Mitigating Visual Fatigue in Urine Cytology: AIxURO, an AI-Driven Review Platform, Improves Diagnostic Accuracy and Efficiency

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Highlights

- Visual fatigue is a recognized occupational issue in cytopathology due to prolonged microscopic review.

- Although some AI applications have shown promise in reducing case review time, their potential to alleviate occupational visual strain remains underexplored.

- In this pilot study, we evaluated whether the AI-assisted urine cytology platform, AIxURO, could reduce visual fatigue while improving the performance and efficiency of bladder cancer detection compared with microscopy.

- AI assistance may offer a promising approach to improving ergonomics in cytopathology.

Design

- A total of 100 urine cytology cases were analyzed, including 60 bladder cancer cases and 40 negative cases.

- All slides were digitized as whole-slide images (WSIs) using a Hamamatsu S360 scanner.

- AIxURO was applied to each WSI to detect abnormal urothelial cells, quantify cytomorphologic features, and display target cells in the viewer software for review.

- Four cytologists independently reviewed all cases by microscopy and AI-assisted review, with a washout period between arms.

- Reviewer's visual fatigue was assessed using the Computer Vision Syndrome Questionnaire (CVS-Q, total score of 0–32; scores ≥6 indicate CVS).

- Diagnostic performance and review time for binary bladder cancer prediction were recorded and compared between two modalities.

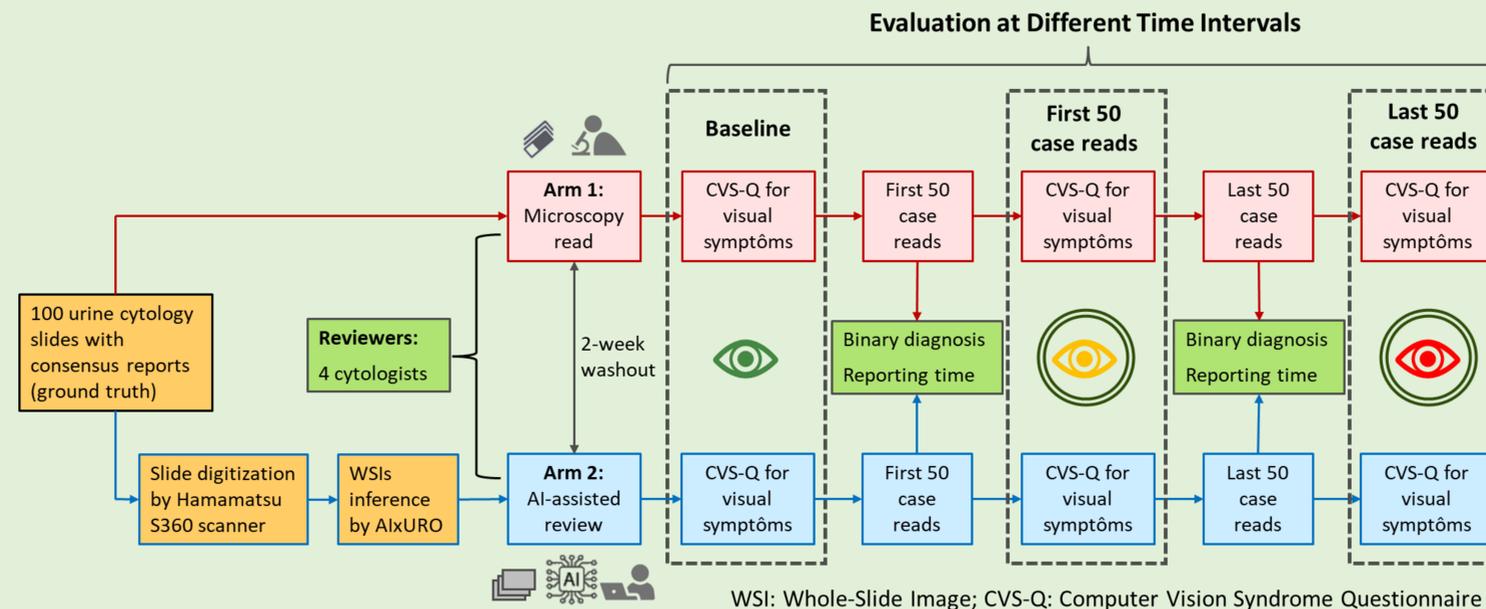## Figure 1. The Study Design and Flowchart

WSI: Whole-Slide Image; CVS-Q: Computer Vision Syndrome Questionnaire

Table 1. Evaluation of CVS Scores between Two Modalities

Arm	Reviewer	Baseline	First 50 Cases	Last 50 Cases
Microscopy	Mean	1.8	5.8	10.5*
	A	0	6*	10*
	B	4	14*	25*
	C	3	3	3
	D	0	0	4
AI-assisted Review	Mean	1.5	1.2	2.8
	A	0	0	0
	B	3	3	7*
	C	3	2	2
	D	0	2	2

*Scores ≥6 indicate Computer Vision Syndrome (CVS)

Table 2. Diagnostic Performance and Review Time for Binary Bladder Cancer Prediction

Time Interval	Modality	Microscopy (N=400)	AI-assisted (N=400)	p-value*
First 50 case reads	Sensitivity	86.7%	97.5%	<0.001
	Accuracy	89.0%	96.0%	0.006
	Mean Time (sec)	80.3	24.2	<0.001
Last 50 case reads	Sensitivity	90.0%	94.2%	0.182
	Accuracy	93.5%	91.0%	0.359
	Mean Time (sec)	57.6	18.6	<0.001
Total case reads	Sensitivity	88.3%	95.8%	<0.001
	Accuracy	91.2%	93.5%	0.212
	Mean Time (sec)	69.0	21.4	<0.001

*McNemar's test for sensitivity and accuracy; paired t-test for review time

Results

- Microscopy-related fatigue increased over time (CVS scores: 1.8 to 10.5), while fatigue remained low with AI assistance (1.5 to 2.8).

- Compared with microscopy, AIxURO reduced visual fatigue with lower mean CVS-Q scores after both the first 50 cases (5.8 vs 1.2) and last 50 cases (10.5 vs 2.8).

- AIxURO significantly improved early bladder cancer prediction, with higher sensitivity (97.5% vs 86.7%) and overall accuracy (96.0% vs 89.0%) in the first 50 cases.

- With AI-assistance, reviewers substantially reduced mean review time (21.4 sec vs 69.0 sec in total case reads).

Take-Home Messages

- These findings support the potential role of AIxURO in routine urine cytology practice by reducing visual strain and improving workflow efficiency, while maintaining diagnostic performance.

- This pilot study provides preliminary evidence that AI assistance may help reduce reviewer fatigue and improve efficiency in cytopathology, although its ergonomic benefit requires further validation.

- In clinical practice, AI-assisted platforms may offer particular value in high-volume cytopathology laboratories.

For more information, please scan the QR codes below:

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