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Original article

ACR Breast Density: Relationship with Age, and Its Impact on Mammographic and Ultrasound Findings

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ABSTRACT

Breast cancer is a commonest cancer among women. Early detection by screening and diagnostic mammography could be reduced morbidity rate. ACR breast density is a risk factor in diagnosis of breast cancer in women whom have dense breast. ACR density mostly reduced with increasing age. A retrospective study carried on 222 female patients aged between 32-75 years with a mean 49 years, range 43 years, all patient subjected to mammography and complementary ultrasound, aimed to detect relation between ACR breast density and the age and the impact of ACR breast density on mammographic and ultrasound findings. Dense breasts (ACR d) seen only at younger age groups around 16 patients from 31-40 years age group and 14 patients from 41-50 years age group, the sensitivity and specificity of mammography in detection suspicious lesions in fatty breasts (ACR a) around 94.7% and 100 % respectively while the sensitivity and specificity of mammography in detection suspicious lesions in dense breasts (ACR c & d) were around 50% and 100 % respectively. ACR breast density usually has inverse relationship with the age, it could be reduced sensitivity of mammography in early detection of suspicious breast lesion especially in women have dense breasts, Addition of breast ultrasound as complementary imaging tool could be helpful in detection of occult mammographic lesions that could not detected in dense breasts.

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INTRODUCTION

Breast cancer remains the most prevalent malignancy among women, constituting approximately one-third of all female cancer diagnoses. The lifetime probability of developing invasive breast disease is estimated at 12%, representing a 1-in-8 risk ratio. Consequently, this pathology represents a primary driver of female oncology-related mortality [1]. While conventional risk matrices heavily rely on individual demographic profiles and familial predisposition [2], contemporary evidence identifies mammographic breast density as a potent, independent oncological risk factor [2-5]. Specifically, elevated parenchymal density correlates with a four- to six-fold increase in the relative risk of developing malignant breast disease [6]. Concurrently, dense fibroglandular tissue compromises the diagnostic sensitivity of screening mammography, thereby creating a dual clinical challenge of masked radiological detection and heightened oncological susceptibility [6].

Age remains a critical determinant of parenchymal composition. Over 50% of women aged 25 to 49 years exhibit dense breast profiles (>50% density), whereas 76% of postmenopausal women aged over 70 years present with predominantly fatty tissue involution [7]. Furthermore, an inverse relationship exists between overall breast volume and parenchymal density, with smaller breast phenotypes demonstrating a higher propensity for dense configurations [7].

Historical frameworks for quantifying parenchymal variations began with the pioneering work of John Wolfe in 1976.

Wolfe established a foundational four-tier classification system: N1 (predominantly fatty), P1 (prominent ductal patterns occupying less than 25% of the breast), P2 (prominent ductal patterns exceeding 25%), and DY (severe dysplasia presenting as dense fibroglandular tissue). His retrospective analysis demonstrated that the DY cohort experienced a 37-fold increase in cancer incidence compared to the N1 cohort, with the combined P2 and DY groups accounting for approximately 82% of all diagnosed breast malignancies within just 33% of the study population [8].
Subsequently, in 1997, Tabár introduced an alternative classification system that categorized mammographic parenchymal architecture into five distinct grades: Grade I (balanced tissue components with slight fibrous prominence), Grade II (predominantly adipose tissue), Grade III (fatty replacement featuring residual retroareolar fibrous tissue), Grade IV (prominent nodular and linear densities), and Grade V (extensive, severe fibroglandular density) [9,10].
Currently, the Breast Imaging Reporting and Data System (BI-RADS™), developed by the American College of Radiology (ACR), serves as the international reference standard for breast density classification [11]. The latest fifth edition, published in 2013, refines this assessment into four descriptive categories rather than percentages: (a) almost entirely fatty; (b) scattered areas of fibroglandular density; (c) heterogeneously dense, which may obscure small masses; and (d) extremely dense, which severely lowers mammographic sensitivity [11].

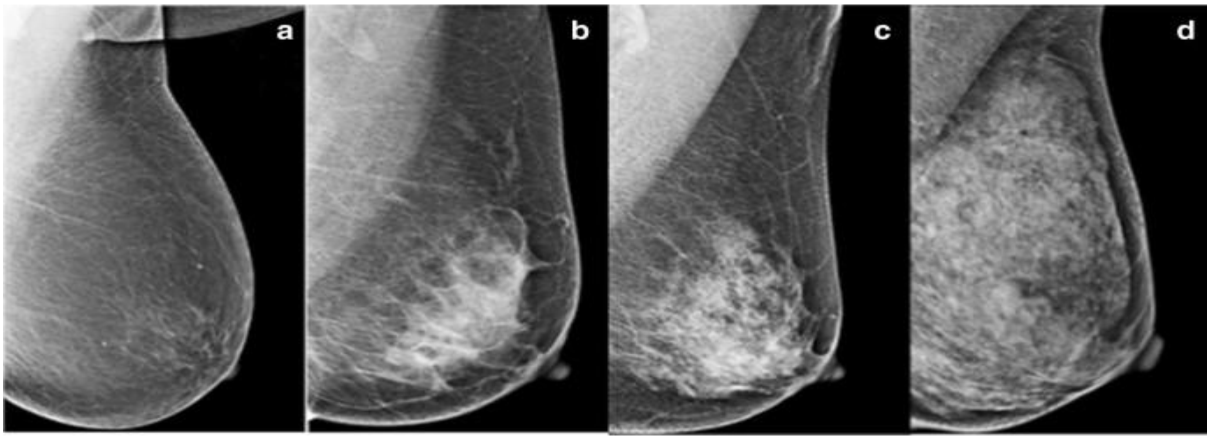

Figure 1. BI-RADS Density Types in Four Types. a) almost entirely fat; b) scattered fibroglandular densities; c) heterogeneously dense; d) extremely dense pattern [11].

Although the exact pathophysiological mechanisms linking elevated mammographic density to an increased incidence of breast cancer remain elusive, it is well established that high parenchymal density severely compromises the diagnostic sensitivity of screening mammography [12,16]. Age represents a critical determinant of both screening sensitivity and specificity [13,14]. Younger women characteristically present with denser fibroglandular tissue compared to older cohorts, a physiological factor that significantly diminishes the diagnostic accuracy of standard mammographic evaluations [13,14]. Furthermore, exogenous hormonal influences alter parenchymal patterns; specifically, combined estrogen and progestin hormone replacement therapies are documented to increase breast density by 3% to 5% [15].
While increasing the screening frequency for patients with dense breasts may facilitate early malignancy detection [17], clinical guidelines in both the United States and Europe increasingly advocate for the integration of complementary imaging modalities alongside standard mammography [18-20]. Consequently, substantial interest has shifted toward utilizing supplemental ultrasonography—administered via either hand-held or automated systems—for dense breast evaluation [20,21].
Ultrasonography has become increasingly integral to breast cancer diagnostic pathways. In asymptomatic populations, supplemental breast ultrasound yields superior sensitivity for detecting occult malignancies in women with dense parenchymal tissue, patients under 50 years of age, and individuals stratified as high-risk [22,23]. Mechanistically, breast ultrasound provides critical diagnostic utility across several clinical indications, including the evaluation of palpable masses inadequately characterized by mammography, the differentiation of cystic from solid lesions, and the assessment of palpable abnormalities associated with focal mammographic asymmetry or completely negative mammographic findings. Additionally, ultrasound serves as the primary modality for evaluating breast implant integrity [22,23]. Depending on the patient's age and specific breast density profile, supplemental ultrasound successfully identifies approximately 10% to 40% of malignancies that are otherwise mammographically occult [22,23].

Building upon these clinical challenges, the present study investigates the correlation between the American College of Radiology (ACR) breast density categories and patient age, while concurrently evaluating how these variables impact specific mammographic and ultrasonographic findings.

METHODS

Study design

This retrospective study was conducted on 222 female patients and data were collected from 1st January 2022 to 31 May 2023. All patients referred to Tyba imaging center that is a private centre for Radiodiagnosis located at Albaida city at Libya.

Data collection

The patients were referred for further evaluation to their complaints whatever breast mass, mastalgia and/or nipple discharge or referred for breast cancer screening, all patients were subjected to mammography followed by complementary ultrasound. Conventional film-screen mammography was executed utilizing standard bilateral two-view protocols, encompassing craniocaudal (CC) and mediolateral oblique (MLO) projections. Parenchymal density was categorized qualitatively in accordance with the American College of Radiology Breast Imaging Reporting and Data System (BI-RADS) four-point assessment scale (categories a to d).

Supplemental ultrasonographic evaluations were performed using a high-resolution Mindray ultrasound system equipped with a 7.5MHz linear array transducer. To optimize imaging geometry and ensure comprehensive parenchymal coverage, patients were examined in the supine position during evaluation of the medial breast quadrants, and transitioned to a contralateral posterior oblique position with elevated arms to facilitate scanning of the lateral quadrants. Whole-breast sonographic sweeps were performed in all cases.

To minimize interobserver variability, a single experienced radiology specialist conducted all clinical breast examinations, mammographic interpretations, and ultrasonographic assessments. Radiographical and sonographic findings were standardized and categorized using the definitive BI-RADS six-point diagnostic scale: BI-RADS 1 (negative), BI-RADS 2 (benign finding), BI-RADS 3 (probably benign), BI-RADS 4 (suspicious abnormality), BI-RADS 5 (highly suggestive of malignancy), and BI-RADS 6 (known biopsy-proven malignancy).

Statistical analysis

Statistical analyses were performed using SPSS software, utilizing descriptive statistics to calculate frequencies and percentages for all categorical variables. The processed data were organized systematically within tabular frameworks, with numerical distributions expressed as absolute counts and corresponding percentages. To evaluate statistical associations between the observed categorical variables under study, Pearson's chi-square test was applied. Statistical significance for all comparative analyses was rigorously defined at a two-tailed P-value threshold of <0.05.

RESULTS

Our study is carried on 222 female patients aged between 32-75 years with a mean 49 years, range 43 years and standard deviation 8.74. The age of patients was distributed into groups as illustrated in table 1.

Table 1. Distribution of patients according to age groups.

Age group	Frequency	Percentage
31-40	38	17.1
41-50	96	43.2
51-60	64	28.8
61-70	20	9.0
71-80	4	1.8
Total	222	100.0

The largest number of patients were from 41-50 years age group which representing around 43.2 % study group number followed by 51-60 years age group was around 28.8%, where 71-80 years age group was the smallest group in number of patient (around 1.8 %). All patients were subjected to mammography and complementary ultrasound. The breast density of patients was assessed and classified according to BIRADS –ACR breast density classification and the relation between age groups and breast density seen in table (2) and figure (1).

Table 2. The relation between age group and ACR breast density among group study (Chi square value 66.1 and P value were 0.000)

Age group		ACR breast density				Total
		ACR a	ACR b	ACR c	ACR d	
	31-40	4	6	12	16	38
	41-50	28	31	23	14	96
	51-60	38	13	13	0	64
	61-70	12	5	3	0	20
	71-80	4	0	0	0	4
Total		86	55	51	30	222

Dense breasts (ACR d) seen only at younger age groups around 16 patients from 31-40 years age group and 14 patients from 41-50 years age group. The largest number of ACR c breast density group was from 41-50 years age group (around 23 patients from 51 patients had ACR c breast density). While in 61-70 years age group were 12 of 20 patients (around 60 %) have fatty breasts (ACR a), also all patients of 71-80 year's age group had fatty breast (ACR a). Mammographic findings were interpreted and classified according to their nature into 3 groups (no abnormality could be detected, benign findings and malignant findings).

Mammographic benign findings including well defined oval iso or hypodense lesion, coarse calcification and post-operative or post radiation skin thickening.

Mammographic suspicious findings including irregular speculated or rounded hyperdense lesions, ill-defined borders, skin thickening or/ and retraction, nipple retraction, architectural distortion and pathological lymph nodes enlargement. Nature of lesion in mammography cross tabulated with breast density among the study group to detect the relation to each other as seen in table 3.

Table 3. The relation between ACR breast density and nature of lesion in mammography among group study (Chi square 12.4 and P value 0.053).

ACR breast density		Nature of lesion in mammography			Total
		No abnormality could be detected	Benign nature	Suspicious nature	
	ACR a	50	18	18	86
	ACR b	32	16	7	55
	ACR c	40	8	3	51
	ACR d	23	5	2	30
Total		145	47	30	222

No abnormality could be detected in around 145 patients (40 patients have ACR c and 23 patients have ACR d) while only 30 patients have a suspicious finding in mammography.

Ultrasound performed for all patients and ultrasound finding also classified into 3 groups (no abnormality could be detected, benign findings and malignant findings). Ultrasonographic benign findings including fibrocystic diseases of breast, breast cyst, fibroadenoma, lipoma, hematoma, post-operative seroma, post radiation skin thickening, duct ectasia, mastitis, abscess and reactive axillary lymph nodes enlargement.

Ultrasonographic suspicious findings include hypoechoic speculated lesions, rounded lesions (longer than wider), heterogeneous solid and cystic lesions, microcalcifiction, soft tissue mass within dilated duct, skin thickening with interstitial edema and pathological axillary lymph nodes enlargement. Nature of lesion in ultrasound cross tabulated with breast density among the study group to detect the relation to each other as seen in table 4.

Table 4. Relation between ACR breast density and nature of lesion in ultrasound among group study (Chi square 11.4 and P value 0.075).

ACR breast density		Nature of lesion in ultrasound			Total
		No abnormality could be detected	Benign nature	Suspicious nature	
	ACR a	27	40	19	86
	ACR b	12	32	11	55
	ACR c	11	34	6	51
	ACR d	3	23	4	30
Total		53	129	40	222

Number of patients with no abnormality could be detected around 53 patients (markedly reduced in comparison with the number of same categories in mammographic examination), marked increase in patient number with benign nature of detected lesions (40 patients had ACR a, 34 patients had ACR c and 23 patients had ACR d), increasing in number suspicious lesions detected in ultrasound (around 40 patients) in comparison with suspicious lesions detected by mammography (around 30 patients). Table (5) and (6) showing distribution of groups study according to nature of lesion in mammography and ultrasound respectively.

Table 5. Distribution according to nature of lesion in mammography

Mammography	Frequency	Percentage
No abnormality could be detected	145	65.3
Benign nature	47	21.2
Suspicious nature	30	13.5
Total	222	100.0

Table 6. Distribution according to nature of lesion in ultrasound among study group.

Ultrasound detection	Frequency	Percentage
No abnormality could be detected	53	23.9
Benign nature	129	58.1
Suspicious nature	40	18
Total	222	100.0

Mammographic and ultrasound findings were interpreted according to the Breast Imaging Reporting and Data system (BI-RADS) diagnostic categories on a six-point scale and its relation to age group is illustrated in table 7.

Table 7. The relation between age group and BIRADS classification among study group (Chi square 30.9 and P value 0.055).

Age groups	BIRADS						Total
	BIRADS 1	BIRADS 2	BIRADS 3	BIRADS 4	BIRADS 5	BIRADS 6	
31-40	7	2	24	3	2	0	38
41-50	25	19	39	10	3	0	96
51-60	13	7	32	9	1	2	64
61-70	4	2	6	4	3	1	20
71-80	2	0	1	0	1	0	4
Total	51	30	102	26	10	3	222

Most of patients classified as BIRADS 3 (around 39 patients from 41-50 years age group and 32 patients from 51-60 years age group) and advised for follow up, around 51 patients classified as BIRADS (completely normal imaging for annual routine mammography as respect to age) while around 36 patients had a suspicious finding in mammography and/or ultrasound and further assessment by biopsy is advised. In our study the sensitivity and specificity of mammography in detection suspicious lesions in fatty breasts (ACR a) around 94.7% and 100 % respectively while the sensitivity and specificity of mammography in detection suspicious lesions in dense breasts (ACR c &d) were around 50% and 100 % respectively.

DISCUSSION

Investigation into mammographic parenchymal patterns spans more than 45 years. Elevated breast density functions as a potent, independent oncological risk factor while simultaneously compromising screening mammography efficacy through a distinct radiological masking effect [8]. The current investigation evaluated a cohort of 222 female patients aged 32 to 75 years (mean: 49 years; range: 43 years) to elucidate the correlations between the American College of Radiology (ACR) breast density categories and patient age, alongside evaluating the subsequent impact of parenchymal variation on mammographic and ultrasonographic outcomes.

The empirical findings demonstrate a distinct inverse relationship between ACR breast density and chronological age. High-density parenchymal patterns (ACR category d) occurred exclusively within younger cohorts, specifically affecting 16 patients in the 31–40 age demographic and 14 patients in the 41–50 demographic. Conversely, involution to adipose tissue predominated in older cohorts: 60% of patients aged 61–70 years and 100% of patients within the 71–80 age presented with entirely fatty breasts (ACR category a). This age-dependent decline in parenchymal density aligns with the epidemiological trends observed by Checka et al. [6]. Notably, outlier phenotypes persisted within this study population; select elderly patients exhibited dense breast architecture (ACR category c or d), whereas certain younger individuals presented with complete fatty involution (ACR category a). Consistent with previous literature, the precise etiology underlying these atypical deviations remains unestablished [6].

In this study parenchymal composition profoundly influenced diagnostic accuracy. As in fatty breasts (ACR category a), mammography demonstrated a diagnostic sensitivity of 94.7% and a specificity of 100%. However, in dense breast phenotypes (ACR categories c and d), mammographic sensitivity precipitously declined to 50%, though specificity remained stable at 100%. This diagnostic degradation corroborates earlier investigations by Mandelson et al., who reported a reduction in mammographic sensitivity from 80% in predominantly fatty tissue to 30% in extremely dense configurations [24].

Similarly, Carney et al. documented a significant divergence in screening accuracy, with mammographic sensitivity falling from 88.2% in entirely fatty breasts to 62.2% in extremely dense tissue, noting that 7.8% of their study cohort fell into the highest density classification [13].

The pathophysiological mechanism driving this diagnostic decrement is rooted in radiographic attenuation: malignant pathologies—whether presenting as soft-tissue masses, microcalcifications, architectural distortions, or developing opacities—manifest as radiopaque white areas on a mammogram. Consequently, dense fibroglandular tissue, which also appears white, physically obscures underlying malignancies, a confounding effect largely absents in radiolucent, adipose-predominant breasts [25,26].

In this series, 10 patients who received false-negative mammographic interpretations were subsequently diagnosed with suspicious lesions via supplemental ultrasonography. These false-negative outcomes are directly attributable to advanced parenchymal density. This finding reinforces the conclusions of Rebolj et al., whose research consistently demonstrated that supplemental ultrasound screening significantly improves the detection of small, invasive malignancies within dense parenchymal environments [27].

Given the inherent limitations of standalone mammography, executing an auxiliary sonographic evaluation following a negative mammogram provides vital clinical utility for patients with dense breast tissue (ACR categories 3 and 4). This multi-modality approach typically identifies invasive occult cancers at a mean size of 9.9 mm, with approximately 90% of these cases presenting with lymph-node-negative staging [28].

CONCLUSION

An inverse correlation typically characterizes the relationship between patient age and the American College of Radiology (ACR) breast density classifications. Elevated parenchymal density significantly compromises the diagnostic sensitivity of screening mammography, thereby impeding the early detection of suspicious breast lesions, particularly in women presenting with dense breast phenotypes (ACR categories c and d). To mitigate this diagnostic limitation, the integration of supplemental breast ultrasonography functions as a critical complementary imaging modality, substantially enhancing the identification of occult malignant pathologies that remain mammographically obscured within dense fibroglandular tissue.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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كثافة الثدي حسب ACR: العلاقة بالعمر وتأثيرها على نتائج التصوير الشعاعي للثدي والموجات فوق الصوتية

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المستخلص
سرطان الثدي هو أكثر أنواع السرطان شيوعًا بين النساء. يمكن أن يؤدي الاكتشاف المبكر عن طريق الفحص والتصوير الشعاعي للثدي التشخيصي إلى تقليل معدل الإصابة بالمرض. تعد كثافة الثدي في ACR عامل خطر في تشخيص سرطان الثدي لدى النساء اللاتي لديهن ثدي كثيف. تنخفض كثافة ACR في الغالب مع تقدم العمر. أجريت دراسة بأثر رجعي على 222 مريضة تتراوح أعمارهن بين 32 و 75 عامًا بمتوسط 49 عامًا ونطاق 43 عامًا، وجميع المريضات خضعن للتصوير الشعاعي للثدي والموجات فوق الصوتية التكميلية، بهدف اكتشاف العلاقة بين كثافة الثدي في ACR والعمر وتأثير كثافة الثدي في ACR على نتائج التصوير الشعاعي للثدي والموجات فوق الصوتية. الثدي الكثيف (ACR d) يُرى فقط في الفئات العمرية الأصغر حوالي 16 مريضة من الفئة العمرية 31-40 عامًا و 14 مريضة من الفئة العمرية 41-50 عامًا، حساسية وخصوصية التصوير الشعاعي للثدي في الكشف عن الآفات المشبوهة في الثدي الدهني (ACR a) حوالي 94.7٪ و 100٪ على التوالي بينما كانت حساسية وخصوصية التصوير الشعاعي للثدي في الكشف عن الآفات المشبوهة في الثدي الكثيف (ACR c & d) حوالي 50٪ و 100٪ على التوالي. عادة ما يكون لكثافة الثدي في ACR علاقة عكسية مع العمر، يمكن تقليل حساسية التصوير الشعاعي للثدي في الكشف المبكر عن آفة الثدي المشبوهة خاصة عند النساء ذوات الثدي الكثيف، يمكن أن يكون إضافة الموجات فوق الصوتية للثدي كأداة تصوير تكميلية مفيدًا في الكشف عن الآفات الماموغرافية الخفية التي لا يمكن اكتشافها في الثدي الكثيف.

الكلمات المفتاحية. سرطان الثدي، التصوير الشعاعي للثدي، كثافة الثدي حسب ACR، BIRADS.