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Congenital breast asymmetry: subjective and objective assessment

C. M. Malata, J. C. Boot, E. T. Bradbury, A. R. B. Ramli and D. T. Sharpe

Department of Plastic Surgery, St Luke's Hospital, and Civil Engineering Department, University of Bradford, Bradford

SUMMARY. **There is currently no standard objective method for the assessment of developmental breast asymmetry. The results of corrective surgery in 24 patients with congenital breast deformities were evaluated subjectively (symmetry scores by patients and panels of observers), and objectively (linear measurements of nipple position and stereophotogrammetrically determined breast volumes). The latter were obtained using a newly developed prototype computer based technique (*Bodymap*).**

This study is the first reported use of stereophotogrammetry in assessing results of surgery for the correction of congenital breast asymmetry. The results obtained, their clinical implications, and the usefulness of *Bodymap* in the objective measurement of breast asymmetry are discussed.

Symmetry is considered an attribute of beauty and normality,[1] and significant breast asymmetry can lead to psychological problems.[2,3] Rintala and Nordström describe severe developmental asymmetry of the female breast as a "socio-aesthetic handicap".[1] However, there is no consensus as to what constitutes significant asymmetry meriting treatment, nor regarding standard pre- or postoperative assessment procedures for measuring the outcome of surgical correction. Previous studies have focused on the surgical techniques employed[2,5–8] and have assessed the results of surgery using patient satisfaction with outcome and/or subjective analyses of breast symmetry by the patient or surgeons. Few studies have made objective assessments of the operative results, let alone correlated objective measurements with subjective evaluations of symmetry.[9,10]

The first comprehensive classification of breast asymmetry was by Maliniac in 1950.[11] Since then it has variously been classified based on aetiology,[1,12] or the anatomical abnormality.[1,2,5,9,13] In this study a modification of the system proposed by Elsahy[5] was adopted (Table 1).

Of the presently available methods for evaluating breast symmetry, subjective visual assessment is simple and is widely used by surgeons to assess their own results. However, difficulties may occur in the presence of rib cage deformities such as those associated with scoliosis.[14] Photographic analysis using split-and-reversed negatives is a related technique which is said to be helpful in evaluating minor geometric discrepancies,[15] but in common with all qualitative visual characterisations the procedure is subjective and therefore potentially unreliable.

The objective assessment of breast symmetry using linear measurements has yielded conflicting results: Stark and Olivari[10] obtained favourable results while Smith *et al.*[9] reported poor correlation with aesthetic and symmetry scores. Volume measurements using fluid displacement methods[16–20] or plaster of Paris moulds[9,20] can provide a measure of overall symmetry but these contact procedures are cumbersome, demeaning to patients and possess limited reproducibility and hence accuracy.

Stereophotogrammetry[21] is a non-contact technique by which the volume and shape of the breast can be quantified.[22,23] However, in its traditional form it is too slow, cumbersome and labour intensive for routine clinical use.[21] The recent availability of high quality and portable image processing computer hardware at

Table 1 Morphological classification of breast asymmetry

Elsahy (1976)	*Schurter and Letterman (1974)*	*Present Study*
Bilateral asymmetrical hypertrophy ("one breast large and the other breast larger")	Asymmetrical hypermastia	Bilateral symmetrical hyperplasia
Bilateral asymmetrical hypomastia ("one breast small and the other breast smaller")	Asymmetrical hypomastia	Bilateral asymmetrical hypoplasia
Unilateral hypertrophy + contralateral micromastia ("one breast large and the other breast small")	Hypermastia and hypomastia	Hypertrophy + hypoplasia
Unilateral hypertrophy ("one breast large and the other breast normal")	Unilateral hypermastia	Unilateral hyperplasia
Unilateral hypomastia or amastia ("one breast small and the other breast normal")	Unilateral hypomastia	Unilateral hypoplasia

Table 2 Indications for surgery and procedures undertaken (n = 46). (The figures for the subset reviewed are in brackets)

Deformity type	*Patients*	*Surgery undertaken*	
Unilateral hypoplasia	26 (11)	unilateral augmentation	13 (5)
		tissue expansion + implant	12 (5)
		augmentation + mastopexy	1 (1)
Asymmetrical hypoplasia	5 (2)	asymmetrical reduction	3 (1)
		augmentation + mastopexy	1 (1)
		tissue expansion only	1 (0)
Unilateral hyperplasia	6 (5)	unilateral reduction	6 (5)
Asymmetrical hyperplasia	5 (3)	reduction + mastopexy	4 (2)
		asymmetrical reduction	1 (1)
Hypoplasia/hyperplasia	2 (2)	tissue expansion + implant	1 (1)
		reduction + mastopexy	1 (1)
Tuberous breasts	2 (1)	tissue expansion + implant	2 (1)

reasonable prices has enabled the development of *Bodymap*, an automated stereophotogrammetric procedure[25] offering the possibility of a simple but reliable method of symmetry assessment. A joint study was therefore set up by the Departments of Plastic Surgery (St Luke's Hospital, Bradford) and Civil Engineering (University of Bradford) with the following specific objectives:

1. To study the correlation between established linear measurements and the patients' and observers' subjective evaluation of symmetry.
2. To assess the relationship of stereophotogrammetrically determined breast volumes to the patients' and observers' perceived symmetry.
3. To evaluate the clinical usefulness of stereophotogrammetrically-determined breast volumes in the objective determination of symmetry and hence the value of continuing the development of the *Bodymap* system.[25]

Table 3 Indications for surgery by aetiology (n = 46). (The figures for the subset reviewed are in brackets)

Aetiology	*Patients*
Postinfantile surgery	2 (1)
Postinfantile mastitis	1 (0)
Postinfantile radiotherapy	1 (0)
Poland's syndrome	6 (3)
Associated pectus excavatum	1 (0)
Associated pectus carinatum	1 (0)
Associated scoliosis	2 (2)
Idiopathic	29 (19)

Clinical material and assessment procedures

All 46 patients with primary congenital breast deformities operated on at St Luke's Hospital, Bradford from 1984 to 1991 were identified from the hospital records and included in the study. Tables 2 and 3 show the

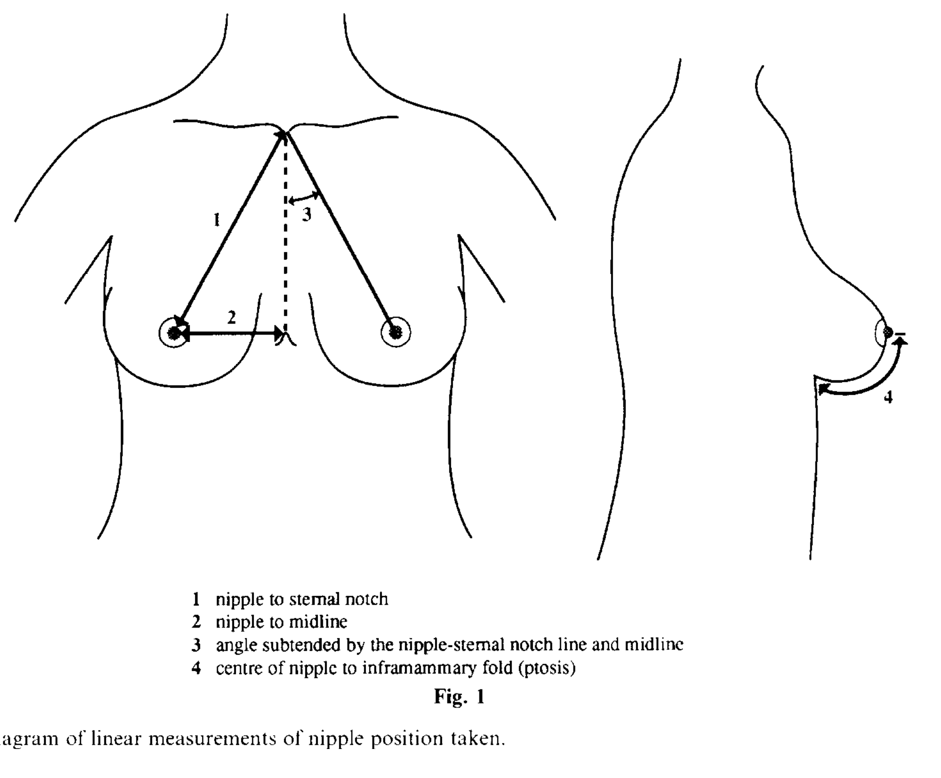

Figure 1—Line diagram of linear measurements of nipple position taken.

Table 4 Point scoring system for right to left differences in linear measurements*

Linear difference (cm)	*Points*	*N-SN-M angle difference (°)*
≤ 1	4	≤ 2.5
> 1 ≤ 1.5	3	> 2.5 ≤ 5
> 1.5 ≤ 2	2	> 5 ≤ 7.5
> 2	1	> 7.5

* = after Stark and Olivari (1991)[10]; N-SN-M = nipple to sternal notch to midline

Table 5 Category of surgical outcome (based on Stark and Olivari, 1991)[10]

Total points	*Category of result*	*Patients*
16	Excellent	3
12 < 16	Good	11
8 < 12	Fair	4
4 < 8	Poor	6

indications for surgery both anatomically and aetiologically and the range of corrective surgical techniques used. The mean age at presentation of these patients was 22.6 years (range 11–49 years), and that at the time of their first surgery was 24.3 years (range 13–50), a mean delay of 1.7 years (range 0–6 years) between presentation and surgery. The mean follow up time was 1.8 years (range 5 months to 5 years) and only 2 patients had become pregnant in the interim.

All the 46 patients were asked to return to a specially arranged review clinic. A postal questionnaire was sent with the invitation letter and consisted of a combination of open and closed ended questions, designed to elicit from the patients their reasons for surgery, their preoperative concerns, and their evaluation of the success of surgery. Out of the 46 patients, 24 completed the questionnaire and returned for evaluation; these patients comprised the study sample. At the follow-up clinic patients were also asked to rate their satisfaction with the surgical outcome on a 5-point scale (5 = very pleased, 1 = very unhappy) and to give a judgement of their own breast symmetry on a visual (linear) analogue scale 10 cm long.

Panel judgements

Subjective evaluation of symmetry of the patient's pre- and postoperative photographs was undertaken by 2 panels of observers using identical linear analogue scales. These panels were made up of an independent group of 10 university personnel, and a group of 7 surgical staff regularly involved in caring for plastic surgery patients, including the surgeon who performed the corrective surgery.

Linear measurements

After a short interview the seated patient had linear measurements of the nipple position (Fig. 1) determined. These results were analysed by calculating the difference between the breast pairs for each linear parameter and then using a scoring system similar to that used by Stark and Olivari[10] (Table 4), the only difference being in the degree of ptosis which was measured from the centre of the nipple. The total number of points scored by each patient was used to categorise the surgical outcome (Table 5) and then converted to a percentage to give the "Stark and Olivari score" (Table 6).

Volume measurements by stereophotogrammetry

The *Bodymap* system has been described in detail elsewhere.[25] Figure 2 illustrates the basic principle;

Table 6 Summary of numerical results

Mean preop symmetry	*Mean panels' score*	*Stark & Olivari score*	*Patient symmetry*	*"Volume score" σ*	*Measured Vm*	*Patient satisfaction*
17.5	68.5	63	67	95	1273	100
23.0	54.5	100	50	92	771	80
	39.0	63	81	93	907	100
24.5	71.5	94	95	98	675	100
	32.0	56	16	77	681	80
11.0	65.0	94	77	78	1030	40
15.5	62.0	81	75	98	1071	100
37.5	66.5	88	73	89	465	80
35.0	29.5	38	50	76	760	80
15.0	68.0	44	75	98	1159	80
	49.5	63	80	82	464	100
18.0	41.5	75	76	93	1061	80
23.5	26.0	44	26	81	695	60
42.0	69.5	81	76	90	487	80
17.0	81.0	100	96	100	1225	80
	64.0	69	98	90	1057	100
12.0	15.0	31	50	67	580	60
10.5	60.5	94	31	97	698	40
56.5	81.0	100	84			80
	53.0	44	72	88	1277	80
	62.0	75	67			100
19.5	36.5	81	81	60	684	80
	66.5	88	90	87	1363	100
		14	73			80

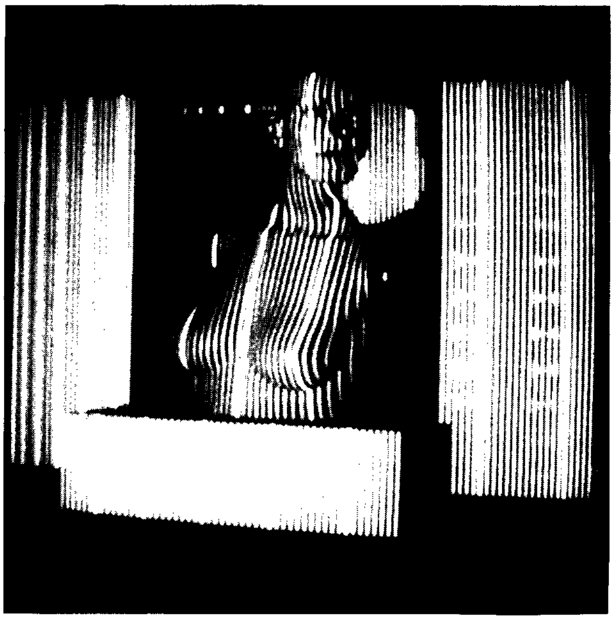

Fig. 2

Figure 2—Structured light image of mannequin and control space (Image capture).

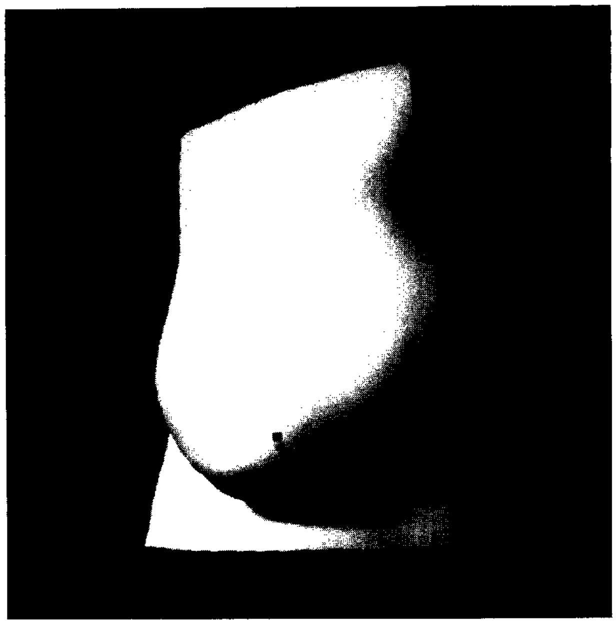

Fig. 4

Figure 4—Computer simulated view of a typical reconstructed breast surface.

when a (non-flat) surface is illuminated by structured light (here a regular grid of lines obtained using a standard slide projector), then a unique pattern of distortion of the light is observed. Any image of the distortion (*e.g.*, photograph) together with the original slide forms a stereopair from which the coordinates of the projected grid lines on the surface can be analytically determined. A digital image of the illuminated surface is essential for rapid analysis of the image coordinates because it allows the use of computerised image processing techniques to abstract the necessary data. For this purpose we used charged couple device (CCD) cameras (*Pulnix TM-765*, 12.5 mm C mounted lenses). To obtain full coverage of a human breast efficiently a mono-projector and stereo-camera configuration is required. Figure 3 illustrates the basic *Bodymap* system configuration.

After image capture and storage, subsequent processing to obtain the breast surface profile was then undertaken objectively with errors in the reconstruction of individual points being everywhere less than 1 mm.[24,25] Figure 4 shows a computer simulated view of a typical reconstructed breast surface and Figure 5 a representative cross section through the visible breast surface. For the present purposes only an estimate of the volumetric similarity of a given patient's breasts was required, rather than the actual volume of mammary tissue. This criterion facilitated the use of a simple definition of breast volume as that between the visible surface and a suitably defined plane of intersection as shown. The breast volume could then be obtained using standard numerical techniques.[25]

The percentage volume difference or estimate of

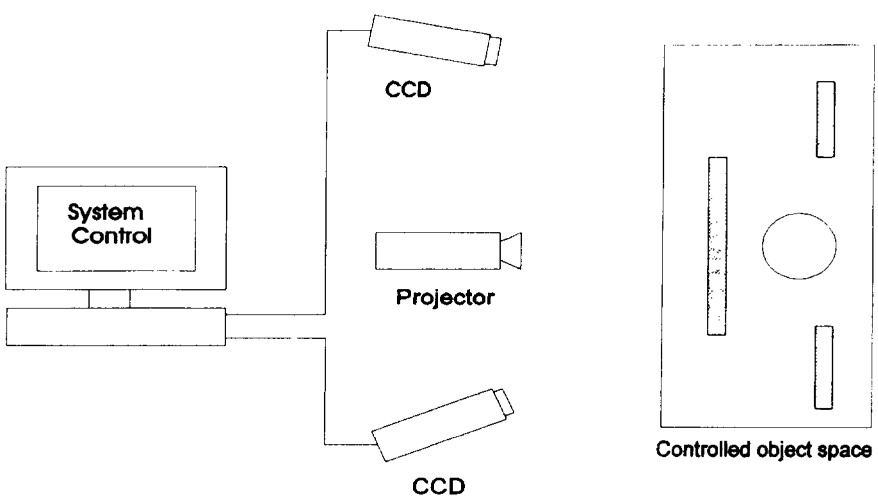

Fig. 3

Figure 3 Configuration (geometrical and hardware) for the body map system.

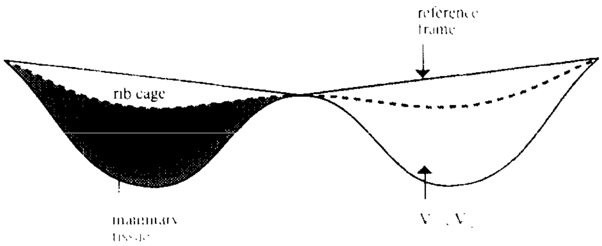

Fig. 5

Figure 5 Horizontal section through upper trunk.

asymmetry (α) of each breast pair was then obtained as:

$$\alpha = \frac{(V_l - V_s)}{V_l} \times 100 \qquad (1)$$

where V_l and V_s are the volumes of the larger and smaller breasts respectively. The corresponding measure of symmetry (σ = 100-α) is then:

$$\sigma = \frac{V_s}{V_l} \times 100 \qquad (2)$$

Loughry *et al.*[23] used V_s in the denominator of equation (1) as this yields the most sensitive estimate of asymmetry obtainable from volumetric measurements. However, the alternative estimate is preferred here as this correlates with visual assessments which award a 0% symmetry score (100% asymmetry) to a unilateral mastectomy.

Results

The retrospective questionnaire demonstrated that prior to the operation 60% of patients were very self-conscious about their breast asymmetry, having problems particularly in social situations such as communal changing rooms (100%) and with restricted clothing. 40% of the sample reported problems in sexual relationships because of self-consciousness about their breasts. The expectations of the patients from surgery are shown in Figure 6. To a large extent these were realised: in particular they reported greatly reduced levels of self-consciousness with only 5% still experiencing some post treatment self-consciousness which was associated with problems in acceptance of the implant.

Data capture and storage by stereophotogrammetry was very quick (2 min per patient) and straightforward and no patient resistance to the procedure was encountered.

Table 6 summarises the relevant numerical data abstracted from the visual, linear and volumetric assessments. Except where otherwise indicated statistical analysis of these results was undertaken using the Spearman Rank Order Correlation Coefficient (r_s) with a two-tailed probability (p) and a level of significance = 0.05.[26]

Because of the excellent correlation of the symmetry assessments from the 2 panels (Z = −0.455, 2-tailed p = 0.65, Wilcoxon Matched-pairs Signed-ranks Test)[26] these assessments were amalgamated and used as mean panel symmetry score in subsequent analyses and discussion. There was a significant difference between the preoperative symmetry scores by the panels and their postoperative scores, providing a quantitative documentation of the improvement in symmetry brought about by the corrective surgery (Z = −3.361, 2-tailed p = 0.0008; Wilcoxon Matched-pairs Signed-ranks Test). Additionally, on questionnaire results 68% of the patients also reported that their breasts were even postoperatively.

Surprisingly, there was also good correlation between the mean panel and patient assessment of symmetry (r_s = 0.552, p = 0.0063).

There were high levels of patient satisfaction with the results of surgery as measured by the simple rating (Fig. 7) with dissatisfaction primarily related to the unresolved concerns of a few patients who said that the

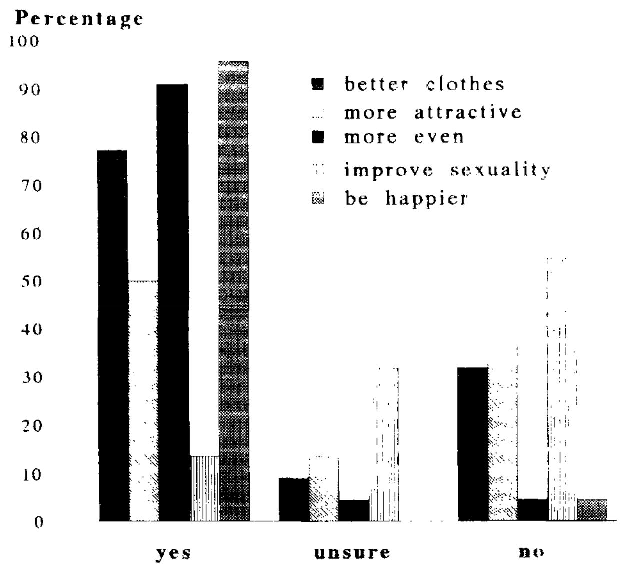

Fig. 6

Figure 6 Patient expectations from surgery.

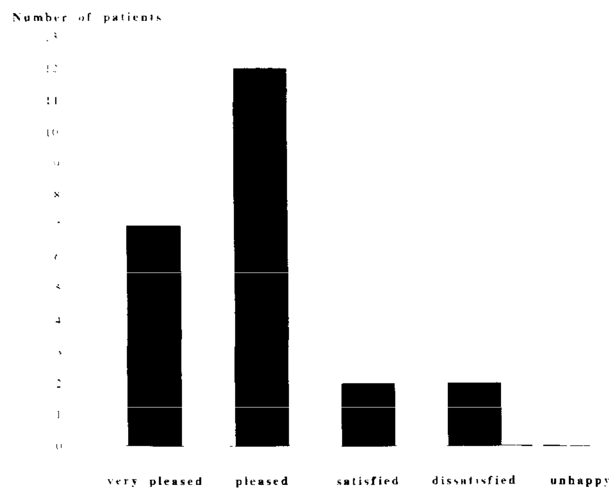

Fig. 7

Figure 7 Satisfaction with surgery.

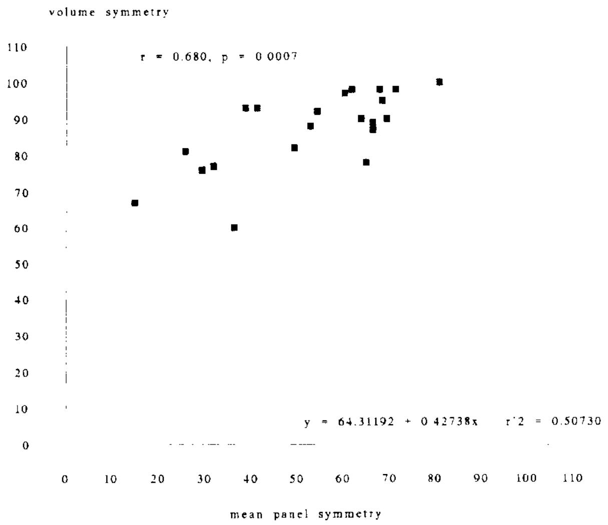

Fig. 8

Figure 8 Scatter diagram of correlation of volume estimate of symmetry and mean panel score.

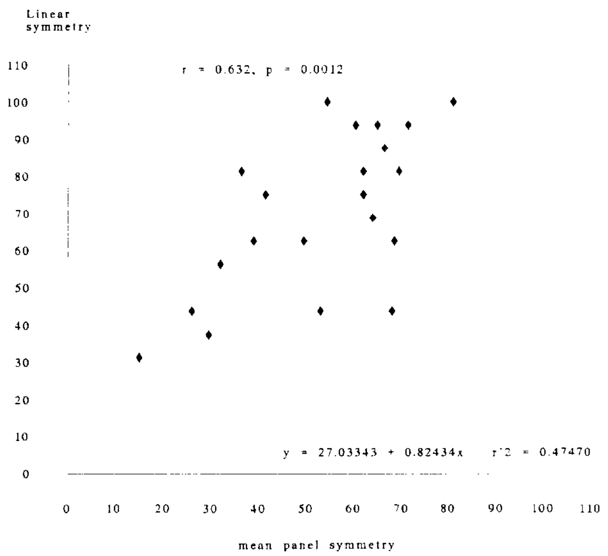

Fig. 9

Figure 9—Scatter diagram of correlation of linear symmetry score and mean panel score.

implants felt unnatural to them. Patient satisfaction was significantly correlated with their degree of perceived symmetry achieved by the surgery ($r_s = 0.457$, $p = 0.025$). It was, however, poorly correlated with volume estimates of symmetry σ ($r_s = 0.334$, $p = 0.140$) and even more so with the linear measurements ($r_s = 0.020$, $p = 0.926$). Patient assessment of symmetry was similarly poorly correlated with these two quantitative estimates of symmetry ($r_s = 0.276$, $p = 0.227$ for volume and $r_s = 0.433$, $p = 0.349$ for linear measurements).

In contrast, the mean panel symmetry was strongly correlated both with the volume measurements (Fig. 8) and linear measurements (Fig. 9). Despite the relatively small difference between the statistical indicators, visual comparison of Figures 8 and 9 suggests a significantly better correlation with the volumetric results.

Discussion

Although the study sample on which visual, linear and volume estimates of symmetry were made was relatively small it was representative of the whole group (Table 2) and includes a wide spectrum of anatomical deformities and corrective surgical techniques,[1,9] thus permitting a valid comparison of the different assessment procedures. As in other studies most cases of developmental breast asymmetry are congenital,[1] and Poland's syndrome constituted the commonest cause of syndromic breast asymmetry.[4] Our follow-up time of almost 2 years is consistent with the recommendations of others.[7,10,12]

The good correlation between patient visual estimates of symmetry and those of the panels was rather surprising, because more variability in the patients' estimates of symmetry was expected as they represented a single individual (patient's) score, whereas the panel score for each pair of breasts was a mean of 17 observer scores. Additionally, we had expected differences because patients have a different vantage point of viewing their own breasts from that of the observers. Parkhouse, in a consecutive series of 50 patients to determine the predominant breast view in the patient's self image, has shown that 100% felt that the downward view was important and 75% felt that the downward view was more important than the view in the mirror (equivalent to the observers' view), in contrast to the 4% who felt the reverse (that the mirror view was more important).[27] In our survey, panel judgements were made by viewing a mirror image photograph, whilst the patient assessments were returned as part of a clinical interview just before examination. The higher symmetry scores awarded by the patients to themselves than those by the panels are possibly because of:

1. initially low levels of expectation preoperatively,
2. reluctance to criticise the surgeons, and
3. having been through the psychological trauma associated with major surgery they are more likely to be positive about the results.

The mean panel symmetry score was strongly correlated with both sets of quantitative estimates, suggesting that in their assessment of symmetry the panels were predominantly using geometric features of the breast even though the symmetry assessment was made subjectively.

Smith *et al.*[9] found that linear measurements of nipple position were more strongly correlated to perceived symmetry than volume and areolar diameter and suggested that this might account for the lower patient satisfaction found in augmented patients compared to those who had undergone reduction mammoplasty. They concluded that "creating the perception of volumetric equality is more important than actually establishing equal breast volume".

The difficulties associated with interpretation of patient assessments are also apparent from our study, in which no significant correlation between patient symmetry and either set of quantitative measures was obtained. Figure 6 shows that the most important aspects of symmetry to the patients (in addition to looking more even) were those which enable them to feel happier and look better when clothed. Given these patients' expectations from surgery and that the bra defines clothed shape provided the generalised distribution of mammary tissue is reasonably symmetrical, it was expected that achievement of volumetric equivalence would be the most important aspect of corrective surgery for the majority of patients. The lack of correlation between volumetric and patient symmetry scores may have been caused by the patients taking non-geometric factors into account. Evidence for this assumption comes from the observed strong correlation between satisfaction and symmetry which may imply that the distinction between symmetry and satisfaction may be blurred in the patients' minds. The poor correlation between linear and patient estimates of symmetry may be because location of the nipple position is a relatively minor issue to the patients. However, it may also be that difficulty in interpreting the patient assessments is caused primarily by their being a single subjective judgement in each case.

The average breast volume obtained in our study was 875cc, more than double the 405cc obtained by Loughry *et al.* in a large survey of normal women undergoing mammography.[22,23] This is because of our chosen definition of breast volume, which includes tissue between the chest wall and the reference plane (Fig. 5). This difficulty in the suitable delineation of the breast-chest wall boundary has been a universal problem with all symmetry evaluations reported to date.[23-29] However, what is significant about the *Bodymap* assessment is that, in the absence of a significant rib cage deformity, the volume difference is correctly obtained since the volume of extramammary tissue included in the volume estimates is the same on both sides.

The good correlation between panel means and both simple quantitative measures of symmetry evaluated here suggests that the panel means are a good reflection of objective estimates of symmetry. However, the volumetrically based symmetry measure would appear to have greater value as a planning and counselling aid.

Despite the good correlation between *Bodymap* generated measurements and panel mean estimates of symmetry (Fig. 8), improved agreement could be obtained by enhancing the former to include better geometric analyses of the surface data based on criteria more directly related to symmetry. In this respect further developments could be:

(i) superposition of the photogrammetrically generated mirror images of the two breasts to aid preoperative planning, and

(ii) superposition of pre- and postoperative shapes so that the effects of surgery could be more accurately and objectively assessed.

The use of stereophotogrammetry to determine breast volumes is more convenient, less demeaning to patients and has the potential to be more accurate than volume determination by contact methods. The current state of development of the *Bodymap* system represents significant progress towards establishing a role for stereophotogrammetry in the assessment of the results of breast surgery. However, this first extensive clinical application of the system to the assessment of breast symmetry postoperatively has exposed some shortcomings with the present generation software. These include the need for an experienced operator, the lengthy data processing and the presence of a subjective element in data analysis to determine breast boundaries from the camera image. In addition, the system must be amended to calculate the actual volume of mammary tissue exclusive of any chest wall if its full potential in the field of preoperative planning is to be realised.

An increased future role for good quality volumetric assessment can be anticipated because with current surgical techniques volume is the major parameter over which surgeons have control. An accurate knowledge of breast volume is therefore a very important piece of information to the surgeons which can be used not only for preoperative planning but also for postoperative assessment. We envisage stereophotogrammetry having a number of clinical applications. Predicting the tissue expander size from a difference of the right and left breast volumes can prove useful in both congenital breast asymmetry and postmastectomy reconstruction. Predicting the implant size can be applied to asymmetrical and bilateral breast hypoplasia. Additionally, this technique may help in predicting the amount of breast tissue to be excised in reduction mammaplasty. Finally, an estimate of the volume of the unoperated breast following mastectomy can be made. This would yield a preoperative determination of the volume of flap tissue required in reconstruction.[30]

Conclusions

Although visual assessments of surgical outcomes are simple and there is no evidence from this study that their use by observers for partial assessment of breast symmetry involves significant error, they are subject to bias. Similarly, although linear and volume measurements are objective, this study shows that breast symmetry is a complex geometric property which cannot be comprehensively quantified using these simple numerical indicators.

The degree of volumetric equivalence is only marginally better correlated to symmetry as assessed by the panels than are linear measurements. Stereophotogrammetrically determined breast volumes may, however, have a role in planning cosmetic and other operations on the human female breast, and in the preoperative evaluation and planning of breast surgery, especially for developmental breast asymmetry. The information that this assessment provides may in the future even help in deciding the ideal treatment modalities to use for different congenital breast problems.

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The Authors

C. M. Malata, BSc, MB ChB, LRCP MRCS, FRCS(G), Research Registrar, Department of Plastic Surgery, St Luke's Hospital, Bradford

J. C. Boot, B Eng, PhD, Lecturer, Civil Engineering Department, University of Bradford

E. T. Bradbury, PhD, Psychological Counsellor in Plastic Surgery (now at Withington Hospital, Manchester)

A. R. B. Ramli, B Eng, Research Student, Civil Engineering Department, University of Bradford

D. T. Sharpe, OBE, MA, FRCS, Consultant Plastic Surgeon, Department of Plastic Surgery, St Luke's Hospital

Requests for reprints to: Mr C. M. Malata, Plastic Surgery and Burns Research Unit, Department of Biomedical Sciences, University of Bradford, Bradford BD7 1DP.

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