Accuracy of tumor size assessment in the pre-operative staging of breast cancer: comparison of digital mammography (DM), breast tomosynthesis (BT) and MRI

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Purpose

The accuracy of breast cancer staging involves the estimation of the tumor size for the initial decision-making in the treatment.

Indeed, the accurate assessment of breast cancer size is important as a determinant of primary therapeutic options and as a prognostic indicator.

The ability to accurately and reliably measure the size of the breast cancer prior to any surgical treatment or primary medical therapy is essential.

There have been several attempts to predict breast tumor size based on medical imaging.

Tumour size is usually assessed using a clinical examination, mammography, ultrasound and magnetic resonance imaging (MRI) of the breast, or combinations of these methods.

The accuracy of clinical assessment is influenced by many factors such as skin thickness, edema, and obesity (1,2); however, it is prone to overestimation of tumor size (3) and is not useful for clinically occult tumors. Mammography overcomes some of these confounding factors and is more accurate than palpation. However, mammographic estimates of maximum tumor dimension may be unreliable due to variation in the distance between the tumor and the film, indistinct tumor boundaries, compression during examination or because standard imaging projections do not capture the maximum tumor diameter (2,3). Therefore, despite high diagnostic accuracy rates, mammography is relatively inaccurate in determining breast cancer size (4,5).

Mammographic imaging systems have steadily improved over recent years, in particular thanks to the introduction in the clinical practice of digital breast tomosynthesis (BT); this technology has being developed to improve detection and characterization of breast lesions especially in women with non-fatty breasts (6) by reducing the obscuring effect of overlying and underlying breast tissues.

Preliminary works (7,8) reported that the size of breast lesions can be estimated more accurately by BT than by digital mammography (DM).

As reported in literature (9,10), MRI remains currently the most accurate breast imaging modality for the tumor extent of breast cancer, although MRI has a propensity for overestimation of risk.

The aim of our study was to compare the accuracy of DM, BT and MRI for the pre-operative evaluation of breast cancer extent.
Methods and Materials

We retrospectively reviewed 95 breast cancers in 70 patients who had DM, BT and MRI between January 2010 and July 2011, prior to undergo definitive surgery.

The 70 consecutive patients had undergone BT for suspicious findings for malignancy, or referred for clinical symptoms, or even if asymptomatic but with dense breast.

They also had preoperative breast MRI following the main indications: dense breasts (BI-RADS 3,4), suspect of multifocal/multicentric/controlateral lesions, lobular cancer, discrepancy in size of >1 cm between MX and US findings and at high-risk for breast cancer.

Each patient, who signed an informed consent, underwent bilateral two view cranio-caudal and medio-lateral-oblique DM and BT mammography using Hologic Selenia Dimensions. The DM and BT images were acquired during the same compression for each view.

The MRI images were acquired with a 1.5 T MRI scanner with a seven channel dedicated breast coil. The dynamic study was performed with a three-dimensional T1-weighted gradient recolled echo (GRE) acquisition in the axial plane, obtained before and for five times after intravenous bolus injection of 0,2 ml/Kg body weight Gd-BOPTA at rate of 2ml/sec, followed by 20ml saline solution flush.

The lesions were measured by two radiologists in consensus, without knowledge of the final histological examination, which was used as the gold standard.

Tumors were graded mammographically into masses (spiculated or circumscribed), architectural distortions and microcalcification, and whether they were found in fatty replaced parenchyma or dense parenchyma (based on the BIRADS classification for breast tissue density).

For each imaging modality, the maximum tumor extent was measured to the nearest millimeter, using the distance measurement tool in the workstation software.

The size measurements were done independently for each modality (DM, BT and MRI)

The measurements were considered concordant if they were within ±5 mm.

Pearson's correlation analysis was performed on the data in order to compare different imaging measurement methods with the pathological size and also for subgroup lesions by mammographic features.
P values for comparative performance in size determination were calculated by Student’s t-test and chi-square test.

**Results**

The median pathologic tumor size was 18.9 mm.

In the cohort of 95 lesions, 63/95 were masses (66%), 18/95 architectural distortion (19%) and 14/95 micro-calcifications (15%) (*Figure 1*).

![Figure 1: Percentage of mammographic features in the study population.](image)

**References:** A. Luparia; Istituto di Radiologia Diagnostica ed Interventistica. Università di Torino, Torino, ITALY

A significantly larger number of tumors was detectable and measurable on BT (89) and MRI (93) than on DM (79). (*Table 1*)

<table>
<thead>
<tr>
<th></th>
<th>DM</th>
<th>BT</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visible</td>
<td>79</td>
<td>89</td>
<td>93</td>
</tr>
<tr>
<td>Not visible</td>
<td>16</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>Detection Rate (%)</td>
<td>83.2</td>
<td>93.7</td>
<td>97.9</td>
</tr>
</tbody>
</table>

**Table 1**: Table 1: Number of measurable tumors and detection rate (%) by modality. **References**: A. Luparia; Istituto di Radiologia Diagnostica ed Interventistica. Università di Torino, Torino, ITALY
BT and MRI had the highest proportion (both 66%) of concordant cases with pathology, although there wasn't a statistically significant (p>0.05) difference compared to DM size agreement (62%). *(Figures 2.a, 2.b, 2.c)*

**Fig. 3**: Figure 2a: Size agreement by DM and pathological size.

*References: A. Luparia; Istituto di Radiologia Diagnostica ed Interventistica. Università di Torino, Torino, ITALY*
Fig. 4: Figure 2b: Size agreement by BT and pathological size.
References: A. Luparia; Istituto di Radiologia Diagnostica ed Interventistica. Università di Torino, Torino, ITALY
Fig. 2: Figure 2c: Size agreement by MRI and pathological size.

References: A. Luparia; Istituto di Radiologia Diagnostica ed Interventistica. Università di Torino, Torino, ITALY

BT and MRI size correlated well with pathological tumor extension (r:0.85 and r:0.92, respectively), better than DM (r:0.79). Combined BT and DM tumor size assessment had also a good correlation with pathology (r:0.86). (Figure 3)
In the subgroups (graded by breast density and mammographic features), the strength of correlation between imaging modality and histology was summarized by Pearson's correlation coefficient with the following corresponding values reported in *Table 2 and 3*.

**Table 2**: Table 2: Pearson’s correlation coefficient between imaging modality and histology graded by breast density.  
*References: A. Luparia; Istituto di Radiologia Diagnostica ed Interventistica. Università di Torino, Torino, ITALY*  

<table>
<thead>
<tr>
<th>Modality</th>
<th>Non dense breast (D1+D2)</th>
<th>Dense breast (D3+D4)</th>
</tr>
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<tbody>
<tr>
<td>DM</td>
<td>0.87</td>
<td>0.78</td>
</tr>
<tr>
<td>BT</td>
<td>0.90</td>
<td>0.87</td>
</tr>
<tr>
<td>MRI</td>
<td>0.94</td>
<td>0.89</td>
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**Fig. 5**: Figure 3: Pearson’s correlation coefficient between imaging modality and histology.  
*References: A. Luparia; Istituto di Radiologia Diagnostica ed Interventistica. Università di Torino, Torino, ITALY*
Table 3: Pearson’s correlation coefficient between imaging modality and histology graded by mammographic features.

References: A. Luparia; Istituto di Radiologia Diagnostica ed Interventistica. Università di Torino, Torino, ITALY

Images for this section:

<table>
<thead>
<tr>
<th></th>
<th>Masses</th>
<th>Distorsions</th>
<th>Microcalcifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>0,84</td>
<td>0,76</td>
<td>0,72</td>
</tr>
<tr>
<td>BT</td>
<td>0,88</td>
<td>0,88</td>
<td>0,77</td>
</tr>
<tr>
<td>MRI</td>
<td>0,90</td>
<td>0,96</td>
<td>0,82</td>
</tr>
</tbody>
</table>
Fig. 6: 40 year-old woman (BIRADS 4): In 2D MLO view we can see a mass with ill-defined margins, containing clustered heterogeneous microcalcifications.
Fig. 7: 40 year-old woman (BIRADS 4): In 2D CC view we can also see the mass with ill-defined margins, containing clustered heterogeneous microcalcifications.
Fig. 8: 40 year-old woman: Tomosynthesis in the oblique view confirms a well-defined irregular mass, associated with microcalcifications, whose largest diameter was measured to be 16 mm.
**Fig. 9:** 40 year-old woman: The lesion is also confirmed in the 3D cranio-caudal view.

![Fig. 9 Image](image_url)

**Fig. 10:** 40 year-old woman: MR subtracted axial image: we can see a mass enhancing lesion, whose largest diameter was measured to be 20 mm. Final histological examination was DCIS (16 mm).
Fig. 11: 45 year-old woman (BIRADS 2): no lesion detectable in 2D MLO view.
Fig. 12: 45 year-old woman (BIRADS 2): no lesion detectable in 2D CC view.
**Fig. 13:** 45 year-old woman: Tomosynthesis in the oblique view identifies an architectural distortion with a central mass, whose largest diameter was measured to be 21 mm (only the core) or 39 mm (considering spiculations).
21mm core, 39mm spicule
**Fig. 14:** 45 year-old woman: Tomosynthesis in the cranio-caudal view.

**Fig. 15:** 45 year-old woman: MR subtracted axial image: we can see a mass enhancing lesion with irregular margins, whose largest diameter was measured to be 16 mm. Final histological examination was IDC (23 mm).
Conclusion

BT and MRI are superior to DM in the assessment of breast tumor extent.

Especially, BT was more accurate than DM in measurement of tumor size for distortions or masses, while no significant difference was found between DM and BT in measuring microcalcifications.

MRI proved to be the most useful modality for predicting histological tumor size. However, the use of BT improved the accuracy of the mammographic measurement and could complement DM in order to obtain MRI similar results.

References

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