Original Article

Preoperative digital mammography imaging in conservative mastectomy and immediate reconstruction

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Background: Digital mammography clearly distinguishes gland tissue density from the overlying non-glandular breast tissue coverage, which corresponds to the existing tissue between the skin and the Cooper's ligaments surrounding the gland (i.e., dermis and subcutaneous fat). Preoperative digital imaging can determine the thickness of this breast tissue coverage, thus facilitating planning of the most adequate surgical techniques and reconstructive procedures for each case.

Methods: This study aimed to describe the results of a retrospective study of 352 digital mammograms in 176 patients with different breast volumes who underwent preoperative conservative mastectomies. The breast tissue coverage thickness and its relationship with the breast volume were evaluated.

Results: The breast tissue coverage thickness ranged from 0.233 to 4.423 cm, with a mean value of 1.952 cm. A comparison of tissue coverage and breast volume revealed a non-direct relationship between these factors.

Conclusions: Preoperative planning should not depend only on breast volume. Flap evaluations based on preoperative imaging measurements might be helpful when planning a conservative mastectomy. Accordingly, we propose a breast tissue coverage classification (BTCC).

Keywords: Breast tissue coverage; conservative mastectomy; digital mammography

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Introduction

Oncoplastic surgery, which combines oncologic and reconstructive surgery, has become increasingly popular (1-3). Conservative mastectomy, including skin sparing mastectomy (SSM), nipple sparing mastectomy (NSM), and skin reducing mastectomy (SRM) (1), is a well-established, validated (4), and widely used procedure for breast cancer treatment; in such cases, immediate breast reconstruction is the current standard (1,4).

Ideally, oncoplastic surgery will provide aesthetically pleasing results while achieving appropriate oncologic safety (5). However, a potential pitfall of these oncoplastic techniques is uncertainty regarding the blood supply to the remaining flaps and the nipple-areola complex (NAC) (2,3). Post-procedural nipple and skin necrosis rates as high as 38% have been reported (5). Patients with a large cup size or a previous history of surgery or radiation are considered high risk for nipple-sparing mastectomies

because these factors are associated with even higher rates of complications (2).

Currently, standard film mammograms do not allow the clear identification and measurement of non-glandular breast tissue coverage. In contrast, digital mammography clearly distinguishes gland tissue density from tegument and fat coverage; accordingly, this preoperative imaging modality can determine the coverage thickness (6,7) (i.e., distance between the breast skin and Cooper's ligaments surrounding the gland; *Figures 1*,*2*). As incision planning, treatment selection, surgical technique, and reconstructive procedures are usually related to the breast volume, tumor characteristics, and surgeons' and patients' preferences, preoperative information regarding the breast tissue coverage thickness might highlight the likelihood of post-mastectomy flap issues and assist with the planning process, rather than relying on breast volume alone as a guideline (2).

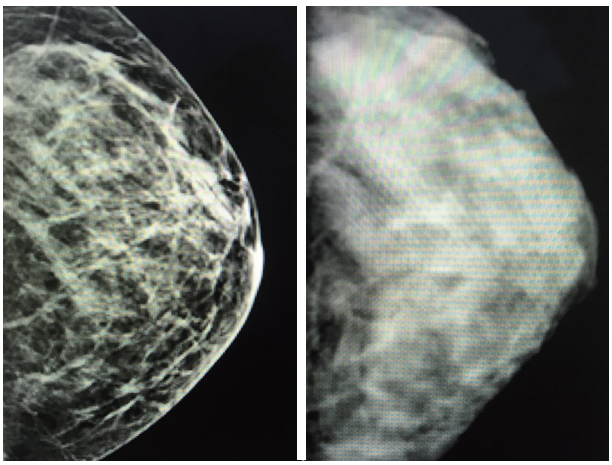

Figure 1 Difference of density between digital and standard (film) mammograms of a same patient.

Methods

A total of 176 Caucasian women were stratified into five groups according to the Lalardie and Jouglard (8) classification of breast volume. Descriptive statistics regarding data from each group are summarized in *Table 1*.

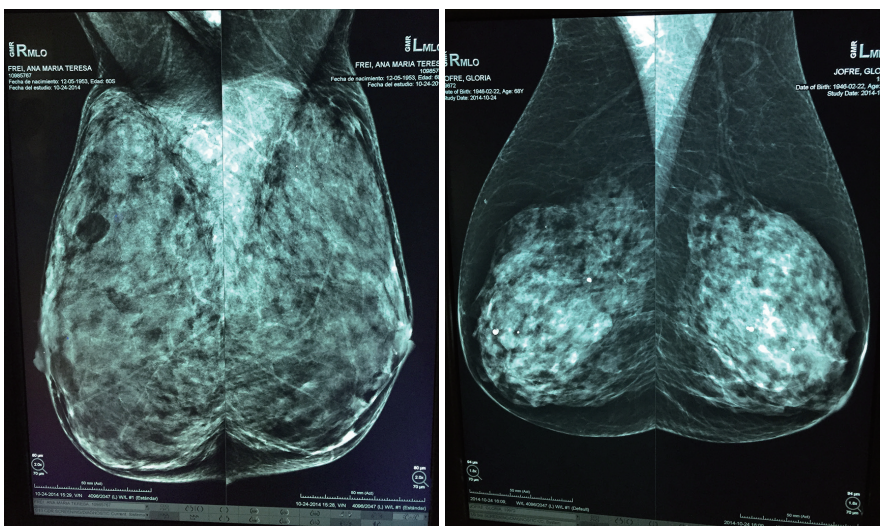

Figure 2 Pre operation. Digital mammograms, Group D. Breast volume between 801 and 1,000 cc, showing different thickness in breast tissue coverage on two different large breast patients.

Table 1 Descriptive patient data

Breast volume	Group A 200-400 cc	Group B 401-600 cc	Group C 601-800 cc	Group D 801-1,000 cc	Group E 1,001-1,500 cc
Number of patients	30	42	35	36	33
Breast volume (cm^3) median value	292	459	652	936	1,263
Breast coverage median value (cm)	1.02	2.43	2.62	1.68	1.7

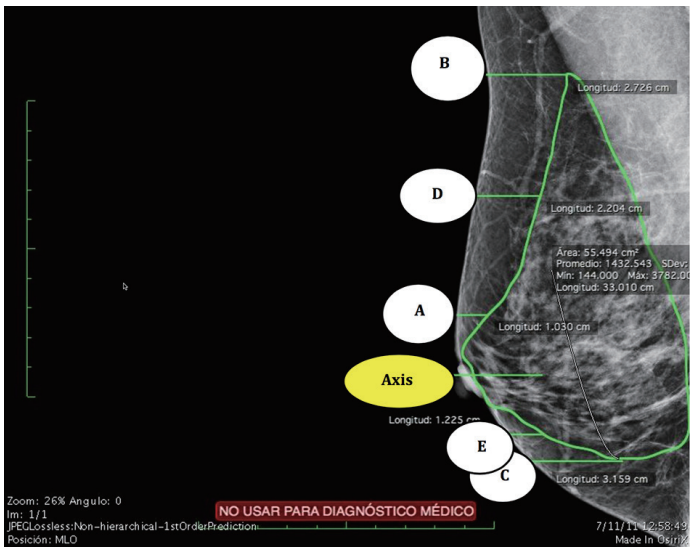

Figure 3 Measurements over digital mammogram with OSIRIX software on Dicom format.

Table 2 Breast tissue coverage classification (BTCC)

Classification	Size (cm)	Coverage
Type 1	<1	Poor
Type 2	1-2	Medium
Type 3	>2	Good

Initially, 200 patients who underwent preoperative digital mammography for conservative mastectomy at our institution between January 2013 and February 2015 were selected randomly. Twenty-four cases were excluded. The exclusion criteria were severe breast asymmetry (>20% difference in size between breasts) and previous breast surgery. A total of 352 preoperative digital mammograms corresponding to the 176 remaining patients were retrospectively reviewed. The subject ages ranged from 33 to 70 years (mean: 49 years).

Breast volume was assessed using the BREAST-V (9), a free simple tool for IOS and Android devices (available from the Apple Store and Google Play Store, respectively) based on a mathematical algorithm that allows estimations of breast volume using direct measurements of three anthropomorphic values. Patients were stratified into groups as described above. All digital mammographic studies were performed on a 3D Selenia Dimensions Full Field Digital Mammograph (Hologic, Bedford, MA, USA). A single evaluator obtained all measurements with OSIRIX Software (available at www.osirix-viewer.com) from DICOM-format digital mammogram files with a lateral medium oblique incidence and angulation between 40° and 50°.

Breast tissue coverage measurements were reported in cm and mm. For each mammogram, measurements were taken at five different points (*Figure 3*) as follows:

With the axis corresponding to the nipple line:

A: Parallel to and 2 cm above the nipple (Axis);

B: Parallel to the superior border of the gland;

C: Parallel to the inferior border of the gland;

D: Parallel to and at a midpoint between A and B;

E: Parallel to and at a midpoint between the Axis and C.

For each image, average tissue coverage was obtained and correlated with the corresponding breast volume group (A to E; *Table 1*).

Statistical analyses were performed using R software (version 2.14.2) (10). As 95% of our sample fell within approximately two standard deviations of the mean, we obtained mean tissue cover thickness measures to establish reference intervals for our breast tissue cover classification. As a result, breast tissue coverage was coded as poor (type 1), medium (type 2), and good (type 3) according to the mean standard deviations of the overall values (*Table 2*).

Results

Differences between two directly consecutive breast volume groups were not statistically significant; however, there was a trend toward a flap thickness increase when comparing groups with greater differences in breast volume. Breast

Table 3 Numbers of patients by volume (A-B-C-D-E), clustered in three different groups according to breast soft tissue coverage

Group	N	Type 1 (<1 cm)	Type 2 (1 to 2 cm)	Type 3 (>2 cm)
A	30	19	9	2
B	42	12	20	10
C	35	8	15	12
D	36	6	14	16
E	33	7	13	13
Coverage		Poor	Medium	Good

tissue coverage varied from 0.2 to 4.4 mm, with an average of 1.952 cm (*Table 1*). The median values for measurements A, B, C, D, and E were 1.02, 2.43, 2.62, 1.68, and 1.71 cm, respectively.

In our analysis of breast tissue coverage and breast volume (*Table 3*), we observed the following. In group A (30 patients with breast volumes of 200-400 cm^3), 19 patients had tissue coverage of 0.1-1 cm, 9 had tissue coverage of 1.1-2 cm, and 2 had tissue coverage exceeding 2 cm. In group B (42 patients with breast volumes of 401-600 cm^3), 12 patients had tissue coverage of 0.1-1 cm, 20 had tissue coverage of 1.1-2 cm, and 10 had tissue coverage exceeding 2 cm. In group C (35 patients with breast volumes of 601-800 cm^3), 8 patients had tissue coverage of 0.1-1 cm, 15 had tissue coverage of 1.1-2 cm, and 12 had tissue coverage exceeding 2 cm. In group D (36 patients with breast volumes of 801-1,000 cm^3), 6 patients had tissue coverage of 0.1-1 cm, 14 had tissue coverage of 1.1-2 cm, and 16 had tissue coverage exceeding 2 cm. In group E (33 patients with breast volumes of 1,001-1,500 cm^3) 7 patients had tissue coverage of 0.1-1 cm, 13 had tissue coverage of 1.1-2 cm, and 13 had tissue coverage exceeding 2 cm.

Discussion

To our knowledge, no reports have previously addressed the relationship between breast tissue coverage and breast volume. However, adequate fat tissue coverage thickness is one of the most important independent factors in immediate breast reconstruction and flap survival (11-13). Anatomically, the vascular network that ensures flap survival and NAC runs between Cooper's ligaments and the skin (14). Compression of this vascular network by implant insertion, surgical damage, tissue tension at closure, or extremely thin flaps might endanger vascularization, and such events have been shown to cause tissue damage in the distal parts of flaps (8-21). Consideration must therefore be given to this preoperative breast tissue coverage measure as an important factor in immediate reconstruction.

Preoperative evaluation of gland coverage can help to predict the viability of the remaining flaps after conservative mastectomies and to select the optimal immediate reconstructive procedure to diminish post-operative coverage complications. Additionally, the use of surgical materials may be evaluated according to this coverage measure. According to our classification, for patients in the Poor coverage group (type 1), it would be helpful to add supplementary coverage for the reconstruction, such as ADM, retropectoral implant placement, and delayed fat grafting. In the medium coverage group (type 2), a 2-stage reconstruction should be suggested to avoid tension at the flap closure, whereas in the good coverage group (type 3), single-stage reconstruction with implants could be performed.

One of the most important factors for vascularization of the remaining post-mastectomy flaps is preservation of the skin perforators and flap thickness (11,12,17,18). The remaining skin flap thickness after gland resection during conservative mastectomy plays an important role in flap integrity and NAC vitality. Cooper's ligaments separate the mammary gland from the superficial fat and skin tissue layers that contain the vascular plexus, of which the mastectomy flaps are composed (13). The vascularization and, therefore, the viability of the remaining flaps may be compromised after gland resection if this flap tissue coverage is too thin and/or closure tension is forced. Preoperative information regarding this tissue coverage is therefore of the utmost importance to avoid complications associated with immediate reconstruction procedures (11,16,17).

The selection of mastectomy and reconstruction procedures should be made jointly by the oncologic and plastic surgeon based on objective pre-operative information (12,18,19). In this study, we observed that breast tissue coverage and breast volume are independent factors (*Table 1*). This finding suggests that a preoperative measurement of the breast tissue coverage thickness is important for surgical decisions.

For large breasts, conservative mastectomy is usually designed according to the Wise pattern for skin reduction, shape, and projection. This procedure is considered suitable for single-stage reconstruction with implants (4). Regardless of breast volume, however, a preoperative evaluation of

tissue coverage is crucial for surgical planning by both the oncologic and plastic surgeon as this factor is directly related to flap and NAC ischemia/necrosis. Thin flaps can lead to ischemic complications following mastectomies and reconstructive procedures (11,17). Preoperative digital mammography is therefore potentially useful not only for tumor detection, but as an objective tool for predicts the resulting flap thickness, thus improving patient safety.

Flap damage after mastectomy is a serious complication during immediate breast reconstruction (22-24). Preoperative breast tissue coverage and flap thickness evaluations via digital mammography should be considered during surgical planning, and the proposed classification may help to identify patients at high risk for flap ischemia and necrosis. Digital mammography offers the possibility of preoperative measurements and better predictions of flap thickness and vitality after mastectomy (6,7), thus improving patient safety (13,14,20,25,26).

Based on the obtained range of coverage values, we propose a 3-stage breast tissue coverage classification (BTCC) as follows: type 1, ≤1 cm (poor coverage); type 2, 1-2 cm (medium coverage); and type 3, >2 cm (good coverage; *Table 2*). This classification may inform the rational use of materials for individual patients rather than according to breast volume, surgeon's experience, or comfort (21,27). As a result, preoperative communication between the reconstructive and oncologic surgeons regarding the incision choice and integumentary preservation according to digital mammogram findings might lead to improved outcomes with a decreased rate of complications.

This study has generated normative data for breast tissue coverage measurements in different breast volumes to provide three thickness classification levels. This information may be useful as a reference for future investigations of various breast surgical procedures and for the rational use of materials in conservative mastectomies and immediate reconstruction. Our study is limited, however, by the lack of validation of the BREAST-V tool against standard 3D virtual techniques; nevertheless, this tool underwent a strict development process that included internal and cross-validation of the model to verify the reliability of the algorithm (9,19). A comparison of the predictive performances of BREAST-V with a previous published formula demonstrated higher accuracy when evaluating breast volumes on new breasts (i.e., those not used to derive the formula). These considerations highlight the reliability of this tool.

Conclusions

This report provides a complete data bank of normative non-glandular breast tissue coverage measurements from digital mammograms across a wide range of breast volumes, and suggests that breast volume and flap thickness are independent factors; in other words, large breasts, (C, D, and E volume categories) can have poor tissue coverage, whereas small breasts (A and B categories) can have good tissue coverage.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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