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PRS GLOBAL OPEN
ORIGINAL ARTICLE
Breast

Coronal, Sagittal, and Horizontal Classification of the Chest Shape and Its Role in Selection of Proper Implants

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Background: The number of female breast correction procedures has been steadily increasing. Despite extensive literature being available on these procedures, few authors have discussed the role of preoperative chest wall analysis in relation to postoperative outcomes. To date, no comprehensive classification of chest shape has been introduced in the literature. The aim of this study was to present a novel classification of chest shapes, based on three basic planes: coronal (C), sagittal (S), and horizontal (H), hence the proposed name "CSH classification."
Method: In this study, a retrospective analysis of 1000 randomly selected chest and breast images was conducted by three independent nonmedical evaluators, using standardized digital images captured with the Vectra 3D body scanner. All examined patients were qualified for breast augmentation surgery.
Results: Among 1000 randomly examined patients, 923 were classified in the coronal plane, 920 in the sagittal plane, and 627 in the horizontal plane. Other patients were excluded from the study due to insufficient quality of the images. A notable 43.2% of women have shoulder height asymmetries. A relationship between shoulder height asymmetry and chest width was confirmed by the chi-square Pearson test ($P = 0.04$), indicating that a higher shoulder is associated with a greater chest width on the same side. Furthermore, 84.7% of women displayed excessive upper chest projection, whereas 28.4% showed excessive lower chest projection. Additionally, 84.4% of women had chest projection asymmetries.
Conclusions: The vast majority of the women had natural asymmetries of the breast or and chest wall. The CSH classification allows systematizing the chest shape assessment. The chest shape has a significant impact on breast implant selection and the choice of the breast surgery technique. *(Plast Reconstr Surg Glob Open 2023; 11:e5422; doi: 10.1097/GOX.0000000000005422; Published online 27 November 2023.)*

INTRODUCTION

The number of female breast correction procedures continues to rise. In 2021, the International Society of Aesthetic Plastic Surgery reported 3,227,832 breast correction procedures performed worldwide, comprising 1,685,471 breast augmentations, 781,404 mastopexies, 253,594 breast implant removals, and 507,363 breast reductions.[1] Although there is extensive literature on these procedures, few authors have addressed the importance of preoperative chest wall analysis in determining postoperative outcomes. Studies have shown that between 88% and 100% of women who undergo elective breast augmentation have some degree of breast or chest wall asymmetry[2,3] Identifying these defects preoperatively is crucial for discussing it with the patient and devising a personalized surgical plan for correction.

The final decision on the appropriate technique of breast augmentation, as well as the type and size of implant should

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Received for publication August 28, 2023; accepted September 26, 2023.

Presented at the 7th International Breast Surgery Workshop, October 8–9, 2021, Rome, Italy, and at the American Academy of Cosmetic Surgery (AACS) 2023 Annual Scientific Meeting, February 9–11, 2023, San Diego, California.

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DOI: 10.1097/GOX.0000000000005422

Disclosure statements are at the end of this article, following the correspondence information.

Related Digital Media are available in the full-text version of the article on www.PRSGlobalOpen.com.

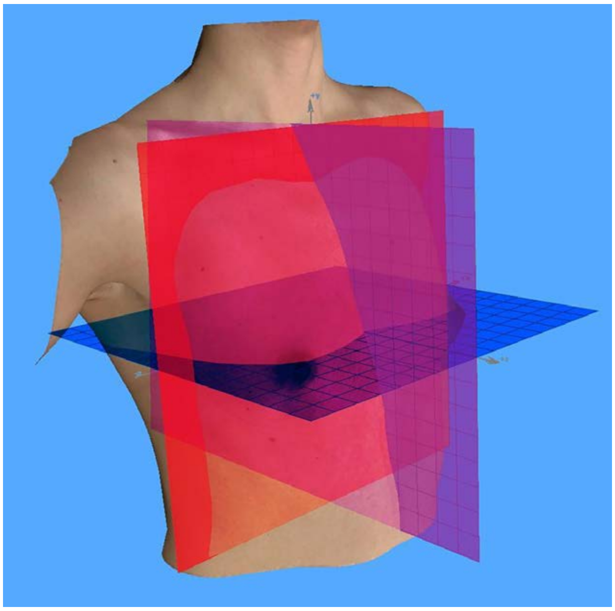

Fig. 1. CSH classification of the chest shape based on three basic planes: coronal (C), sagittal (S), and horizontal (H).

be less subjective and more reliant on any asymmetry found during preoperative examination. Although there is a classification of chest wall deformity based on computed tomography (CT) scans, its use is limited to complex cases where the additional radiation exposure is justified. Currently, the most frequent preoperative analysis in plastic surgery clinic involves validated computerized measurement photography. There is an unmet clinical need for a chest deformity classification that is based on easily obtainable, standardized photography and that can be performed before any elective aesthetic procedure. In this article, we introduce our own classification system for chest wall deformities, based on three basic planes: coronal (C), sagittal (S), and horizontal (H), and therefore, propose the name CSH classification (Fig. 1).

MATERIAL AND METHODS

The study was approved by the ethics committee of our institution, and patients gave informed consent for the documentation and publication of their images; the principles outlined in the 1964 Declaration of Helsinki have been followed. A retrospective analysis of chest and breast imaging randomly selected in 1000 patients who were qualified for bilateral breast augmentation surgery from 2016 and 2020 has been assessed. Standardized preoperative digital images taken with the Vectra 3D and Mirror (Canfield Scientific, Inc, Fairfield, N.J.) were examined by three independent nondoctor evaluators. Relationships between measured parameters were calculated using the χ^2 Pearson test.

The Coronal Plane

The coronal plane (C) allows for assessing the proportion of chest width and shoulder height (Fig. 2). This classification was divided into two subgroups: coronal chest (Cc) and coronal shoulder (Cs). The reference was a vertical line guided down from the sternal notch to the xiphoid process of the sternum. Distances between this line and right (R) and left (L) top of the axillary fold were measured and compared. In this way the R to L chest width ratio was assessed. A 5% margin of tolerance was accepted (Fig. 3). Cc0 was defined when R and L chest width were equal (Supplemental Digital Content 1a); Cc1, when R was wider than L (Supplemental Digital Content 1b); and Cc2, when R was narrower than L (Supplemental Digital Content 1c). [**See figure, Supplemental Digital Content 1,** which shows Cc classification: Cc0 – R and L chest width are equal (a), Cc1 – R is wider than L (b), Cc2 – R is narrower than L (c). **http://links.lww.com/PRSGO/C870**.]

In the Cs classification, the R to L shoulder height ratio was measured in relation to the axillary level. The reference was a horizontal line guided from R to L axillary folds. Distances between this line and the R and L top of the clavicle (canoid tubercle) were measured and compered. In this way the R and L shoulder's height ratio was

Takeaways

Question: What impact does chest wall asymmetry have on the breast implant selection process?

Findings: The aim of the retrospective analysis of 1000 patients using standardized digital images taken with Vectra 3D and Mirror was to present our classification of chest shape based on three basic planes: coronal (C), sagittal, (S) and horizontal (H). Individual selection of breast implants is crucial for patients with significant chest wall asymmetry. There is a statistically confirmed relationship between the asymmetry of shoulder height and chest width.

Meaning: The CSH classification allows for systematizing the chest shape assessment and has a huge impact on the choice of breast implant.

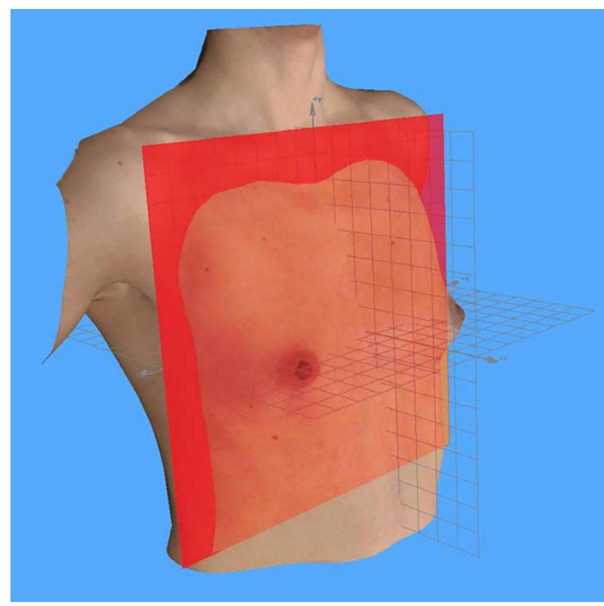

Fig. 2. Coronal chest plane.

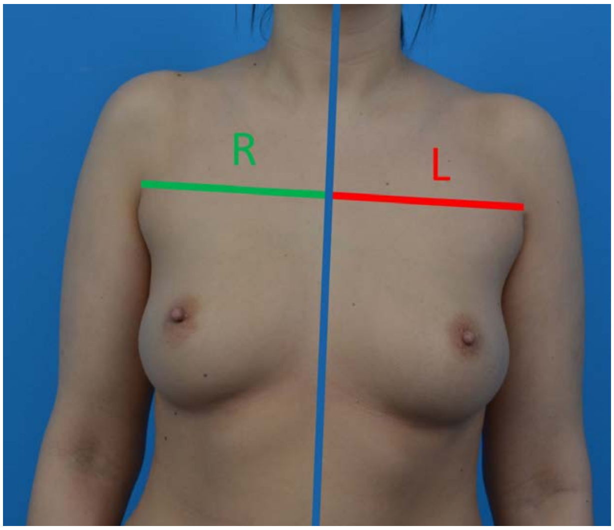

Fig. 3. Coronal chest (Cc) classification: R to L chest width ratio was measured.

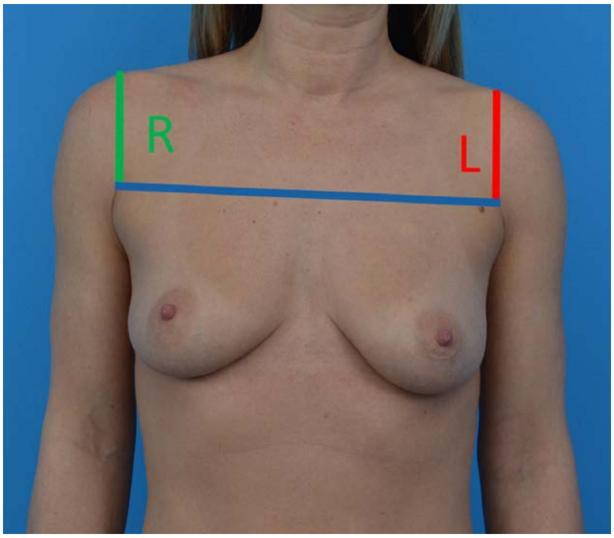

Fig. 4. Coronal shoulder (Cs) classification: R to L shoulder height ratio was measured.

assessed (Fig. 4). A 5% margin of tolerance was accepted. Cs0 was defined when R and L shoulder heights were equal (Supplemental Digital Content 2a); Cs1, when R was higher than L (Supplemental Digital Content 2b); and Cs2, when R was lower than L (Supplemental Digital Content 2c). [See **figure**, **Supplemental Digital Content 2**, which shows Cs classification: Cs0 – R and L shoulder height are equal (a), Cs1 – R is higher than L (b), Cs2 – R is lower than L (c).) (**http://links.lww.com/PRSGO/C871**.]

The Sagittal Plane

The sagittal plane (S) allows for assessing the profile of the chest wall (Fig. 5). In this plane, the reference was a vertical line (vl) guided down from the sternal notch and an oblique line (ol) connecting the sternal notch with the most prominent point of the costal arch. Then two horizontal

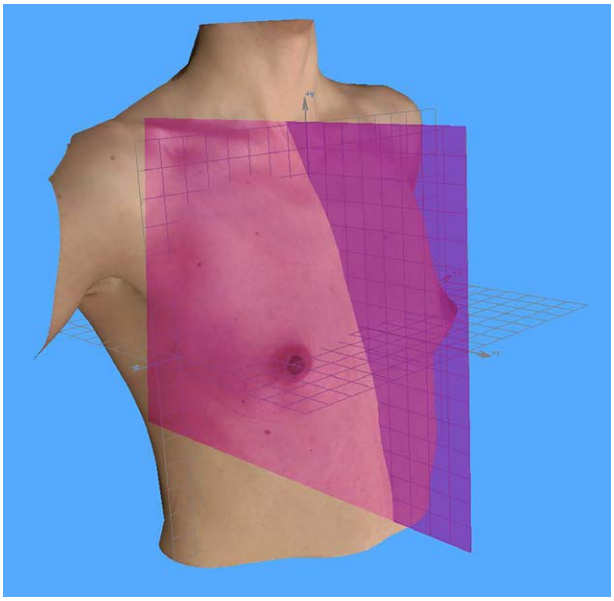

Fig. 5. Sagittal chest plane.

lines were drawn: first, at the level of the top of axilla and second, at the level of the most prominent point of the costal arch. Three measurements were calculated: A, distance between the most convex point of the chest and ol; B, distance between the ol and vl; and C, distance between the most prominent point of the costal arch and vl. The A to B ratio and A + B to C ratio were measured and compared (Fig. 6). S0 was defined when the A to B ratio was 33

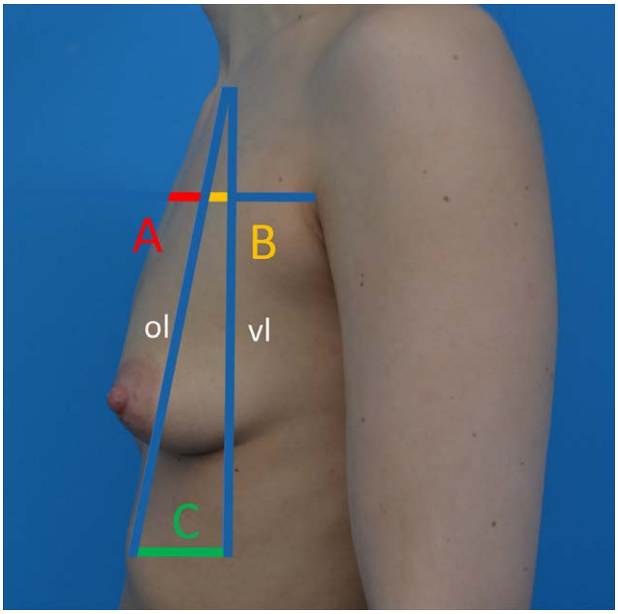

Fig. 6. Sagittal chest (S) classification. Vl, the vertical line guided down from the sternal notch; ol, the oblique line connecting the sternal notch with most prominent point of the costal arch; A, distance between the most convex point of the chest and ol; B, distance between the ol and vl; C, distance between the most prominent point of the costal arch and vl.

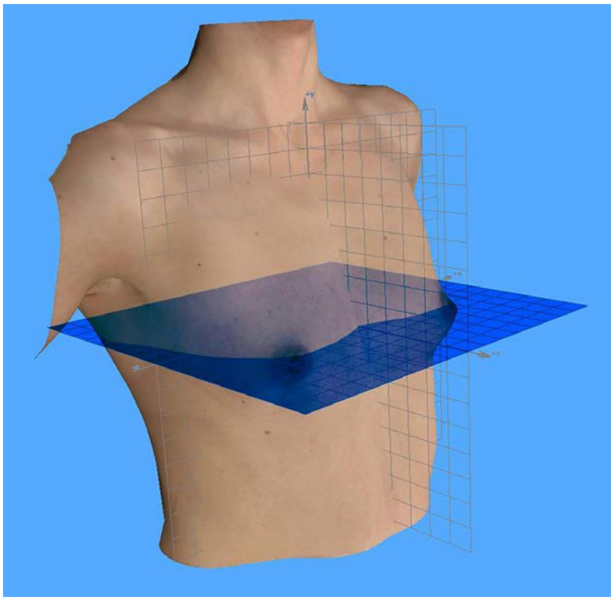

Fig. 7. Horizontal chest plane.

to 67 (A was 33% and B was 67%) and A + B was half of C (Supplemental Digital Content 3a); S1 was defined when A was more than 33%: the chest was excessively convex at the top (Supplemental Digital Content 3b); and S2 was defined when A + B was less than half of C: the costal arch was more protruded (Supplemental Digital Content 3c). [**See figure, Supplemental Digital Content 3,** which shows Sagittal (S) classification: S0—A is 33%, B is 67%, A + B = 50% of C (a), S1—A is more than 33% (b), S2—half of C is more than A + B (c). **http://links.lww.com/PRSGO/C872.**]

The Horizontal Classification

The horizontal classification (H) allows for assessing the projection of right and left chest wall (Fig. 7). In this plane, the reference was a horizontal line guided on the level of the frontal axilla–horizontal axillary line (hal). There were also two oblique lines connecting the middle of the sternum with the axilla–sternum axillary lines (sal). Half of the sternum axillary line marked the center of chest projection R versus L distance between the center of the chest projection and horizontal sternum line (hsl) was compared. A 5% margin of tolerance was accepted (Fig. 8). H0 was defined when R and L distances were equal: the same chest projection on both sides (Supplemental Digital Content 4a). H1 was defined when L was more than R: the L side of the chest was more projected than R side (Supplemental Digital Content 4b). H2 was defined when L was less than R: the R side of the chest was more projected than L side (Supplemental Digital Content 4c). [**See figure, Supplemental Digital Content 4,** which shows Horizontal (H) classification: H0—R and L chest projection are equal (a), H1—L is more projected than R (b), H2—L is less projected than R (c). **http://links.lww.com/PRSGO/C873.**]

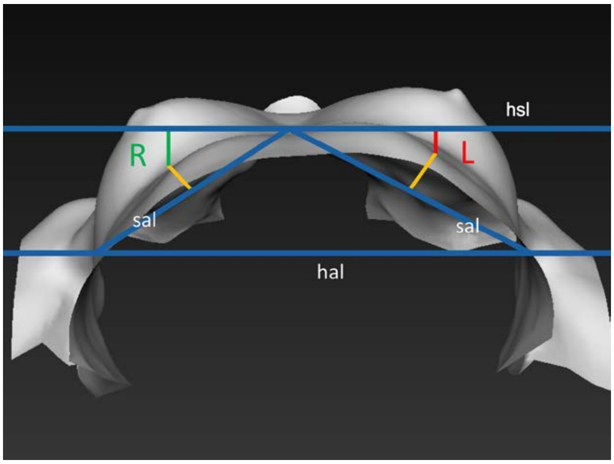

Fig. 8. Horizontal chest (H) classification: R to L chest projection was measured. Hal, horizontal axillary line guided on the level of frontal axilla; sal, sternum axillary lines connecting middle of the sternum with axilla; hsl, horizontal sternum line; R, distance between the center of the right chest projection and hsl; L, distance between the center of the left chest projection and hsl.

RESULTS

Among 1000 randomly examined patients, 923 were classified in the coronal plane, 920 in the sagittal plane, and 627 in horizontal plane. Other patients were excluded from the study due to insufficient quality of the images. Results of the analysis of 923 patients who were classified in the coronal chest plane (Cc) are shown in Figure 9. As many as 34.6% of women have chest width asymmetries. The range of chest width asymmetry (Cc classification) is shown in Figure 10. Results of the analysis of 923 patients who were classified in the coronal shoulder plane (Cs) are shown in Figure 11. As many as 43.2% of women have shoulder height asymmetries. The range of shoulder height asymmetry (Cs classification) is shown in Figure 12. There was a relationship between the asymmetry of shoulder height and chest width confirmed by the χ^2 Pearson test ($P = .03638$). This means that, if the shoulder is higher,

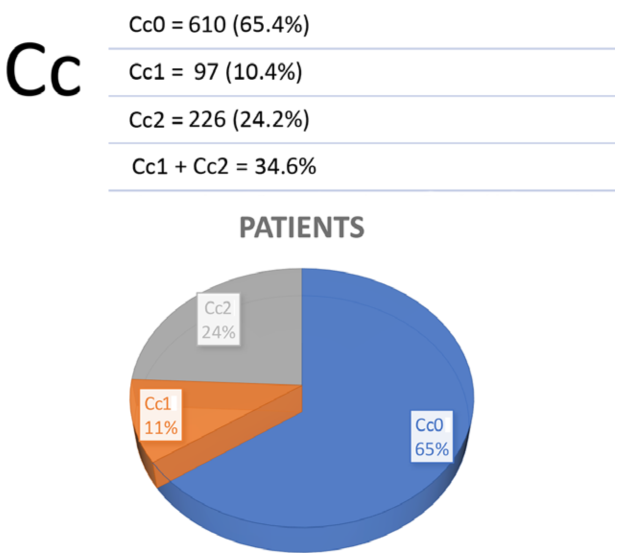

Fig. 9. Chest asymmetry of 923 patients in coronal chest plane: Cc classification.

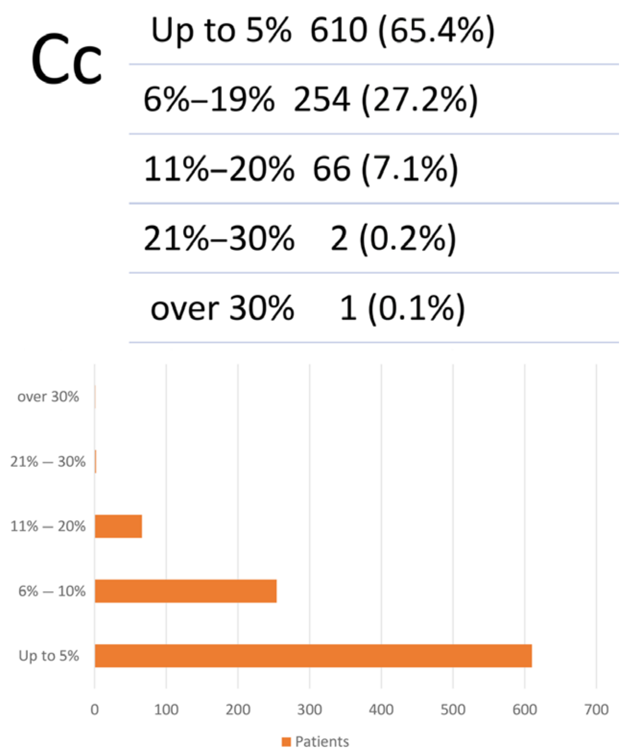

Fig. 10. The range of chest width asymmetry: Cc classification.

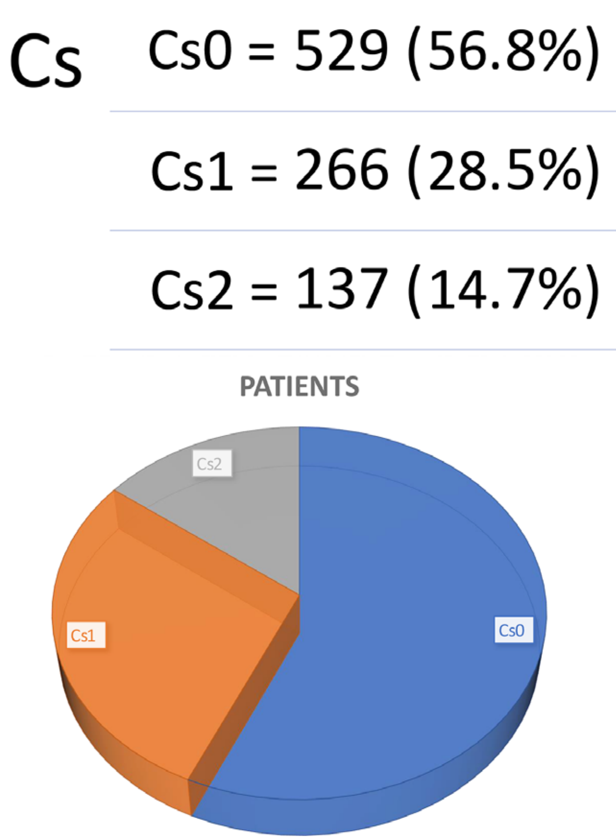

Fig. 11. Chest asymmetry of 923 patients in coronal shoulder plane: Cs classification.

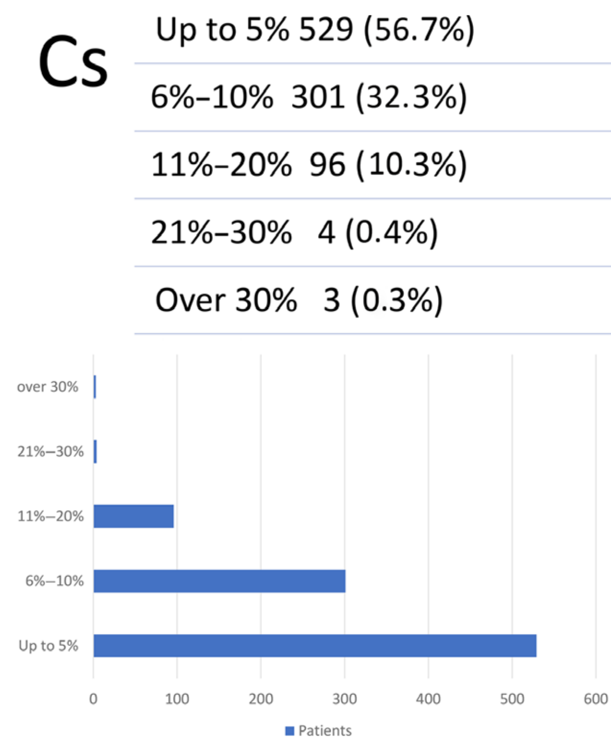

Fig. 12. The range of shoulder height asymmetry: Cs classification.

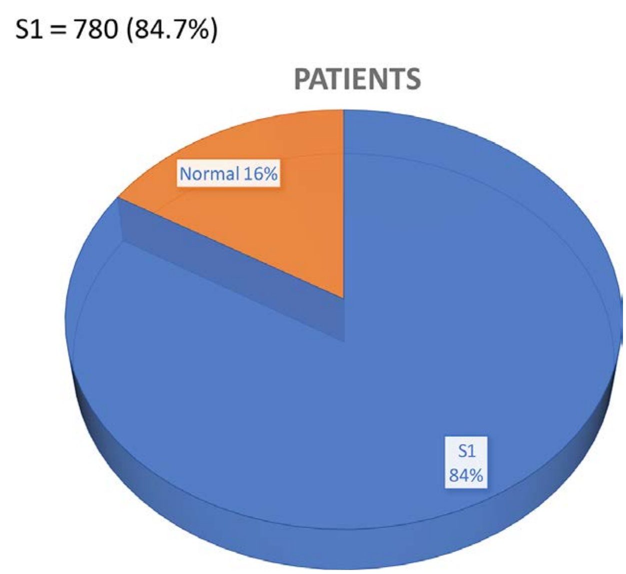

Fig. 13. The range of upper chest projection: S1 classification.

greater chest width on the same side is expected. Results of the analysis of 920 patients who were classified in the sagittal chest plane (S) are shown in the Figures 13 and 14.

As many as 84.7% of women have an excessive projection of the upper chest, and 28.4% of women have excessive projection of the lower chest (the costal arch). Results of the analysis of 627 patients who were classified in the horizontal chest plane (H) are shown in Figure 15. Only 15.6% of women have chest symmetry in the horizontal plane (H0), 55.3% of women have excessive projection of

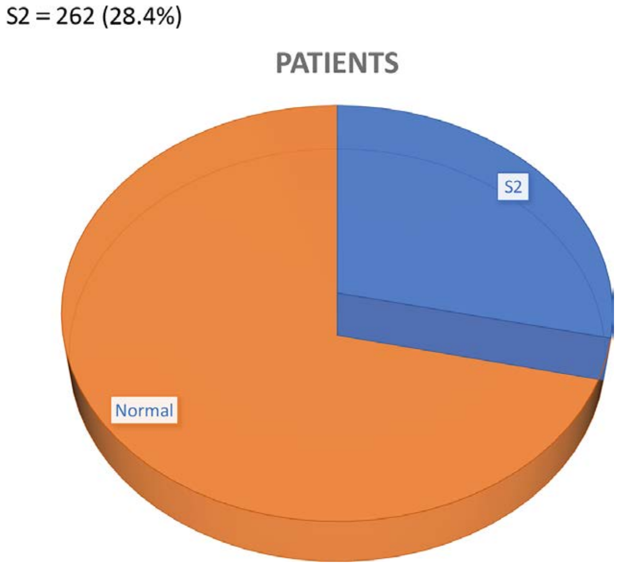

Fig. 14. The range of lower chest projection: S2 classification.

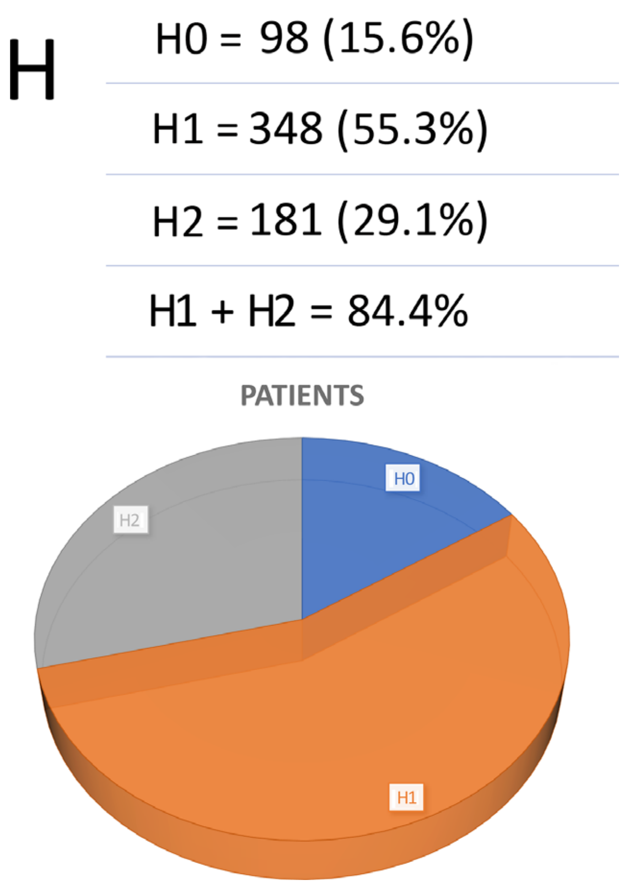

Fig. 15. The range of right and left chest projection: H classification.

the left side (H1), and 29.1% of women have excessive projection of the right side (H2). As many as 84.4% of women have chest projection asymmetries. The range of horizontal chest asymmetry (H classification) is shown in Figure 16. As many as 32.2% of women have excessive, more than 30%,

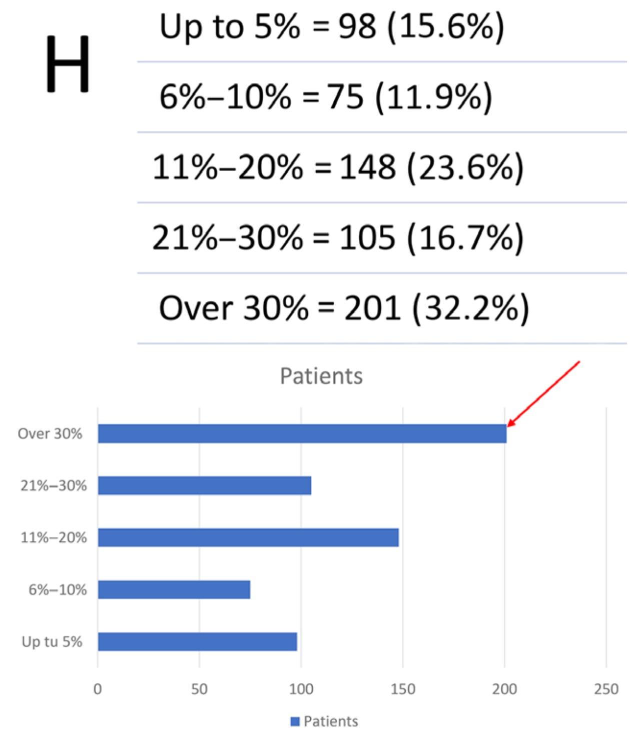

Fig. 16. The range of horizontal chest asymmetry: H classification.

horizontal projection asymmetry between the right and left chest side. There was not any relationship between chest width in the coronal plane (Cc) and chest wall projection in the horizontal plane (H) ($P = 0.63831$ in χ^2 Pearson test). There was not any relationship between shoulder height in the coronal plane (Cs) and chest wall projection in the horizontal plane (H) ($P = 0.17233$ in χ^2 Pearson test).

DISCUSSION

Chest deformities can be evaluated using various techniques, such as simple chest radiographs[4] and CT scans,[5] including three-dimensional (3D) chest CT.[6] Makiguchi et al evaluated the extent of chest wall deformity quantitatively using CT and the Chest Wall Deformity Index before and after breast reconstruction with tissue expanders.[7] However, this method involves radiation exposure, which is unnecessary for most patients. Another limitation is that chest wall size in a CT image may vary slightly depending on when the patient stops breathing during the CT scan, potentially affecting the comparison of measurements.

Assessing chest deformity is essential not only for planning standard breast surgery or chest wall corrections[8,9] and breast corrections like in Poland syndrome[10] but also for comparing postoperative outcomes. Tissue expansion,[11] capsular contracture, preoperative radiotherapy,[12] and delayed reconstruction[13] have all been identified as potential risk factors for chest wall deformities. These deformities are relatively common after tissue expansion in breast reconstruction, with an occurrence rate of 53.0%–77.8%.[11,13–15]

Three-dimensional imaging systems are increasingly used in plastic surgery.[16–18] Patients should be informed about their asymmetries during the initial consultation to select the most appropriate correction technique. It is recommended to document all objective preoperative measurements and photographs, and use them as the basis for implant selection. In breast augmentation, 3D imaging offers a preoperative simulation of postoperative results. Roostaeian et al compared preoperative simulations with 3-month postoperative breast augmentation results, demonstrating more than 90% accuracy in predicting postoperative breast volume.[17] Glicksman et al described the complexity of detailed preoperative evaluation of thoracic and glandular asymmetries using objective measurements with the Vectra M3 Imaging System (Canfield Scientific, Inc, Fairfield, N.J.) for patients who may have undergone thoracic correction procedures in early childhood.[18] The Vectra 3D imaging was used in our study due to its accessibility in the clinic. We did not compare the results between the other 3D imaging technologies.

No significant difference was found between manual measurements and computerized 4D photography in detecting breast asymmetries. However, a significant difference was observed in identifying chest wall asymmetries using 4D photography.[2] Breast and chest wall asymmetries in patients undergoing breast augmentation were found to be high, as evaluated by standardized three-view preoperative photography on 100[3] and 406 patients[19] and by 4D photography on 117 patients.[2] Significant differences between the right and left breasts were reported in 81.7% of patients, nipple-to-IMF position asymmetry in 59.6% of patients, and sternal notch-to-nipple asymmetry in 81.2%. Chest wall asymmetry was observed in only 9%–10.6% of women. Overall, 88%–100% of women exhibited some degree of soft tissue and/or chest wall asymmetry.[19]

Our results confirm that nearly 95% of women have natural chest asymmetries. Previous studies may underestimate chest wall occurrence due to the lack of precise measurements. The CSH classification is a tool for detecting these asymmetries. Obtaining 3D or 4D images of patients allows for reporting asymmetries in the horizontal plane. According to our results, 84.4% of patients had extensive right or left chest wall projection, with 30% being significant (a difference of more than 30% between both sides). This result could not be obtained using a 2D imaging system. The lack of reports in the literature verifying our results is likely due to authors not recognizing the significant chest asymmetry in the horizontal plane. However, this is a very crucial aspect that should be clearly explained to the patient before the surgery. Furthermore, precise measurement of the chest projection difference should encourage the surgeon to correct this asymmetry with implants that have the appropriate projection difference, rather than volume.

It is also interesting to note that a remarkable 84% of patients exhibit an increased projection of the upper parts of the chest in the sagittal plane (S1). There is a concern that this might be a result of the method's measurement sensitivity and requires further research. Nevertheless, it does not change the fact that the use of implants in these patients significantly alleviates the perception of chest deformities.

These findings suggest that to achieve optimal results in breast augmentation, plastic surgeons should consider a highly individualized and comprehensive imaging approach. Four practical examples regarding patients with chest asymmetries are provided in Supplemental Digital Contents 5–8. (See **figure**, **Supplemental Digital Content 5**, which shows example 1: In a case of chest width asymmetry, it is recommendable to correct it with two different widths of breast implants. If inserting the same width of implants, it is expected to cause an overprojection on the narrower side of the chest. **http://links.lww.com/PRSGO/C874**.) (**See figure, Supplemental Digital Content 6,** which shows example 2: In a case of shoulder height asymmetry, it is recommendable to correct it with low-height anatomic breast implants to avoid noticeable cleavage asymmetry postoperatively. **http://links.lww.com/PRSGO/C875**.) (**See figure, Supplemental Digital Content 7,** which shows example 3: In a case of prominent upper chest, it is recommendable to correct it with low-height anatomic breast implants to avoid an overprojection of the upper pole of breast. **http://links.lww.com/PRSGO/C876**.) (**See figure, Supplemental Digital Content 8,** which shows example 4: In a case of chest projection asymmetry in a horizontal plane, it is recommendable to correct it with two different breast implants regarding their projection. **http://links.lww.com/PRSGO/C877**.)

The number of elective breast procedures is increasing, and all efforts must be made to decrease reoperation rates and improve postoperative satisfaction for both patient and surgeon with long-term aesthetic results. Improved patient communication regarding expectations and outcomes is crucial. Deformities of the breast and chest have to be identified preoperatively because implants magnify asymmetries, and they may become more obvious to a woman postoperatively, regardless of having been present her whole adult life.

CONCLUSIONS

The vast majority of the women had natural asymmetries of the breast and/or chest wall. The CSH classification allows for systematization of chest shape assessment. There is a statistically confirmed relationship between the asymmetry of shoulder height and chest width. The chest shape has a significant impact on the choice of the breast surgery technique. Individual selection of breast implants is crucial for correction in breast surgery of patients with significant chest wall asymmetry.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

ETHICS STATEMENT

The study was approved by the ethics committee of our institution. The principles outlined in the 1964 Declaration of Helsinki were followed.

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