Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 15 [9] August 2026. 138-149

Online ISSN 2277-1808
Journal's URL: http://www.bepls.com
CODEN: BEPLAD

REVIEW ARTICLE **OPEN ACCESS**

Breast Cancer Screening and Diagnostic Modalities: A Comprehensive Review of Mammography, MRI, and Biopsy

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ABSTRACT
One of the most common cancers and a major contributor to cancer-related death in women globally is breast cancer. Improving survival rates and lowering the burden of disease depend heavily on early detection. Breast cancer is detected and confirmed using a variety of screening and diagnostic techniques, such as biopsy, magnetic resonance imaging (MRI), and mammography. Because of its accessibility, affordability, and demonstrated potential to reduce mortality, mammography remains the recommended screening method. The gold standard for a definitive diagnosis is a biopsy, which histopathologically confirms worrisome lesions. Recent developments in breast cancer screening are also highlighted in the review, along with the significance of a multimodal approach for precise diagnosis and efficient patient care. By incorporating these modalities, early detection, prompt treatment, and overall clinical outcomes in breast cancer care can be improved. Recent innovations, including Digital Breast Tomosynthesis (DBT), Contrast-Enhanced Mammography (CEM), Artificial Intelligence (AI)-based imaging, and MRI-guided biopsy, have substantially improved the precision and reliability of breast cancer screening and diagnosis. These advanced technologies enhance lesion detection, support risk-based screening, and assist clinicians in making more accurate diagnostic decisions while minimising unnecessary procedures. The integration of conventional screening methods with these emerging techniques provides a comprehensive approach to breast cancer management, facilitating earlier diagnosis, individualised treatment planning, and improved patient outcomes. Ongoing advancements in imaging technologies and artificial intelligence are expected to further optimise screening strategies and contribute to better healthcare delivery in the future.
Keywords: Breast Cancer; Mammography; Magnetic Resonance Imaging (MRI); Biopsy; Screening Methods; Early Detection; Diagnostic Imaging.

Received 12.07.2026 Revised 30.07.2026 Accepted 21.08.2026

INTRODUCTION

Breast cancer is the most commonly diagnosed cancer among women worldwide and remains a major public health concern due to its high incidence and mortality rates. It originates from the uncontrolled proliferation of breast epithelial cells and is characterised by diverse molecular subtypes and clinical manifestations. Despite significant advances in diagnosis and treatment, breast cancer continues to be one of the leading causes of cancer-related deaths among women globally [1]. Early detection through effective screening programs has been shown to significantly reduce mortality and improve patient outcomes [2]. Screening and diagnostic modalities such as mammography, magnetic resonance imaging (MRI), ultrasonography, and biopsy play crucial roles in the detection and management of breast cancer. Mammography remains the primary screening tool for average-risk women because of its proven ability to detect early-stage disease and reduce breast cancer mortality [3]. MRI offers enhanced sensitivity, particularly in women with dense breast tissue and those at high genetic risk, whereas biopsy remains the gold standard for definitive diagnosis through histopathological examination [4].

Global Epidemiology and Burden of Breast Cancer

Breast cancer is the most frequently diagnosed cancer worldwide and represents a substantial global health burden. According to GLOBOCAN 2022 estimates, approximately 2.3 million new breast cancer cases were diagnosed globally, accounting for nearly 11.6% of all newly diagnosed cancers and making it the most common cancer among women. Furthermore, breast cancer was responsible for approximately 670,000 deaths worldwide in 2022.The incidence of breast cancer varies considerably across different geographical regions. Developed countries generally report higher incidence rates due to lifestyle factors, delayed childbearing, obesity, and widespread screening practices [5]. In contrast, many low- and middle-income countries experience lower incidence but higher mortality rates owing to delayed diagnosis and limited access to healthcare facilities [6]. In India, breast cancer has emerged as the most common cancer among women, surpassing cervical cancer in recent years. The increasing incidence is attributed to urbanization, changing reproductive behaviors, sedentary lifestyles, and improved life expectancy. Despite advancements in treatment, a significant proportion of cases in India are diagnosed at advanced stages, contributing to poorer survival outcomes compared with developed nations.

RISK FACTORS ASSOCIATED WITH BREAST CANCER

Breast cancer is a multifactorial disease influenced by genetic, hormonal, reproductive, lifestyle, and environmental factors. Understanding these risk factors is essential for identifying high-risk individuals and implementing appropriate preventive and screening strategies. Although some risk factors are non-modifiable, others can be controlled through lifestyle modifications and increased awareness [7].

1. Gender and Age

Female sex is the most significant risk factor for breast cancer, with women accounting for nearly 99% of all diagnosed cases. The risk of developing breast cancer increases with age, particularly after 40 years, and the majority of cases are diagnosed in women aged 50 years and older [8].

2. Genetic and Family History Factors

A family history of breast cancer significantly increases an individual's risk. Women with first-degree relatives, such as a mother, sister, or daughter diagnosed with breast cancer, have a higher likelihood of developing the disease [9]. Inherited mutations in the BRCA1, BRCA2, and PALB2 genes are strongly associated with an increased lifetime risk of breast cancer [10].

3. Reproductive and Hormonal Factors

Several reproductive factors influence breast cancer risk. Early menarche (before 12 years of age), late menopause (after 55 years), nulliparity, delayed first pregnancy, and reduced breastfeeding duration increase cumulative exposure to estrogen and consequently elevate breast cancer risk. Long-term use of hormone replacement therapy and certain oral contraceptives may also contribute to increased risk [11].

4. Lifestyle Factors

Lifestyle-related factors play an important role in breast cancer development. Obesity, particularly after menopause, is associated with increased estrogen production from adipose tissue and a higher risk of breast cancer [12]. Physical inactivity, excessive alcohol consumption, smoking, and unhealthy dietary habits have also been linked to elevated risk.

5. Environmental and Radiation Exposure

Exposure to ionizing radiation, especially during adolescence and early adulthood, increases the likelihood of breast cancer development later in life [10]. Environmental pollutants and occupational exposure to carcinogenic substances may also contribute to breast cancer risk, although further research is needed to establish definitive associations [11].

6. Previous Breast Conditions

Women with a history of atypical hyperplasia, ductal carcinoma in situ (DCIS), lobular carcinoma in situ (LCIS), or previous breast cancer have a substantially increased risk of developing invasive breast cancer [12].

IMPORTANCE OF EARLY DETECTION AND SCREENING

Early detection and screening are fundamental components of breast cancer control programs. Identifying breast cancer at an early stage significantly improves treatment outcomes, reduces mortality, and enhances the quality of life of affected individuals [13].

1. Improved Survival Rates

Early-stage breast cancer is associated with substantially higher survival rates compared with advanced-stage disease. The five-year survival rate for localised breast cancer exceeds 90%, whereas survival decreases considerably once the disease has spread to regional or distant sites [14].

2. Reduced Treatment Complexity

Detection of breast cancer at an early stage often allows less invasive treatment options such as breast-conserving surgery and limited chemotherapy. In contrast, advanced disease frequently requires aggressive treatments, including mastectomy, extensive chemotherapy, and radiotherapy [15].

3. Lower Healthcare Costs
Early diagnosis reduces overall treatment costs by minimizing the need for complex surgical procedures, prolonged hospitalization, and advanced therapeutic interventions. This is particularly important in low- and middle-income countries where healthcare resources are limited [16].
4. Enhanced Quality of Life
Women diagnosed at an early stage generally experience better physical, psychological, and social outcomes. Early treatment helps preserve body image, reduces emotional distress, and improves long-term well-being [17].
5. Role of Screening Modalities
Screening methods such as mammography, MRI, and clinical breast examination facilitate the detection of breast abnormalities before clinical symptoms become apparent. Numerous studies have demonstrated that regular mammographic screening can reduce breast cancer mortality by approximately 20–30% among screened populations [18]. MRI further enhances detection in high-risk women and those with dense breast tissue, while biopsy provides definitive confirmation of suspicious lesions [19]. Therefore, effective screening programs combined with public awareness initiatives are essential for reducing the global burden of breast cancer and improving patient outcomes.

OVERVIEW OF BREAST CANCER SCREENING METHODS
Breast cancer screening refers to the systematic use of diagnostic techniques to detect breast cancer at an early stage before the appearance of clinical symptoms. The primary goal of screening is to reduce breast cancer-related mortality through early diagnosis and timely intervention. Various screening modalities are available, including breast self-examination (BSE), clinical breast examination (CBE), mammography, ultrasonography, magnetic resonance imaging (MRI), and biopsy. Among these, mammography remains the most widely accepted and recommended screening tool for average-risk women due to its proven effectiveness in reducing mortality rates [20]. Magnetic resonance imaging (MRI) is commonly used as an adjunctive screening modality in women at high risk of breast cancer, particularly those with dense breast tissue or genetic predisposition [21]. Biopsy is not considered a routine screening method but serves as the definitive diagnostic procedure for confirming suspicious findings detected through imaging techniques. The selection of an appropriate screening method depends on factors such as age, breast density, family history, genetic risk, and overall clinical presentation [22].
I. Mammography
Principle
Mammography is a specialised radiographic imaging technique that utilizes low-dose X-rays to produce detailed images of breast tissue. It is designed to identify abnormalities such as masses, microcalcifications, and architectural distortions that may indicate the presence of breast cancer before clinical symptoms become apparent [11].
During the procedure, the breast is compressed between two plates to obtain high-quality images while minimising radiation exposure and tissue overlap. Standard mammographic examination typically includes two views of each breast: the craniocaudal (CC) view and the mediolateral oblique (MLO) view [24].
Types of Mammography (Table 1)
Advantages: Mammography remains the cornerstone of breast cancer screening because of several clinical advantages [25,26]. **(Figure 1)**

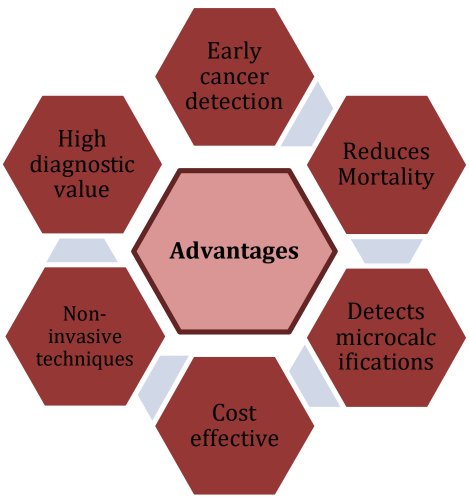


Figure 1. Advantages of Mammography

Table 1: Types of Mammography

Type of Mammography	Description	Advantages	Clinical Applications
Screen-Film Mammography (SFM)	Conventional mammography that records breast images on photographic film.	Widely used historically; effective for breast cancer detection.	Routine breast cancer screening and diagnosis.
Digital Mammography (DM)	Uses digital detectors to capture and store breast images electronically.	Improved image quality, easier image storage and transmission, better performance in dense breasts.	Standard screening and diagnostic evaluation of breast abnormalities.
Digital Breast Tomosynthesis (DBT) *(3D Mammography)*	Acquires multiple low-dose X-ray images from different angles to create a three-dimensional reconstruction of the breast.	Increased cancer detection rate, reduced false-positive recalls, improved visualization of overlapping tissues.	Screening women with dense breast tissue and diagnostic assessment of suspicious lesions.
Contrast-Enhanced Mammography (CEM)	Combines mammography with intravenous iodinated contrast agents to highlight areas of increased blood supply.	Better lesion characterization and improved detection of malignant tumors.	Evaluation of suspicious findings, dense breasts, and preoperative assessment of breast cancer.
Diagnostic Mammography	Specialized mammographic examination performed when breast symptoms or abnormal screening results are present.	Provides detailed imaging of suspicious areas.	Investigation of breast lumps, nipple discharge, breast pain, and abnormal screening findings.
Screening Mammography	Routine mammographic examination performed in asymptomatic women for early cancer detection.	Detects breast cancer before symptoms develop and reduces mortality.	Population-based breast cancer screening programs.

LIMITATIONS AND CLINICAL APPLICATIONS OF MAMMOGRAPHY

Mammography is an effective screening tool for breast cancer; however, it has certain limitations. Its sensitivity is reduced in women with dense breast tissue and younger women. False-positive results may lead to unnecessary anxiety and investigations, while false-negative findings can delay diagnosis. Additionally, mammography involves exposure to low-dose ionizing radiation and may result in overdiagnosis of clinically insignificant lesions [25].

Clinically, mammography is primarily used for breast cancer screening in asymptomatic women aged 40 years and above. It is also employed for diagnostic evaluation of breast symptoms such as lumps, nipple discharge, and breast pain, as well as for monitoring suspicious lesions and assessing treatment outcomes in breast cancer patients [12].

II. Magnetic Resonance Imaging (MRI)

Principle

Magnetic Resonance Imaging (MRI) is an advanced, non-invasive imaging modality that uses a strong magnetic field, radiofrequency pulses, and computer-generated signals to produce high-resolution images of breast tissues. Unlike mammography, MRI does not use ionizing radiation. Breast MRI is typically performed with intravenous administration of gadolinium-based contrast agents, which enhance the visualization of abnormal vascular patterns associated with malignant lesions. Due to its excellent soft-tissue contrast, MRI is highly sensitive for detecting breast cancer, particularly in women with dense breast tissue and those at high genetic risk [26, 14].

Types of Breast MRI (Table 2)

Advantages and Limitations of Breast MRI

Breast MRI offers several advantages in breast cancer detection and evaluation. It has a very high sensitivity (>90%) for detecting breast malignancies and is particularly effective in women with dense breast tissue. Since MRI does not use ionizing radiation, it is considered a safer imaging modality for repeated examinations. It is highly valuable in assessing multifocal, multicentric, and bilateral breast cancers and is useful for monitoring the response to neoadjuvant chemotherapy. Additionally, MRI can detect lesions that may not be visible on mammography or ultrasound [27, 28].

Despite these benefits, breast MRI has certain limitations. It is more expensive than mammography and may not be readily available in all healthcare settings. The technique has lower specificity, which can lead to increased false-positive findings and unnecessary follow-up procedures. MRI examinations require intravenous contrast administration, have longer scanning times, and may cause discomfort in claustrophobic patients. Therefore, it is generally not recommended as a routine screening tool for women at average risk of breast cancer [27, 29, 30].

Table 2: Types of Breast MRI

Type of Breast MRI	Description	Clinical Application
Contrast-Enhanced Breast MRI (CE-MRI)	Uses gadolinium contrast to visualise abnormal blood flow and lesion enhancement.	Breast cancer detection and characterisation.
Screening Breast MRI	Performed in asymptomatic women at high risk of breast cancer.	Screening of BRCA mutation carriers and high-risk women.
Diagnostic Breast MRI	Conducted after abnormal findings on mammography or ultrasound.	Evaluation of suspicious lesions and inconclusive imaging results.
Preoperative Breast MRI	Performed before surgery to determine tumour size and extent.	Surgical planning and assessment of multifocal disease.
Abbreviated Breast MRI (AB-MRI)	Shortened MRI protocol with reduced imaging time.	Rapid screening in women with dense breasts.
MRI-Guided Breast Imaging	MRI used to guide interventions such as biopsy.	Sampling lesions visible only on MRI.

Clinical Applications

i. Screening of High-Risk Women

Breast MRI is recommended for women with BRCA1/BRCA2 mutations, strong family history of breast cancer, or a lifetime breast cancer risk exceeding 20–25% [31].

ii. Evaluation of Dense Breast Tissue

MRI improves cancer detection in women whose dense breast tissue limits mammographic sensitivity.

iii. Preoperative Assessment

MRI helps determine tumor size, multifocality, multicentricity, and contralateral disease before surgery.

iv. Monitoring Treatment Response

MRI is used to assess tumor response during neoadjuvant chemotherapy and guide treatment modifications.

III. Breast Biopsy

Breast biopsy is a diagnostic procedure involving the removal of breast tissue or cells for microscopic examination. It is considered the gold standard for confirming breast cancer and determining tumor characteristics necessary for treatment planning [32].

i. Fine Needle Aspiration Cytology (FNAC)

Fine-needle aspiration cytology (FNAC) involves the insertion of a thin needle into a suspicious breast lesion to obtain cellular material for cytological examination [33].

Advantages and Limitations of Fine Needle Aspiration Cytology (FNAC)

Fine Needle Aspiration Cytology (FNAC) is a widely used diagnostic technique due to its minimally invasive nature, low cost, and rapid turnaround time. The procedure is quick to perform, causes minimal patient discomfort, and provides preliminary diagnostic information within a short period, making it a convenient option for the initial evaluation of breast lesions.

However, FNAC has certain limitations. It provides limited information regarding tissue architecture, which may affect diagnostic accuracy. Compared with core needle biopsy, FNAC generally has lower diagnostic reliability and may occasionally yield inadequate or non-representative samples, necessitating repeat procedures or additional diagnostic investigations [34].

ii. Core Needle Biopsy (CNB)

Core Needle Biopsy utilizes a larger hollow needle to obtain cylindrical tissue samples from the suspicious lesion. It is usually performed under ultrasound, stereotactic, or MRI guidance [35].

Advantages and Limitations of Core Needle Biopsy (CNB)

Core Needle Biopsy (CNB) is a highly accurate diagnostic procedure that preserves tissue architecture, enabling detailed histopathological examination and tumor grading. It also allows assessment of hormone receptor status and HER2 expression, which are essential for treatment planning. Additionally, CNB is less invasive than surgical biopsy while providing reliable diagnostic information.

Despite its advantages, CNB may be associated with minor bleeding, bruising, or discomfort at the biopsy site. Sampling errors can occasionally occur if the tissue specimen does not adequately represent the lesion, and the procedure requires local anaesthesia.

iii. Surgical Biopsy

Surgical biopsy involves partial or complete removal of the suspicious lesion through an operative procedure. It may be classified as incisional or excisional biopsy [36].

Advantages and Limitations of Surgical Biopsy

Surgical biopsy provides large tissue samples and offers the highest level of diagnostic certainty, making it particularly useful when needle biopsy results are inconclusive. However, it is the most invasive biopsy procedure, requiring anaesthesia and incurring higher costs. Additionally, it carries a risk of scarring and postoperative complications and is associated with a longer recovery period.

Advantages and Limitations of Different Biopsy Techniques Types of Breast MRI (Table 3)

Table 3: Advantages and Limitations of Different Biopsy Techniques Types of Breast MRI

Biopsy Type	Advantages	Limitations
FNAC	Simple, rapid, inexpensive, minimally invasive	Limited tissue sampling, lower diagnostic accuracy
Core-Needle Biopsy	High accuracy, histological assessment possible, and receptor testing	Minor bleeding, sampling error possible
Surgical Biopsy	Largest tissue sample, definitive diagnosis	Invasive, costly, requires anaesthesia, longer recovery

Diagnostic accuracy of Mammography, MRI, and Biopsy

Diagnostic accuracy is a critical parameter in evaluating the effectiveness of breast cancer screening and diagnostic modalities. It is commonly assessed using sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Mammography, magnetic resonance imaging (MRI), and biopsy differ considerably in their diagnostic performance due to variations in imaging capabilities and diagnostic objectives. While mammography and MRI are primarily used for screening and lesion detection, biopsy provides definitive histopathological confirmation of malignancy and remains the gold standard for diagnosis [37]. (Table 4)

Table 4: Diagnostic accuracy of Mammography, MRI, and Biopsy

Parameter	Mammography	MRI	Biopsy
Primary Role	Screening	Advanced Imaging/Screening	Definitive Diagnosis
Sensitivity (%)	75–90	90–99	>95
Specificity (%)	85–95	72–90	~100
PPV (%)	20–40	25–50	~100
NPV (%)	>90	>95	>95
Detection in Dense Breasts	Limited	Excellent	Not Applicable
Invasiveness	Non-invasive	Non-invasive	Invasive
Radiation Exposure	Yes	No	No
Diagnostic Confirmation	No	No	Yes

Recent advances in Breast Cancer Screening

Breast cancer screening has undergone remarkable advancements over the past decade, leading to improved detection rates, enhanced diagnostic accuracy, and more personalized patient care. Traditional screening methods such as mammography continue to play a vital role; however, newer technologies including Digital Breast Tomosynthesis (DBT), Contrast-Enhanced Mammography (CEM), Artificial Intelligence (AI)-assisted imaging, and MRI-guided biopsy have significantly improved the ability to detect breast cancer at earlier stages. These innovations aim to overcome the limitations of conventional screening methods, particularly in women with dense breast tissue and those at high risk of developing breast cancer [38].

I. Digital Breast Tomosynthesis (DBT)

Digital Breast Tomosynthesis (DBT), commonly referred to as three-dimensional (3D) mammography, is an advanced imaging technology that acquires multiple low-dose X-ray images of the breast from different angles. These images are reconstructed into thin slices, allowing radiologists to evaluate breast tissue layer by layer and minimise the problem of tissue overlap seen in conventional mammography [39].

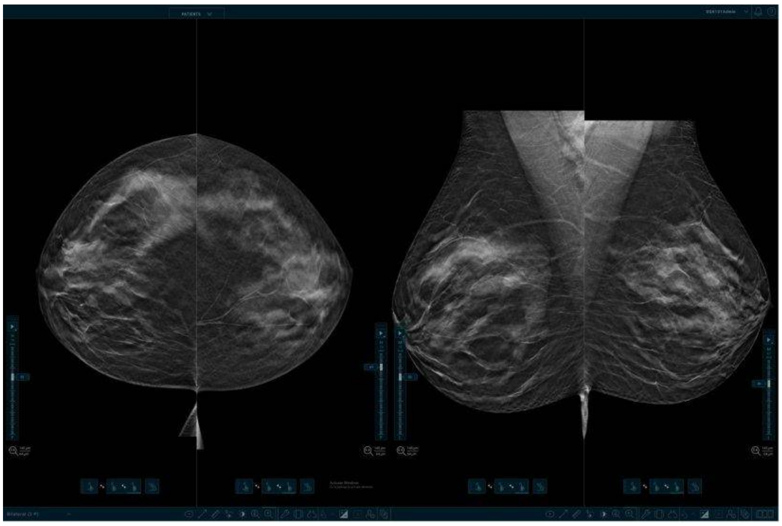


Figure 2(a). Digital Breast Tomosynthesis

Advantage and clinical Significance

Digital Breast Tomosynthesis (DBT) offers several advantages over conventional mammography, including higher breast cancer detection rates, reduced false-positive recalls, improved visualization of breast lesions, and enhanced diagnostic accuracy, particularly in women with dense breast tissue. It also provides better characterisation of masses and architectural distortions. Studies have shown that DBT improves the detection of invasive breast cancers while minimizing unnecessary follow-up examinations, making it an increasingly preferred breast cancer screening modality [40-42].

II. Contrast-Enhanced Mammography (CEM)

Contrast-Enhanced Mammography (CEM) combines standard digital mammography with intravenous administration of an iodinated contrast agent. The contrast highlights areas of increased vascularity, a common feature of malignant breast tumors, thereby improving lesion detection and characterisation [43]. Contrast-Enhanced Mammography (CEM) offers improved sensitivity compared with conventional mammography and provides better characterization of breast lesions, particularly in women with dense breast tissue. It is a cost-effective alternative to MRI, requiring a shorter examination time while maintaining high diagnostic performance. CEM is commonly used for evaluating suspicious breast lesions, assessing tumor extent before surgery, monitoring response to chemotherapy, and detecting recurrent breast cancer, making it a valuable tool in modern breast imaging [16, 39]. Figure 2(b).

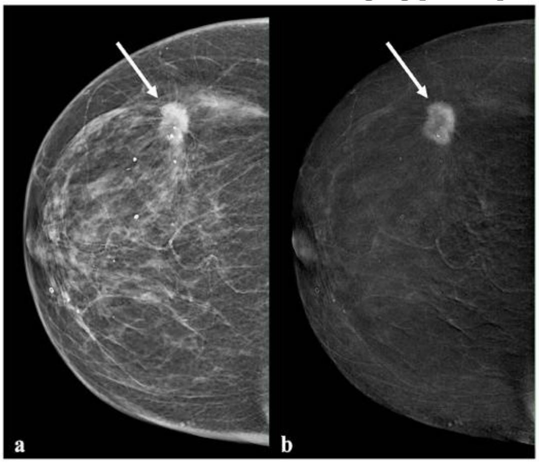


Figure 2(b). Contrast-Enhanced Mammography

Clinical Significance

Recent evidence suggests that the diagnostic performance of CEM approaches that of breast MRI in selected patient populations, making it a promising adjunctive imaging modality in breast cancer screening and diagnosis.

III. AI-Assisted Imaging: Artificial Intelligence (AI) has emerged as a transformative tool in breast cancer screening. AI-based algorithms use machine learning and deep learning techniques to analyse mammographic and MRI images, helping radiologists identify suspicious lesions and improve diagnostic accuracy [11].

AI-assisted imaging has significantly enhanced breast cancer screening by improving cancer detection rates, reducing false-positive and false-negative interpretations, and increasing workflow efficiency. It also promotes greater consistency among radiologists and supports individualised risk assessment. AI applications include automated lesion detection, breast density evaluation, risk prediction modelling, computer-aided diagnosis, and decision-support systems, making it a valuable tool for improving the accuracy and effectiveness of breast cancer screening programs. **Figure 2(c).**

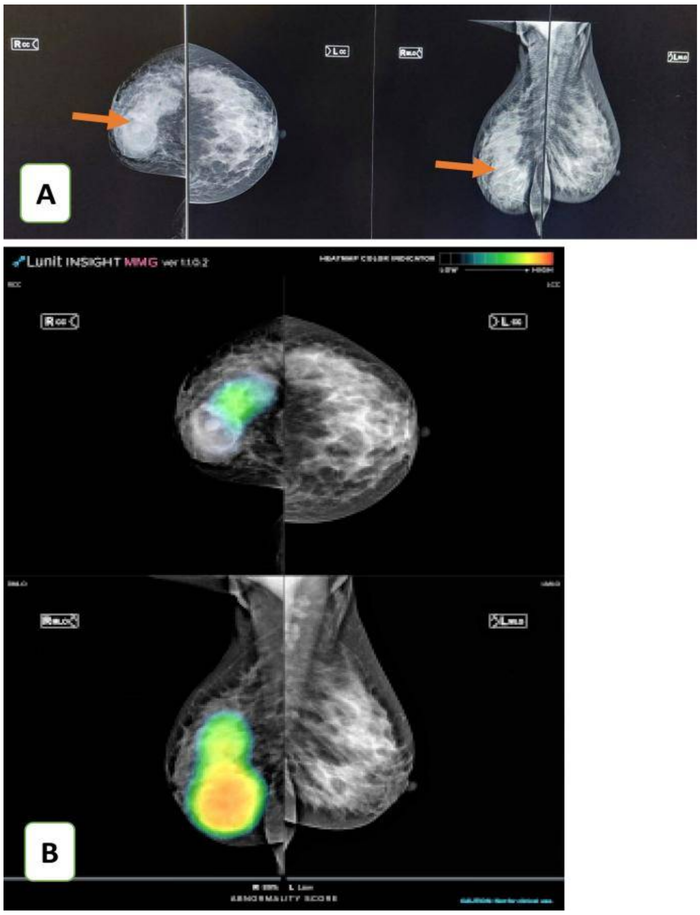


Figure 2(c). AI-Assisted Breast Imaging

CLINICAL SIGNIFICANCE

Research has shown that AI-assisted imaging can achieve performance comparable to experienced radiologists and may improve screening outcomes when integrated into clinical practice.

IV. MRI-Guided Biopsy

MRI-guided biopsy is a specialised minimally invasive procedure used to obtain tissue samples from breast lesions that are visible only on MRI and cannot be accurately localised using mammography or ultrasonography.

Procedure

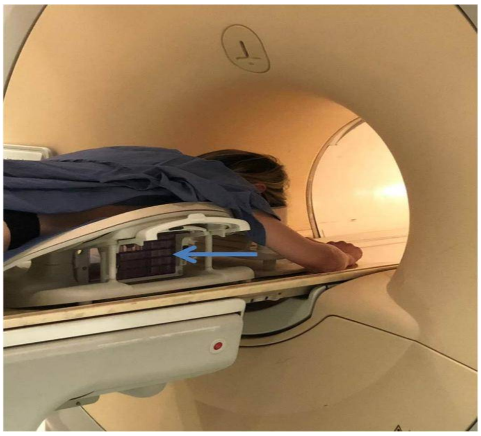
The suspicious lesion is identified using MRI imaging, and a biopsy needle is precisely guided to the target area. Tissue samples are subsequently collected for histopathological evaluation.

MRI-guided biopsy is a highly accurate and minimally invasive procedure used to obtain tissue samples from lesions detected exclusively by MRI. It enables precise targeting of suspicious abnormalities, reduces the need for surgical biopsy, and facilitates definitive diagnosis of occult breast lesions. This technique is particularly useful for evaluating MRI-only abnormalities, confirming suspicious findings, assessing high-risk patients, and supporting pre-treatment planning. However, its widespread use is limited by high procedural costs, limited availability, longer procedure times, and the requirement for specialised equipment and expertise. Figure 2(d)

Clinical Significance

MRI-guided biopsy has become an important component of modern breast imaging by enabling accurate diagnosis of lesions that would otherwise remain inaccessible to conventional biopsy techniques.

Figure 2(a,b,c,d): These four images provide a clear visual representation of the latest technological developments in breast cancer detection and diagnosis. By using three-dimensional breast imaging, Digital Breast Tomosynthesis (DBT) improves lesion detection and minimises tissue overlap. Using contrast agents, Contrast-Enhanced Mammography (CEM) enhances lesion characterisation and tumour vascularity visualisation. By enhancing picture interpretation, boosting diagnostic precision, and lowering false-positive and false-negative results, artificial intelligence (AI)-assisted imaging helps radiologists. Accurate histological diagnosis is made possible by MRI-guided biopsy, which allows for precision sampling of lesions found only by MRI. When taken as a whole, these advancements lead to superior clinical results in the treatment of breast cancer as well as earlier identification, increased diagnostic confidence, and individualised patient care.



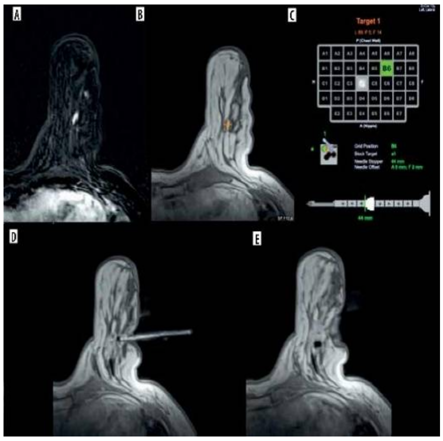


Figure 2(d). MRI-Guided Breast Biopsy

Recent advances in breast cancer screening and diagnosis, including (a) Digital Breast Tomosynthesis (DBT), (b) Contrast-Enhanced Mammography (CEM), (c) Artificial Intelligence (AI)-assisted imaging, and (d) MRI-guided biopsy, highlighting their roles in enhancing early detection, diagnostic accuracy, and patient management.

CHALLENGES AND LIMITATIONS OF CURRENT SCREENING STRATEGIES

Despite significant advances in breast cancer screening, several challenges continue to limit the effectiveness of current screening strategies. One of the major concerns is the occurrence of false-positive and false-negative results, which may lead to unnecessary biopsies, patient anxiety, delayed diagnosis, and increased healthcare costs [41]. Mammography, although considered the gold standard screening tool, demonstrates reduced sensitivity in women with dense breast tissue, resulting in missed cancers and delayed detection.

Another important limitation is overdiagnosis, where screening detects slow-growing or indolent tumors that may never become clinically significant during a patient's lifetime. Overdiagnosis can lead to overtreatment, exposing patients to unnecessary surgical procedures, chemotherapy, and radiotherapy. Additionally, exposure to low-dose ionizing radiation during repeated mammographic examinations remains a concern, particularly among younger women and high-risk populations undergoing frequent screening [42].

Accessibility and affordability also pose significant challenges. Advanced imaging modalities such as MRI offer superior sensitivity but are associated with high costs, limited availability, and longer examination times, restricting their routine use in resource-limited settings. Furthermore, disparities in healthcare infrastructure, socioeconomic status, and public awareness contribute to unequal access to screening services, especially in low- and middle-income countries.

Patient-related factors such as fear, lack of awareness, cultural beliefs, and poor adherence to screening recommendations further hinder the effectiveness of breast cancer screening programs. Therefore, addressing these challenges is essential for improving screening outcomes and reducing breast cancer-related mortality worldwide [43].

FUTURE PERSPECTIVES

The future of breast cancer screening is expected to focus on personalised, risk-based screening approaches that integrate clinical, genetic, and imaging data to optimise early detection and minimise unnecessary interventions. Advances in genomics and molecular diagnostics may enable individualised screening

schedules based on a woman's specific risk profile, thereby improving screening efficiency and cost-effectiveness.
Artificial Intelligence (AI) and machine learning technologies are anticipated to play an increasingly important role in breast cancer screening. AI-assisted systems can enhance image interpretation, improve cancer detection rates, reduce diagnostic errors, and support clinical decision-making. Additionally, the integration of radiomics and deep-learning algorithms may facilitate the identification of subtle imaging features associated with malignancy, leading to earlier diagnosis and improved prognostic assessment.
Emerging imaging modalities such as Contrast-Enhanced Mammography (CEM), abbreviated MRI protocols, and molecular breast imaging are expected to improve diagnostic performance, particularly in women with dense breast tissue. The development of less invasive and more accurate biopsy techniques, including image-guided vacuum-assisted biopsy and liquid biopsy, may further enhance diagnostic precision while reducing patient discomfort.
Future screening strategies should also emphasise increasing public awareness, expanding access to screening services, and implementing cost-effective technologies in underserved regions. Such efforts will contribute to reducing global disparities in breast cancer detection and improving patient outcomes.

DISCUSSION

One of the biggest health issues facing women globally is breast cancer, which highlights the necessity of efficient screening and diagnostic techniques. MRI, biopsy, and mammography all have different but complementary functions in the diagnosis and treatment of breast cancer. Due to its accessibility, cost, and proven capacity to lower breast cancer mortality through early diagnosis, mammography continues to be the mainstay of population-based screening. Superior sensitivity is provided by MRI, which is especially useful for women with high-risk profiles, hereditary predispositions, and dense breast tissue. However, compared to mammography, it is more expensive, less specific, and less accessible, which restricts its broad use. MRI may improve cancer detection rates, but it also raises the risk of false-positive results and necessitates further testing. Because it provides crucial details on tumour type, grade, and receptor status, in addition to histological confirmation of malignancy, biopsy remains the gold standard for a definitive diagnosis. Tissue diagnosis remains essential for treatment planning and therapeutic decision-making, even when imaging can detect worrisome anomalies. Digital breast tomosynthesis, contrast-enhanced mammography, AI-assisted imaging, and MRI-guided biopsy are examples of recent developments that have increased the possibilities of breast cancer screening and improved diagnostic accuracy. However, the efficacy of existing screening methods is still impacted by issues with cost, accessibility, overdiagnosis, and patient compliance. All things considered, the best method for detecting and treating breast cancer is an integrated approach that combines mammography for routine screening, MRI for certain high-risk populations, and biopsy for conclusive diagnosis.

CONCLUSION

Since breast cancer still poses a significant global health burden, increasing survival rates and lowering mortality rates depend on early detection and precise diagnosis. MRI, biopsy, and mammography are essential elements of modern breast cancer screening and diagnostic procedures. Due to its established efficacy, accessibility, and affordability, mammography continues to be the main screening method. While biopsy is the final diagnostic technique through histological confirmation of suspicious lesions, MRI offers higher sensitivity and is especially helpful for women with thick breasts and increased genetic risk. Digital breast tomosynthesis, contrast-enhanced mammography, AI-assisted imaging, and MRI-guided biopsy are examples of recent technical developments that have greatly improved patient care and diagnostic performance. However, issues including false-positive results, overdiagnosis, restricted access, and financial limitations still affect how successful screening is. Optimising breast cancer detection and care requires a multidisciplinary, patient-centred strategy that combines cutting-edge imaging technology with histological examination. Future advancements in less invasive diagnostic methods, artificial intelligence, and tailored screening are anticipated to increase screening accuracy, enable earlier detection, and eventually improve clinical outcomes for women globally.

ACKNOWLEDGEMENTS

The authors express their sincere gratitude to their respective institutions for providing the academic environment, facilities, and resources necessary for the successful completion of this review manuscript. The authors also acknowledge the contributions of researchers whose published work has provided valuable insights for the preparation of this article.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest, financial or otherwise, related to this work.

AUTHOR'S CONTRIBUTION

[Sudhir]: Conceptualization, literature review, study design, and manuscript drafting.
[Reetika Gupta]: Literature review, data analysis, manuscript writing, editing, and formatting.
[Dr. Ashutosh Badola]: Literature review, data collection, and manuscript editing.
[Dr. Abhishek Bhardwaj]: Literature review, data collection, and critical revision of the manuscript.
[Dr. Esha Vatsa]: Data analysis, manuscript drafting, and editing.
[Dr. Nitin Kumar]: Literature review, reference management, and manuscript editing.
[Dr. Amandeep Singh]: Supervision, manuscript review, and final approval.
(All authors have read and approved the final manuscript.)

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

DATA AVAILABILITY

The data supporting the findings of this study are available within the article. No additional external datasets were generated or analysed during this study.

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CITATION OF THIS ARTICLE

Kanwal S, Sumya G, Ahmad Farzad Q, Saba S, Rabia L, Kaneez F. Evaluation of Bronchial Epithelial Histological Changes and Serum IgE Levels in the Pathogenesis of Bronchial Asthma. Bull. Env. Pharmacol. Life Sci., Vol 15 [9] August 2026. 138-149