

Breast Volume Measurement in Young Chinese Women and Clinical Applications

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Abstract. The authors carried out research on breast volume and body surface anatomy of 125 women. As a result, an average breast volume for Chinese women was obtained (325.36 ± 12.66 ml), and a table with several linear equations for calculating breast volume was derived. The authors applied these results to their clinical work and succeeded in making mammaplasty more precise in 178 patients.

Key words: Breast—Breast volume—Chinese women

Over 2 years, we carried out research on breast volume and body surface anatomy of 125 women in order to find the standards of breast volume, shape and body development for Chinese women.

Materials and Methods

Subjects

The 125 female patients included in this study ranged in age from 18 to 26 years, with normal body development and absence of chest deformity. The total number of measured breasts was 250.

Research Parameters

The 8 general and 10 special parameters included in this study are listed in Table 1.

Posture

For data acquisition, the subjects were in an erect position with their arms by their sides.

Data Grouping

Fourteen data groups were constructed with reference to body side, height, weight, chest circumference, and breast volume. Grouping criteria and the number of subjects falling into each group are summarized in Table 2.

Data Analysis

Breast volume was calculated from the following formula:

$$V = 1/3 \times 3.14 \times MP^2 \times (MR + LR + IR - MP)$$

Mean value (\bar{X}), standard deviation (S), standard error ($S\bar{x}$) and coefficient of variation (CV) were determined for each variable in each group. The significance of difference was computed by variance analysis or *t*-test applied to the mean value of each variable in each group. Standard correlation analysis for bivariate data of breast volume and other variables adopted the least-squares line, $Y = ax + b$, and polyvariate progressive regression analysis were applied as well. All data was processed on an IBM computer according to American Biomedical Data Processing procedures.

Results

An average of the total data was calculated and was regarded as the control group. The basic results derived from each variable in this group are listed in Table 3.

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Table 1. Research parameters and measurements

| Parameter | Symbol | Unit | Measurement |
|--------------------------------|--------|------|--|
| Height | H | cm | |
| Weight | W | kg | |
| Width of shoulder | AA | cm | Acromion to acromion |
| Chest circumference 1 | CC1 | cm | Under the axilla |
| Chest circumference 2 | CC2 | cm | Across the nipple |
| Chest circumference difference | CCD | cm | CC2-CC1 |
| Lumbus circumference | LC | cm | Across the umbilicus |
| Buttock circumference | BC | cm | Across the fullest part of the buttock |
| Mid-sternal line | MSL | cm | Vertical line dropped from the suprasternal notch to the nipple line |
| Sternum-nipple line | SNL | cm | Suprasternal notch to nipple |
| Clavicle-nipple line | CNL | cm | Mid-clavicular point to nipple |
| Medial breast radius | MR | cm | Nipple to medial terminal crest |
| Lateral breast radius | LR | cm | Nipple to lateral terminal crest |
| Inferior breast radius | IR | cm | Nipple to inframammary fold |
| Nipple-sternum line | NSL | cm | Nipple to mid-sternal line |
| Mammary projection | MP | cm | |
| Nipple projection | NP | mm | |
| Areola diameter | AD | mm | |

Table 2. Data classification

| Grouping | Number | Grouping criterion |
|-----------------|--------|------------------------------|
| Control | 250 | All data |
| Left | 125 | All left breast data |
| Right | 125 | All right breast data |
| Short | 110 | $H < 160.00$ cm |
| Tall | 140 | $H \geq 160.00$ cm |
| Standard weight | 44 | $W = (H - 100) \pm 1$ |
| Overweight | 120 | $W > (H - 110) + 1$ |
| Underweight | 86 | $W < (H - 110) - 1$ |
| CCD > 0 | 166 | CCD > 0 |
| CCD < 0 | 52 | CCD < 0 |
| CCD = 0 | 32 | CCD = 0 |
| Large breast | 96 | Breast volume > 350 ml |
| Small breast | 93 | Breast volume < 250 ml |
| Standard breast | 61 | Breast volume = 250 – 350 ml |

Important developmental characteristics of Chinese women are as follows:

- Average height = 159.00–160.00 cm.
- Average weight = 50.40–60.00 kg.
- Standard weight = height minus 110.
- The average chest circumference difference (CCD) = 2.0 cm.
- The average distance from the nipple to the suprasternal notch is 19.05 cm, the average distance between the nipples is 20.00 cm, forming an isosceles triangle. This characteristic has also been described in Western women, but the mean value of each distance in our study is 1.0 cm less than that in Western women
- The average breast volume is 310–330 ml, with the standard breast volume ranging between 250 ml and 350 ml.

- In overweight women, breast volume increased by 20 ml/kg overweight.
- The standard breast forward projection is 3.0–4.0 cm.

The major variables influencing breast volume are as follows:

- Breast volume is positively correlated with weight, chest circumference, lumbar circumference, and buttock circumference.
- Breast volume is negatively correlated with height.
- Breast volume is closely related to the chest circumference difference (CCD), with a correlation equation of approximately $V = 250 + 50 \times \text{CCD} + 20 \times \text{WO}$ (wo = weight over the standard).
- Nipple position is not dependent on height, but is influenced by breast volume, that is, for each 300 ml increase above the standard breast volume, nipple position is displaced 1.0 cm down and outward. This conclusion is very important to prevent the high location of the new nipple areolar complex after reduction mammoplasty, e.g., while marking the new location of the nipple areolar complex, the superior margin of the new location is initially determined at the crossing point of a line joining the suprasternal notch to the nipple and the inframammary fold, after that, the superior margin must be extended downward 1–2 cm according to the reference value of the breast volume to be removed (see Case 3).

A table for calculating breast volume from the radii (MR + LR + IR) and forward breast projection is presented in Table 4.

Table 3. Basic results of the control group

| Item | No. | $\bar{X} \pm S\bar{x}$ | S | CV | Max. | Min. |
|-----------------|-----|------------------------|---------|---------|----------|--------|
| H | 125 | 159.548 ± 0.446 | 4.986 | 3.125 | 170.00 | 148.00 |
| W | 125 | 50.644 ± 0.527 | 5.892 | 11.636 | 69.00 | 40.00 |
| AA | 125 | 37.476 ± 0.258 | 2.880 | 7.685 | 45.00 | 29.00 |
| CC ₁ | 125 | 79.656 ± 0.402 | 4.489 | 5.635 | 95.00 | 68.00 |
| CC ₂ | 125 | 81.488 ± 0.489 | 5.468 | 6.710 | 101.00 | 69.00 |
| CCD | 125 | 1.832 ± 0.250 | 2.793 | 152.469 | 9.00 | -5.00 |
| LC | 125 | 66.520 ± 0.585 | 6.537 | 9.827 | 89.00 | 55.00 |
| BC | 125 | 86.088 ± 0.466 | 5.215 | 6.057 | 100.00 | 68.00 |
| MSL | 125 | 16.596 ± 0.119 | 1.328 | 8.005 | 20.00 | 13.50 |
| SNL | 250 | 19.052 ± 0.107 | 1.691 | 8.875 | 23.00 | 13.00 |
| CNL | 250 | 19.260 ± 0.096 | 1.516 | 7.874 | 23.00 | 15.00 |
| MR | 250 | 8.634 ± 0.081 | 1.284 | 14.876 | 12.00 | 4.50 |
| LR | 250 | 9.604 ± 0.111 | 1.747 | 18.19 | 15.00 | 5.00 |
| IR | 250 | 6.836 ± 0.086 | 1.357 | 19.859 | 10.50 | 4.00 |
| NSL | 250 | 10.028 ± 0.076 | 1.194 | 11.904 | 14.00 | 6.00 |
| MP | 250 | 3.618 ± 0.061 | 0.967 | 26.72 | 6.00 | 1.00 |
| NP | 250 | 4.666 ± 0.169 | 2.679 | 57.411 | 13.00 | 0.00 |
| AD | 250 | 33.204 ± 0.358 | 5.665 | 17.061 | 48.00 | 20.00 |
| BV | 250 | 325.369 ± 12.66 | 200.146 | 61.54 | 1017.875 | 25.656 |

Several linear equations for calculating breast volume from height (H) and weight (W) were also derived:

- Breast volume = 2145.32 - 11.4069 × H (standard weight)
- Breast volume = 1874.268 - 9.254 × H (over weight)
- Breast volume = 9.074 × W - 134.18

Clinical Application

Over the last 8 years, we applied the results of breast volume measurement to our clinical work and succeeded in making mammoplasty more precise in 178 patients including augmentation mammoplasty in 96 patients, reduction mammoplasty in 60 patients, breast reconstruction in 10 patients and other breast deformities in 12 patients.

For augmentation mammoplasty, the size of the prostheses to be used could be determined by subtracting real breast volume from the ideal breast volume, both of which can be drawn from the Table 4.

Case 1

A 25-year old woman with small breasts. R = 25 cm (MR = 9 cm, LR = 10 cm, IR = 6 cm), MP = 2.5 cm. According to Table 4:

- Real breast volume = 147 ml (R = 25, MP = 2.5)
- Ideal breast volume = 352 ml (R = 25, MP = 4)
- Size of the implant to be used is 200 ml (352-147).

Pre- and postoperative instances are shown in Figure 1.

Case 2

A 29-year-old woman with a unilateral breast defect after breast tumor excision. In normal side, R = 23 cm (MR = 8 cm, LR = 9 cm, IR = 6 cm), MP = 2.5 cm. According to Table 4:

- Real breast volume = 134 ml (R = 23, MP = 2.5)
- Ideal breast volume = 318 ml (R = 23, MP = 4)
- Size of the implant to be used for the normal side is 180 ml, the other affected breast required a 240 ml implant (see Fig. 2).

For reduction mammoplasty, the volume of the breast tissue to be removed from patients with macromastia could be computed by subtracting the ideal volume derived from the linear H and/or W equations from the real breast volume derived from the formula $V = 250 + 50 \times \text{CCD} + 20 \times \text{WO}$.

Case 3

A 27-year-old woman with hypertrophic breasts, H = 165 cm, W = 60 kg, CCD = 10 cm, standard weight = 55 kg

- Real breast volume = 250 + 50 × 10 + 20 × 5 = 850 g
- Ideal breast volume = 1874.268 - 9.254 × 165 = 347.358 g (H)
- Ideal breast volume = 9.074 × 60 - 134.18 = 410.26 g (W)
- Ideal breast volume = (347.358 + 410.26)/2 = 380 g

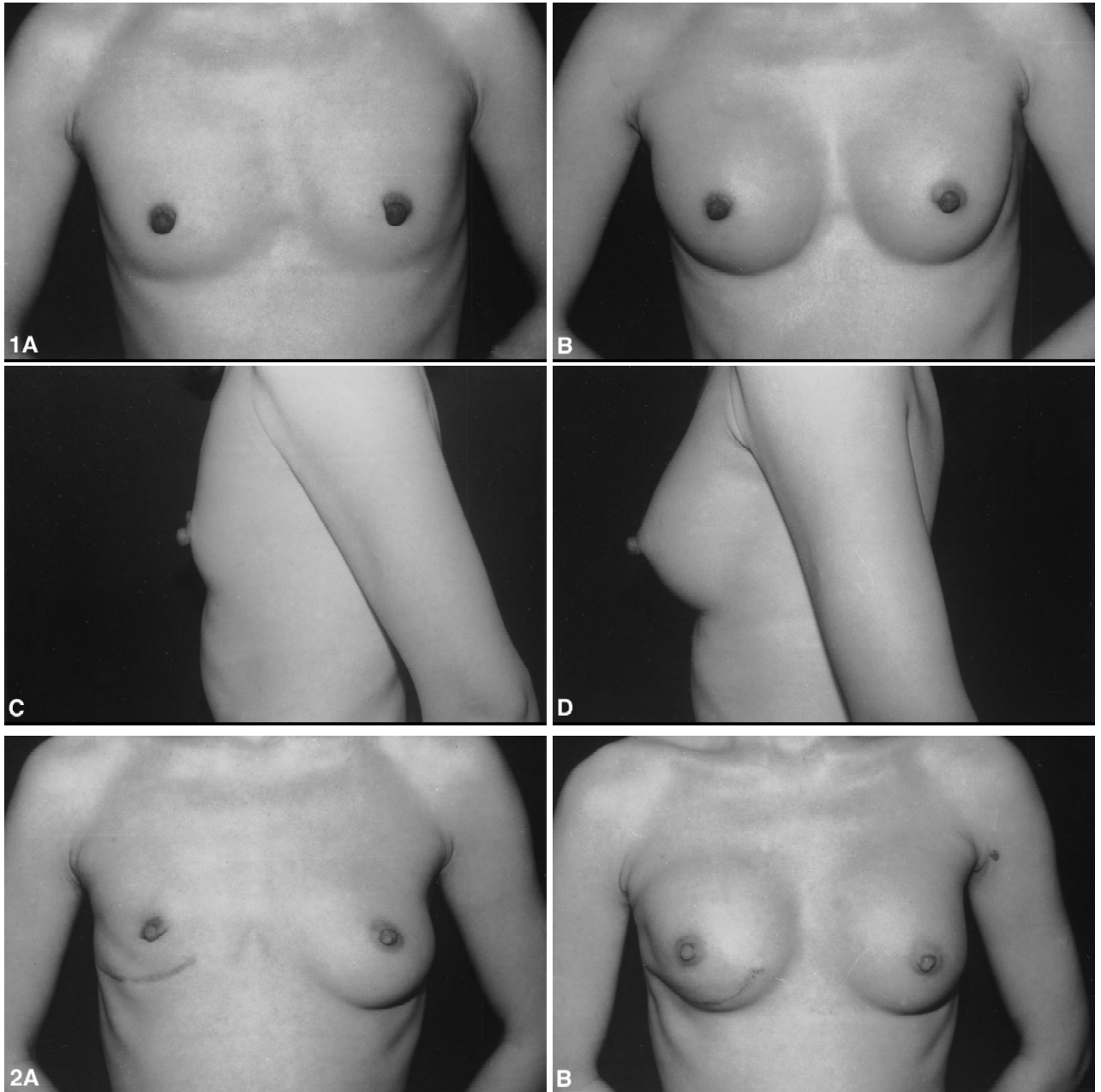


Fig. 1. (A) A 25-year-old preoperative woman, (B) 2 months postoperative following breast augmentation through the transaxillary submuscular placement with 200-cc prostheses. (C) Preoperative profile view. (D) Postoperative profile view.

Fig. 2. (A) A 29-year-old woman with a unilateral breast de-

fect after breast tumor excision. (B) One month postoperatively after augmentation. A 180-cc implant was inserted through a transaxillary incision under the muscle on the left side (right breast). A 240-cc implant was inserted through the first operative incision on the right side (left breast).

- Volume intended reduction = $850 - 380 = 470$ g

Pre- and postoperative examples are shown in Figure 3.

For breast reconstruction, the size of the myocutaneous flap necessary for breast reconstruction could be determined in reference to the volume of the patient's other breast.

Case 4

A 35-year-old woman with a unilateral breast absence after radical mastectomy. A double lumen breast implant (180 ml silicone gel + 30 ml saline water) was inserted into the left breast under the muscle, a pedicled latissimus dorsi myocutaneous flap and a double lumen breast

Table 4. Breast volume calculation (ml)

| R | P | | | | | | | | | | | | |
|----|----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| | 1 | 1.5 | 2 | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 | 6 | 6.5 | 7 |
| 10 | 9 | 20 | 34 | 49 | 66 | 83 | 101 | 117 | 131 | 143 | 151 | 155 | 154 |
| 11 | 10 | 22 | 38 | 56 | 75 | 96 | 117 | 138 | 157 | 174 | 188 | 199 | 205 |
| 12 | 12 | 25 | 42 | 62 | 85 | 109 | 134 | 159 | 183 | 206 | 226 | 243 | 257 |
| 13 | 13 | 27 | 46 | 69 | 94 | 122 | 151 | 180 | 209 | 238 | 264 | 288 | 308 |
| 14 | 14 | 29 | 50 | 75 | 104 | 135 | 168 | 201 | 236 | 269 | 302 | 332 | 359 |
| 15 | 15 | 32 | 54 | 82 | 113 | 148 | 184 | 223 | 262 | 301 | 339 | 376 | 411 |
| 16 | 16 | 34 | 59 | 88 | 123 | 160 | 201 | 244 | 288 | 333 | 377 | 420 | 462 |
| 17 | 17 | 37 | 63 | 95 | 132 | 173 | 218 | 265 | 314 | 364 | 415 | 465 | 513 |
| 18 | 18 | 39 | 67 | 101 | 141 | 186 | 235 | 286 | 340 | 396 | 452 | 509 | 564 |
| 19 | 19 | 41 | 71 | 108 | 151 | 199 | 251 | 307 | 367 | 428 | 490 | 533 | 616 |
| 20 | 20 | 44 | 75 | 115 | 160 | 212 | 268 | 329 | 393 | 459 | 528 | 597 | 667 |
| 21 | 21 | 46 | 80 | 121 | 170 | 224 | 285 | 350 | 419 | 491 | 565 | 642 | 718 |
| 22 | 22 | 48 | 84 | 128 | 179 | 237 | 302 | 371 | 445 | 523 | 603 | 686 | 770 |
| 23 | 23 | 51 | 88 | 134 | 188 | 250 | 318 | 392 | 471 | 554 | 641 | 730 | 821 |
| 24 | 24 | 53 | 92 | 141 | 198 | 262 | 335 | 414 | 497 | 586 | 679 | 774 | 872 |
| 25 | 25 | 55 | 96 | 147 | 207 | 276 | 352 | 435 | 524 | 618 | 716 | 819 | 924 |
| 26 | 26 | 58 | 101 | 154 | 217 | 289 | 369 | 456 | 550 | 649 | 754 | 863 | 975 |
| 27 | 27 | 60 | 105 | 160 | 226 | 301 | 385 | 477 | 576 | 681 | 792 | 907 | 1026 |
| 28 | 28 | 62 | 109 | 167 | 236 | 314 | 402 | 498 | 602 | 713 | 829 | 951 | 1078 |
| 29 | 29 | 65 | 113 | 173 | 245 | 327 | 419 | 520 | 628 | 744 | 867 | 995 | 1129 |
| 30 | 30 | 67 | 117 | 180 | 254 | 340 | 436 | 541 | 654 | 776 | 905 | 1040 | 1180 |
| 31 | 31 | 70 | 121 | 187 | 264 | 353 | 452 | 562 | 681 | 808 | 942 | 1084 | 1232 |
| 32 | 32 | 72 | 126 | 193 | 273 | 366 | 469 | 583 | 707 | 839 | 980 | 1128 | 1283 |
| 33 | 34 | 74 | 130 | 200 | 283 | 378 | 486 | 604 | 733 | 871 | 1018 | 1172 | 1334 |
| 34 | 35 | 77 | 134 | 206 | 292 | 391 | 503 | 626 | 759 | 903 | 1056 | 1217 | 1385 |
| 35 | 36 | 79 | 138 | 213 | 302 | 404 | 519 | 647 | 785 | 934 | 1093 | 1261 | 1437 |
| 36 | 37 | 81 | 142 | 219 | 311 | 417 | 536 | 668 | 812 | 966 | 1131 | 1305 | 1488 |
| 37 | 38 | 84 | 147 | 226 | 320 | 430 | 553 | 689 | 838 | 998 | 1169 | 1349 | 1539 |
| 38 | 39 | 86 | 151 | 232 | 330 | 443 | 570 | 710 | 864 | 1030 | 1206 | 1394 | 1591 |
| 39 | 40 | 88 | 155 | 239 | 339 | 455 | 586 | 732 | 890 | 1061 | 1244 | 1438 | 1642 |
| 40 | 41 | 91 | 159 | 245 | 349 | 468 | 603 | 753 | 916 | 1093 | 1282 | 1482 | 1693 |

P = MP; R = MR + LR + IR.

implant (180 ml silicone gel + 60 ml saline water) were used to reconstruct her right breast (see Fig. 4).

Discussion

With the recently improved techniques for cosmetic breast surgery and an increasing public awareness toward such procedures, many women who have undergone mastectomy are choosing to undergo breast reconstruction. Also, more and more women are opting for breast reduction/augmentation mammoplasty as a means of improving their physical appearance. Thus, plastic surgeons require methods for accurate breast volume determination. In this area, Bouman [1], Kirianoff [3] and Schultz [6] applied Archimedes' principle to measure breast volume or to determine the size of gel implants necessary to construct breasts of a given size, while Grossman [2] and Strombeck [7] developed various devices for measuring breast volume based on geometric principles. Regnault [5] discussed the relationship between the size and shape of the commercial brassiere,

and regarded brassiere cup sizes as an acceptable indication of breast size. In 1986, Loughry [4] applied the technique of biostereometric analysis to breast volume measurement.

All of the above-mentioned investigations involved Western women, therefore, we required 2 years to research breast volume on Chinese women. This study defined standards of body development among Chinese women and, more specifically, obtained average breast volume and its relation to a variety of parameters. As a result, a table and set of equations for computing breast volume were developed, thus providing plastic surgeons with useful tools for planning breast augmentation, reduction, and reconstruction procedures. This study also negated the general clinical impression that the left breast is larger than the right [4] and confirmed Strombeck's view that, in overweight patients, breast volume increases by 20 cm³ for each kilogram overweight [7].

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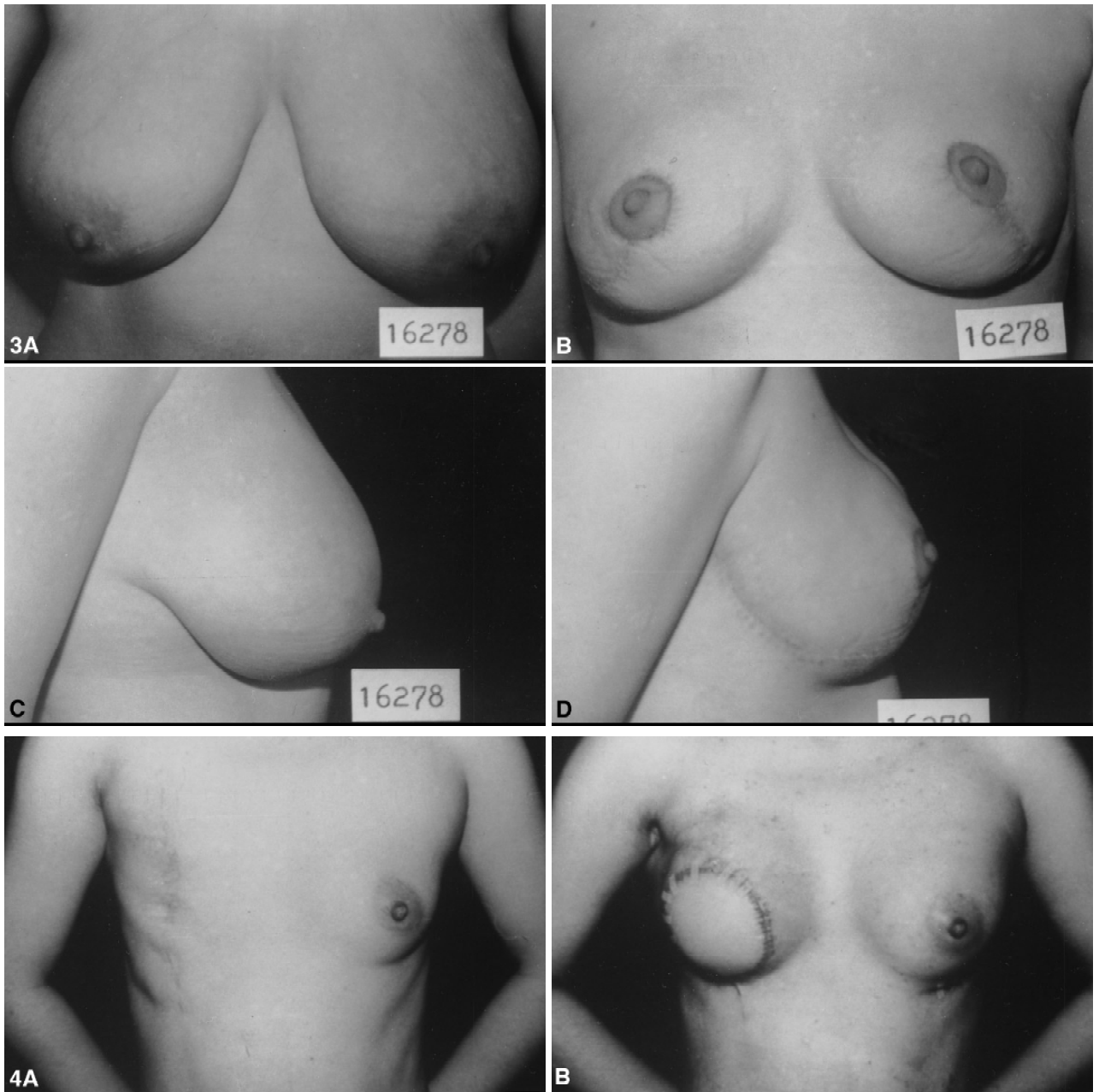


Fig. 3. (A) A pre-operative view of a 27-year-old woman with moderate hypertrophic breasts. (B) Two weeks postoperative, 500 gm was removed from the left breast, 412 gm was removed from the right breast, and the nipples were elevated 10 cm. The patient has sensation in her nipples. (C) Preoperative profile view. (D) Postoperative profile view.

Fig. 4. (A) A 35-year-old woman with unilateral breast ab-

sence after radical mastectomy shown preoperatively. (B) The patient shown 2 weeks postoperatively. A double lumen breast implant (180 ml silicone gel + 30 ml saline water) was inserted into the left breast under the muscle, a pedicled latissimus dorsi myocutaneous flap and a double lumen breast implant (180 ml silicone gel + 60 ml saline water) were used to reconstruct the right breast.

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