A Deep Learning Artificial Intelligence Algorithm Helps Pathologists Improve Diagnostic Accuracy and Efficiency in the Detection of Lymph Node Metastases in Breast Cancer Patients.

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Background:

The detection of metastases to lymph nodes constitutes an essential task in breast cancer staging, which is done by pathologists worldwide. However, this is tedious and time-consuming, and the sensitivity of pathologists at this task is suboptimal.[1] The literature shows that pathology review by experts results in a change of nodal status in up to 24% of patients.[2] The literature also shows that artificial intelligence (AI) tools can help pathologists in detecting breast cancer metastases to lymph nodes, which could potentially improve their diagnostic accuracy and alleviate workload issues.[1] We set out to study how the diagnostic performance of pathologists varied when they were aided by a tumor detection AI tool.

Design:

An AI algorithm was trained using multiple instance learning, a weakly supervised deep learning approach whereby the digitized glass slide image (known as whole slide image or WSI) is paired with its corresponding pathology report.[3] More than 32,000 breast sentinel lymph node WSIs from more than 8,000 patients were used to train this algorithm, which is designed to highlight areas suspicious to harbor metastasis in digitized WSIs of lymph node tissue. Three pathologists were asked to review a challenging dataset comprising 167 breast sentinel lymph node WSIs, of which 69 harbored cancer metastases of different sizes, enriched for challenging cases. Ninety-eight slides were benign. The pathologists read the dataset twice, both digitally without AI assistance and with AI assistance, staggered to control for reading order bias, after a three-week washout period. They were asked to record their slide level diagnosis and were timed during their reads.

Results:

The average sensitivity of the pathologists during the unassisted phase in this challenging dataset was 81%, which improved to 93% during the assisted phase. Specificity was non-inferior during the assisted phase and remained at 98%. The average reading time was 131 seconds per slide during the unassisted phase, compared with 58 seconds per slide during the aided phase, resulting in an overall efficiency gain of 55% when the pathologists were assisted by AI. These shorter reading times applied to both benign and malignant WSIs regardless of metastasis size.

AI Displays Suspicious Areas

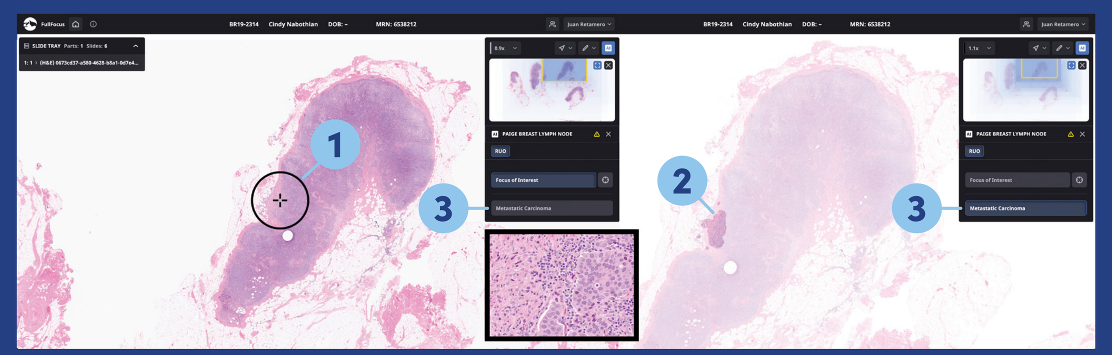
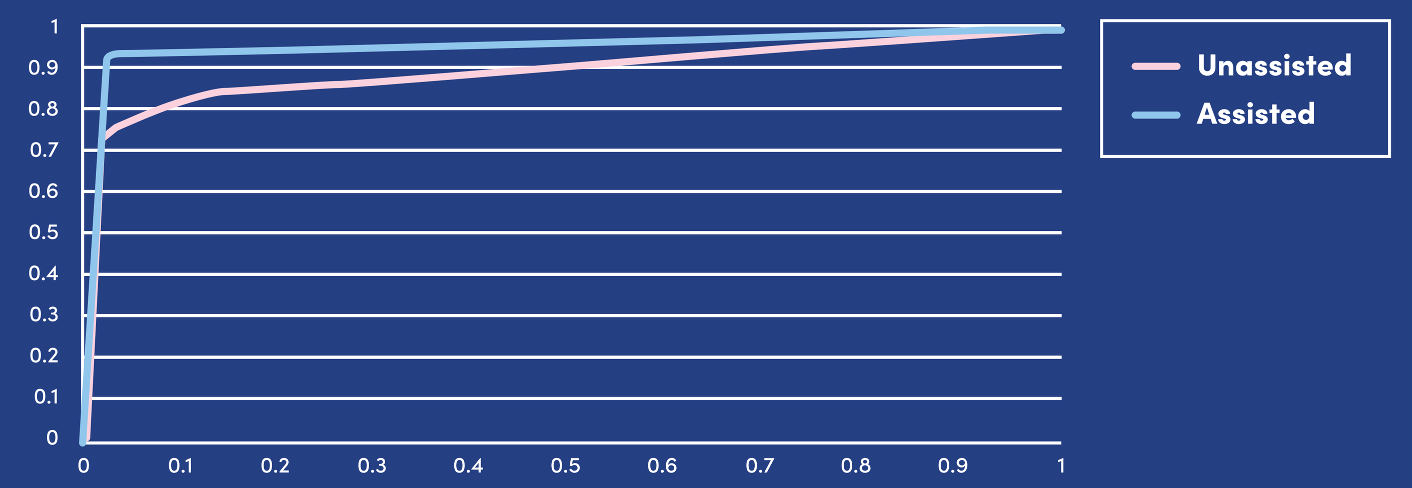
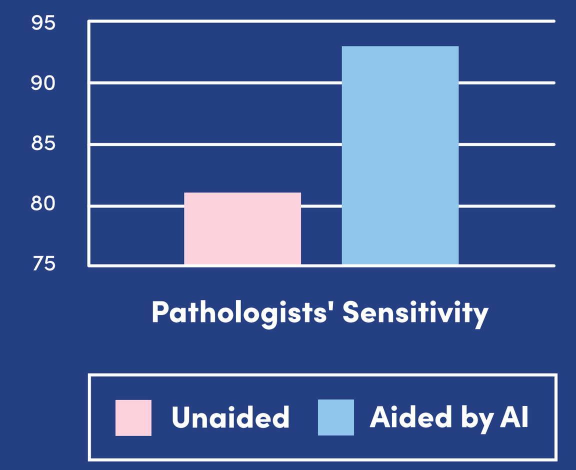


Fig 3. The AI displays results in three different ways. When a suspicious region is detected, a crosshair indicating the area with the greatest mathematical probability of harboring cancer is displayed (1). Also, the AI can fog out benign tissue to direct the pathologist's attention to the suspicious area (2). Additionally, a message panel indicating "Metastatic Carcinoma" is shown (3)

A Pathologists ROC Curve



B Diagnostic Sensitivity



C Average Time Required Per Slide

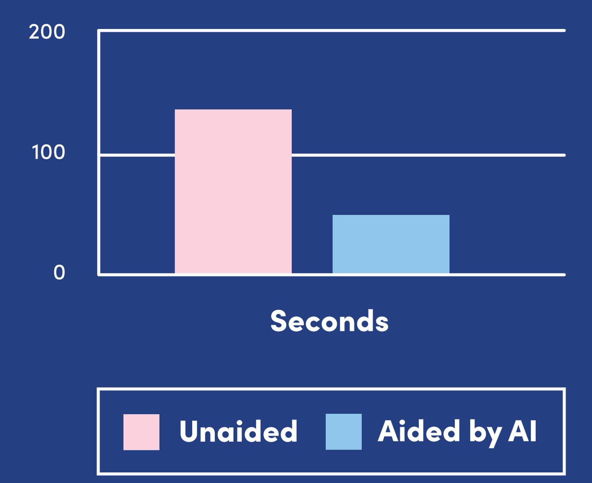


Fig 4. A. Receiver operating characteristic (ROC) curve for the three pathologists in both phases of the study. The unassisted phase (pink line) had an area under the curve (AUC) of 0.896, whereas the AI-assisted phase presented an AUC of 0.956. This was largely driven by improvements in sensitivity (B). The three pathologists required 58% less time on average to assess the WSIs when they were aided by AI (C).

AI Training

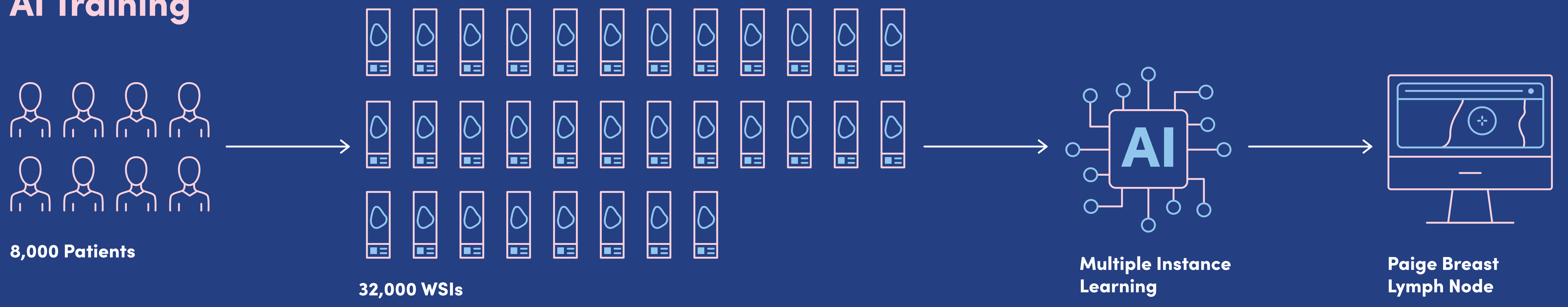


Fig 1. AI algorithm training. More than 32,000 breast sentinel lymph node WSIs from more than 8,000 patients were used to train Paige Breast Lymph Node, a deep learning algorithm trained using multiple instance learning, a weakly supervised approach that couples the WSI image with the corresponding pathology report and does not require manual annotations.

Study Design

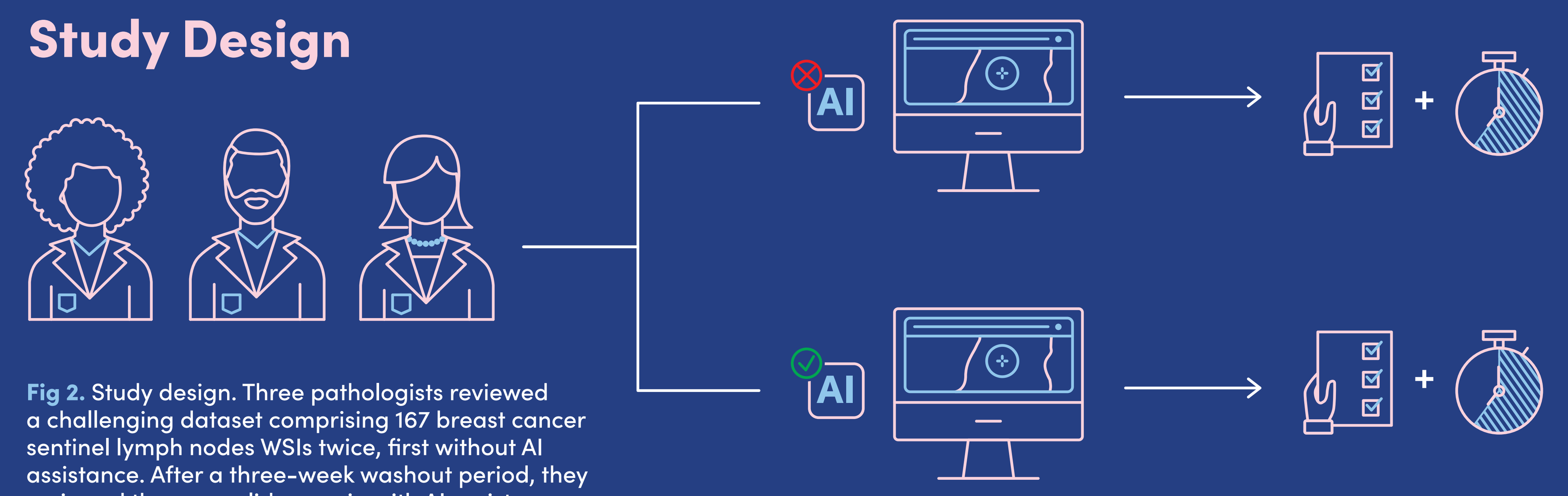


Fig 2. Study design. Three pathologists reviewed a challenging dataset comprising 167 breast cancer sentinel lymph nodes WSIs twice, first without AI assistance. After a three-week washout period, they reviewed the same slides again with AI assistance. Diagnostic accuracy (sensitivity and specificity) and reading times were measured for each phase.

Conclusion:

This study highlights how AI can help pathologists improve their diagnostic performance, as measured by sensitivity improvements, to detect metastases of any size. In addition, AI helped pathologists reduce their reading times by more than half.

12% Increase in Pathologists' Sensitivity

55% Reduction in Slide Reading Times

Bibliography:

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3. Campanella, Gabriele, et al. "Clinical-grade computational pathology using weakly supervised deep learning on whole slide images." Nature medicine 25.8 (2019): 1301-1309.

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