 breasts (virtual and real), analyzing the association between the Fibonacci sequence, the phi ratio, and independently rated breast aesthetics. The results indicate that those with an optimal phi ratio for subclavicular-height to width have an increased aesthetic overall score. Optimal nipple position as defined by the Fibonacci spiral estimate also correlates with high aesthetic scores.

Although used in clinical practice by many surgeons, the 21-cm notch-to-nipple distance was not associated with high aesthetic scores.

When the breasts were analyzed as pairs, only bilateral optimal phi ratios showed significant increase in aesthetic scores, indicating that symmetry is of importance in breast aesthetics, but it does not overwhelm the impact of the golden ratio for symmetric pairs. This is evidenced by the fact that (1) unilateral Fibonacci breasts are rated more highly than unilateral 21-cm nipple-to-notch breasts; (2)

Table 2. Frequency of Bilateral Optimal Phi Ratio (N = 37)

	Frequency (%)	Mean Overall Bilateral Breast Score, Mean (SD)
Neither breast optimal	28 (75.7)	3.43 (0.51)
One breast optimal	4 (10.8)	3.30 (0.24)
Both breasts optimal	5 (13.5)	4.16 (0.24)

Table 3. Comparison of Mean Overall Score among Optimal Phi Ratio Groups

Groups Compared	Difference in Means	Adjusted P
Both optimal—one optimal	0.860	0.0253
Both optimal—none optimal	0.728	0.0079
One optimal—none optimal	−0.132	0.8575

Table 4. Frequency of Optimal Phi Ratio for Individual Breasts (N = 74)

	Frequency (%)	Mean Overall Unilateral Breast Score	P
Not optimal	60 (81.1)	3.47 (0.46)	<0.001
Optimal	14 (18.9)	4.07 (0.44)	

Table 5. Likert Scale Aesthetic Height Score and Width Score for Optimal Phi Ratio Individual Breasts (N = 74)

Variable	Not Optimal	Optimal	P
No. breasts	60 (81.1)	14 (18.9)	
Breast height score	3.8 ± 0.5	4.3 ± 0.4	<0.001
Breast width score	3.8 ± 0.4	4.2 ± 0.4	0.006

Table 6. Distance (mm) between Actual and Optimal Fibonacci Nipple Position

Variable	(n)	Mean ± SD	Median (Range)
Distance between actual and optimal nipple position in all breasts with optimal phi	14	16.9 ± 9.6 (mm)	13.8 (0-34.9) (mm)
Unilateral overall breast score for breasts with optimal phi score	14	4.1 ± 0.4 (score)	4.3 (3.2-4.5) (score)
Bilateral overall breast score for subject with bilateral optimal phi	5	4.2 ± 0.2 (score)	4.1 (3.9-4.5) (score)

Table 7. Frequency of Bilateral Optimal Notch-to-nipple Distance 21 ± 1 cm (N = 37)

	Frequency, n, (%)	Mean Overall Bilateral Breast Score, Mean (SD)	P
Neither breast optimal	23 (62.2)	3.4 ± 0.5	0.521
One breast optimal	8 (21.6)	3.7 ± 0.5	
Both breasts optimal	6 (16.2)	3.6 ± 0.6	

Table 8. Frequency of Unilateral Optimal Notch-to-nipple distance 21 ± 1 cm (N = 74)

	Frequency (%)	Mean Overall Unilateral Breast Score	P
Not optimal	54 (73)	3.6 ± 0.5	0.534
Optimal	20 (27)	3.6 ± 0.5	

symmetric pairs of Fibonacci breasts are rated more highly than symmetric 21-cm notch-to-nipple pairs; and (3) unilateral breasts that belong to symmetrical pairs do not score better than individually aesthetic breasts that do not belong to a symmetrical pair.[12]

In a landmark study performed single-handedly by Penn[11] in 1954, the static 21-cm notch-to-nipple distance was introduced. In the study, 20 of 150 volunteers were selected for being "aesthetically perfect or nearly so." Measures were then performed from sternal-notch-to-nipple and 8–8.5 inches (20.32–21.59 cm) seemed to occur frequently. "There is scarcely any difference in the breast dimensions of the normal woman, no matter what her height or weight may be. The conclusion to be drawn, therefore, is that there is a standard type of breast, the measurements of which would be aesthetically correct for any woman."[11] Liu and Thomson[13] found similar results in 2011; however, the underlying scientific method is incompletely described. Our results show that the 21 (±1 or ±0.5 cm) cm static measure is not correlated with high aesthetic scores. Static measures are easy to use and can be applied to cookie-cutter-approaches in surgery; they are, however, not individualized and do not correlate to ideal proportions. Certainly, in women with larger breasts or long torsos, this number is an underestimation of what would be proportional or ideal.

There is a paucity of reproducible literature on proportions of the breast. Malluci has described the 45/55 ratio in a three-quarter view. This ratio focuses on the aesthetics of tissue distribution in the vertical dimension.[14–16] The vertical dimension has previously been suggested by Sandberg et al[12] to be more aesthetically determinative than the horizontal. Our findings relate proportions in two dimensions in a frontal projection with both height and width. We believe a frontal projection is more easily standardized for measuring purposes as opposed to the three-quarter view, which involves more variable rotation. Recently, Lee and Ock[17] also described proportions of the aesthetic breast in the Asian population, also suggesting that proportions and not static measures are of importance.

The concept of the Fibonacci series and its occurrence in nature has been discussed repeatedly over time.[2,18] It is believed that the spiral pattern optimizes stereotactic growth and organization of modules (modularization) to, for example, capture light in photosynthesis and growth providing an optimal organization of subunits in a biologic pattern.[2] Phyllotaxis, the structure of pinecones, the packing patterns of florets of sunflowers and cauliflower,[18–21] and coronary artery branching[5] have all been shown to correlate with the Fibonacci sequence. The shape of snail shells are further examples.[2] Fibonacci principles have even been used to optimize prosthetic and robotic hand function.[4] It is, however, unknown why we perceive beauty when the golden ratio is found to be present.[2] Aristotle claimed that "the science of mathematics demonstrates the chief forms of beauty—order, proportionality, symmetry, and definitude."[22] It may be that the phi ratio signals healthy biology, healthy growth—that is, healthy beauty.[23] Beauty is believed to be part of the necessary mating and reproductive cues in nature,[23,24] and the beauty of symmetry is known to correlate to the faithful, error-free reproduction of the genome on a phenotypic level.[2]

Mathematics describes order and harmony. Mathematical ratios are very specific with multiple decimal places, such as pi; however, they are approximations. Phi in itself is an approximation in that it is built on a numeral series, rather than an absolute number. In any clinical situation where an exact and perfect measuring precision is difficult to achieve, exact ratios are often not possible to achieve. In fact, it is precisely the relative nature of phi that allows it to be applied to different size individuals with different size breasts. Bridging mathematics and clinical reality using a tight but permissive range seems to be the most reasonable approach. For this reason, the optimal phi ratio was set by us to be 1.618 ± 0.05 and 21 ± 1 cm, respectively, ±0.5 cm used for the static notch-to-nipple measure.

Is the golden ratio, the Fibonacci sequence and spiral, merely a case of seek and you shall find? The phi ratio is certainly not represented in all relative measures of the breast. The incorporation of the optically sharply demarcated outlines of the whole breast in a straight frontal view was chosen as a natural and unbiased starting point. We believe that for the golden proportions to be appreciated and perceived, clearly demarcated boundaries have to be present (hard targets or bright line metrics, statistically speaking). In the evaluation of overall aesthetic breast proportions, this is the rationale for using the whole outline of the breast.

Finally, the presence of a golden aesthetic ratio could suggest that there is a universal consensus perception of beauty. Broer et al[25] has previously shown that there are cultural differences in the perception of the aesthetic breast. There is no doubt that regional differences exist in the perception of beauty. A regional difference in rating does not, however, exclude the existence of ratios and proportions that are universally considered beautiful. Several studies using pictures of different actual subjects show that preference is toward the same subjects when looking at facial morphology[23,26]; this likely is also true for the breast. It may be that different types of beauty coexist. One being an "agreed-upon, timeless and universal beauty," which the authors are defining as "aesthetics." The other one being "influenced beauty," which fluctuates with trends, cultures, and individuals. Both types of beauty have to be considered and respected in the process of a patient consultation and may be relevant to a different extent depending on the audience. A patient with wishes far beyond what is generally considered aesthetic might be counseled and carefully evaluated to avoid strange results. Personal wishes are a critical component of shared decision-making and patient satisfaction. Ideal proportions are the fundamental principles that have to be adapted to such wishes.

Trends over time as a concept in beauty has been suggested and described by Rubano et al.[27] Variances in the perception of beauty are influenced by trends, social and cultural differences including body modification.[27] Cosmetic trends may also include different degrees of emphasis or even exaggeration of the type of primitive mating cues mentioned by Sarwer et al[23] and Dixson et al.[24] Balanced, natural aesthetics could be timeless, universal and a crucial factor in the survival of our species,[23] possibly relating back to some version of "evolutionary fitness" and "natural selection criteria" as fundamental as the structure of DNA itself.

Limitations

The complex shape of the breast and the paucity of landmarks make formal measures of the breast complicated. The breast, like all other aesthetic subunits of the body, relates to its surroundings; the exact subtle limits of the upper pole in natural breasts are sometimes not clearly demarcated. In a frontal projection, upper pole boundaries can be hard to define. The concept of subunits of the breast was originally described by Spear and Davison.[28] They noted that the shadowed valleys and lighter ridges that so clearly limited the aesthetic subunits of the nose were not present in the female breast in the same way.[28] This limits the precision of female breast measures. The subclavicular-demarcation was used because it is a more obvious landmark and includes the entire upper pole. Lateral inferior and medial boundaries of the breast are more easily identified and measured due to obvious optical demarcation.

Rating of breast aesthetics has previously been shown to differ between plastic surgeons and laymen.[29,30] In this study, only plastic surgeons rated the aesthetics of the 3D scans to provide a more detailed clinical evaluation.

International differences have previously been shown when assessing breast aesthetics[25] and ratings in this study were performed by plastic surgeons who had practiced their whole career in Scandinavia.[12] A study with multiethnic raters would be needed to generalize the findings of this study.

CONCLUSIONS

The Fibonacci sequence and the phi ratio applied to subclavicular-breast-height and breast width were significantly correlated with high aesthetic breast scores, as was the optimal Fibonacci nipple position. The 21-cm notch-to-nipple distance was not correlated with high overall aesthetic scores.

Lars Johan Sandberg, MD, FACS, FEBOPRAS
Department of Plastic Surgery
Klinikk for hode, hals og rekonstruktiv kirurgi
Oslo universitetssykehus HF
Postboks 4956, Nydalen
0424 Oslo, Norway
E-mail: johansandberg@hotmail.com

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