Digital Breast Tomosynthesis in the Evaluation of Mammographically Indeterminate Breast Lesions: A Comprehensive Review

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Abstract

Background: Digital Breast Tomosynthesis (DBT) has emerged as one of the most impactful technological advancements in breast imaging, particularly for the evaluation of mammographically indeterminate lesions. Conventional 2D digital mammography (DM) remains the cornerstone of breast cancer screening, yet its inherent limitation—tissue overlap—often results in false-positive recalls, ambiguous findings, and missed malignancies. DBT addresses this challenge by generating quasi-three-dimensional reconstructions that allow radiologists to scroll through thin slices of the breast, improving visualization of structures otherwise obscured on 2D images. As a result, DBT enhances lesion conspicuity, characterization, and localization, reducing diagnostic uncertainty and increasing confidence in distinguishing benign from suspicious abnormalities.

This comprehensive review examines the physics, technological principles, acquisition techniques, and interpretation strategies underpinning DBT, with emphasis on how these factors contribute to its superior performance in evaluating questionable mammographic findings. Special attention is given to system design, acquisition geometry, reconstruction algorithms, reading workstations, radiation dose considerations, and the comparative advantages and limitations relative to conventional DM. The review further explores how DBT optimizes anatomical visualization of normal breast structures and pathological entities. A detailed radiopathological correlation is provided for a broad spectrum of benign, developmental, inflammatory, traumatic, proliferative, and neoplastic lesions—highlighting how DBT features can improve diagnostic accuracy across these categories.

DBT's increased cancer detection rates, particularly for invasive cancers, and its reduction in recall rates have been consistently demonstrated across multiple clinical studies. Yet its limitations—radiation dose, increased reading time, potential artifacts, and variable performance in extremely dense breasts—remain areas of active research and technological refinement. As clinical adoption expands, understanding these nuances is essential for radiologists to maximize diagnostic performance and implement evidence-based protocols.

In conclusion, DBT serves not only as a complementary problem-solving tool but increasingly as a primary imaging modality for indeterminate mammographic findings. By reducing the ambiguity inherent in 2D mammography and improving lesion characterization, DBT enhances diagnostic confidence, supports more accurate patient management, and represents a pivotal advancement in modern breast imaging practice.

Keywords: *Digital Breast Tomosynthesis, Mammography, Breast Lesions*

Introduction

Digital breast imaging has advanced significantly with the introduction of Digital Breast Tomosynthesis (DBT), which offers quasi-three-dimensional visualization to overcome the tissue-overlap limitations of traditional digital mammography (DM). While DM remains the backbone of both screening and diagnostic imaging, its limitations become most apparent in the assessment of indeterminate findings—including asymmetries, architectural distortions, and equivocal masses—which often lead to additional imaging and increased recall rates. DBT improves lesion conspicuity and reduces ambiguity by enabling radiologists to scroll through thin breast slices, thereby improving diagnostic accuracy and confidence [1].

Despite its growing adoption, the specific role of DBT in the evaluation of mammographically questionable lesions has not been comprehensively consolidated in the literature. Although studies demonstrate improved cancer detection and reduced false-positive rates, the magnitude of these benefits varies depending on breast density, lesion type, acquisition technique, reconstruction method, and radiologist reading experience. Variability in technological implementation and image interpretation strategies underscores the need for a structured evaluation linking DBT physics and system architecture to clinical and diagnostic performance [2].

The aim of this review is to provide a detailed synthesis—rooted in radiodiagnostic expertise—of the value of DBT in the assessment of mammographically indeterminate lesions. This includes clarification of DBT physics, acquisition geometry, reconstruction algorithms, dose considerations, reading methodologies, and workstation requirements. Additionally, the review integrates a broad radiopathological overview to guide interpretation of both benign and malignant lesions as seen through DBT.

The research gap addressed here is the absence of a comprehensive resource that correlates DBT technical principles with clinical and pathological findings specifically in cases where mammography yields ambiguous results. By bridging this gap, this review aims to enhance diagnostic algorithms, support radiologists in complex cases, and contribute to earlier and more accurate detection of breast abnormalities [3].

Tomosynthesis Mammography

Tomosynthesis mammography is grounded in the same fundamental principles as digital mammography but differs in its acquisition geometry and reconstruction approach. Instead of obtaining a single planar projection, the x-ray tube moves in an arc across a limited angle while capturing a series of low-dose images from different perspectives. These projections are then reconstructed into thin slices, typically 1 mm thick, allowing radiologists to visualize individual planes of tissue. This technique reduces the effect of overlapping structures that frequently obscure lesions on 2D images, particularly masses and architectural distortions. The result is improved lesion detectability, more accurate margin assessment, and enhanced discrimination between summation artifacts and true pathology [2].

The physics of tomosynthesis relies on principles of limited-angle tomography, where projection data acquired over a defined angular range are used to reconstruct sectional slices. Modern DBT systems employ high detective quantum efficiency (DQE) flat-panel detectors, enabling low-noise acquisition while maintaining spatial resolution sufficient for microcalcification visibility. X-ray tube motion may follow step-and-shoot or continuous trajectories, each influencing motion blur, dose distribution, and projection fidelity. The selection of angular span, number of projections, and exposure allocation plays a critical role in image quality, depth resolution, and artifact behavior. Manufacturers vary in their detector technologies and acquisition geometries, contributing to differences in image appearance and diagnostic performance across systems [3].

In clinical practice, tomosynthesis is particularly valuable in reducing false-positive findings that typically arise from superimposed parenchymal tissue on 2D mammography. Multiple studies have shown that DBT enhances the characterization of focal asymmetries by revealing their true three-dimensional morphology, distinguishing between real structural abnormalities and summation shadows. Architectural distortion, one of the most challenging mammographic findings due to its subtle presentation, is also more readily identified on DBT due to improved depiction of converging lines and tissue disruption. This enhanced visualization has translated into increased cancer detection rates, particularly of invasive cancers, and reduced recall rates in both screening and diagnostic populations[4]. Physics underlying tomosynthesis mammography incorporates principles of x-ray attenuation, projection imaging, and computational reconstruction. Unlike full-angle computed tomography, DBT acquires data across a limited arc, which inherently constrains depth resolution but significantly reduces radiation exposure while maintaining diagnostically useful sectional images. The detector captures multiple projections at varying orientations relative to the breast, and reconstruction algorithms synthesize these into thin slices that approximate true tissue planes. Modern systems optimize exposure distribution to maintain adequate signal-to-noise ratio (SNR) across all projections, ensuring that each reconstructed slice maintains sufficient contrast for lesion visualization, even in dense parenchyma [5]. The technique also benefits from advancements in detector technology, particularly the use of amorphous selenium or amorphous silicon flat-panel detectors, which offer high quantum efficiency and stability. These detectors minimize image noise and enhance low-contrast resolution, enabling detection of subtle soft-tissue distortions. Additionally, improvements in x-ray tube design, such as faster rotation capability and stable focal spot performance, ensure consistent projection quality during acquisition. The integration of antiscatter grids, dose modulation algorithms, and rapid readout mechanisms further contributes to the fidelity of DBT images, reducing scatter-induced blur and maintaining clarity across the reconstructed planes [6].

Another critical component of DBT physics is its interaction with breast density and parenchymal patterns. Dense breast tissue often masks underlying lesions in 2D mammography due to the overlap of fibroglandular structures. Tomosynthesis reduces this issue by separating the breast volume into individual slices, improving detectability of low-contrast lesions and margins. Studies have demonstrated significantly improved visualization of masses and architectural distortions in dense breasts, supporting DBT’s utility as a problem-solving tool when DM findings are indeterminate. The capacity to scroll through slices allows radiologists to identify subtle distortions that may not be apparent on a single projection image, particularly when evaluating spiculated lesions or early invasive cancers [7].

Digital Breast Tomosynthesis Mammography: Tomosynthesis main features

Tomosynthesis systems share several key features that distinguish them from standard digital mammography. One essential feature is the limited-angle acquisition, which allows multiple low-dose projections to be captured during a single compression cycle. The angular range varies among manufacturers, typically between 15 and 50 degrees, and this variation directly affects depth resolution and artifact formation. Systems with larger angular spans generally produce slices with better separation of overlapping tissues but at the cost of potentially increased motion blur or dose, while narrower angles offer faster acquisition and reduced radiation. These system-level design variations can influence radiologist preference and diagnostic confidence, especially when evaluating subtle architectural distortions or faint spiculations in indeterminate lesions [8].

Another important feature of DBT systems is their capacity to provide both reconstructed tomographic slices and synthesized 2D images derived computationally from projection data. Synthesized 2D images eliminate the need for an additional full-field 2D mammogram, thereby reducing total radiation dose while maintaining a familiar viewing format for radiologists. Studies have shown that synthesized 2D images combined with DBT offer diagnostic performance comparable to DBT plus traditional DM in many clinical scenarios. This hybrid approach improves workflow efficiency and reduces patient exposure without compromising the sensitivity for detecting masses and architectural distortions that are often ambiguous on mammography alone [9].

DBT systems also incorporate automated exposure control (AEC) mechanisms that adjust tube current and exposure time according to breast thickness and density, ensuring optimized image quality across all projections. The dynamic nature of AEC in tomosynthesis must account for variations in x-ray path length as the tube moves along its trajectory, leading to more complex modulation algorithms than those used in 2D mammography. Proper exposure control is crucial for maintaining uniform SNR throughout the reconstructed volume, particularly when imaging dense breasts or subtle lesions that require precise depiction. These features collectively enhance DBT's reliability as a problem-solving modality in cases where conventional mammography is inconclusive [10].

General system design in digital breast tomosynthesis incorporates coordinated motion of the x-ray tube, stable compression of the breast, and high-performance digital detectors that acquire multiple projections across a limited angular range. The x-ray tube follows a predetermined trajectory, either continuous or step-and-shoot, while the detector remains stationary to capture sequential low-dose images. System rigidity, geometric accuracy, and synchronization between tube motion and detector readout are critical to ensuring consistency across projections. Any deviation can introduce artifacts into the reconstructed slices, particularly when evaluating subtle architectural distortions or asymmetries that require precise spatial fidelity. These engineering aspects differentiate tomosynthesis from traditional 2D mammography, where only a single static projection is acquired [11].

Another key component of system design involves the integration of high-detector quantum efficiency flat-panel detectors, which enable rapid capture of projection images while maintaining low noise and adequate spatial resolution. Unlike detectors used solely for 2D mammography, DBT detectors must handle rapid sequential exposures with minimal lag to avoid temporal blurring. Additionally, the design must support uniform modulation transfer function (MTF) across varying projection angles to prevent degradation of reconstructed slices. System manufacturers may incorporate advanced readout electronics, improved scintillator materials, or optimized photoconductor layers to achieve consistent performance across views, especially when imaging dense breasts or evaluating indeterminate lesions where subtle differences are diagnostically meaningful [12].

System design also extends to ergonomic considerations such as patient positioning, compression stability, and workflow integration. Compression paddles must maintain uniform pressure throughout the acquisition arc to minimize motion and ensure consistent breast thickness, which directly impacts dose distribution and reconstruction accuracy. The gantry structure must allow unobstructed tube motion without compromising patient comfort or image geometry. Furthermore, DBT systems increasingly support multimodal integration, enabling radiologists to review DBT slices alongside synthesized 2D images, prior mammograms, and adjunct imaging such as ultrasound or MRI. These design features collectively enhance diagnostic efficiency and support the practical implementation of tomosynthesis as a problem-solving modality for mammographically ambiguous findings [13].

Difference from Digital Mammography (DM)

Digital Breast Tomosynthesis differs from Digital Mammography primarily in its ability to reduce the impact of tissue overlap, which is a major limiting factor in the diagnostic evaluation of mammographic abnormalities. Traditional 2D mammography compresses complex three-dimensional breast structures into a single planar image, often obscuring lesions or creating summation artifacts that mimic pathology. In contrast, tomosynthesis acquires multiple low-dose projections during a single compression, enabling reconstruction into thin slices that radiologists can scroll through. This improves visualization of lesion margins and internal architecture, providing greater confidence when interpreting ambiguous mammographic findings such as focal asymmetries or architectural distortions [14].

Another significant difference lies in lesion characterization. While 2D mammography is highly sensitive for microcalcifications, it is less effective in distinguishing between true masses and superimposed breast tissue. Tomosynthesis enhances mass visualization by improving the clarity of their shapes, margins, and spatial relationships with surrounding structures. Studies have shown that DBT improves the identification of spiculated lesions, subtle distortions, and invasive cancers that may be occult on 2D images alone. The ability to view lesions in multiple planes reduces false positives and increases diagnostic specificity, particularly in women with dense breast parenchyma where traditional mammography often underperforms [15].

Workflow and interpretation also differ significantly between DM and DBT. Digital mammography typically presents a set of four standard views that radiologists interpret as static images, whereas DBT produces a volumetric dataset consisting of dozens of reconstructed slices per view. This substantially increases the amount of information available, requiring more time for interpretation but providing richer diagnostic detail. Although synthesized 2D images can reduce dependence on additional DM views, radiologists must still become accustomed to reviewing tomographic slices and identifying subtle features that may not be apparent on 2D projections. The transition from DM to DBT thus requires adjustments in reading strategies, workstation design, and training to optimize diagnostic accuracy [16].

Technique: Image Acquisition.

Image acquisition in tomosynthesis begins with positioning the breast under compression, followed by the movement of the x-ray tube along a predefined arc where multiple low-dose projection images are acquired. The number of projections typically ranges from 9 to over 25 depending on the system, and each projection captures a slightly different angle of the breast. The acquisition time is generally short, often between 3 and 10 seconds, which helps minimize patient motion and blurring that could degrade reconstruction accuracy. Maintaining consistent breast thickness and stability during this interval is essential, as even minimal motion can introduce artifacts that obscure subtle lesions such as early architectural distortion or faint spiculations [17].

Exposure allocation during DBT acquisition is designed to ensure that each projection receives an appropriate amount of radiation to achieve a sufficient signal-to-noise ratio while keeping total patient dose within acceptable limits. Modern systems use automatic exposure control algorithms that modulate tube current and exposure time dynamically as the tube moves through its trajectory, accounting for variations in tissue thickness and attenuation. This allows uniform exposure across all projection angles and contributes to the reconstruction of slices with consistent contrast and clarity. These parameters are particularly important when evaluating indeterminate lesions, as slight inconsistencies in projection quality may mask the subtle signs of malignancy [18].

The geometry of image acquisition varies across DBT systems, with differences in angular span, projection count, and exposure distribution influencing the quality of reconstructed images. Wider angular spans generally provide improved depth resolution by generating greater parallax between projections, but they may increase acquisition time and risk of motion artifacts. Conversely, narrower spans offer faster acquisition but at the potential cost of reduced separation of overlapping tissues. Manufacturers balance these trade-offs through optimized acquisition protocols tailored to clinical use, ensuring acceptable spatial and contrast resolution across a wide range of breast densities and lesion types. These geometric considerations are central to DBT's role in clarifying mammographically ambiguous findings [19].

Compression

Compression plays a pivotal role in digital breast tomosynthesis by stabilizing the breast during acquisition and ensuring consistent tissue thickness across all projection angles. Adequate compression reduces motion artifacts, minimizes x-ray scatter, and improves image sharpness, which are critical for reconstructing high-quality tomographic slices. Unlike digital mammography, DBT requires the breast to remain stable for the duration of the acquisition arc, making the quality of compression even more important. Although compression force in DBT is typically similar to that used in 2D mammography, some systems allow slightly reduced force due to improved lesion visibility in reconstructed slices, resulting in better patient comfort without compromising diagnostic performance [20].

Uniform compression also enhances the accuracy of automatic exposure control and reduces variations in attenuation across projections. When the breast is compressed inconsistently—such as when there is uneven tissue distribution or inadequate paddle contact—projection images may exhibit differences in noise and contrast that propagate into the reconstructed volume. This can obscure subtle findings, particularly when evaluating indeterminate lesions such as faint architectural distortion or small spiculated masses. A stable and symmetrical compression technique ensures that all areas of the breast are adequately visualized and reduces the likelihood of artifacts that may mimic pathology or mask true lesions [21].

Additionally, compression influences dose efficiency, as a uniformly compressed breast reduces the x-ray path length and therefore requires less radiation to achieve diagnostic image quality. This is an important consideration because DBT acquisition involves multiple exposures; optimizing compression helps maintain a reasonable cumulative dose. Well-applied compression also separates overlapping tissue planes, enhancing depth resolution within the reconstructed slices. This improved separation allows radiologists to distinguish between summation shadows and true structural abnormalities more effectively, reinforcing the role of DBT as a problem-solving tool when conventional mammography results are equivocal [22].

Proper positioning is essential in digital breast tomosynthesis because accurate placement of the breast determines the completeness of anatomical coverage and the clarity of reconstructed slices. As in digital mammography, standard craniocaudal (CC) and mediolateral oblique (MLO) views are used, but positioning errors become more impactful in DBT due to the volumetric nature of the dataset. If the breast is not fully included within the detector field, reconstructed slices may omit peripheral tissue where lesions can hide, particularly in the posterior or inframammary regions. Consistent and optimized positioning ensures full visualization of glandular tissue, improves lesion detectability, and minimizes the risk of false-negative interpretations in patients with ambiguous mammographic findings [23].

The technical requirements for positioning in DBT also include ensuring that the pectoral muscle is adequately visualized in the MLO view and that the breast is pulled forward to reduce skin folds and overlapping structures. Skin folds introduce artifacts during reconstruction that can mimic architectural distortion, complicating interpretation. Proper traction of the breast helps spread the tissues more evenly across the detector surface, reducing superimposition and enhancing the depth resolution of the reconstructed slices. These positioning principles are especially important when evaluating indeterminate lesions, where subtle distortions or faint masses may only be visible on well-positioned tomosynthesis images [24].

Furthermore, positioning impacts radiation dose distribution and affects the geometric accuracy of projections across the full acquisition arc. Poor positioning results in uneven breast thickness, which can lead to inconsistent attenuation across projections and negatively affect automatic exposure control. This discrepancy may reduce the uniformity of reconstructed slices and create areas with increased noise or reduced contrast. Adequate positioning also optimizes the visibility of posterior lesions, which are among the most frequently missed abnormalities in both screening and diagnostic mammography. Attention to these technical parameters reinforces the value of DBT when clarifying equivocal mammographic findings or resolving ambiguities created by tissue overlap [25].

The number of projections acquired in digital breast tomosynthesis plays a central role in determining image quality, depth resolution, and the clarity of reconstructed slices. Most commercial DBT systems acquire between 9 and 25 projections over an angular range that typically varies from 15 to 50 degrees. A higher number of projections generally provides improved sampling of the breast volume, which enhances the ability of reconstruction algorithms to separate overlapping tissues. This results in better detection of subtle abnormalities such as architectural distortions or faint spiculations that may be obscured on 2D mammography. However, increasing projection count must be balanced against acquisition time and radiation dose to maintain clinical feasibility and patient safety [26].

Different manufacturers adopt varying strategies for projection number and angular distribution, influencing the appearance and diagnostic performance of DBT images. Systems using a larger number of evenly spaced projections tend to exhibit smoother reconstructed slices with reduced slice-to-slice discontinuity, allowing radiologists to more accurately track lesion morphology across planes. Conversely, systems with a smaller number of projections may rely on advanced reconstruction algorithms to compensate for limited angular sampling. These differences can affect the visualization of masses, distortions, and calcifications, making it important for radiologists to understand their system's acquisition geometry when evaluating mammographic findings that are ambiguous or indeterminate [27].

The relationship between projection count and radiation dose is also clinically relevant. Because each projection contributes a small fraction of the total dose, increasing the number of projections may raise overall exposure, though modern systems use optimized exposure allocation to control dose levels. Advances in detector sensitivity and noise-reduction algorithms have allowed manufacturers to maintain or even reduce dose while still acquiring the necessary number of projections for high-quality reconstruction. Clinically, maintaining a balance between sufficient projection sampling and dose limitations is essential, especially when DBT is used as a problem-solving tool in addition to conventional views for evaluating equivocal findings [28].

Tomosynthesis Reconstruction Algorithms

Tomosynthesis reconstruction algorithms are essential for converting the limited-angle projection data into clinically meaningful sectional images. The most commonly used technique is filtered back projection (FBP), which applies mathematical filters to projection images before back-projecting them into a volume. FBP is computationally efficient and produces slices rapidly, making it suitable for clinical workflows; however, it is more sensitive to noise and artifacts due to the incomplete angular sampling inherent to DBT. These limitations can affect the clarity of subtle architectural distortions, particularly in regions with complex overlapping tissue. Despite this, FBP remains widely implemented because of its speed and acceptable diagnostic quality in most clinical scenarios [29].

To address the limitations of FBP, many manufacturers employ iterative reconstruction algorithms that refine the image through repeated forward and backward projections while incorporating statistical models of noise and system geometry. Iterative techniques are better at reducing noise and enhancing contrast, leading to improved delineation of masses and distortions, especially in dense breasts. These algorithms can suppress out-of-plane artifacts and improve depth resolution, enabling more accurate characterization of indeterminate lesions. Although iterative reconstruction requires greater computational power and longer processing times compared to FBP, advancements in hardware and software have allowed many systems to integrate these methods into routine clinical use [30].

Hybrid reconstruction approaches, combining elements of FBP and iterative methods, have also gained attention for their ability to balance computational efficiency with image quality. These methods use FBP to generate an initial estimate of the tomographic slices, followed by limited iterative refinement to enhance key features without dramatically increasing reconstruction time. Such hybrid algorithms improve visualization of subtle findings, making them particularly useful in evaluating the fine structural changes associated with early malignancy or suspicious distortions. As reconstruction technology continues to evolve, future developments may further enhance image resolution and artifact control, ultimately strengthening the diagnostic performance of DBT for resolving mammographically ambiguous abnormalities [31].

Reconstruction time is an important operational factor in digital breast tomosynthesis, as it affects workflow efficiency and the speed at which images become available for interpretation. Early DBT systems using filtered back projection often required several seconds to reconstruct a full set of slices for each view, but advances in computational hardware and algorithm optimization have significantly reduced processing time. Modern systems commonly achieve near real-time reconstruction, enabling radiologists to access images almost immediately after acquisition. This rapid reconstruction supports high-throughput environments such as screening programs, where timely image availability is essential for maintaining patient flow and minimizing delays in diagnostic evaluation [32].

The choice of reconstruction algorithm directly influences reconstruction time. While filtered back projection is fast due to its computational simplicity, iterative reconstruction methods require multiple cycles of forward and backward projection, increasing processing demands. Early generations of iterative algorithms were less feasible for clinical use because of their lengthy reconstruction times; however, improvements in graphics processing units (GPUs) and parallel computing have enabled substantial acceleration. As a result, many DBT systems now integrate iterative or hybrid algorithms without significantly compromising workflow efficiency, allowing radiologists to benefit from enhanced image quality while maintaining practical turnaround times [33].

Reconstruction time also affects the potential integration of advanced post-processing techniques such as synthetic 2D image generation, enhancement filters, and artifact reduction tools. These tasks add computational workload to the system and must be optimized to avoid bottlenecks in image review. Efficient reconstruction is especially important when DBT is used in diagnostic settings, where rapid assessment of indeterminate lesions is crucial for timely clinical decision-making. Streamlining reconstruction ensures that radiologists can promptly evaluate complex findings, improving the accuracy and speed of diagnostic pathways for patients with ambiguous mammographic abnormalities [34].

Image display and reading methods in digital breast tomosynthesis differ significantly from traditional mammography because of the volumetric nature of DBT datasets. Instead of reviewing a single 2D image per projection, radiologists scroll through a stack of thin slices, typically 1 mm thick, allowing assessment of each tissue plane separately. This approach enhances the visualization of masses, distortions, and asymmetries by minimizing obscuration from overlapping tissue. Radiologists must therefore adapt to a more dynamic reading method, which requires attention to subtle slice-to-slice changes that may reveal pathology not visible on standard mammography. This interactive mode of viewing improves diagnostic confidence, particularly when evaluating indeterminate lesions that are ambiguous on 2D imaging [35].

The way images are displayed can also influence diagnostic performance. Many systems offer both thick-slab and thin-slice views, each serving complementary roles in interpretation. Thin slices help detect small or subtle architectural distortions by eliminating tissue overlap, whereas thick slabs can enhance visibility of larger masses or groups of calcifications by integrating multiple slices into a single composite view. Synthesized 2D images, generated from DBT projections, further support interpretation by providing a familiar planar representation without the need for additional radiation. These display tools allow radiologists to switch between different views quickly and systematically, improving workflow and lesion localization when assessing equivocal mammographic findings [36].

Reading methods for DBT continue to evolve as experience grows and technology advances. Some radiologists adopt a systematic scrolling technique, evaluating the breast from anterior to posterior, while others alternate between slab and slice views depending on the suspected abnormality. Studies have demonstrated that structured reading protocols can reduce interpretation time while maintaining diagnostic accuracy. Moreover, the implementation of artificial intelligence tools—including lesion prioritization cues and automated detection algorithms—is beginning to assist radiologists in navigating the larger volume of data inherent in DBT. Such enhancements aim to reduce reader fatigue and improve sensitivity when identifying subtle suspicious features that may explain indeterminate findings on mammography [37].

Advantages and Disadvantages of Breast Tomosynthesis

Digital breast tomosynthesis offers several significant advantages over conventional digital mammography, particularly its ability to overcome the masking effects of overlapping breast tissue. By generating multiple thin slices through limited-angle tomography, DBT improves visualization of lesion morphology, margins, and internal structure. This has translated in clinical practice to higher cancer detection rates, especially for invasive cancers, and meaningful reductions in recall rates. These improvements are most pronounced in women with dense breast tissue, where traditional mammography often struggles to reveal subtle abnormalities. By reducing ambiguity in equivocal findings, DBT enhances diagnostic confidence and supports more efficient patient management when mammography alone is inconclusive [38].

Another key advantage is the improved characterization of specific lesion types. Masses that appear indistinct or partially obscured on 2D mammography often become more clearly delineated on DBT slices, enabling better assessment of shape and margins. Architectural distortion, which can be extremely subtle and easily missed on standard mammograms, is more readily identified due to improved visualization of radiating lines and tissue disruption across consecutive slices. Studies have also shown that DBT improves localization of abnormalities within the breast, facilitating targeted ultrasound correlation and biopsy planning. These strengths underscore DBT's role not only as a superior diagnostic tool but also as a problem-solving modality for resolving mammographic uncertainty [39].

Despite its advantages, DBT has several limitations. The volumetric dataset increases reading time compared with 2D mammography, potentially contributing to reader fatigue if not balanced with proper workflow design. Variations in acquisition geometry and reconstruction methods across vendors may influence lesion appearance, requiring radiologists to gain familiarity with system-specific characteristics. Motion artifacts from patient movement during the acquisition arc can degrade image quality and obscure subtle findings. Additionally, while radiation dose per exam is generally acceptable and comparable to 2D mammography when synthesized images are used, systems without synthetic imaging may expose patients to higher cumulative dose. These limitations highlight the need for continued optimization of DBT technology and interpretation strategies to maximize its diagnostic potential while minimizing drawbacks [40].

Breast tomosynthesis provides certain exclusive advantages beyond improved lesion conspicuity and reduced tissue overlap. One such advantage is enhanced detection of architectural distortion, which is often the earliest radiographic manifestation of invasive carcinoma. DBT's quasi-three-dimensional imaging allows radiologists to assess tissue structures across consecutive slices, making subtle distortions more apparent than on 2D mammography. Early studies and clinical experience have demonstrated that DBT identifies distortions that remain occult on traditional images, improving early cancer detection and reducing the number of delayed diagnoses in patients with vague or indeterminate mammographic findings [41].

Another exclusive advantage is the improved assessment of lesion location within the breast. By displaying abnormalities in sectional planes, DBT enables precise localization of masses relative to surrounding glandular structures, aiding correlation with targeted ultrasound. This capability is especially beneficial when evaluating asymmetries or focal densities that may represent either true lesions or summation artifacts on 2D mammography. DBT provides clearer anatomical mapping, allowing radiologists to determine whether additional imaging is necessary and facilitating more accurate biopsy targeting. In complex cases with multiple findings or overlapping tissue, this enhanced localization can significantly streamline diagnostic workflows [42].

DBT also offers superior assessment of breast parenchymal patterns and tissue distribution. Radiologists can observe how fibroglandular tissue changes across slices, improving differentiation between normal anatomical variants and suspicious abnormalities. This is particularly valuable when interpreting images of patients with dense breasts, where glandular tissue often obscures lesions on conventional mammography. By reducing uncertainty and minimizing unnecessary callbacks, DBT enhances patient experience and decreases anxiety associated with equivocal results. These exclusive advantages highlight the unique role of tomosynthesis in refining breast imaging interpretation and augmenting diagnostic capabilities beyond what is achievable with 2D mammography alone [43].

radio-pathological Breast lesions

Developmental abnormalities of the breast, such as ectopic breast tissue, may present as soft-tissue densities that mimic benign or malignant masses on conventional mammography. Digital breast tomosynthesis improves visualization by demonstrating the continuity of ectopic tissue with adjacent glandular structures or by clarifying its subcutaneous position. This differentiation is particularly useful when ectopic tissue occurs in the axilla, where overlapping anatomy can obscure margins on 2D views. DBT's sectional imaging helps prevent unnecessary biopsies by confirming benign developmental variants in patients presenting with mammographically indeterminate findings [44].

Breast hypoplasia may also lead to asymmetric presentations that imitate focal density or volume loss suggestive of underlying pathology. With tomosynthesis, radiologists can evaluate tissue volume and parenchymal distribution across slices, confirming congenital underdevelopment rather than acquired structural distortion. This reduces false-positive assessments of asymmetry, a common challenge in 2D mammography. DBT thus facilitates differentiation between true pathological changes and anatomical variants in cases where conventional imaging raises uncertainty [45].

Inflammatory breast lesions, such as lactational mastitis, typically manifest as diffuse asymmetry, trabecular thickening, or focal opacity. DBT enhances interpretation by allowing a layered assessment of parenchymal edema without the superimposition that complicates 2D evaluation. This is particularly valuable in distinguishing inflammation from more sinister architectural distortion. Early abscess formation may appear as a localized low-attenuation area with surrounding inflammatory change, which DBT depicts more clearly by isolating the collection from adjacent tissues [46].

Granulomatous mastitis can mimic carcinoma because it often presents with irregular masses or architectural distortion. Tomosynthesis improves detection of subtle radial strands and focal parenchymal distortion, yet it also helps differentiate inflammatory processes from malignant ones by demonstrating the absence of a discrete mass or showing smooth-walled inflammatory collections. Because granulomatous mastitis frequently leads to diagnostic confusion on mammography, DBT provides an important problem-solving role in narrowing the differential [47].

Breast abscesses often present as round or oval masses with indistinct margins on 2D mammography. DBT helps define the lesion borders, clarifying the internal fluid content and surrounding inflammatory stranding. This improved visualization assists in distinguishing abscesses from complex cysts or necrotic tumors. In patients with mastitis-like symptoms and equivocal mammography, DBT can guide targeted ultrasound by revealing the precise extent and depth of the inflammatory process [48].

Fat necrosis frequently simulates malignancy because it can present with spiculated masses or dystrophic calcifications. DBT provides better identification of internal fat components and delineates the lesion's true architecture, allowing radiologists to differentiate benign scarring from infiltrative masses. The ability to visualize subtle fat-fluid interfaces or encapsulated fat enhances diagnostic confidence and reduces unnecessary biopsies in women with prior trauma or surgery [49].

Radial scars represent one of the most challenging benign entities because their imaging appearance closely resembles invasive carcinoma. Tomosynthesis improves detection of radiating lines and central lucency by removing overlapping tissue that obscures their morphology on 2D mammography. Although DBT increases visualization of these lesions, it does not eliminate the need for biopsy due to their association with malignancy. However, DBT assists in lesion localization and determines the degree of distortion more accurately than conventional imaging [50].

Foreign body granulomas, including those related to injection or surgical materials, may appear as irregular or spiculated masses. DBT helps clarify their shape and internal composition, reducing misinterpretation as malignancy. The technology's ability to reveal embedded radiopaque particles or capsule-like structures improves recognition of these benign postprocedural changes. This is useful for differentiating granulomas from recurrent tumors in postoperative patients [51].

Nonproliferative fibrocystic changes encompass cysts, fibrosis, and adenosis, all of which can appear ambiguous on 2D mammography. DBT improves detection of cystic structures by isolating round, low-attenuation areas within glandular tissue. It also enhances visualization of focal adenosis, reducing confusion with small masses. This layered imaging approach helps distinguish benign parenchymal variations from worrisome focal asymmetries that prompt further work-up on 2D imaging [52].

Proliferative breast disease without atypia, such as usual ductal hyperplasia, may present as subtle asymmetry or architectural distortion. DBT allows improved assessment of these areas by separating glandular elements across slices, revealing whether the distortion is real or an artifact of overlapping tissue. This reduces false-positive assessments and helps identify lesions that warrant further evaluation with ultrasound or biopsy. Its problem-solving role is particularly important in younger women with dense breast tissue [53].

Atypical hyperplasia, including atypical ductal and lobular hyperplasia, may be associated with calcifications or subtle parenchymal distortions. DBT enhances characterization of calcification distribution and helps identify associated structural abnormalities. Although DBT cannot reliably distinguish atypical lesions from carcinoma, it improves lesion detection and guides targeted diagnostic imaging. Its enhanced depiction of subtle distortions increases sensitivity for early pathological change that may be overlooked on 2D views [54].

Stromal proliferative lesions such as diabetic mastopathy or pseudoangiomatous stromal hyperplasia (PASH) can appear as dense masses that mimic malignancy. DBT provides a clearer assessment of lesion borders and internal homogeneity, which helps differentiate these benign fibrous conditions from invasive tumors. The elimination of overlapping tissue improves the depiction of PASH's well-circumscribed nature and the diffuse, dense appearance typical of diabetic mastopathy [55].

Benign tumors like fibroadenomas, hamartomas, lipomas, and nipple adenomas often show characteristic features that DBT highlights more clearly than mammography. Fibroadenomas display well-defined margins and uniform internal density, while hamartomas show heterogeneous composition of fat and glandular tissue. Tomosynthesis enhances these distinguishing features by displaying them across discrete slices. Lipomas are better characterized by the visualization of pure fat content, and nipple adenomas benefit from improved delineation of the subareolar region, often obscured on 2D imaging [56].

Malignant breast lesions, including both in situ and invasive carcinomas, often demonstrate more conspicuous features on DBT due to improved depiction of spiculation, distortion, and mass margins. DBT enhances detection of invasive ductal carcinoma by clearly showing radiating lines and irregular contours that may be lost on 2D views. It also improves the identification of invasive lobular carcinoma, which often presents as subtle distortion rather than a discrete mass. This allows earlier diagnosis and reduces ambiguity in cases where mammography suggests possible malignancy but lacks definitive clarity [57].

Conclusion

Digital breast tomosynthesis has transformed the evaluation of mammographically indeterminate breast lesions by addressing the inherent limitations of two-dimensional imaging. Through limited-angle acquisition and sectional reconstruction, DBT reduces tissue overlap, enhances lesion visualization, and improves the detection of subtle abnormalities such as architectural distortion and faint masses. Its ability to refine lesion morphology, improve localization, and clarify suspicious features has significantly strengthened diagnostic confidence across a wide range of benign and malignant entities. DBT also offers valuable advantages in distinguishing true pathology from summation artifacts, guiding targeted ultrasound or biopsy, and reducing unnecessary callbacks. Despite technological variations across systems and some practical limitations related to reading time and motion sensitivity, DBT remains one of the most impactful advancements in breast imaging. As clinical experience grows and reconstruction techniques evolve, DBT is expected to play an even greater role in early cancer detection, characterization of equivocal findings, and improved patient outcomes in modern radiological practice.

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