Workflow Acceleration Using an AI-enabled Lesion Tracking Tool for Longitudinal Assessment of Brain Metastasis

David Weiss, Medical Student, Yale School of Medicine, New Haven, Connecticut
Mariam Aboian, MD PhD; Khaled Bousabarah, PhD; Saahil Chadha; Cornelius Deuschl, MD; Wolfgang Holler, HSc; Julian Lautenschlager, M.Sc; MingDe Lin, PhD; Fatima Memon, MD; Nagaraj Moily, MBBS, PhD

Introduction

Surveillance and assessment of brain metastasis (BM) over time are critical and laborious, particularly in polymetastatic patients. This study investigated the utility of a PACS-integrated artificial intelligence-enabled Lesion Tracking Tool (AI-LTT) in monitoring BMs longitudinally, focusing on the workflow efficiency gains in comparison to fully manual workflow on post Gamma Knife radiosurgery (GKR) studies.

Hypothesis

Utilization of AI-LTT will significantly accelerate the neuroradiological reading workflow while maintaining accuracy.

Methods

This was a retrospective study where follow-up images of patients with BM, who underwent GKR at our institution, were examined on the research instance of our PACS (AI Accelerator, Visage Imaging, Inc.). In the manual workflow, a board-certified neuroradiologist displayed up to eight studies of each patient and measured lesion diameters manually. In the AI-LTT workflow, a custom hanging protocol and layout automatically selected, displayed, and 3D registered T1 gadolinium-enhanced MR sequences in up to eight studies. A nnU-Net trained on the BRaTS 2023 BM dataset and validated (DSC) on this study's dataset automatically detected and 3D segmented the BMs from which the orthogonal maximum diameters are extrapolated per RANO-BM criteria and presented in a chart. The neuroradiologist revised the AI measurements as needed. We recorded the time and the number of mouse clicks for both workflows from study open until completion of lesion measurement.

Results

363 lesions in 50 studies of ten included patients were tracked. Compared to manual measurements, the AI-LTT demonstrated a substantial reduction of mean time (708.8vs.296.5 seconds, $P < 0.01$; 106.4vs.40.9 seconds per lesion, $P < 0.01$) and mean clicks (201.2vs.55.3 clicks, $P < 0.01$; 29.1vs.7.2 clicks per lesion, $P < 0.01$). The mean Dice coefficient of nnU-Net segmentations was 0.75±0.24; sensitivity and F1-score of correct lesion identification (≥5mm) were 0.81 and 0.86, respectively.

Conclusion

The AI-LTT allowed for a substantially faster workflow while maintaining accuracy. Implementation of AI-LTT into clinical practice can enable lesion-specific treatment response monitoring.

Synopsis

The observed results of our performed study, investigating the reading workflow of a board-certified neuroradiologist, exhibit the clinical utility of a workflow-enhancing PACS-integrated AI-LTT while facilitating accurate longitudinal brain tumor assessment and reducing manual input.

Figure(s)

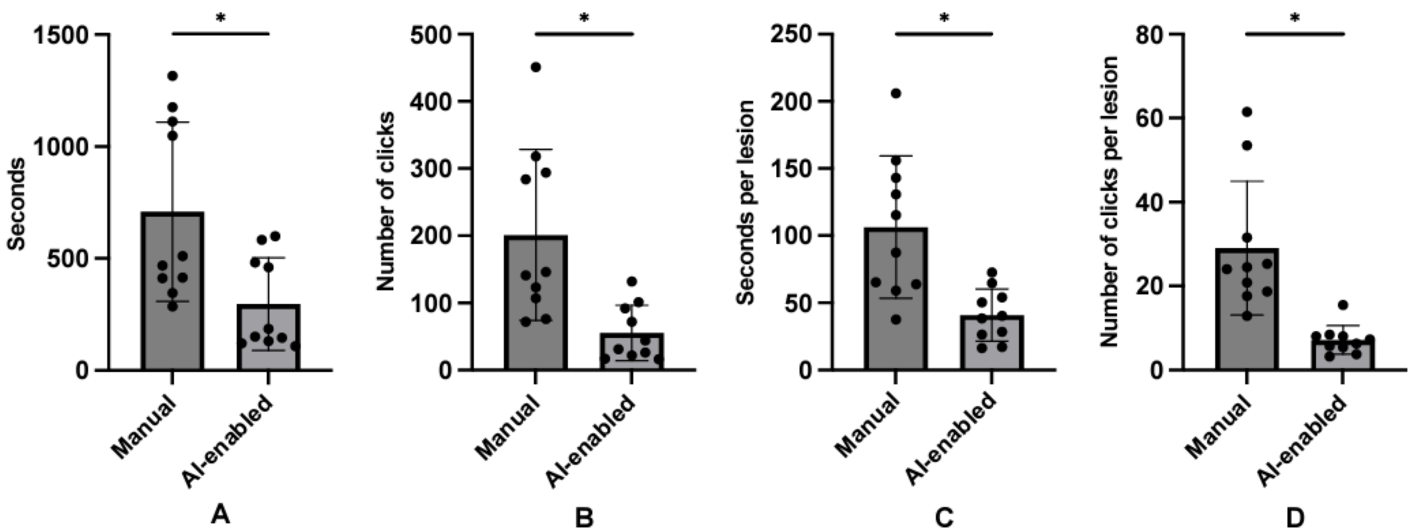

Figure 1. Comparison of measuring and tracking BMs manually versus utilizing AI-LTT. A. and B. Per patient examination, the time and necessary clicks from opening up to eight studies until completion of lesion measurements on all studies were recorded. C. and D. Related times and clicks were correlated with the number of lesions of each patient. Deployment of AI-LTT significantly reduced the mean time and clicks per patient examination (708.8 ± 401.8 vs. 296.5 ± 207.1 seconds, P < 0.01; 201.2 ± 127.2 vs. 55.3 ± 41.2 clicks, P < 0.01) as well as the mean time and clicks per lesion (106.4 ± 52.9 vs. 40.9 ± 19.4 seconds per lesion, P < 0.01; 29.1 ± 15.9 vs. 7.2 ± 3.4 clicks per lesion, P < 0.01). Note that the individual AI-enabled measurements for both time and number of clicks showed a close clustering whereas the manual measurements showed a large spread. This suggests that the AI-enabled measurements provide a more consistent workflow experience. * = P < 0.01

Figure 2. Layout of PACS-integrated AI-enabled BM Lesion Tracking Tool Eight co-registered series of T1 gadolinium-enhanced sequences are depicted, while the implemented hanging protocol and LTT layout feature are activated. Within the shown lesion tool card, two identified metastases and their AI-generated maximum orthogonal diameters, highlighted on each series, are matched and longitudinally aligned. Visualized on the corresponding images, the AI-LTT provides automated critical information regarding the individual behavior in size and treatment response of each lesion over up to eight study dates.

Keywords

Applications; Artificial Intelligence / Machine Learning; Clinical Workflow & Productivity; Emerging Technologies; Imaging Research