A Study of the Relation Between Mastectomy Specimen Weight and Volume With Implant Size in Oncoplastic Reconstruction

UMAR WAZIR, HIBA EL HAGE CHEHADE, CHRISTINA CHOY, ABDUL KASEM and KEFAH MOKBEL

The London Breast Institute, Princess Grace Hospital, London, U.K.

Abstract. Background: There is no general consensus regarding the best and most accurate method for assessing the size of implant required for achieving the best symmetry in oncoplastic reconstruction. Materials and Methods: Breast weight, volume and size of implant were recorded prospectively on patients undergoing immediate reconstruction over a 3-year period. Cases with specimen size greater than 2,000 g were excluded. The primary endpoint was size of implant used in relation to specimen weight and volume. Secondary endpoints were the influence of age and histology on specimen weight, volume and breast density. Results: A total of 278 mastectomies were performed. Correlation of implant size with volume was marginally stronger than that with weight (r=81%, p<0.001 vs. r=78.9%, p<0.001 respectively). Women aged 50 years and above had lower breast weight for the same breast volume than women under 50 years. The difference was merely 4%, but was statistically significant (p=0.001). Histology had no statistically significant influence on breast density. Conclusion: Specimen weight and volume were found to be closely correlated. Weight can be measured more accurately and easily with reproducible readings compared to volume.

Reconstruction surgery is increasingly offered to women undergoing mastectomy. Implant reconstruction with acellular dermal matrix has gained popularity in recent years compared to pedicle and free flap reconstructions (1). There is no general consensus as to what the best and most accurate method of assessing the size of implant to be used in order to achieve desirable result in terms of symmetry. Some surgeons use the volume of mastectomy specimen to determine the implant size, whilst others use specimen weight (2). There are very few published reviews on this topic.

This study examined the relation of mastectomy specimen weight and volume with implant size in order to better inform intra-operative decision-making regarding implant selection.

Materials and Methods

Data were collected prospectively on patients who underwent mastectomy at the London Breast Institute. Breast weight, volume measurement and size of implant were recorded if immediate reconstruction was chosen. Patients were under the care of two senior oncoplastic breast surgeons from January 2014 to December 2016. The exclusion criteria included patients with mastectomy specimen weighing more than 2,000 g. The volume of breast tissue was measured by volume displacement method. The weight of breast tissue was measured on a scale in grams.

The primary endpoint studied was size of implant used in relation to mastectomy specimen weight and volume. Secondary endpoints were the influence of age on specimen weight and volume relation; the influence of the presence of invasive cancer, ductal carcinoma in situ (DCIS) on weight and volume relation, and breast weight to volume ratio (BWV, i.e. breast tissue density).

These variables were analysed using regression, two-sample t-test, Pearson’s correlation test, and Wald test as appropriate.

Results

A total of 278 operations were performed on 221 women, of whom 53 had bilateral mastectomies (N=278). The mean age of women was 48 years (range=24-90 years). There were 150 right and 128 left breast specimens. The complete dataset is presented in Table I.

Relation between breast weight and volume. There was strong positive linear relation between breast weight and volume (r=99.07, p<0.001) (Figure 1). The R-squared parameter of the regression suggested that 98.1% of the variation in weight was explained by the variation in volume.

Influence of histology on BWV. The population was stratified into groups based on histology: Invasive carcinoma, DCIS and benign histology (Figure 2). These were compared for differences in BWV. Different tests led to the conclusion that histology had no statistically significant influence on breast density.

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Correspondence to: Professor Kefah Mokbel, London Breast Institute, the Princess Grace Hospital, 45 Nottingham Place, London W1U 5NY, U.K. E-mail: kefahmokbel@hotmail.com

Key Words: Mastectomy, breast, breast density, body weight.
Influence of age on breast weight, volume and BWV. Breast weight, volume and BWV were studied in patients above and below the age of 50 using regression analysis and the Student’s t-test.

In this population, no statistically significant correlation was seen for breast weight by age group. However, women at an age of 50 years and above had lower breast weight for the same breast volume than women under 50 years of age. The difference was merely 4%, but was statistically significant \((p=0.001)\).

Analysis of the correlation of age with BWV confirmed this finding. We found that women at an age of 50 years and over had a lower breast weight for the same breast volume than women under 50 years of age \((p=0.0001)\). This was confirmed by regression analysis. R-Squared of the regression suggested that age would account for 5.3% of variation in BWV.

Implant size used in relation to breast weight and volume. Correlation of implant size with volume was marginally stronger than that with weight \((r=81\%, p<0.001\) vs. \(r=78.9\%, p<0.001\), respectively).

Discussion

Mastectomy specimen weight and volume are fairly closely correlated. The presence of cancer whether in the form of invasive disease or DCIS did not seem to affect the correlation between weight and volume of the breast tissue. The weight can be measured more accurately easily with repeated readings on a scale, whereas volume measurement is best estimated to the nearest 25-50 cc. However, there are many other factors in deciding the type and size of implant, including whether to use a fixed volume or expandable prosthesis. Patient preference regarding size, and the limits of commercial availability of implants of certain sizes are also crucial considerations.

However, age is an important factor in the relation between weight and volume. A higher age results in lower breast weight for the same volume. On average, specimens from women after 50 years of age, taken arbitrarily as the age of menopause, were found to have about 4% lower weight than those from woman under 50 with the same breast volume. This fits with the general belief that younger breasts have denser glandular breast tissue.
| Case number | Age, years | Laterality | Weight, g | Volume, ml | Implant used | Indication |
|-------------|------------|------------|-----------|------------|--------------|------------|
| 1           | 58         | Right      | 615       | 700        | No reconstruction | Prophylactic: Strong family history. |
| 2           | 58         | Left       | 589       | 600        | No reconstruction | Prophylactic: Strong family history. |
| 3           | 26         | Right      | 236       | 200        | TSF 295      | Prophylactic: PTEN; multiple fibroadenoma and hamartoma; Cowden syndrome. |
| 4           | 26         | Left       | 218       | 200        | TSF 295      | Prophylactic: PTEN; multiple fibroadenoma and hamartoma; Cowden syndrome. |
| 5           | 41         | Right      | 641       | 650        | Becker 500   | Grade 2 IDC, 1/8 lymph node (micro-metastases) |
| 6           | 41         | Left       | 520       | 600        | Becker 500   | Contralateral DCIS |
| 7           | 44         | Left       | 183       | 200        | Becker 25-250 | 2002: Grade 2 IDC (WLE, SNB & radiotherapy). 2014: Recurrent DCIS |
| 8           | 46         | Left       | 368       | 350        | Becker 350   | Prophylactic: BRCA 2 carrier |
| 9           | 37         | Left       | 365       | 350        | TSF 335      | Prophylactic: BRCA 2 carrier |
| 10          | 37         | Right      | 302       | 280        | TSF 335      | Prophylactic: BRCA 2 carrier |
| 11          | 49         | Right      | 143       | 150        | Becker 25-250 | 2007: Grade 2 IDC (WLE, SNB & radiotherapy). 2013: Recurrent grade 1 IDC |
| 12          | 40         | Right      | 186       | 200        | Becker 200   | Prophylactic: Contralateral carcinoma. |
| 13          | 67         | Right      | 584       | 600        | No reconstruction | 7 cm Grade 3 IDC |
| 14          | 50         | Right      | 575       | 600        | Becker 500   | Prophylactic: Previous left sided ILC and LCIS. |
| 15          | 50         | Left       | 523       | 500        | Becker 500   | Prophylactic: Previous left sided ILC and LCIS. |
| 16          | 53         | Left       | 375       | 350        | Becker 350   | Large ILC |
| 17          | 39         | Right      | 520       | 500        | Becker 500   | Prophylactic: BRCA carrier |
| 18          | 39         | Left       | 537       | 530        | Becker 500   | BRCA-positive. Left sided IDC. |
| 19          | 39         | Right      | 517       | 500        | TSF 385      | Extensive DCIS |
| 20          | 39         | Left       | 245       | 250        | TSF 385      | Prophylactic: Contralateral DCIS |
| 21          | 40         | Right      | 312       | 300        | Becker 300   | Prophylactic: left sided IDC |
| 22          | 40         | Left       | 245       | 250        | Becker 300   | Left grade 3 IDC |
| 23          | 45         | Right      | 282       | 300        | Becker 300   | Grade 2 IDC, 3/10 lymph nodes |
| 24          | 77         | Left       | 264       | 250        | Becker 250   | Multifocal grade 1 IDC |
| 25          | 39         | Right      | 434       | 450        | No reconstruction | Grade 3 IDC |
| 26          | 41         | Right      | 250       | 250        | TSF 365      | Prophylactic: Contralateral carcinoma |
| 27          | 55         | Right      | 233       | 245        | Becker 25-300 | Extensive high-grade DCIS |
| 28          | 40         | Left       | 295       | 300        | Becker 400   | Multifocal grade 3 IDC |
| 29          | 39         | Right      | 495       | 500        | Becker 500   | Large area IDC and DCIS |
| 30          | 55         | Right      | 124       | 150        | Becker 250   | Prophylactic: Contralateral DCIS |
| 31          | 55         | Left       | 131       | 150        | Becker 250   | DCIS |
| 32          | 50         | Left       | 413       | 400        | Becker 400   | 3 cm Grade 3 IDC |
| 33          | 47         | Right      | 207       | 200        | Becker 250   | 4 cm Grade 2 IDC |
| 34          | 44         | Left       | 456       | 450        | TSM 445      | Prophylactic: Contralateral carcinoma |
| 35          | 44         | Right      | 412       | 450        | Becker 400   | Extensive grade 2 IDC |
| 36          | 65         | Left       | 325       | 350        | Becker 300   | 3 cm Grade 3 IDC |
| 37          | 61         | Left       | 311       | 300        | Becker 25-250 | Extensive grade 2 IDC |
| 38          | 44         | Left       | 255       | 280        | TSM 175      | Grade 2 IDC |
| 39          | 73         | Right      | 659       | 700        | No reconstruction | Large ILC |
| 40          | 55         | Left       | 582       | 600        | No reconstruction | IDC |
| 41          | 64         | Right      | 538       | 600        | Becker 400   | High grade DCIS |
| 42          | 65         | Right      | 690       | 700        | Becker 500, LD | Invasive carcinoma |
| 43          | 59         | Right      | 583       | 600        | Becker 500   | 4 cm Grade 2 IDC |
| 44          | 35         | Left       | 391       | 400        | TSF 415      | IDC |
| 45          | 35         | Right      | 333       | 350        | TSF 415      | Prophylactic: Contralateral carcinoma |
| 46          | 57         | Left       | 527       | 530        | TSF 385      | Grade 2 IDC. Patient wanted smaller reconstructed breast |
| 47          | 54         | Right      | 130       | 150        | Becker25-200 | Recurrent invasive carcinoma. |
| 48          | 55         | Left       | 1154      | 1100       | No reconstruction | IDC and residual DCIS with 2/14 lymph nodes. Completion mastectomy. |
| 49          | 50         | Left       | 400       | 350        | Becker 50-500 | Grade 2 ILC with-positive margin and subareolar tissue |
| 50          | 54         | Right      | 301       | 300        | Becker 300   | Recurrent invasive disease after radiotherapy. |
| 51          | 49         | Left       | 271       | 250        | TSF 415      | Carcinoma on right breast, LCIS on left. BRCA negative. Risk reduction. Patient wanted larger reconstructed breasts. |

Table I. Continued
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| Case number | Age, years | Laterality | Weight, g | Volume, ml | Implant used | Indication                                                        |
|-------------|------------|------------|-----------|------------|--------------|------------------------------------------------------------------|
| 52          | 40         | Left       | 329       | 300        | SF 335       | Prophylactic: Contralateral carcinoma                             |
| 53          | 43         | Right      | 297       | 300        | Becker 300   | Grade 2 IDC                                                     |
| 54          | 43         | Left       | 325       | 300        | Becker 300   | Grade 1 IDC                                                     |
| 55          | 47         | Right      | 381       | 400        | Becker 50-400 | Prophylactic: Contralateral carcinoma                         |
| 56          | 47         | Left       | 415       | 380        | Becker 50-400 | 3 cm Grade 1 IDC                                                 |
| 57          | 53         | Left       | 230       | 250        | Becker 25-250 | 3.5 cm Grade 2 IDC                                               |
| 58          | 69         | Right      | 800       | 800        | No reconstruction | Invasive carcinoma                                    |
| 59          | 40         | Right      | 424       | 400        | Becker 300   | Prophylactic: Contralateral carcinoma. BRCA 1-positive        |
| 60          | 43         | Left       | 150       | 150        | Becker 300   | Multifocal IDC                                                   |
| 61          | 69         | Left       | 279       | 300        | Becker 50-300 | Extensive ILC >7 cm on MRI                                       |
| 62          | 46         | Right      | 257       | 250        | 324-5275-275 | Grade 2 IDC 20 mm                                               |
| 63          | 44         | Right      | 408       | 400        | No reconstruction | 2013: Grade 3 IDC with 4/16 lymph nodes.         |
| 64          | 48         | Right      | 543       | 600        | Becker 400   | Prophylactic: BRCA carrier                                       |
| 65          | 79         | Right      | 964       | 1000       | No reconstruction | Grade 1 ILC with 0/3 lymph nodes.                                    |
| 66          | 51         | Left       | 439       | 400        | Becker 400   | High grade DCIS                                                  |
| 67          | 57         | Left       | 389       | 400        | Becker 50-400 | Multifocal grade 3 IDC                                          |
| 68          | 42         | Left       | 410       | 400        | Becker 50-400 | Multifocal grade 2 ILC with LCIS                                  |
| 69          | 39         | Right      | 190       | 200        | Becker 25-250 | Grade 2 IDC with DCIS                                           |
| 70          | 50         | Left       | 261       | 250        | Becker 50-300 | DCIS                                                             |
| 71          | 43         | Right      | 541       | 450        | Becker 50-500 | Right high-grade DCIS                                           |
| 72          | 43         | Left       | 722       | 700        | Becker 50-500 | Prophylactic: Contralateral DCIS                                  |
| 73          | 41         | Right      | 292       | 290        | Becker 300   | Multifocal grade 2 IDC                                          |
| 74          | 68         | Right      | 1228      | 1300       | No reconstruction | Multifocal disease with-positive nodes.                          |
| 75          | 43         | Left       | 244       | 250        | Becker 300   | Grade 2 IDC (1.8 cm) with multifocal DCIS                        |
| 76          | 43         | Right      | 115       | 100        | TSF265       | Prophylactic: BRCA carrier                                       |
| 77          | 43         | Left       | 95        | 100        | TSF265       | Prophylactic: BRCA carrier                                       |
| 78          | 50         | Right      | 615       | 600        | Becker 50 - 500 | Multifocal ILC                                                   |
| 79          | 45         | Right      | 230       | 200        | Becker 450   | Prophylactic: Contralateral carcinoma                             |
| 80          | 52         | Right      | 768       | 800        | Becker 50-600 | Multifocal grade 2 invasive carcinoma                            |
| 81          | 65         | Right      | 661       | 630        | No reconstruction | Inflammatory carcinoma. Post neoadjuvant chemotherapy.                 |
| 82          | 55         | Left       | 289       | 275        | Becker 25-300 | 4.0 cm Grade 3 IDC                                             |
| 83          | 45         | Left       | 274       | 250        | TSF485       | Prophylactic: Contralateral carcinoma                           |
| 84          | 46         | Right      | 399       | 400        | TSF450       | Prophylactic: Contralateral carcinoma                           |
| 85          | 56         | Left       | 354       | 350        | TSF450       | Invasive carcinoma                                              |
| 86          | 57         | Left       | 145       | 150        | Mod Plus 150  | Change from TSF200 to Mod Plus 150                               |
| 87          | 49         | Right      | 1024      | 1000       | No reconstruction | 3.8 cm high-grade DCIS                                      |
| 88          | 47         | Left       | 670       | 700        | Becker 25-600 | 2.3 cm Retro-areolar intermediate-grade DCIS and LIQ high-grade DCIS |
| 89          | 45         | Right      | 553       | 600        | Becker 50-500 | Post chemotherapy                                               |
| 90          | 49         | Left       | 237       | 220        | Becker 25-250 | Multifocal DCIS                                                  |
| 91          | 51         | Left       | 472       | 500        | TSF485       | Post chemotherapy                                               |
| 92          | 37         | Right      | 287       | 250        | TSF335       | Prophylactic: family history                                    |
| 93          | 37         | Left       | 230       | 250        | TSF335       | Prophylactic: Contralateral carcinoma                           |
| 94          | 45         | Left       | 167       | 150        | Becker 25-200 | Multifocal grade 1 IDC                                          |
| 95          | 51         | Right      | 1045      | 1000       | Becker 50-600 | Prophylactic: family history                                    |
| 96          | 51         | Left       | 953       | 1000       | Becker 50-600 | High-grade DCIS                                                  |
| 97          | 49         | Left       | 437       | 400        | Becker 50-400 | Multifocal grade 3 IDC                                          |
| 98          | 45         | Right      | 156       | 150        | TSF275       | Multifocal IDC                                                  |
| 99          | 45         | Left       | 137       | 150        | TSF275       | Multifocal bilateral IDC                                       |
| 100         | 58         | Right      | 514       | 500        | Becker 50-400 | Previous WLE                                                   |
| 101         | 37         | Left       | 450       | 500        | Becker 25-400 | Multifocal grade 1 IDC (2.1 cm and 2 cm)                        |
| 102         | 44         | Right      | 428       | 450        | Becker 25-400 | Post chemotherapy and trastuzumab                                |
| 103         | 60         | Right      | 137       | 150        | Becker 25-150 | Grade 1 IDC and DCIS                                            |
| 104         | 68         | Right      | 338       | 380        | Becker 50-400 | 2012: Grade 3 IDC (WLE, SNB and radiotherapy). 2015: Grade 2 IDC |
| 105         | 29         | Right      | 366       | 350        | Becker 25-350 | 2.4 cm grade 2 IDC with satellites                              |
| 106         | 49         | Left       | 802       | 900        | No reconstruction | Post tamoxifen still 5cm carcinoma                          |
| 107         | 38         | Left       | 352       | 350        | Becker 50-300 | Multifocal grade 1 IDC                                          |
| Case number | Age, years | Laterality | Weight, g | Volume, ml | Implant used | Indication |
|-------------|------------|------------|-----------|------------|--------------|------------|
| 108         | 63         | Left       | 191       | 200        | Becker 25-200 | Multifocal DCIS |
| 109         | 39         | Right      | 180       | 190        | Becker 25-250 | IDC, Post chemotherapy |
| 110         | 40         | Right      | 572       | 600        | Becker 50-500 | Prophylactic: Contralateral carcinoma |
| 111         | 49         | Right      | 325       | 300        | Delayed recon later | 2.1 cm Grade 1 IDC |
| 112         | 34         | Right      | 308       | 300        | Becker 50-300 | Prophylactic: Contralateral carcinoma |
| 113         | 34         | Left       | 311       | 300        | Becker 50-300 previous ca | Prophylactic: Family history |
| 114         | 37         | Right      | 474       | 500        | Becker 50-500 | Prophylactic: Family history; previous WLE for carcinoma. |
| 115         | 37         | Left       | 566       | 600        | Becker 50-500 | Prophylactic: family history |
| 116         | 38         | Right      | 385       | 400        | Becker 25-400 | Multifocal (2.5 cm, 0.9 cm) grade 2 IDC |
| 117         | 70         | Right      | 341       | 350        | No reconstruction | 5 cm Grade 2 IDC |
| 118         | 58         | Right      | 533       | 500        | No reconstruction | Prophylactic: family history |
| 119         | 58         | Left       | 375       | 359        | No reconstruction | Recurrent invasive disease |
| 120         | 43         | Right      | 209       | 150        | Becker 25-250 | Prophylactic: Contralateral disease |
| 121         | 43         | Left       | 139       | 100        | Becker 25-250 | Prophylactic: Previous invasive disease |
| 122         | 35         | Right      | 860       | 850        | Becker 35-565 | Multifocal 5.6 cm grade 3 IDC |
| 123         | 40         | Right      | 211       | 175        | Becker 50-300 | Prophylactic: Contralateral carcinoma |
| 124         | 40         | Left       | 272       | 250        | Becker 50-300 | Prophylactic: family history |
| 125         | 74         | Right      | 450       | 500        | Becker 25-500 | Multifocal grade 2 ILIC (more than 7.5 cm) |
| 126         | 27         | Left       | 430       | 450        | Becker 25-400 | 5.4 cm DCIS. Post mantle radiotherapy |
| 127         | 48         | Left       | 146       | 150        | Becker 25-250 | Recurrent grade 2 IDC |
| 128         | 49         | Right      | 287       | 300        | Becker 25-50-300 | Invasive carcinoma. CHEK2 |
| 129         | 49         | Left       | 324       | 300        | Becker 25-300 | Prophylactic: CHEK2 |
| 130         | 58         | Right      | 222       | 275        | Becker 25-250 | Prophylactic: BRCA-positive. Previous contralateral disease |
| 131         | 63         | Left       | 681       | 650        | No reconstruction | ILC |
| 132         | 82         | Left       | 1264      | 1250       | No reconstruction | Multifocal grade 2 ILC |
| 133         | 70         | Right      | 320       | 325        | No reconstruction | 3 cm high-grade DCIS |
| 134         | 47         | Right      | 447       | 450        | Becker 50-400 | 2.4 cm grade 1 IDC |
| 135         | 67         | Right      | 105       | 100        | No reconstruction | Prophylactic: family history |
| 136         | 67         | Left       | 60        | 50         | No reconstruction | Previous carcinoma |
| 137         | 69         | Left       | 258       | 280        | Becker 25-250 | Extensive DCIS and LCIS |
| 138         | 40         | Right      | 312       | 300        | Becker 25-350 | Previous WLE for extensive DCIS |
| 139         | 45         | Right      | 558       | 550        | Becker 50-500 | DCIS |
| 140         | 39         | Right      | 414       | 400        | Becker 50-400 | Prophylactic: Previous carcinoma |
| 141         | 39         | Left       | 379       | 400        | Becker 50-500 | Prophylactic: Contralateral carcinoma |
| 142         | 47         | Left       | 303       | 325        | Becker 50-300 | Prophylactic: family history |
| 143         | 49         | Left       | 740       | 700        | Becker 50-500 | Extensive DCIS |
| 144         | 55         | Right      | 700       | 700        | No reconstruction | High-grade DCIS |
| 145         | 52         | Right      | 337       | 350        | Becker 50-300 | 3.3 cm grade 3 IDC with 1/4 lymph node |
| 146         | 44         | Right      | 341       | 330        | Becker 50-300 | Prophylactic: MUTYH and MHS2 |
| 147         | 44         | Left       | 375       | 350        | Becker 50-300 | Prophylactic: MUTYH and MHS2 |
| 148         | 63         | Right      | 945       | 950        | No reconstruction | Pleomorphic LCIS and ILC |
| 149         | 39         | Right      | 1074      | 1000       | Becker 50-600 | Multifocal IDC |
| 150         | 50         | Right      | 214       | 200        | Becker 50-300 | Multifocal DCIS |
| 151         | 36         | Left       | 812       | 800        | Becker 25-500 | 4.1 cm Grade 3 IDC |
| 152         | 43         | Right      | 362       | 375        | Becker 25-500 | Multifocal high-grade DCIS |
| 153         | 47         | Left       | 235       | 200        | Becker 35-290 | Positive margins in previous WLE |
| 154         | 53         | Left       | 703       | 700        | Becker 50-600 | Prophylactic: Contralateral carcinoma |
| 155         | 31         | Right      | 328       | 300        | Becker 25-250 | Grade 3 IDC, high-grade DCIS |
| 156         | 31         | Left       | 126       | 100        | Becker 25-250 | Prophylactic: Contralateral carcinoma |
| 157         | 37         | Right      | 323       | 300        | Becker 50-300 | Prophylactic: BRCA-positive |
| 158         | 37         | Left       | 242       | 200        | Becker 50-300 | Prophylactic: BRCA-positive |
| 159         | 35         | Right      | 373       | 400        | Becker 25-300 | Prophylactic: family history |
| 160         | 35         | Left       | 375       | 350        | Becker 25-300 | Prophylactic: family history |
| 161         | 55         | Right      | 420       | 400        | Becker 50-300 | Prophylactic: BRCA-positive |
| 162         | 55         | Left       | 440       | 450        | Becker 50-300 | Prophylactic: BRCA-positive |
| 163         | 75         | Right      | 657       | 700        | No reconstruction | IDC, DCIS |
| 164         | 51         | Right      | 146       | 140        | Becker 25-200 | DCIS. Post chemotherapy. |
| 165         | 51         | Left       | 149       | 150        | Becker 25-200 | IDC. Post chemotherapy |

Table I. Continued
| Case number | Age, years | Laterality | Weight, g | Volume, ml | Implant used | Indication |
|-------------|------------|------------|-----------|------------|--------------|------------|
| 166         | 52         | Right      | 199       | 200        | Becker 25-200 | Multifocal high-grade DCIS |
| 167         | 35         | Right      | 475       | 450        | Becker 25-350 | Prophylactic: BRCA-positive |
| 168         | 36         | Left       | 164       | 130        | Becker 25-200 | Post chemotherapy. Grade 3 IDC |
| 169         | 47         | Right      | 385       | 400        | Becker 50-300 | Multifocal grade 3 IDC and high-grade DCIS |
| 170         | 41         | Right      | 233       | 200        | Becker 25-250 | Multifocal grade 2 ILC |
| 171         | 43         | Right      | 575       | 500        | Becker 50-500 | Multifocal grade 2 ILC |
| 172         | 46         | Right      | 241       | 250        | Becker 25-250 | Prophylactic: Contralateral carcinoma |
| 173         | 46         | Left       | 281       | 250        | Becker 25-250 | 0.7 cm Grade 2 IDC with extensive DCIS |
| 174         | 61         | Left       | 550       | 500        | No reconstruction | Bone metastases. Palliative mastectomy |
| 175         | 44         | Right      | 1715      | 1500       | Becker 50-600 | Prophylactic: Contralateral carcinoma. BRCA 1-positive |
| 176         | 44         | Left       | 1582      | 1500       | Becker 50-600 | BRCA 1-positive. Multifocal grade 2 IDC |
| 177         | 40         | Right      | 525       | 500        | Becker 50-300 | 4 cm Grade 2 IDC |
| 178         | 56         | Right      | 1476      | 1500       | Becker 25-600 | Grade 3 IDC |
| 179         | 58         | Left       | 241       | 250        | Becker 25-250 | Previous cancer recurrence IDC |
| 180         | 30         | Left       | 880       | 800        | Becker 25-600 | Multifocal grade 3 IDC |
| 181         | 47         | Right      | 324       | 300        | Becker 50-300 | Prophylactic: Previous carcinoma (DCIS and LCIS) |
| 182         | 47         | Left       | 330       | 300        | Becker 25-250 | Prophylactic: Previous cancer (DCIS and LCIS) |
| 183         | 42         | Right      | 875       | 850        | Becker 25-600 | Multifocal grade 3.0-2 cm IDC. Non-responsive to chemotherapy. |
| 184         | 42         | Right      | 150       | 180        | HP300 | Prophylactic: BRCA 1/2 -positive. |
| 185         | 42         | Left       | 170       | 180        | HP300 | Prophylactic: BRCA 1/2 -positive. |
| 186         | 43         | Right      | 846       | 900        | Becker50-600 | Prophylactic: Contralateral carcinoma. |
| 187         | 43         | Left       | 630       | 700        | Becker50-600 | IDC. Post chemotherapy |
| 188         | 50         | Right      | 422       | 450        | Mod Plus 400 | Multifocal grade 1 IDC |
| 189         | 42         | Right      | 239       | 200        | Becker 25-250 | Extensive multifocal IDC |
| 190         | 45         | Right      | 292       | 180        | Becker50-300 | Recurrent IDC |
| 191         | 45         | Left       | 410       | 300        | Becker50-300 | Prophylactic: Contralateral carcinoma. |
| 192         | 45         | Left       | 611       | 600        | Becker50-500 | Prophylactic: Contralateral carcinoma. BRCA 1/2-positive. |
| 193         | 36         | Left       | 253       | 290        | Becker 25-250 | Multifocal ILC |
| 194         | 42         | Right      | 158       | 200        | Becker25-200 | Prophylactic: Contralateral carcinoma. |
| 195         | 54         | Right      | 108       | 120        | Becker50-300 | IDC. Previous augmentation implant. |
| 196         | 25         | Right      | 486       | 500        | Becker 25-500 | High-grade DCIS |
| 197         | 49         | Right      | 539       | 500        | Becker50-500 | DCIS |
| 198         | 40         | Left       | 346       | 350        | Becker50-400 | Paget’s disease |
| 199         | 47         | Right      | 520       | 500        | Becker 25-500 | High-grade DCIS |
| 200         | 53         | Left       | 464       | 450        | Mod Plus 375 | Multifocal grade 2 IDC |
| 201         | 31         | Right      | 464       | 460        | Becker25-500 | Multifocal grade 2 IDC |
| 202         | 42         | Right      | 287       | 300        | Becker50-300 | Multifocal grade 2 IDC |
| 203         | 41         | Right      | 475       | 400        | TSF275 | Prophylactic: Contralateral DCIS. |
| 204         | 41         | Left       | 383       | 350        | TSF275 | DCIS |
| 205         | 46         | Left       | 400       | 400        | Becker 25-400 | Grade 3 IDC with DCIS |
| 206         | 52         | Right      | 401       | 400        | Becker 25-400 | Grade 3 IDC with DCIS |
| 207         | 34         | Right      | 1223      | 1250       | Becker50-600 | Multifocal high-grade DCIS |
| 208         | 34         | Left       | 1339      | 1250       | Becker50-600 | Multifocal high-grade DCIS |
| 209         | 48         | Right      | 452       | 500        | Becker25-400 | DCIS, radial scar, other B3/B1 areas |
| 210         | 51         | Right      | 230       | 200        | Becker 25-250 | Grade 1 IDC with other enhancements on MRI |
| 211         | 49         | Right      | 715       | 700        | Becker 50-500 | Invasive carcinoma |
| 212         | 31         | Right      | 516       | 500        | Mod Plus 400 | BRCA1 Small focus IDC |
| 213         | 31         | Left       | 332       | 350        | Mod Plus 401 | BRCA1 left previous WLE cancer now risk reduction |
| 214         | 61         | Right      | 112       | 100        | Becker 25-150 | Bilateral DCIS |
| 215         | 61         | Left       | 146       | 150        | Becker 25-150 | Bilateral DCIS |
| 216         | 45         | Right      | 300       | 300        | Becker 50-400 | BRCA bilateral breast cancer with previous WLE, risk reduction |
| 217         | 45         | Left       | 316       | 350        | Becker50-400 | BRCA bilateral breast cancer with previous WLE, risk reduction |
| 218         | 67         | Right      | 550       | 700        | Becker50-500 | IDC subareolar and margins-positive |
| 219         | 49         | Right      | 251       | 300        | Becker 25-250 | Multifocal ILC |
| 220         | 49         | Right      | 780       | 800        | Becker 25-600 | 45 mm and 15 mm grade 3 IDC |
| 221         | 72         | Right      | 122       | 200        | Becker 25-150 | Positive margin DCIS |
| 222         | 51         | Right      | 337       | 350        | Becker50-300 | DCIS |
| 223         | 73         | Left       | 354       | 400        | Becker 25-500 | Multifocal grade 2 IDC |

Table I. Continued
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| Case number | Age, years | Laterality | Weight, g | Volume, ml | Implant used | Indication |
|-------------|------------|------------|-----------|------------|--------------|------------|
| 224         | 51         | Right      | 169       | 150        | No reconstruction | Prophylactic: Contralateral carcinoma |
| 225         | 51         | Left       | 190       | 200        | No reconstruction | Grade 2 IDC |
| 226         | 31         | Right      | 349       | 350        | TSF 365 | Prophylactic: BRCA 1/2-positive. Contralateral carcinoma |
| 227         | 31         | Left       | 275       | 300        | TSF 365 | IDC |
| 228         | 55         | Right      | 686       | 700        | Becker50-300 | Prophylactic: BRCA 1/2-positive. Previous contralateral carcinoma |
| 229         | 47         | Right      | 226       | 250        | HP 325 | Prophylactic: BRCA 2-positive. |
| 230         | 47         | Left       | 233       | 250        | HP 325 | Prophylactic: BRCA 2-positive. |
| 231         | 42         | Left       | 1388      | 1200       | Becker25-500, | Post-chemotherapy 50 to 35 mm grade 3 IDC |
|             |            |            |           |            | no 600 on shelf |           |
| 232         | 25         | Right      | 510       | 600        | Becker 25-600 | Prophylactic: Contralateral carcinoma |
| 233         | 25         | Left       | 606       | 600        | Becker 25-600 | Grade 3 IDC. post chemotherapy |
| 234         | 48         | Right      | 662       | 600        | Becker 25-500 | Multifocal grade 2 IDC |
| 235         | 47         | Left       | 298       | 300        | Becker 25-350 | Multifocal grade 1 IDC |
| 236         | 62         | Right      | 617       | 600        | No reconstruction | Central 3 cm grade 2 mucinous carcinoma |
| 237         | 49         | Right      | 320       | 300        | Becker 50-300 | Multifocal IDC. post chemotherapy |
| 238         | 46         | Left       | 980       | 1000       | Becker 25-600 | Recurrent multifocal grade 3 IDC |
| 239         | 64         | Left       | 442       | 450        | Becker 50-400 | 4.5 cm Grade 2 IDC |
| 240         | 60         | Right      | 656       | 650        | No reconstruction | Multifocal grade 2 IDC over 6.1 cm |
| 241         | 60         | Left       | 588       | 650        | No reconstruction | Prophylactic: Contralateral carcinoma |
| 242         | 45         | Left       | 488       | 500        | Becker 50-500 | Grade 2 IDC |
| 243         | 53         | Left       | 326       | 300        | Mod plus 325 | Extensive grade 3 IDC. Post chemotherapy |
| 244         | 55         | Right      | 365       | 350        | Becker25-350 | Multifocal grade 2 IDC, LCIS |
| 245         | 37         | Left       | 352       | 350        | Becker 25-300, LxR breast | 3.9 cm Grade 2 IDC |
| 246         | 45         | Right      | 292       | 300        | No reconstruction | Multifocal grade 3 IDC |
| 247         | 39         | Right      | 145       | 125        | TSM265 | Prophylactic: Previous carcinoma left breast |
| 248         | 39         | Left       | 154       | 125        | TSM265 | Prophylactic: Previous carcinoma left breast |
| 249         | 45         | Right      | 611       | 600        | Becker 50-500 | Prophylactic: Previous grade 1 IDC on left breast |
| 250         | 45         | Left       | 669       | 650        | Becker 50-5000 | Prophylactic: Previous grade 1 IDC on left breast |
| 251         | 39         | Left       | 638       | 600        | Becker 25-500 | Previous IDC |
| 252         | 60         | Right      | 600       | 600        | Becker 25-500 | Multifocal grade 2 IDC |
| 253         | 42         | Left       | 324       | 320        | No reconstruction | DCIS |
| 254         | 57         | Left       | 1100      | 1000       | Becker 25-500 | Multifocal grade 2 IDC with intermediate-grade DCIS |
| 255         | 35         | Right      | 170       | 180        | Becker 25-250 | Multiple papillary syndrome |
| 256         | 90         | Left       | 85        | 100        | No reconstruction | 1.7 cm Grade 2 IDC |
| 257         | 54         | Left       | 375       | 350        | No reconstruction | Multifocal grade 2 IDC and high-grade DCIS |
| 258         | 56         | Right      | 476       | 510        | No reconstruction | Grade 3 IDC (multifocal) |
| 259         | 50         | Right      | 830       | 800        | Becker 50-500 | Extensive DCIS |
| 260         | 50         | Left       | 640       | 650        | Becker 50-500 | Right DCIS left risk reduction |
| 261         | 56         | Right      | 568       | 600        | Becker 35-460 | 2.2 cm Grade 1 IDC (recurrent) |
| 262         | 49         | Left       | 1640      | 1500       | Becker 25-600 plus LD | Multifocal grade 3 IDC with intermediate-grade DCIS |
| 263         | 36         | Left       | 295       | 300        | Becker 50-300 | IDC |
| 264         | 48         | Left       | 894       | 900        | HP800 | Prophylactic: Contralateral carcinoma |
| 265         | 81         | Right      | 722       | 700        | No reconstruction | High-grade DCIS |
| 266         | 50         | Left       | 750       | 700        | Becker 25-500 | 4.4 cm grade 2 IDC. Post chemotherapy with poor response. |
| 267         | 62         | Left       | 390       | 400        | Becker 25-400 | Multifocal grade 3 IDC |
| 268         | 43         | Right      | 220       | 220        | Becker 25-250 | 2.5 cm Central grade 2 IDC plus separate UQQ mucinous carcinoma |
| 269         | 43         | Right      | 416       | 400        | Becker 25-400 | 3.5 cm Grade 3 IDC |
| 270         | 47         | Right      | 696       | 700        | Becker 50-600 | 7.5 cm DCIS with grade 2 IDC |
| 271         | 48         | Right      | 295       | 300        | Becker 25-350 | 1.7 cm Grade 2 IDC |
| 272         | 37         | Right      | 384       | 350        | TSF 415 | Prophylactic: Contralateral carcinoma |
| 273         | 37         | Left       | 435       | 400        | TSR 415 | Grade 3 IDC |
| 274         | 47         | Right      | 356       | 350        | HP 600 removed implant 225 | DCIS multifocal grade 1 IDC |
| 275         | 69         | Right      | 760       | 800        | No reconstruction | 1.5 cm Grade 2 IDC |
| 276         | 51         | Left       | 356       | 300        | Becker 35-400 | Prophylactic |
| 277         | 41         | Right      | 600       | 600        | TSF 520 | 2 cm Grade 2 IDC |
| 278         | 41         | Left       | 613       | 600        | TSF 520 | Prophylactic: Contralateral carcinoma |

BRCA: Breast cancer type 1 susceptibility protein; BWV: breast weight to volume ratio; CHEK2: checkpoint kinase 2; DCIS: ductal carcinoma in situ; IDC: invasive ductal carcinoma; ILC: invasive lobular carcinoma; LCIS: lobular carcinoma in situ; LIQ: lower inner quadrant; LOQ: lower outer quadrant; MUTYH: mutY DNA glycosylase; MHS2: MutS protein homolog 2; PTEN: phosphatase and tensin homolog; U1Q: upper inner quadrant; SNB: sentinel node biopsy; WLE: wide local excision.
The potential role of breast imaging modalities such as ultrasonography, computed tomography and magnetic resonance imaging in predicting breast volume preoperatively has been investigated with variable results (3). Ultrasound has the limitation of reduced objectivity and reproducibility. Computed tomography involves radiation exposure and in the supine position does not reflect breast geometrics accurately. Magnetic resonance imaging assessment of breast volume has demonstrated a significant correlation with actual breast weight, with breast density influencing the correlation (3).

The correlation between the intraoperative breast specimen weight and volume was previously investigated by other authors (4, 5). Parmar et al. reported non-significant difference of 6.6% between the weight of intraoperative breast specimens and volume, with the difference being smaller in postmenopausal women most likely due to lower breast density in this group. The study was relatively small (69 specimens) and predominantly included breast reduction specimens (4). Lee and colleagues designed equations to calculate the breast volume on the basis of the breast weight, incorporating adjustment for breast density (5).

The strength of our study arises from using adequate sample size, use of intraoperative mastectomy specimens and presence of malignant pathology, which represents the most common indication for mastectomy. The main limitation is the lack of data regarding breast density, where the fibroglandular-to-adipose ratio might affect the correlation. Furthermore, our methodology does not provide a means of predicting breast volume preoperatively in order to guide reconstructive surgery planning.

We utilized our simple approach in selecting the best implant for breast reconstruction following skin-sparing mastectomy after carrying out an adjustment for the use of SurgiMend™ (Integra Life Sciences, Plainsboro, NJ, USA), a foetal bovine acellular dermal matrix (ADM) with the following dimensions: 16 cm × 8 cm × 0.1 cm. The volume of the ADM after integration was estimated to be 32 cc, assuming an additional thickness of 1.5 mm of granulation tissue. The required implant size was, therefore, calculated as follows:

\[ \text{Volume of implant} = \text{mastectomy weight (g)} - 32 \]

We previously reported an excellent subjective patient satisfaction and objective independent aesthetic assessment scores (9 out of 10) after oncoplastic breast reconstruction (6, 7). We are currently extrapolating our methodology to the evolving technique of pre-pectoral ADM-assisted implant-based immediate breast reconstruction following skin-sparing mastectomy (8).

In conclusion, our study provides evidence that intraoperative measurement of the weight of mastectomy specimens accurately reflects the breast volume and this simple approach can be used to guide implant selection during breast reconstruction.

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Conflicts of Interests
The Authors have no conflicts of interest to report pertaining to this study. The Senior Author (KM) provides clinical and academic advisory sevices to Q Medical Technologies.

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