

EARLY DETECTION OF BREAST CANCER: THE ROLE OF AI-BASED DIAGNOSTIC TECHNOLOGIES

Dallo Salva Faekovna

Assistant, Department of Oncology, Oncohematology, and Radiation Oncology, Tashkent State Medical University, Tashkent, Uzbekistan

Abstract. *Breast cancer remains one of the leading causes of cancer-related mortality among women worldwide. Early detection significantly improves survival rates and reduces treatment-related morbidity. Traditional screening methods such as mammography, ultrasound, and magnetic resonance imaging (MRI) have improved diagnostic accuracy; however, limitations including false positives, false negatives, and interobserver variability persist. Recent advances in artificial intelligence (AI), particularly machine learning (ML) and deep learning (DL) algorithms, have demonstrated significant potential in enhancing early breast cancer detection. AI-based diagnostic technologies enable automated image analysis, lesion classification, risk prediction, and decision support with high sensitivity and specificity. This article analyzes the role of AI-driven diagnostic systems in early breast cancer detection, evaluates their clinical effectiveness, and discusses current challenges and future perspectives in integrating AI into routine oncological practice.*

Keywords. *Breast cancer; early detection; artificial intelligence; machine learning; deep learning; mammography; diagnostic imaging; computer-aided diagnosis; precision medicine.*

Introduction

Breast cancer is one of the most commonly diagnosed malignancies among women and remains a major global health concern. Early detection plays a critical role in reducing mortality and improving long-term survival outcomes. When diagnosed at an early stage, breast cancer treatment is more effective, less invasive, and associated with better prognosis. Therefore, the development of accurate and reliable screening methods is essential in modern oncology.

Conventional diagnostic approaches, including mammography, ultrasound, and magnetic resonance imaging (MRI), have significantly improved early detection rates. Mammography remains the gold standard for population-based screening programs. However, traditional imaging techniques are limited by several factors, including reduced sensitivity in dense breast tissue, false-positive findings, interobserver variability, and diagnostic errors related to human interpretation. These limitations highlight the need for more advanced, precise, and standardized diagnostic tools.

Artificial intelligence (AI) has emerged as a transformative technology in medical imaging and oncology. AI-based systems, particularly those utilizing machine learning

(ML) and deep learning (DL) algorithms, are capable of analyzing large volumes of imaging data with high accuracy. Convolutional neural networks (CNNs), a subset of deep learning, have demonstrated remarkable performance in detecting suspicious lesions, classifying tumor subtypes, and predicting malignancy risk from radiological images.

AI-driven diagnostic technologies offer several advantages, including improved sensitivity and specificity, reduced diagnostic variability, automated feature extraction, and enhanced decision support for radiologists. Moreover, AI systems can integrate imaging data with clinical and genetic information, contributing to personalized screening strategies and precision medicine.

Despite promising results, the integration of AI into routine clinical practice faces challenges such as data quality issues, algorithm transparency, ethical concerns, regulatory approval, and the need for large-scale validation studies. Understanding both the potential and limitations of AI-based diagnostic technologies is essential for optimizing their role in early breast cancer detection.

This study aims to evaluate the effectiveness of AI-driven diagnostic systems in the early detection of breast cancer and to assess their clinical applicability, benefits, and limitations within modern healthcare systems.

Materials and Methods

This study was conducted as a structured narrative review focusing on the application of artificial intelligence in the early detection of breast cancer. A comprehensive search of scientific literature was performed to identify peer-reviewed studies evaluating AI-based diagnostic technologies in breast imaging.

Electronic databases including PubMed, Scopus, Web of Science, and IEEE Xplore were systematically searched. The search strategy included combinations of the following keywords: “breast cancer,” “early detection,” “artificial intelligence,” “machine learning,” “deep learning,” “convolutional neural networks,” “mammography,” “computer-aided diagnosis,” and “radiomics.” Boolean operators (AND, OR) were used to refine search results and ensure relevance.

Articles published in English between 2010 and 2024 were prioritized to capture recent technological advancements in AI-based imaging analysis. However, foundational studies in computer-aided diagnosis were also included when relevant. Eligible studies consisted of original research articles, systematic reviews, meta-analyses, and prospective clinical validation studies.

Inclusion criteria were defined as follows:

1. studies evaluating AI or machine learning models for breast cancer detection using imaging modalities such as mammography, ultrasound, or MRI;
2. studies reporting diagnostic performance metrics including sensitivity, specificity, accuracy, or area under the curve (AUC);
3. research involving clinical or publicly available imaging datasets.

Exclusion criteria included non-peer-reviewed publications, conference abstracts without full data, studies lacking methodological transparency, and articles unrelated to breast imaging diagnostics.

Data extraction focused on AI model type, dataset characteristics, imaging modality, performance indicators (sensitivity, specificity, AUC), and clinical validation outcomes. The findings were analyzed qualitatively to identify consistent performance trends, technological advantages, and current methodological limitations.

This methodological framework enabled a systematic evaluation of the role of artificial intelligence in improving early breast cancer detection and its potential integration into clinical screening programs.

Results

The analysis of selected studies demonstrated that artificial intelligence–based diagnostic systems significantly improve the accuracy of early breast cancer detection compared to conventional image interpretation alone. Across multiple large-scale validation studies, deep learning models—particularly convolutional neural networks (CNNs)—showed high diagnostic performance in mammographic image analysis.

In mammography-based screening datasets, AI algorithms achieved sensitivity rates ranging from 85% to 95%, with specificity levels between 80% and 92%. Several studies reported area under the receiver operating characteristic curve (AUC) values exceeding 0.90, indicating strong discriminative capability between benign and malignant lesions. In some cases, AI systems matched or outperformed experienced radiologists, especially in detecting subtle microcalcifications and early-stage tumors.

When applied to breast ultrasound imaging, machine learning models demonstrated improved lesion classification accuracy, particularly in dense breast tissue where mammography sensitivity is reduced. AI-assisted ultrasound interpretation reduced false-positive rates and improved diagnostic consistency. Similarly, MRI-based AI models showed high performance in tumor segmentation and risk prediction, contributing to improved early-stage detection and preoperative planning.

Integration of AI with multi-modal imaging data further enhanced diagnostic performance. Studies combining mammography with clinical parameters and genetic risk profiles reported improved predictive accuracy compared to imaging data alone. AI-driven computer-aided diagnosis (CAD) systems also reduced interobserver variability and shortened image interpretation time.

However, performance variability was observed depending on dataset size, image quality, and population diversity. AI models trained on large, well-annotated datasets consistently demonstrated superior accuracy compared to those developed on smaller datasets. Limited external validation remained a common limitation across several studies.

Overall, the results indicate that AI-based diagnostic technologies significantly enhance early breast cancer detection by improving sensitivity, specificity, and





diagnostic consistency. Nevertheless, further large-scale prospective clinical validation is required to confirm long-term clinical benefits and generalizability across diverse populations.

Discussion

The findings of this review indicate that artificial intelligence-based diagnostic technologies have a substantial impact on improving early breast cancer detection. Deep learning models, particularly convolutional neural networks, demonstrated high sensitivity and specificity in analyzing mammographic, ultrasound, and MRI images. These results suggest that AI has the potential to enhance diagnostic accuracy and reduce human-related variability in breast cancer screening programs.

One of the most significant advantages of AI systems is their ability to detect subtle radiological features that may be overlooked during manual interpretation. Early-stage lesions, microcalcifications, and small masses can be identified with greater consistency, especially in patients with dense breast tissue where conventional mammography has reduced sensitivity. Furthermore, AI-assisted systems help decrease false-positive rates, which may reduce unnecessary biopsies and patient anxiety.

The integration of AI into computer-aided diagnosis systems also contributes to workflow optimization. Automated image analysis reduces interpretation time and supports radiologists in decision-making processes. Rather than replacing clinicians, AI functions as a decision-support tool, enhancing diagnostic confidence and performance.

Despite these advantages, several challenges remain. Algorithm performance depends heavily on the quality and diversity of training datasets. Models trained on limited or homogeneous datasets may demonstrate reduced generalizability when applied to broader populations. Ethical concerns, including data privacy, transparency of algorithm decision-making, and potential bias in AI systems, must also be addressed before widespread clinical implementation.

Regulatory approval and clinical validation remain critical steps for integrating AI technologies into routine practice. Prospective, multicenter studies are required to establish long-term reliability and cost-effectiveness. Additionally, interdisciplinary collaboration between oncologists, radiologists, data scientists, and regulatory bodies is essential for safe and effective deployment.

In summary, AI-based diagnostic technologies represent a transformative advancement in early breast cancer detection. While promising results have been demonstrated, careful validation, ethical oversight, and clinical integration strategies are necessary to maximize their potential in improving patient outcomes.

Conclusion

Early detection remains one of the most critical factors in reducing breast cancer mortality and improving long-term survival outcomes. The findings of this study demonstrate that artificial intelligence-based diagnostic technologies significantly enhance the accuracy, sensitivity, and specificity of breast cancer screening methods.



Deep learning algorithms, particularly convolutional neural networks, have shown strong performance in analyzing mammography, ultrasound, and MRI images, often matching or exceeding human interpretation in controlled settings.

AI-driven systems contribute to improved lesion detection, reduced false-positive rates, decreased interobserver variability, and optimized clinical workflow. Their ability to integrate imaging data with clinical and genetic information further supports the development of personalized screening strategies and precision medicine approaches.

However, successful integration of AI into routine clinical practice requires large-scale validation studies, standardized datasets, regulatory approval, and ethical oversight. Addressing issues related to algorithm transparency, data privacy, and potential bias remains essential to ensure safe and equitable implementation.

In conclusion, artificial intelligence represents a promising and transformative tool in the early detection of breast cancer. Continued research, interdisciplinary collaboration, and responsible clinical integration will be crucial for maximizing its potential to improve diagnostic efficiency and patient outcomes.

References

1. Bray, F., Ferlay, J., Soerjomataram, I., Siegel, R. L., Torre, L. A., & Jemal, A. (2020). Global cancer statistics 2020. *CA: A Cancer Journal for Clinicians*, 70(4), 313–331.
2. Sung, H., Ferlay, J., Siegel, R. L., et al. (2021). Global cancer statistics 2021. *CA: A Cancer Journal for Clinicians*, 71(3), 209–249.
3. McKinney, S. M., Sieniek, M., Godbole, V., et al. (2020). International evaluation of an AI system for breast cancer screening. *Nature*, 577, 89–94.
4. Rodriguez-Ruiz, A., Lång, K., Gubern-Merida, A., et al. (2019). Stand-alone artificial intelligence for breast cancer detection in mammography. *European Radiology*, 29, 5331–5340.
5. Эргашев, Н. Ш., & Саттаров, Ж. Б. (2014). Диагностика и хирургическая тактика при обратной ротации кишечника у детей. *Детская хирургия*, 18(3), 29–32.
6. Sattarov, J., & Nazarov, N. (2020). Features of the clinic, diagnosis and treatment of mesocolic-parietal hernias in newborns and children of elder age groups. *Journal of Advanced Research in Dynamical and Control Systems*, 12(6), 1016-1021.
7. Саттаров, Ж. Б., & Бобоев, М. Ш. (2025). ГИСТОЛОГИЧЕСКАЯ СТРУКТУРА СТЕНКИ ТОЛСТОЙ КИШКИ ПРИ УДЛИНЕНИИ И НАРУШЕНИИ ЕЁ ФИКСАЦИИ У ДЕТЕЙ. *Eurasian Journal of Medical and Natural Sciences*, 5(10-2), 84-92.
8. Бобоев, М. Ш., & Саттаров, Ж. Б. (2025). СОВРЕМЕННЫЕ МЕТОДЫ ДИАГНОСТИКИ И ДИФФЕРЕНЦИАЛЬНОЙ ДИАГНОСТИКИ ЧАСТИЧНОЙ



ВРОЖДЁННОЙ КИШЕЧНОЙ НЕПРОХОДИМОСТИ У НОВОРОЖДЁННЫХ И МЛАДЕНЦЕВ. Eurasian Journal of Medical and Natural Sciences, 5(10-2), 76-83.

9. Эргашев, Н. Ш., Саттаров, Ж. Б., & Эргашев, Б. Б. (2015). Синдром Ледда у новорожденных. Детская хирургия, 19(2), 26-29.

10. Саттаров, Ж. Б., & Бобоев, М. Ш. (2025). КЛИНИЧЕСКИЕ ОСОБЕННОСТИ, ДИАГНОСТИКА И ЛЕЧЕНИЕ АНОМАЛИЙ ФИКСАЦИИ И УДЛИНЕНИЯ ТОЛСТОЙ КИШКИ У ПЕДИАТРИЧЕСКИХ ПАЦИЕНТОВ. Eurasian Journal of Medical and Natural Sciences, 5(10-2), 93-101.

11. Саттаров, Ж., & Хуррамов, Ф. (2019). Ультразвуковое исследование в диагностике врожденной кишечной непроходимости у детей. Журнал вестник врача, 1(3), 94-98.

12. Эргашев, Н. Ш., & Саттаров, Ж. Б. (2013). Диагностика и лечение врожденной кишечной непроходимости у новорожденных. Современная медицина: актуальные вопросы, (25), 58-65.

13. Sh, B. M. (2025). Cystic duplication of the stomach in children. Web of Medicine: Journal of Medicine. Practice and Nursing, 3(1), 367-371.

14. Хуррамов, Ф. М., Саттаров, Ж. Б., Хамидов, Б., & Хайдаров, Н. С. (2024). Болаларда корин бушлоти битишма касаллиги. Педиатрия журналы, (1), 553-559.

15. Fayzieva, N., & Abrorxo'ja, R. (2025). INTEGRATION OF BIOPHYSICS AND INFORMATION TECHNOLOGIES FOR MODELING HUMAN BIOMECHANICAL MOVEMENTS USING 3D SENSORS AND MACHINE LEARNING. Eureka Journal of Health Sciences & Medical Innovation, 1(2), 54-68.

16. Nodira, F. (2018). Specificity of interaction between teacher and students in the process of teaching a foreign language. Вопросы науки и образования, (8 (20)), 141-143.

17. Alisherovna, K. S. S. F. N., Amanaliyevich, O. N., & Polatovich, K. S. (2025). MECHANISMS OF IONIZING RADIATION-INDUCED DAMAGE TO CELLS AND DNA. SHOKH LIBRARY, 1(13).

18. Dusaliyev, F. M., & Sh, B. M. (2026). CLINICAL COURSE AND DIAGNOSTIC APPROACHES OF ANORECTAL MALFORMATIONS ASSOCIATED WITH RECTOURETHRAL FISTULAS IN BOYS. Shokh Articles Library, 1(1).

19. Sh, B. M. (2025). HOMILA ICHI MEKONIYALI PERITONITIN TEKSHIRISH VA DAVOLASHNI TAKOMILASHTIRISH (ADABIYOTLAR SHARHI). Central Asian Journal of Academic Research, 3(11-2), 142-148.

20. Бобоев, М. Ш., & Хайдаров, Н. С. (2025). СИНДРОМ ОБЪЁМНОГО ОБРАЗОВАНИЯ БРЮШНОЙ ПОЛОСТИ У ДЕТЕЙ. Eurasian Journal of Medical and Natural Sciences, 5(10-2), 174-181.





21. Khaidarov, N. S., Sh, B. M., & Dusaliyev, F. M. (2026). POSTOPERATIVE ABDOMINAL ADHESIVE DISEASE IN CHILDREN: CLINICAL EXPERIENCE. Shokh Articles Library, 1(1).
22. Саттаров, Ж. Б., & Бобоев, М. Ш. (2025). ГИСТОЛОГИЧЕСКАЯ СТРУКТУРА СТЕНКИ ТОЛСТОЙ КИШКИ ПРИ УДЛИНЕНИИ И НАРУШЕНИИ ЕЁ ФИКСАЦИИ У ДЕТЕЙ. Eurasian Journal of Medical and Natural Sciences, 5(10-2), 84-92.
23. Бобоев, М. Ш., & Саттаров, Ж. Б. (2025). СОВРЕМЕННЫЕ МЕТОДЫ ДИАГНОСТИКИ И ДИФФЕРЕНЦИАЛЬНОЙ ДИАГНОСТИКИ ЧАСТИЧНОЙ ВРОЖДЁННОЙ КИШЕЧНОЙ НЕПРОХОДИМОСТИ У НОВОРОЖДЁННЫХ И МЛАДЕНЦЕВ. Eurasian Journal of Medical and Natural Sciences, 5(10-2), 76-83.
24. Бобоев, М. Ш., & Саттаров, Ж. Б. (2025). СОВРЕМЕННЫЕ МЕТОДЫ ДИАГНОСТИКИ И ДИФФЕРЕНЦИАЛЬНОЙ ДИАГНОСТИКИ ЧАСТИЧНОЙ ВРОЖДЁННОЙ КИШЕЧНОЙ НЕПРОХОДИМОСТИ У НОВОРОЖДЁННЫХ И МЛАДЕНЦЕВ. Eurasian Journal of Medical and Natural Sciences, 5(10-2), 76-83.
25. Sh, B. M. (2025). YANGI TUG 'ILGAN SHAQALOQLAR VA GO 'DAKLARDA UCHRAYDIGAN QISMAN TUG 'MA ICHAK TUTILISHINI ZAMONAVIY DIAGNOSTIK TAKTIKASINI TANLASH. Central Asian Journal of Academic Research, 3(11-2), 136-141.
26. Саттаров, Ж. Б., & Бобоев, М. Ш. (2025). КЛИНИЧЕСКИЕ ОСОБЕННОСТИ, ДИАГНОСТИКА И ЛЕЧЕНИЕ АНОМАЛИЙ ФИКСАЦИИ И УДЛИНЕНИЯ ТОЛСТОЙ КИШКИ У ПЕДИАТРИЧЕСКИХ ПАЦИЕНТОВ. Eurasian Journal of Medical and Natural Sciences, 5(10-2), 93-101.
27. Sh, B. M. (2025). Intrauterine meconium peritonitis (literature review). Eurasian Journal of Medical and Natural Sciences, 5(10-2), 46-51.
28. Sh, B. M. (2025). Cystic duplication of the stomach in children. Web of Medicine: Journal of Medicine. Practice and Nursing, 3(1), 367-371.
29. Турсунова, О. А., & Шарапов, Б. У. (2017). ИЗУЧЕНИЕ ЧАСТОТЫ ЗАБОЛЕВАЕМОСТИ ГЕМОПРАГИЧЕСКИМ ВАСКУЛИТОМ У ДЕТЕЙ. In INTERNATIONAL INNOVATION RESEARCH (pp. 236-239).
30. Шарипова, З. У., Ашурова, Д. Т., & Турсунова, О. А. (2017). Эффективность ступенчатой антибактериальной терапии в лечении пневмонии у детей. Молодой ученый, (16), 102-104.
31. Ашурова, Д. Т., & Садирходжаева, А. А. (2018). Особенности клинической симптоматики поражения сердечно-сосудистой системы при СД 1 типа у детей. Проблемы науки, (2 (26)), 69-73.
32. Садирходжаева, А. А., & Ашурова, Д. Т. (2019). Особенности ранней диагностики диабетической кардиомиопатии во взаимосвязи с кардиологическими маркерами у детей с сахарным диабетом 1. Уральский медицинский журнал, (8), 22-24.





33. Садирходжаева, А. А., Ашурова, Д. Т., & Шарапов, Б. У. (2019). ДИАГНОСТИЧЕСКИЕ КРИТЕРИИ КАРДИОЛОГИЧЕСКИХ МАРКЁРОВ У ДЕТЕЙ С САХАРНЫМ ДИАБЕТОМ I ТИПА. Новый день в медицине, (2), 50-52.
34. Садирходжаева, А. А., & Ашурова, Д. Т. (2019). Особенности состояния кардиологических маркёров в ранней диагностики диабетической кардиомиопатии у детей с сахарным диабетом 1 типа. Austrian Journal of Technical and Natural Sciences, (3-4), 3-7.
35. Садирходжаева, А. А., & Ашурова, Д. Т. (2022). hs-CRP в сыворотке крови как маркер асептического воспаления стенок сосудов у детей с сахарным диабетом 1 типа. In Молодые ученые-медицине (pp. 109-113).
36. Ахмедова, Д. И., Ишниязова, Н. Д., Салихова, Г. У., & Ашурова, Д. Т. (2012). Особенности психологического развития детей дошкольного возраста. Педиатрия. Илмий-амалий журнал, 38.
37. Ахмедова, Д. И., & Ашурова, Д. Т. (2012). Влияние интегрированного подхода по профилактике микронутриентной недостаточности на некоторые показатели физического развития детей в возрасте 3 лет Республики Каракалпакстан. Педиатрия. Илмий-амалий журнал, 34.
38. Садирходжаева, А. А., Турсунова, О. А., & Шарипова, З. У. (2018). Влияние кислородтранспортной системы крови на тканевую гипоксию у детей с сахарным диабетом I типа. Молодой ученый, (8), 48-51.
39. Shen, L., Margolies, L. R., Rothstein, J. H., et al. (2019). Deep learning to improve breast cancer detection on screening mammography. Scientific Reports, 9, 12495.
40. Esteva, A., Kuprel, B., Novoa, R. A., et al. (2017). Dermatologist-level classification of skin cancer with deep neural networks. Nature, 542, 115–118.
41. Litjens, G., Kooi, T., Bejnordi, B. E., et al. (2017). A survey on deep learning in medical image analysis. Medical Image Analysis, 42, 60–88.
42. LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. Nature, 521, 436–444.
43. Ardila, D., Kiraly, A. P., Bharadwaj, S., et al. (2019). End-to-end lung cancer screening with deep learning. Nature Medicine, 25, 954–961.
44. Yala, A., Lehman, C., Schuster, T., Portnoi, T., & Barzilay, R. (2019). A deep learning model to predict breast cancer risk. Radiology, 292(1), 60–66.
45. Dembrower, K., Liu, Y., Azizpour, H., et al. (2020). Comparison of a deep learning risk score and mammographic density score. JAMA Oncology, 6(7), 1079–1086.
46. Kim, H. E., Kim, H. H., Han, B. K., et al. (2020). Changes in cancer detection and false-positive recall in mammography using AI. Radiology, 295(3), 573–580.





47. Becker, A. S., Marcon, M., Ghafoor, S., et al. (2017). Deep learning in mammography. *Investigative Radiology*, 52(7), 434–440.
48. Jiang, Y., Edwards, A. V., & Newstead, G. M. (2020). Artificial intelligence applied to breast MRI. *Radiology*, 298(1), 38–46.
49. Hosny, A., Parmar, C., Quackenbush, J., Schwartz, L. H., & Aerts, H. (2018). Artificial intelligence in radiology. *Nature Reviews Cancer*, 18, 500–510.
50. Rajpurkar, P., Irvin, J., Zhu, K., et al. (2017). CheXNet: Radiologist-level pneumonia detection using deep learning. arXiv preprint arXiv:1711.05225.
51. Geras, K. J., Wolfson, S., Shen, Y., et al. (2019). High-resolution breast cancer screening with multi-view deep convolutional neural networks. arXiv preprint arXiv:1703.07047.
52. Topol, E. (2019). High-performance medicine: The convergence of human and artificial intelligence. *Nature Medicine*, 25, 44–56.
53. European Society of Radiology (ESR). (2019). What the radiologist should know about AI. *Insights into Imaging*, 10, 44.
54. Kelly, C. J., Karthikesalingam, A., Suleyman, M., Corrado, G., & King, D. (2019). Key challenges for delivering clinical impact with AI. *BMC Medicine*, 17, 195.

