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Radiological BI-RADS Scoring and Histopathological Results: Correlation and Pitfalls

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ABSTRACT

Objective: The Breast Imaging Reporting and Data System (BI-RADS) is an internationally utilized radiological reporting system for the classification of breast lesions, categorizing cases based on increasing malignancy rates. Given that breast cancer is the most common type of cancer among women and that early diagnosis and treatment are of paramount importance, the correlation between histomorphological changes and the BI-RADS scoring system holds critical significance. In this study, we aimed to evaluate the histopathological correlation with the BI-RADS scoring system and identify potential diagnostic pitfalls.

Materials and Methods: The radiological findings from breast imaging of 881 women over the age of 40 were retrospectively reviewed and reclassified according to the updated BI-RADS scoring system. The classifications were then correlated with the histopathological results of the biopsies.

Results: In our study, the positive predictive values for detecting malignancy increased progressively from BI-RADS category 4A to 4C, with rates of 6.2%, 34.3%, and 85.7%, respectively. This rate further increased to 94% in category 5.

Conclusion: Although the BI-RADS scoring system, which is effectively used in breast biopsies today, demonstrates a high radiological and pathological correlation, new and innovative studies focusing on subtypes within category 3 and category 4 will contribute to reducing discrepancies observed in these categories.

Keywords: BI-RADS, Breast, Pathology, Radiology

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INTRODUCTION

The Breast Imaging Reporting and Data System (BI-RADS), established by the American College of Radiology (ACR) in the late 1980s, aimed to standardize reporting in breast imaging and to improve communication and research in the field. It has become a standardized system for reporting breast pathology detected by mammography, ultrasound, and magnetic resonance imaging. This comprehensive system provides a structured approach to reporting, ensuring consistency in the interpretation of imaging results. At the heart of BI-RADS is a detailed lexicon, a dictionary-like collection of terms that describe specific imaging features. This lexicon is based on data and research to effectively differentiate between benign and malignant breast conditions, thereby enhancing the accuracy and reliability of breast imaging assessments. Since its first edition in 1993, BI-RADS has undergone several revisions, with subsequent editions released in 1995, 1998, and 2003, each adding important elements for clarification, management, and quality assurance.[1] The fourth edition in 2003 introduced a significant enhancement to the BI-RADS assessment category 4.[2] It subdivided this category into three levels: 4A, indicating low suspicion for malignancy; 4B, indicating intermediate suspicion; and 4C, indicating moderate concern but not definitively malignant. This refinement aimed to improve risk stratification, offering more precise assessment and reporting to aid both physicians and patients in understanding probable biopsy results and subsequent follow-up steps. The fifth edition of BI-RADS, released in 2013, brought about significant updates.[3] It eliminated underutilized or redundant findings from the lexicon, thereby streamlining the system. Additionally, it incorporated newer technologies such as shear-wave elastography, making it more contemporary and user-friendly.[4] This latest revision reflects ongoing efforts to enhance the system's relevance and ease of use in breast imaging practice.

The structured lexicon of BI-RADS enhances interaction among various medical professionals involved in complex clinical care. The BI-RADS final assessment categories, coupled with management recommendations, have set a standard in breast care decision-making based on imaging. This uniformity is particularly beneficial in multidisciplinary breast care teams, including surgeons, pathologists, oncologists, and radiologists. For instance, the specific BI-RADS categories such as 4A, 4B, 4C, and 5 serve as valuable tools for conveying the degree of suspicion to pathologists for lesions undergoing imaging-guided biopsies. This promotes accurate histologic diagnoses by fostering a correlation between imaging and pathology. Moreover, clear communication between pathologists and radiologists is crucial for identifying potential sampling errors in percutaneous core biopsies and preventing delayed cancer detection by facilitating timely excisional biopsies.

MATERIALS AND METHODS

Definitions of the Study Groups and Clinical/Pathologic/Radiologic Parameters

Women aged 40 years and older who underwent tru-cut biopsy for breast lesions in the radiology department and received a diagnosis in the pathology clinic at Istanbul Bağcılar Training and Research Hospital between 2020 and 2022 were retrospectively evaluated. The lesions were evaluated using ultrasound (US), mammography, and magnetic resonance imaging (MRI) available in the hospital system and were categorized as BI-RADS 2, 3, 4A, 4B, 4C, or 5. A total of 881 cases were included in the study. Cases with non-diagnostic image quality (mammography, MRI, US) and those that underwent only US examination but had reports that did not conform to the BI-RADS categorization were excluded from the study. Radiologically described lesions were measured in millimeters based on their largest dimension and were classified according to their location as the upper outer quadrant, upper inner quadrant, lower outer quadrant, or lower inner quadrant of the right or left breast. Lesions that did not fully correspond to a specific quadrant, including those located at the 3, 6, 9, and 12 o'clock positions, as well as those in the retroareolar region, were categorized separately. Clinical information of the cases was obtained from the hospital automation system. Histopathological evaluations were classified into six groups based on the morphological findings of the tru-cut biopsies: malignant tumors (regardless of subtype), pure in situ carcinomas (lobular/ductal), fibroadenomas/benign phyllodes tumors (benign fibroepithelial tumors), papillary neoplasms, lipomatous tumors, and fibrocystic changes/benign breast tissue (FCC/BBT), including adenosis, inflammatory conditions, and other non-neoplastic alterations.

Statistical Analysis

A retrospective analysis was conducted on a dataset comprising 881 breast lesions. Descriptive statistics summarized patient demographics, lesion characteristics, pathological outcomes, and radiological classifications based on the BI-RADS categories. Continuous variables, such as patient age and lesion diameter, are presented as means±standard deviations, while categorical variables are expressed as frequencies and percentages. To evaluate differences in mean ages and tumor diameters across different pathological diagnoses, the Kruskal–Wallis test was employed due to the non-parametric distribution of the data. Post hoc analyses identified specific group differences, with significance levels set at $p<0.05$. Chi-square tests assessed associations between pathological diagnoses and both BI-RADS categories and lesion locations within breast quadrants. Adjusted residuals identified significant deviations from expected frequencies, highlighting specific associations between pathology types and radiological classifications or anatomical locations.

Ethical Approval

This study was conducted in accordance with the principles outlined in the Declaration of Helsinki and received approval from the Non-Interventional Clinical Research Ethics Committee of Bağcılar Training and Research Hospital (Decision No:2023/08/08/043, dated August 8, 2023).

RESULTS

The study evaluated 881 breast lesions with a mean patient age of 51.3±9.9 years. The average lesion diameter was 18.5±12.3 mm. Lesion laterality was nearly balanced, with 469 lesions (53.2%) located in the left breast and 412 lesions (46.8%) in the right breast.

The distribution of pathological diagnoses revealed that fibroadenoma/benign phyllodes tumors were the most common lesion type, identified in 317 cases (36%). Invasive carcinoma was present in 282 lesions (32%), while FCC/BBT was found in 238 lesions (27%). Less frequent pathologies included papillary neoplasms in 24 lesions (2.7%), lipomatous tumors in 13 lesions (1.5%), and pure ductal carcinoma in situ (DCIS) in 7 lesions (0.8%).

Radiologically, the lesions were classified based on BI-RADS categories as follows: BI-RADS 3 in 316 lesions (35.9%), BI-RADS 5 in 244 lesions (27.7%), BI-RADS 4A in 145 lesions (16.5%), BI-RADS 2 in 99 lesions (11.2%), BI-RADS 4C in 42 lesions (4.8%), and BI-RADS 4B in 35 lesions (4%). The distribution of the cases according to BI-RADS categories and the relationships between BI-RADS categories, age, and lesion size are shown in Table 1.

The Kruskal–Wallis test indicated statistically significant differences in mean ages across categories of pathological diagnosis (p<0.001). Post hoc analysis revealed that patients with invasive ductal carcinoma had a significantly higher mean age (55.9 years) compared to those with fibroadenoma (47.6 years) and FCC/BBT (50.4 years) (p<0.001).

Significant differences were also observed in tumor diameters across pathological diagnoses (p<0.001). Post hoc analysis showed that patients with invasive carcinomas had significantly larger mean tumor diameters (24.2 mm) compared to those with fibroadenoma (15.7 mm), papillary neoplasms (16.2 mm), and in situ carcinomas (9.4 mm) (p<0.001).

An analysis of lesion distribution across breast quadrants revealed significant associations between pathological diagnoses and specific anatomical locations (p<0.05). At the 9 o'clock position, FCC/BBT was significantly more frequent, representing 11.8% of all FCC/BBT cases, while invasive carcinomas were significantly less frequent at this location (3.2% of invasive cases). Cases with diffuse involvement (described as more than one quadrant) exhibited a higher frequency of FCC/BBT (19.3% of these cases) and a lower frequency of fibroadenomas (6.3% of fibroadenoma cases).

In the upper inner quadrant (UIQ), invasive carcinomas were significantly more common, accounting for 16.7% of invasive cases, whereas FCC/BBT was less frequent in this quadrant (8% of cases). Similarly, in the upper outer quadrant (UOQ), invasive carcinomas had the highest frequency, representing 38.7% of invasive cases, while FCC/BBT lesions were less common in this region (24.4% of FCC/BBT cases) (Fig. 1).

The chi-square test revealed a significant association between pathological diagnoses and BI-RADS categories (p<0.001). FCC/BBT cases were significantly more frequent in BI-RADS 2, comprising 69.7% of lesions in this category. Fibroadenoma/benign phyllodes tumors were predominantly classified as BI-RADS 3 and BI-RADS 4A, accounting for 66.8% and 25.6% of lesions in these categories, respectively. Invasive carcinomas were significantly associated with higher BI-RADS categories, particularly BI-RADS 5 and BI-RADS 4C (93.7% of all cases). Papillary neoplasms showed a significant association with BI-RADS 4B, comprising 20.0% of lesions in this category.

The malignant cases consisted of invasive carcinomas, pure in situ carcinomas, and papillary lesions, including invasive papillary carcinoma, encapsulated papillary carcinoma, and papilloma containing ductal carcinoma in situ. In our study, there were 145 cases evaluated as BI-RADS 4A, of which 9 were malignant

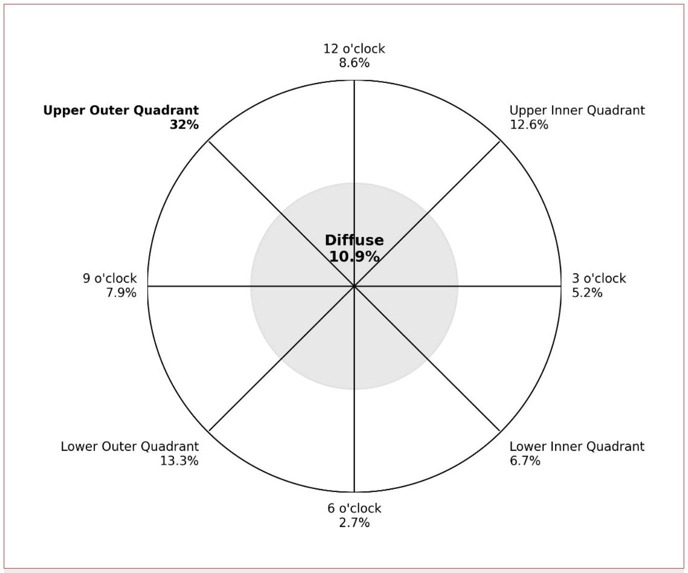

Figure 1. Distribution of all cases by quadrants (*'diffuse' described as more than one quadrant*).

Table 1. Distribution of BI-RADS classification, patient age, and lesion diameter according to pathological diagnosis.[41,48]

Pathology	Median Age (Min, Max)	BI-RADS Class	n	%	Lesion Diameter (Mean±Std)
Fibrocystic changes/benign breast tissue (n=238)	49 (40.78)	BIRADS 2	69	29.0	17.51±1.45
		BIRADS 3	90	37.8	13.24±0.66
		BIRADS 4A	52	21.8	18.03±1.43
		BIRADS 4B	15	6.3	12.87±1.92
		BIRADS 4C	4	1.7	15.4±4.09
		BIRADS 5	8	3.4	18.75±2.87
Invasive carcinomas (n=282)	54 (40.94)	BIRADS 3	3	1.1	15.33±2.91
		BIRADS 4A	7	2.5	20.71±2.52
		BIRADS 4B	8	2.8	23.71±6.93
		BIRADS 4C	34	12.1	22.18±3.1
		BIRADS 5	230	81.6	24.72±0.8
Fibroadenoma/benign filloides tumors (n=317)	45 (40.79)	BIRADS 2	15	4.7	23.62±7.04
		BIRADS 3	211	66.6	14.07±0.5
		BIRADS 4A	81	25.6	17.25±0.88
		BIRADS 4B	5	1.6	12.6±2.89
		BIRADS 4C	2	0.6	65±35
		BIRADS 5	3	0.9	19.5±8.32
Papillary Neoplasms (n=24)	49 (40.94)	BIRADS 2	1	4.2	8
		BIRADS 3	8	33.3	8.31±2.58
		BIRADS 4A	4	16.7	8.88±1.16
		BIRADS 4B	7	29.2	29.14±8.62
		BIRADS 4C	2	8.3	25.5±10.5
		BIRADS 5	2	8.3	11.5±3.5
In situ carcinomas (n=7)	52 (41.71)	BIRADS 2	1	14.3	7
		BIRADS 3	4	57.1	10.2±2.38
		BIRADS 4A	1	14.3	6
		BIRADS 5	1	14.3	12
Lipomatous Tumors (n=13)	53 (40.64)	BIRADS 2	13	100.0	24.24±6.78

(6.21%). The number of BI-RADS 4B cases was 35, with 12 being malignant (34.29%). For cases classified as BI-RADS 4C, there were 42 in total, of which 36 (85.71%) were malignant. Additionally, there were 95 cases categorized as BI-RADS 5, and 90 of these were pathologically confirmed as malignant (94.74%).

The chi-square analysis demonstrated significant associations between specific pathological diagnoses and BI-RADS categories. Patients diagnosed with invasive carcinoma tended to be older and have larger tumors, and their lesions were more likely to be classified as BI-RADS 4C and BI-RADS 5 and located in the upper quadrants of the breast. Fibroadenomas were predominantly associated with BI-RADS 3 and BI-RADS 4A and did not show a strong predilection for specific breast quadrants, while FCC/BBT lesions were more commonly classified as BI-RADS 2 and had higher frequencies at certain anatomical locations, such as the 9 o'clock position (11.8% of all FCC/BBT cases) and in diffuse presentations.

DISCUSSION

Breast carcinomas represent the most frequently diagnosed type of cancer in women.[5] Alongside increasing awareness among individuals, the widespread adoption of diverse imaging modalities has enabled the early detection of lesions, resulting in a rise in both the number and variety of biopsies obtained from these patients. The findings derived from imaging performed for this purpose are categorized into risk groups using the BI-RADS (Breast Imaging Reporting and Data System) classification, which is employed worldwide and serves as one of the cornerstones in patient management.

Breast core biopsies, which hold a significant place in routine pathology practice, play a crucial role in both diagnosis and treatment, making them an indispensable component of contemporary medical practice. In the histopathological evaluation of breast core biopsies, the integration of patients' clinical information and findings with radiological data is an essential requirement for an accurate diagnosis. In this context, pathologists correlate the microscopic changes observed with the BI-RADS category indicated in imaging studies. Apart from category 5, which is reported to have a malignancy likelihood exceeding 95%, malignant cases can also be encountered in category 4 and, to a lesser extent, in category 3. Particularly in category 4, which is subdivided into 4A, 4B, and 4C with progressively increasing malignancy potential, cases that do not exhibit overt malignancy histopathologically are a cause for concern among pathologists due to the risk of missing a malignant lesion. In this context, there has been a noticeable increase in studies focusing specifically on the BI-RADS 4 group in recent years.[6–8]

In our study, 9 of 145 cases classified as BI-RADS 4A were reported as malignant. Among these, 7 were diagnosed as invasive carcinoma, 1 as ductal carcinoma in situ, and 1 as a papilloma containing ductal carcinoma in situ. Pathological evaluation of 35 cases classified as BI-RADS 4B revealed 8 cases of invasive carcinoma and 7 cases of papillary proliferation. Among these papillary lesions, 4 were primarily evaluated as malignant (invasive papillary carcinoma, encapsulated papillary carcinoma, and papilloma containing ductal carcinoma in situ), while 3 were assessed as intraductal papillomas. Of the 42 cases classified as BI-RADS 4C, 34 were identified as invasive carcinoma, while 2 were evaluated as consistent with encapsulated papillary carcinoma. It was observed that the positive predictive value (PPV) for malignancy in BI-RADS category 4 increased across subcategories. The increasing PPV rates from 4A to 4C were 6.2%, 34.3%, and 85.7%, respectively. The findings reported by Yoon et al.[9] indicated rates of 7.6%, 37.8%, and 81.9%, respectively. In another study, the rates were found to be 13.6%, 50%, and 86%.[10] Kim et al.[11] conducted an analysis in which the PPV was calculated as 9.4% for category 4A and 21.4% for category 4B. Similarly, Bent et al.[12] reported PPV values of 13% for category 4A, 36% for category 4B, and 79% for category 4C. The results we obtained are consistent with the literature, with this rate reaching 94% in category 5. However, considering that the final objective is 100%, the potential reasons underlying this discrepancy require further investigation. Even though these rates and the "discordance" may appear minor, they are quite significant and concerning in daily clinical practice for a tertiary hospital.

While BI-RADS 4C and 5 lesions are considered highly suggestive of malignancy, a portion of these lesions are ultimately benign, highlighting the challenges of imaging-based classification. This discrepancy arises from multiple factors, including imaging characteristics, clinical context, and differences in interpretation. Suspicious ultrasound features such as spiculated margins, microcalcifications, nonparallel orientation, microlobulated contours, posterior shadowing, and complex echogenicity are often associated with malignancy; however, their presence does not always indicate a malignant process.[13] Additionally, patient-related factors such as age, prior cancer history, multiple lesions, and clinical symptoms can influence how lesions are categorized.[9,14] Another contributing factor is variability in radiological interpretation, as differences in experience can lead to inconsistencies. While malignancy rates are expected to exceed 50% in BI-RADS 4C and 95% in BI-RADS 5 lesions, a subset of benign lesions still falls into these categories.[15] All these considerations indicate that current breast imaging techniques and the BI-RADS classification system are still insufficient for achieving optimal diagnostic predictability, as radiology alone cannot always provide a definitive diagnosis, with some BI-RADS 4C and 5 lesions still proving to be benign. In this study, among the cases classified as BI-RADS 4C but not diagnosed with invasive carcinoma, 2 were evaluated as encapsulated papillary carcinoma, 2 as fibroadenoma with cellular stroma/benign phyllodes tumor (Fig. 2), 1 as granulomatous mastitis, 1 as fat necrosis, 1 as chronic nonspecific inflammation, and 1 as microcalcification foci.

Among the 13 cases classified as BI-RADS 5 but not diagnosed with invasive carcinoma or pure in situ carcinoma, there were 2 intraductal papillomas, 1 case of granulomatous mastitis (Fig. 3), 2 cases of fat necrosis, and 3 fibroadenomas. In this context, although the number of discordant cases in the 4C and 5 groups is limited, it can be suggested that cellular fibroadenomas, signs of inflammation, and areas of fat necrosis are the primary contributors to this discordance. Certainly, atypical proliferations may be observed within or at the periphery of a fibroadenoma or an inflammatory lesion, and these atypical areas may not be present in the core biopsy sample. However, in cases of potential discordance,

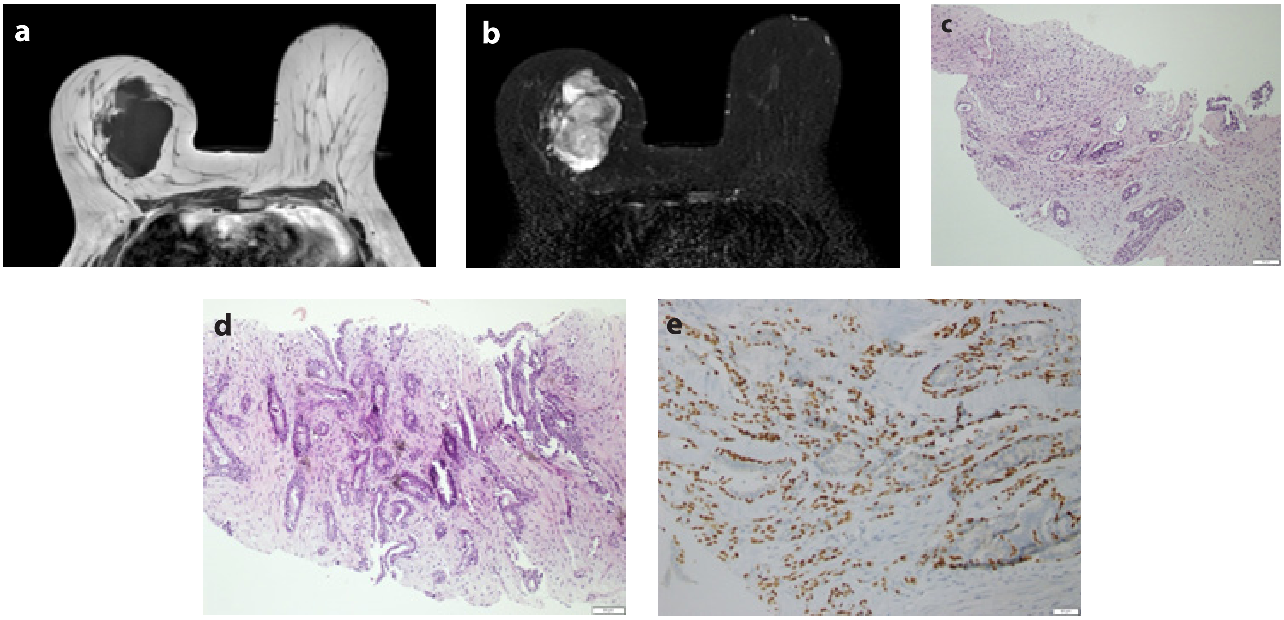

Figure 2. The lesion in the middle-inner section of the right breast, which has an irregular medial contour and is radiologically classified as BI-RADS 4C in conjunction with ultrasound, is shown in T1-weighted **(a)** and post-contrast fat-suppressed **(b)** MRI images. H&E sections reveal glands with a benign appearance, embedded in a mildly cellular stroma, mimicking invasive carcinoma **(c, d)**. Immunohistochemical staining with P63 demonstrates widespread positivity in myoepithelial cells, supporting the diagnosis of fibroadenoma **(e)**.

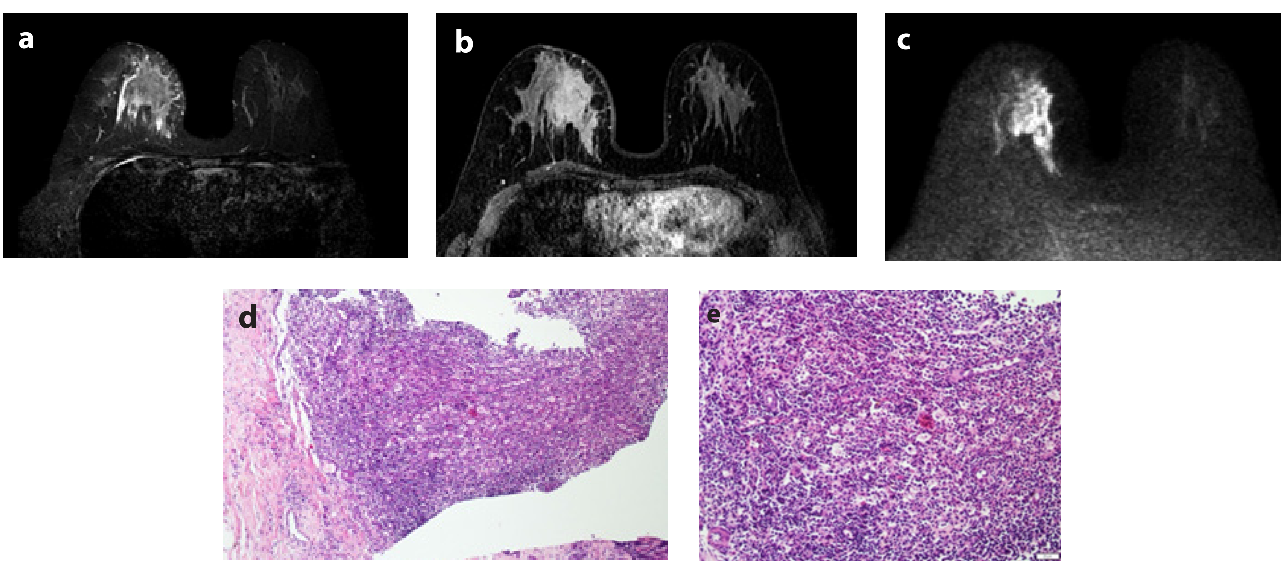

Figure 3. The T2 STIR **(a)**, fat-suppressed post-contrast **(b)**, DWI **(c)**, MRI images of a lesion with spiculated contours and significant diffusion restriction, causing nipple retraction and almost completely filling the lower inner quadrant of the right breast, assessed as BI-RADS 5. Histopathological examination revealed findings of active chronic mastitis accompanied by histiocytes and associated with focal non-necrotizing granuloma formation. (**d, e**; H&Ex10, H&Ex20) *(STIR: Short tau inversion recovery, DWI: Diffusion-weighted imaging, ADC: Apparent diffusion coefficient).*

the biopsy should be examined through serial sectioning, and if necessary, the recommendation for a repeat biopsy should not be avoided.

In our study, 24 cases of papillary neoplasms were included. A notable finding is that papillary neoplasms constitute 20% of the cases classified as BI-RADS 4B, which represents the highest proportion among the categories. Among the seven cases within this group, three were identified as intraductal papillomas, while the remaining four consisted of papillary proliferations with atypia. Notably, the majority of papillary lesions were classified as BI-RADS 4 (54.2%), followed by BI-RADS 3 as the second most common category (33.3%). All eight cases described as BI-RADS 3 demonstrated histopathological findings consistent with intraductal papilloma upon tru-cut biopsy evaluation. Among the four cases categorized as BI-RADS 4A, three were assessed as intraductal papillomas, while one was interpreted as a papilloma containing DCIS. In the histopathological evaluation of tru-cut biopsies of the two cases defined as BI-RADS 4C, the differential diagnoses included invasive papillary carcinoma and encapsulated carcinoma. The histopathological examination of the excisional materials from these cases revealed a diagnosis of invasive papillary carcinoma accompanied by invasive ductal carcinoma in one case, while the other was diagnosed as invasive ductal carcinoma arising in the periphery of a solid papillary carcinoma. On the other hand, the histopathological evaluation of tru-cut biopsies of the two cases described as BI-RADS 5 primarily indicated intraductal papilloma (excisional materials of these cases could not be obtained) (Fig. 4). Histopathological assessment of papillary neoplasms, which are highly heterogeneous tumors, is open to unexpected findings, and surgical excision is generally recommended.

In our study, fibroadenomas/benign phyllodes tumors were the most common diagnosis among biopsied cases (36%), followed by invasive carcinomas (32%). Patients diagnosed with invasive carcinoma were older, with a mean age of 55.9 years. The rate of malignancy increased as lesion size increased. As expected, the most common quadrant for malignancy was the upper outer quadrant. In this study, we also found that invasive carcinomas tend to occur more frequently in the upper quadrants of the breast, particularly in the upper outer quadrant. Although there are opinions suggesting that the frequent occurrence of malignancies in the upper outer quadrant may be related to cosmetic products, some studies have indicated that the higher malignancy rates in this region could be attributed to the greater amount of breast parenchyma compared to other areas.[16,17] Furthermore, there are publications reporting that genomic instability is higher in the breast parenchyma of the outer quadrants.[18] In our study, the second most common quadrant for malignancy after the upper outer quadrant was the upper inner quadrant. Similarly, in the study conducted by Lee AHS, the upper inner quadrant was also identified as the second most frequent site for malignancy. From this perspective, it can be suggested that masses observed in the upper quadrants have a higher likelihood of being malignant.[16] Cases involving multiple quadrants in this study were most commonly diagnosed with FCC/BBT, as mentioned. Fibrocystic disease can present with various patterns of involvement; however, it is most frequently observed in the upper outer quadrant.[16,19] As mentioned above, this can be explained by the greater amount of breast parenchyma in this region. In our study, FCC/BBT cases were more evenly distributed but showed higher frequencies at specific locations, such as the 9 o'clock position and in diffuse presentations.

The FCC/BBT cases encompass non-neoplastic conditions such as adenosis, granulomatous changes, and inflammatory processes. Nonetheless, in situations where the radiologically identified lesion may not have been fully sampled, there remains a risk that an underlying malignant lesion could have been overlooked. This represents one of the limitations of our study and should be carefully considered when interpreting the results.

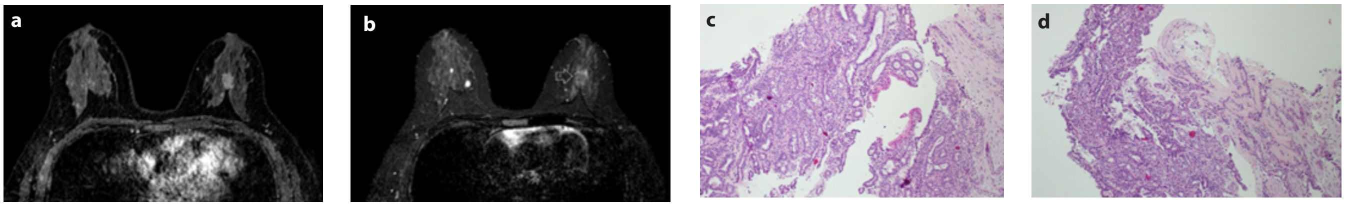

Figure 4. The T2 STIR **(a)** and post-contrast fat-suppressed **(b)** MRI images of a case classified as BI-RADS 5, showing an irregular, partially spiculated lesion with heterogeneous contrast enhancement in the middle quadrant of the right breast. Histopathological examination reveals an intraductal papilloma observed within the duct **(c)**, while hyalinized stroma mimics the appearance of invasive carcinoma **(d)** *(STIR: Short tau inversion recovery).*

CONCLUSION

In routine clinical practice, needle biopsies occupy a pivotal role in the diagnosis of breast tumors, and close collaboration between pathologists and radiologists is of critical importance for accurate diagnosis. There is a remarkably strong concordance between pathology and radiology in evaluations based on the BI-RADS classification system in core biopsies; however, potential diagnostic pitfalls in BI-RADS category 4B and 4C cases must be carefully addressed. In particular, papillary lesions of the breast and inflammatory processes may represent challenging pitfalls in diagnosis.

Currently, innovative studies utilizing advanced methodologies such as deep learning and artificial intelligence are being conducted to further enhance the BI-RADS scoring system.[20,21] The BI-RADS system, which has been effectively employed in the diagnosis of breast lesions both historically and in contemporary practice, is anticipated to undergo further refinements that will enhance its diagnostic utility in the future. As tumors are increasingly characterized at the molecular level—breast tumors perhaps being among the most comprehensively studied—a scoring system that incorporates molecular profiling is emerging as a key expectation for future advancements.[22] Therefore, we propose that collaborative efforts, particularly among radiologists, pathologists, and clinicians, will play a pivotal role in advancing the diagnosis and treatment of these patients.

DECLARATIONS

Ethics Committee Approval: The study was approved by Bağcılar Training and Research Hospital Ethics Committee (No: 2023/08/08/043, Date: 08/08/2023).

Conflict of Interest: The authors declare that there is no conflict of interest.

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