Mammographic Predictors of the Presence and Size of Invasive Carcinomas Associated With Malignant Microcalcification Lesions Without a Mass

**OBJECTIVE.** Our objective was to determine the degree with which mammographic features predict the presence and size of invasive carcinomas associated with malignant mammographic microcalcification lesions without a mass.

**MATERIALS AND METHODS.** Mammographic features were correlated with pathologic features in 304 consecutive breast carcinomas manifested by mammographic calcifications only in a prospective evaluation.

**RESULTS.** Mammographic calcifications associated with breast carcinoma had the final pathologic diagnoses of pure ductal carcinoma in situ (DCIS) in 65% of patients, DCIS with a focus of invasion in 32%, and invasive carcinoma only in 4%. Invasive foci were more likely associated with mammographic calcification size of 11 mm and greater (40%, 77/194) compared with 1–10 mm (26%, 29/110; \( p = 0.019 \)). Invasive foci were also more likely associated with linear calcifications (44%, 55/126) compared with granular calcifications (29%, 51/178; \( p = 0.007 \)). The frequency of invasion did not increase with calcification extents greater than 10 mm. The frequency of invasion ranged from 22% for less than or equal to 5-mm granular calcifications to 45% for linear calcifications of 11 mm and greater. Only 11% of cancers characterized by fine granular calcifications were associated with invasion as compared with 32% of those with coarse and mixed granular calcifications (\( p = 0.002 \)).

**CONCLUSION.** Mammographic calcification features of malignant lesions cannot predict the absence of invasion with greater than 90% predictive value or predict the presence of invasion with greater than 45% predictive value. Increased extent of calcifications greater than 10 mm was not associated with greater likelihood of invasion.

Mammographic lesions manifested by microcalcifications constitute approximately half of the clinically occult breast carcinomas detected on mammography [1, 2]. Mammographic calcifications associated with malignancy are usually found within ducts and lobules containing ductal carcinoma in situ (DCIS). In general, 26–38% of biopsy-proven malignant microcalcification lesions without a mass also contain an associated focus or foci of invasive carcinoma [2, 3].

Because the presence of an associated invasive carcinoma cannot be excluded without surgical removal and pathologic evaluation of the entire DCIS lesion, knowledge of the risk and the size of invasive carcinomas found in DCIS microcalcifications would be helpful in patient counseling and possibly clinical management, such as selection of patients for axillary lymph node sampling, including sentinel node biopsy techniques.

To our knowledge, little information in the literature describes the associations between mammographic features of malignant microcalcification lesions and the presence and size of an associated invasive carcinoma component. This analysis was undertaken to determine the degree with which the features of patient age, mammographic calcification extent and appearance, and mammographic background parenchymal density predict the presence or absence of associated invasion. The pathologic size of invasive carcinomas associated with malignant mammographic calcification lesions was also determined.

**Materials and Methods**

This study analyzed all 304 women with breast carcinomas presenting as clinically occult mammographic calcifications without a soft-tissue abnormality who were seen in a mammography center and a multidisciplinary breast clinic in a cancer insti-
The following data were retrieved from the mammo- 
graphy–pathology correlation database: the age of 
each patient at the time of diagnosis and the greatest 
dimension of the suspicious mammographic calci-
fications based on the prospective analysis of the stan-
dard and magnification mammography projections. 
Mammographic calcification extent was categorized 
as 1–5 mm, 6–10 mm, 11–20 mm, 21–40 mm, and 
greater than 40–160 mm. The mammographic 
appearance or type of microcalcifications was catego-
rized in a manner similar to that of prior 
mammography–pathology correlation studies of mi-
crocalcifications in the literature [3–6]: predomi-
nantly granular, fine or coarse nonlinear particles of 
varying size and shape; linear, linear branching or 
casting calcifications. For the purposes of this analy-
ysis, subgroups of granular-type mammographic cal-
cifications used were the following: fine, fine 
powderlike granular calcifications only; coarse, gran-
ular calcifications; mixed, combinations of fine and 
coarse granular calcifications.

The surrounding mammographic background den-
sity was the background mammographic parench-
ynal density in the region of the mammographic 
microcalcifications considered to be normal breast pa-
renchymal density by the mammographer. For this 
analysis, the mammographic surrounding parench-
ymal density was categorized as dense, greater than 
90% dense tissue; fatty, greater than 90% fatty or hetro-
geneous; any other combination of fatty and dense 
parenchyma. Pathologic data was obtained from pa-
thology reports of all biopsy and surgical specimens 
of each malignant lesion by pathology staff of the 
cancer institute at the time of initial staging.

Whole-specimen radiography was performed 
during the surgery to confirm and assess the ade-
quacy of excision of the clinically occult mammo-
graphic calcifications. The surgical specimens were 
oriented and stained for histologic margin assess-
ment. For the excised specimens containing mam-
mographic calcifications and for the majority 
individuals containing extensive mammographic 
calcifications, sliced-specimen radiography of 4- to 
5-mm-thick consecutive slices was performed to 
precisely identify the location and the distribution of 
the mammographic calcifications for pathologic eval-
uation. This tissue was embedded and evaluated in its 
totality. The whole- and sliced-specimen radi-
ographs and mammographic–pathologic correlation of 
calcification have been recommended by several con-
sensus groups and have been described and illustrated 
previously [3, 7–10].

Histologic material derived from a combination of 
core biopsies and surgical excisions and resections 
or mastectomy for each patient was stained with H 
and E for pathologic evaluation and staging. The 
pathologic diagnoses in this study are based on all 
the biopsied and excised material. For this analysis, final 
pathologic malignant diagnoses were categorized as 
pure DCIS without an invasive component, DCIS as-
associated with an invasive ductal carcinoma (IDC) 
component, IDC only without DCIS, and invasive 
lobular carcinoma. The pathologic size of the inva-
sive carcinoma was that reported during staging by 
the attending pathologist at the cancer institute. The 
greatest histologic dimension of the invasive tumor in 
any plane was recorded according to the pathology 
staging standards of the College of American Pathol-
ologists [13]. According to the TNM staging classifica-
tion, for patients with multiple foci of invasive 
tumors, the greatest dimension of the largest invasive 
focus was recorded [14]. The size of the pathologic 
invasive carcinoma as a percentage of the mamma-
graphic calcification extent was categorized as less 
than or equal to 5%, 6–10%, 11–25%, 26–50%, 51– 
99%, and 100% or greater; it was also categorized as 
greater than the mammographic calcification extent. 
The invasive carcinoma extent was recorded as not 
assessable by the pathologist in some cases when the 
tumor was received in multiple fragments. The 
pathologic axillary lymph node status determined by 
sentinel node biopsy or axillary dissection was also 
included. Sentinel node biopsy was not performed at 
the beginning of this study but gradually replaced ax-
illary lymph node dissection as the predominant tech-
nique for axillary node sampling for patients with 
invasive carcinomas.

Statistical comparisons of associations between 
mammographic features and the presence and sizes 
of invasive carcinomas were performed using the 
chi-square test, with a p value of less than 0.05 as the 
limit of statistical significance [15].

Results

This study group consisted of 304 consecu-
tive patients with clinically occult mammo-
graphic calcifications without a mass with 
founds of breast carcinoma on final patholo-
logic evaluation. The median age of the pa-
tients was 54 years (range, 29–86 years). One 
hundred sixteen (38%) of the patients were 49 
years old or younger; 188 (62%) of the pa-
tients were 50 years old or older.

The frequency and distribution of malignant 
mammographic calcification lesion extent and type 
are shown in Table 1. Thirty-six percent of the 
mammographic calcification extents were 
1–10 mm; the mammographic calcification ex-
tents of 11–20 mm, 21–40 mm, and greater than 
40 mm were approximately 20% each. Fifty-
ine percent (n = 178) of the mammographic 
calcifications were the predominantly granular 
type, and 41% (n = 126) were the linear type.

The final pathologic diagnoses of the mamma-
graphic calcification lesions in the study 
are in Table 2. Overall, 65% of the malignant 
lesions manifested by mammographic calcifi-
cations only were pure DCIS. Thirty-two per-
cent were DCIS associated with invasion; 
only 4% were invasive carcinomas only. The 
association between patient age and the pres-
ence of pure DCIS or invasive carcinoma is 
shown in Table 3. There were no significant 
differences between patient age and the pres-
ence of invasive carcinoma.

The association between mammographic 
calcification extent and invasive carcinoma

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Totals</th>
<th>Linear</th>
<th>Granular</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>1–10</td>
<td>110</td>
<td>36</td>
<td>18</td>
</tr>
<tr>
<td>11–20</td>
<td>58</td>
<td>19</td>
<td>28</td>
</tr>
<tr>
<td>21–40</td>
<td>71</td>
<td>23</td>
<td>41</td>
</tr>
<tr>
<td>&gt; 40</td>
<td>65</td>
<td>21</td>
<td>39</td>
</tr>
<tr>
<td>Total</td>
<td>304</td>
<td>100</td>
<td>126</td>
</tr>
</tbody>
</table>

\(^{a} p = 0.00\) (comparing linear calcification fractions for 1–10 mm and ≥ 11 mm).

<table>
<thead>
<tr>
<th>Histopathology</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductal carcinoma in situ</td>
<td>198</td>
<td>65</td>
</tr>
<tr>
<td>Ductal carcinoma in situ and</td>
<td>96</td>
<td>32</td>
</tr>
<tr>
<td>invasive ductal carcinoma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invasive ductal carcinoma</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Invasive lobular carcinoma</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>304</td>
<td>100</td>
</tr>
</tbody>
</table>

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Invasive carcinoma size as a percentage of the mammographic calcification extent is shown in Table 5. The invasive carcinoma size was less than or equal to 10% of the calcification extent in 23% of patients. The invasive carcinoma size was 100% or greater relative to the mammographic calcification extent in 21% of patients.

The associations between mammographic calcification types and pure DCIS and invasion are shown in Table 6. Linear mammographic calcifications were more likely to be associated with invasive carcinoma: 40% (77/194) of patients, compared with 26% (29/110) for calcification extents of 1–10 mm ($p = 0.019$). However, there was no difference in the presence of an invasive component between calcification extents of 11–20 mm, 21–40 mm, and greater than 40 mm (range, 41–60 mm).

Overall, 65% (69/106) of the invasive carcinomas were pathologically staged at 10 mm or less. Twenty-one percent ($n = 22$) of the invasive carcinomas measured 2–5 mm, and 23% ($n = 24$) measured 1 mm or less. There were no significant differences in these size distributions of associated invasive carcinomas when comparing mammographic calcification extents of 1–10 mm and 11 mm and greater. Among the mammographic calcification extents of greater than 40 mm, 38% had associated invasive carcinoma; 56% of these invasive carcinomas were pathologically staged at 10 mm or less, 16% were 2–5 mm, and 24% were 1 mm or less.

### Table 3: Patient Age and Invasive Carcinoma

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Totals</th>
<th>Pure Ductal Carcinoma</th>
<th>Invasive Carcinoma</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>&lt; 40</td>
<td>25</td>
<td>100</td>
<td>12</td>
</tr>
<tr>
<td>40–49</td>
<td>91</td>
<td>100</td>
<td>66</td>
</tr>
<tr>
<td>50–59</td>
<td>77</td>
<td>100</td>
<td>49</td>
</tr>
<tr>
<td>60–69</td>
<td>60</td>
<td>100</td>
<td>37</td>
</tr>
<tr>
<td>70–79</td>
<td>40</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>≥ 80</td>
<td>11</td>
<td>100</td>
<td>9</td>
</tr>
<tr>
<td>≤ 49</td>
<td>116</td>
<td>100</td>
<td>78</td>
</tr>
<tr>
<td>≥ 50</td>
<td>188</td>
<td>100</td>
<td>120</td>
</tr>
<tr>
<td>Total</td>
<td>304</td>
<td>100</td>
<td>198</td>
</tr>
</tbody>
</table>

Note.—Numbers in parentheses are percentages. NA = not assessable.

### Table 4: Malignant Mammographic Calcification Lesion Extent and Associated Invasive Carcinoma

<table>
<thead>
<tr>
<th>Lesion Size (mm)</th>
<th>No.</th>
<th>Pure Ductal Carcinoma</th>
<th>Invasive Carcinoma</th>
<th>Invasive Carcinoma Size (mm)$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤ 1</td>
</tr>
<tr>
<td>1–5</td>
<td>50</td>
<td>39 (78)</td>
<td>11 (22)</td>
<td>3 (6)</td>
</tr>
<tr>
<td>6–10</td>
<td>60</td>
<td>42 (70)</td>
<td>18 (30)</td>
<td>5 (8)</td>
</tr>
<tr>
<td>11–20</td>
<td>58</td>
<td>33 (57)</td>
<td>25 (43)$^b$</td>
<td>5 (9)</td>
</tr>
<tr>
<td>21–40</td>
<td>71</td>
<td>44 (62)</td>
<td>27 (38)$^c$</td>
<td>5 (7)</td>
</tr>
<tr>
<td>&gt; 40</td>
<td>65</td>
<td>40 (62)</td>
<td>25 (38)$^c$</td>
<td>6 (9)</td>
</tr>
<tr>
<td>Total</td>
<td>304</td>
<td>198 (65)</td>
<td>106 (35)</td>
<td>24 (8)</td>
</tr>
<tr>
<td>1–10</td>
<td>110</td>
<td>81 (74)</td>
<td>29 (26)</td>
<td>8 (7)</td>
</tr>
<tr>
<td>≥ 11</td>
<td>194</td>
<td>117 (60)</td>
<td>77 (40)$^d$</td>
<td>16 (8)</td>
</tr>
</tbody>
</table>

Note.—Numbers in parentheses are percentages. NA = not assessable.

$^a$Pathologic measurement.

$^b$p = 0.027 (comparing designated fraction with invasive carcinoma with 1- to 10-mm-size subgroup).

$^c$p = not significant.

$^d$p = 0.019 (comparing designated fraction with invasive carcinoma with 1- to 10-mm-size subgroup).

### Table 5: Pathologic Invasive Carcinoma Size as a Percentage of Mammographic Calcification Extent

<table>
<thead>
<tr>
<th>Calcification Size (mm)</th>
<th>No.</th>
<th>≤ 5%</th>
<th>6–10%</th>
<th>11–25</th>
<th>26–50%</th>
<th>51–99%</th>
<th>≥ 100%</th>
<th>Not Assessable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–10</td>
<td>29 (100)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>7 (24)</td>
<td>5 (17)</td>
<td>4 (14)</td>
<td>12 (41)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>11–20</td>
<td>25 (100)</td>
<td>2 (8)</td>
<td>3 (12)</td>
<td>2 (8)</td>
<td>5 (20)</td>
<td>5 (20)</td>
<td>7 (28)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>21–40</td>
<td>27 (100)</td>
<td>5 (19)</td>
<td>2 (7)</td>
<td>6 (22)</td>
<td>7 (26)</td>
<td>3 (11)</td>
<td>3 (11)</td>
<td>2 (7)</td>
</tr>
<tr>
<td>&gt; 40</td>
<td>25 (100)</td>
<td>9 (36)</td>
<td>3 (12)</td>
<td>6 (24)</td>
<td>3 (12)</td>
<td>1 (4)</td>
<td>0 (0)</td>
<td>3 (12)</td>
</tr>
<tr>
<td>Total</td>
<td>106 (100)</td>
<td>16 (15)</td>
<td>8 (8)</td>
<td>21 (20)</td>
<td>20 (19)</td>
<td>13 (12)</td>
<td>22 (21)</td>
<td>7 (7)</td>
</tr>
</tbody>
</table>

Note.—Numbers in parentheses are percentages.
TABLE 6

<table>
<thead>
<tr>
<th>Type</th>
<th>Pure Ductal Carcinoma</th>
<th>Invasive Carcinoma</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Linear</td>
<td>126</td>
<td>71</td>
</tr>
<tr>
<td>Granular</td>
<td>178</td>
<td>127</td>
</tr>
<tr>
<td>Coarse</td>
<td>108</td>
<td>71</td>
</tr>
<tr>
<td>Mixed</td>
<td>42</td>
<td>31</td>
</tr>
<tr>
<td>Fine</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>Coarse and mixed</td>
<td>150</td>
<td>102</td>
</tr>
</tbody>
</table>

Total 304 198 65 106 35

aP = 0.007 (comparing designated fractions with invasive carcinoma).
bP = 0.022 (comparing designated fractions with invasive carcinoma).

TABLE 7

<table>
<thead>
<tr>
<th>Density</th>
<th>No.</th>
<th>Pure Ductal Carcinoma</th>
<th>Invasive Carcinoma</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>Dense</td>
<td>117</td>
<td>79</td>
<td>68</td>
</tr>
<tr>
<td>Heterogeneous</td>
<td>150</td>
<td>93</td>
<td>62</td>
</tr>
<tr>
<td>Fatty</td>
<td>37</td>
<td>26</td>
<td>70</td>
</tr>
<tr>
<td>Total</td>
<td>304</td>
<td>198</td>
<td>65</td>
</tr>
</tbody>
</table>

*p = not significant (comparing fractions with invasive carcinomas).

TABLE 8

| Malignant Mammographic Calcification Lesion Extent and Type and Associated Invasive Carcinoma |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Calcification Size (mm) | No. | Pure Ductal Carcinoma In Situ | Invasive Carcinoma | Invasive Carcinoma Size (mm) |
| | | | ≤ 1 | 2–5 | 6–10 | 11–15 | 16–20 | > 20 | NA |
| 1–10 | 110 | 81 (74) | 29 (26)b | 8 (7) | 9 (8) | 6 (5) | 4 (4) | 0 (0) | 1 (1) | 1 (1) |
| Linear | 18 | 12 (67) | 6 (33) | 2 (11) | 0 (0) | 2 (11) | 2 (11) | 0 (0) | 0 (0) | 0 (0) |
| Granular | 92 | 69 (75) | 23 (25) | 6 (7) | 9 (10) | 4 (4) | 2 (2) | 0 (0) | 1 (1) | 1 (1) |
| ≥ 11 | 194 | 117 (60) | 77 (40)b | 16 (8) | 13 (7) | 17 (9) | 11 (6) | 5 (3) | 9 (5) | 6 (3) |
| Linear | 108 | 59 (55) | 49 (45)c | 11 (10) | 7 (6) | 11 (4) | 7 (6) | 3 (3) | 7 (6) | 3 (3) |
| Granular | 86 | 56 (67) | 28 (33) | 5 (6) | 6 (7) | 6 (7) | 4 (5) | 2 (2) | 2 (2) | 3 (3) |
| Total | 304 | 198 (65) | 106 (35) | 24 (8) | 22 (7) | 23 (8) | 15 (5) | 5 (2) | 10 (3) | 7 (2) |
| Linear | 126 | 71 (56) | 55 (44)c | 13 (10) | 7 (6) | 13 (10) | 9 (7) | 3 (2) | 7 (6) | 3 (2) |
| Granular | 178 | 127 (71) | 51 (29)c | 11 (6) | 15 (8) | 10 (1) | 6 (3) | 1 (1) | 3 (2) | 4 (2) |

Note.—Numbers in parentheses are percentages. NA = not assessable.
aPathologic measurement.
bP = 0.019 (comparing designated fraction with invasive carcinoma component).
cP = 0.07 (comparing designated fraction with invasive carcinoma component).

Discussion

Mammographic calcifications proven to be malignant lesions are nearly always DCIS or DCIS with a smaller focus of invasion. This analysis showed that mammography, in general, is a poor predictor of either pure DCIS or DCIS associated with an invasive carcinoma. Mammographic calcification extents greater than 10 mm were more likely associated with invasion than were those with lesser extents; however, there was no increase in the frequency of invasive carcinomas with increasing mammographic calcification extents greater than 10–40 mm. Mammographic linear calcifications had significantly greater association with invasive carcinoma compared with granular calcifications. However, when combining these significant mammographic features, the lowest predictive value features, we found that less than 5-mm granular calcifications were associated with a 22% frequency of invasive carcinoma; the highest predictive value features, linear calcifications 11 mm and greater, were associated with a 45% frequency of invasive carcinoma. The mammographic calcification subtype of fine granular was associated with a frequency of invasive carcinoma of only 11%, but this uncommon subset constituted only 9% of the malignant calcification lesions overall.
This study describes the modern presentation of these breast carcinomas, the mammographic calcification appearance and extent based on high-resolution film-screen mammography, including orthogonal magnification projections. These projections are important to aid optimally in characterization of linear and granular calcifications in two planes and in assessment of calcification extent, because DCIS often extends in a longitudinal ductal or patchy lobular distribution in the breast [3–6]. The distribution or orientation of the DCIS calcifications was not recorded in this study.

Although it is possible that dense rather than fatty mammographic parenchymal density surrounding a region of mammographic calcifications could more likely obscure a soft-tissue abnormality representing an invasive carcinoma, mammographic surrounding parenchymal density and patient age showed no associations with the presence of invasion, in part, because of the small size (≤ 5 mm) of many of the invasive foci associated with mammographic calcifications.

The observation that the size distribution of the associated invasive carcinomas is similar for different DCIS mammographic calcification extents suggests a DCIS field phenomenon. If one considers the size of the invasive carcinoma as a measure for the age or the degree of malignant transformation of the lesion, these data suggest that both large and small fields of DCIS and mammographic calcifications are at similar points in the malignant transformation process because they contain similar frequency and size distribution of invasive cancers.

It has been well established in the mammography–pathology correlation literature that the extent of mammographic calcifications can underestimate the pathologic extent of DCIS [3, 5]. Also, a discontinuous distribution of mammographic calcifications associated with DCIS is often associated with continuous DCIS pathology in a ductal–lobule system [3, 5]. There may be areas of microscopic DCIS in mammographically normal tissue between clusters of DCIS calcifications.

It has also been shown that in some patients, the extent of mammographically suspicious calcifications may overestimate the pathologic extent of DCIS, especially in those cases of DCIS found in benign adenosis calcifications [3, 16, 17]. However, in prospective clinical management, excision of the entire mammographic region of suspicious calcifications is usually required to exclude the possibility of additional DCIS or invasive carcinoma. Using sliced-specimen mammography–pathology correlation of excised mammographic calcifications, we have shown that in some cases, the calcifications are predominately benign, and we do not recommend further excision of the mammographic calcifications remaining on the postexcision mammogram if the pathologic margins are satisfactorily negative for surgical management [3].

Lagios et al. [16, 17] reported data on 115 mastectomy specimens resected for an initial biopsy diagnosis of DCIS. The pathologic extent of DCIS was determined using the serial subgross and radiographic method modeled after Egan et al. [18]. Lagios et al. correlated the pathologic extent of DCIS, including mammographically occult noncalcified DCIS, with the presence of occult invasion. They defined occult invasion as invasive carcinoma not detected in the original biopsy procedure and not evident as a suspicious focal soft-tissue abnormality on mammograms, including earlier mammographic and xenomammographic techniques. Occult invasion in their series was confined to breasts in which the pathologic size of DCIS exceeded 45 mm, occurring in nearly 50% of breasts with a pathologic extent of DCIS of 55 mm or greater. Their series also included cases in which the DCIS was not evident on mammography at all or in part (noncalcified DCIS).

The case selection, mammographic evaluation, and correlation in our study differs in that only patients with mammographic calcification lesions without a clinical or mammographic mass were included. The mammographic calcification extent appearance and the absence of soft-tissue abnormalities suspicious for invasion were determined with a high-resolution film-screen mammography technique with orthogonal magnification projections, and the prebiopsy mammographic extent of suspicious calcifications, not the final pathologic extent of DCIS, was correlated with the presence of associated invasion after complete surgical removal of the lesion. These data reflect the ability to prospectively predict the presence of associated invasion on the basis of mammographic findings available to clinicians during routine clinical management. Comparison of the mammographic and pathologic size of DCIS is beyond the scope of this study.

The observation that the frequency of associated invasive carcinoma did not increase for mammographic calcification extent greater than 10 mm in our study does not support recent reports in the surgical literature that suggest that sentinel node biopsy be performed selectively for extensive mammographic calcifications associated with DCIS because of an increased risk of associated invasive carcinomas [19–22]. Although 40% of patients with calcification extents 11 mm and greater had associated invasion as compared with 16% with calcification extents of less than or equal to 10 mm, no difference was seen in the frequency of associated invasion for calcification extents of 11–20 mm, 21–40 mm, or greater than 40–160 mm.

The observation that the pathologic size of invasive carcinomas associated with DCIS mammographic calcifications is often much smaller than the extent of calcifications explains the underestimation of invasive carcinoma or stereotactic core biopsies showing DCIS only. Stereotactic core biopsy methods, even large core needle vacuum-assisted techniques, fail to detect the invasive component in 11–20% of core biopsies showing DCIS only [23]. This analysis sheds no light on sampling during core biopsy to increase the detection of the smaller invasive carcinomas, including 1-mm foci, within larger regions of DCIS calcifications.

These data may improve the mammographer’s, the surgeon’s, and the patient’s understanding of mammographic calcifications, DCIS, and associated invasive carcinomas during clinical management as well as provide some mammography-derived empiric observations regarding the biologic associations and characteristics of DCIS and invasive carcinoma.
Acknowledgments

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