

1 BACKGROUND

- Cerebral microbleeds (CMBs) are key imaging markers of cerebral small vessel disease.
- CMB detection is clinically relevant for evaluating amyloid-related imaging abnormalities (ARIA) in patients receiving or considered for anti-amyloid therapies.
- Manual rating is time-consuming, reader-dependent, and challenging in heterogeneous routine clinical MRI.
- Study objective: develop and validate a clinically applicable automated deep learning method for CMB detection on routine MRI.

🎯 Objective

Reliable automated CMB detection on routine paired T2* and FLAIR MRI.

2 METHODS

👥 Population

- 1,640 paired T2* and FLAIR MRI examinations from routine clinical practice.
- Data acquired on 25 different MRI scanners.
- Mean patient age: 54.2 years.
- 272 cases (16%) contained at least 1 CMB.
- Mean number of CMBs per positive case: 4.7.

📷 Imaging

- Inputs: paired T2* (2D) and FLAIR (2D or 3D) MRI.

🧠 Deep Learning Framework

- Stage 1: highly sensitive CNN for CMB candidate segmentation.
- Stage 2: CNN classifier for false-positive reduction.
- All scans manually annotated by an experienced rater (ACO).
- Subset of 49 scans independently annotated by 2 experienced (neuro)radiologists (KV and IG) to assess inter-rater agreement.

📊 Statistical Analysis

- 5-fold cross-validation.
- Lesion-wise metrics: sensitivity and false positives per case.
- Case-based metrics: sensitivity, specificity, and accuracy for presence/absence of CMBs.

N=1,640
scans

METHODS HIGHLIGHTS

25
scanners

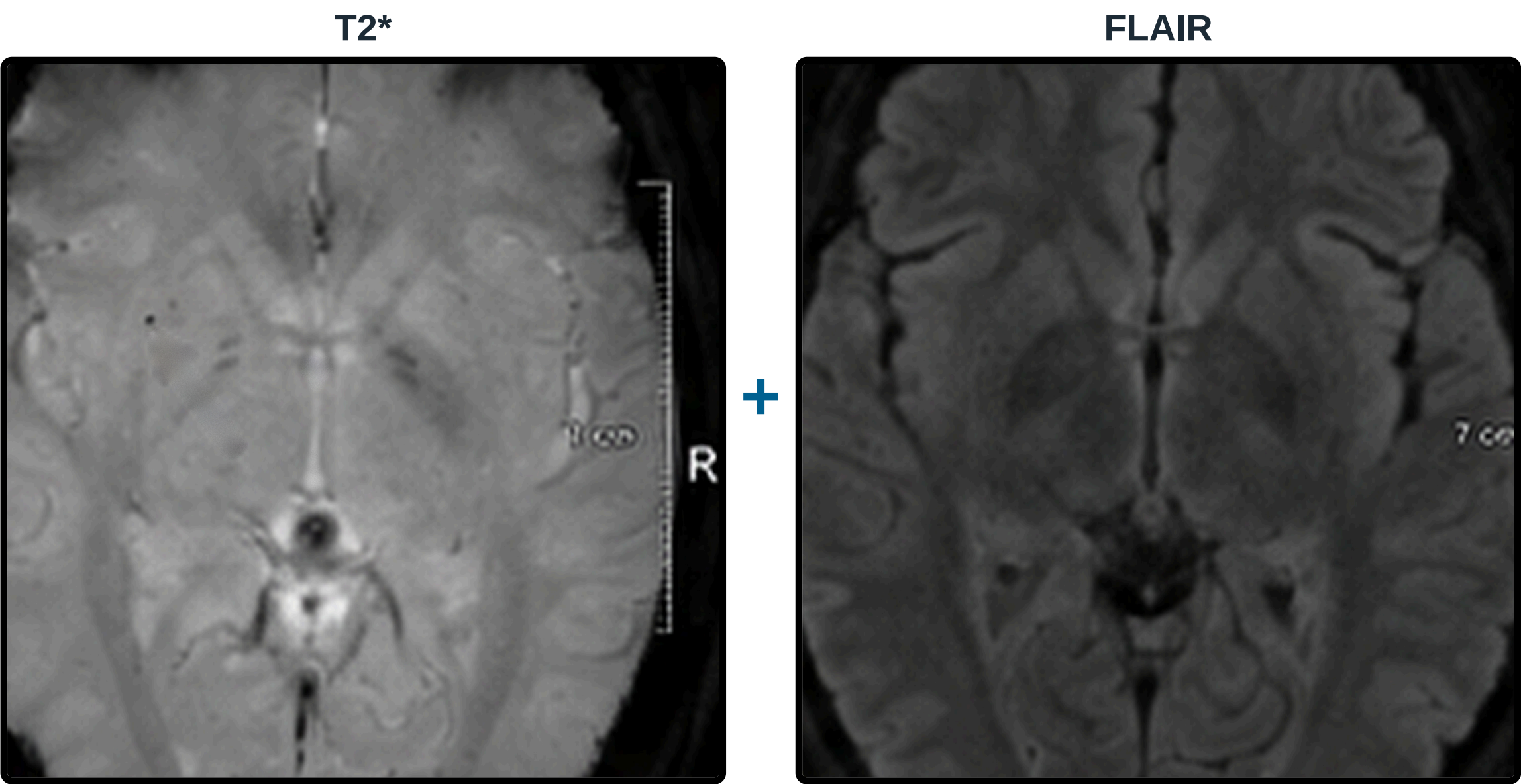
5-fold
CV

4 DISCUSSION

- Performance remained robust across heterogeneous, real-world, multi-scanner MRI data.
- Combining T2* with FLAIR provides anatomical context and helps reduce false positives.
- Automated CMB detection may support ARIA monitoring, small vessel disease assessment, and large-scale clinical workflows.
- Model performance approached expert inter-rater agreement, supporting practical clinical applicability.
- Limitations: retrospective design, modest size of the dual-rater subset, and no fully independent external test cohort presented here.

2 METHODS (CONT.)

Two-Stage Deep Learning Workflow



Stage 1
Candidate Segmentation CNN

Stage 2
False-Positive Reduction CNN

Final CMB Detections

Cohort Summary	
Total scans	1,640
CMB-positive cases	272 (16%)
Mean CMBs / positive case	4.7
MRI scanners	25

Performance Summary

Case-based performance
Sensitivity 86% | Specificity 91% | Accuracy 90%

Lesion-wise performance
Sensitivity 67% | 0.23 FP per case

3 RESULTS

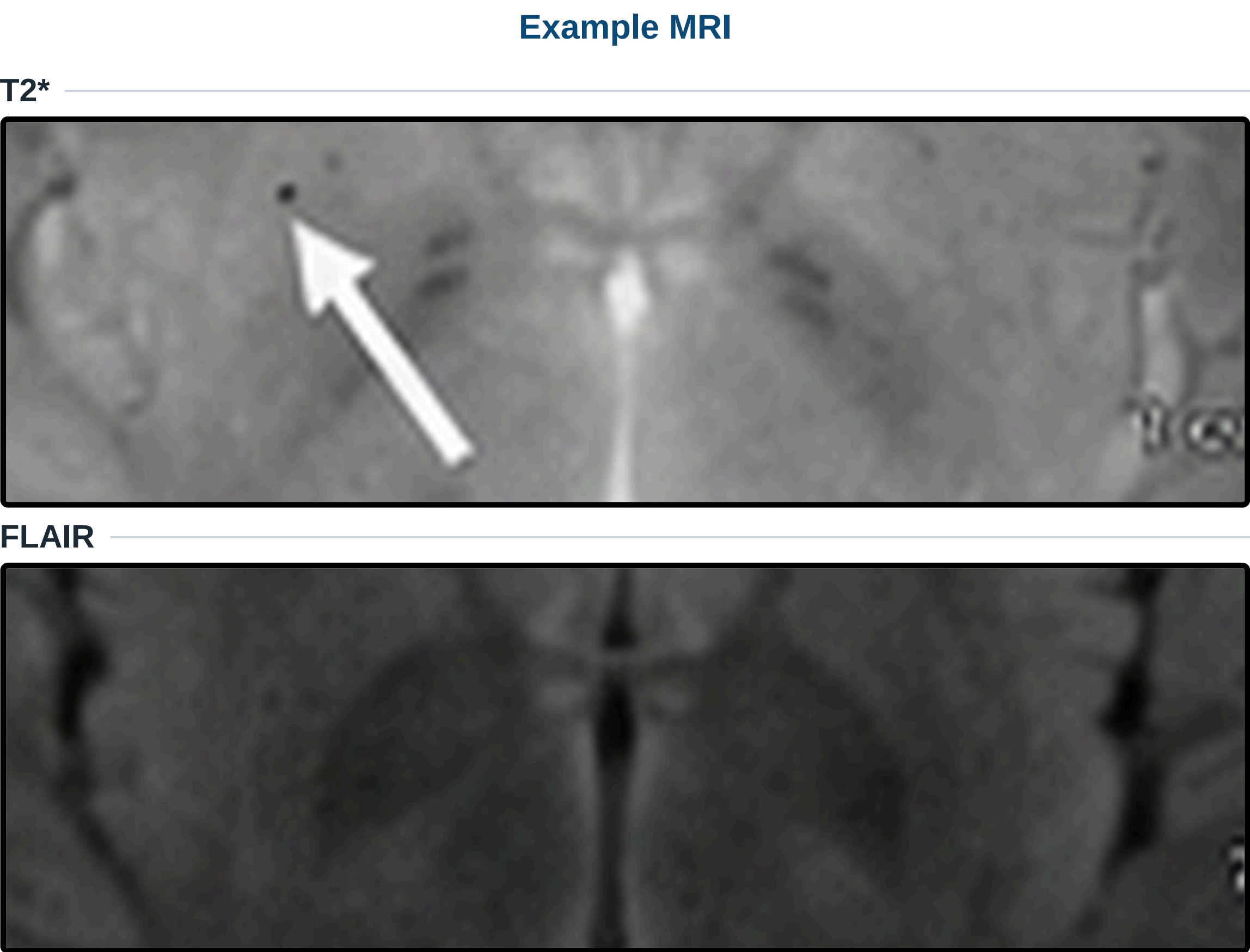
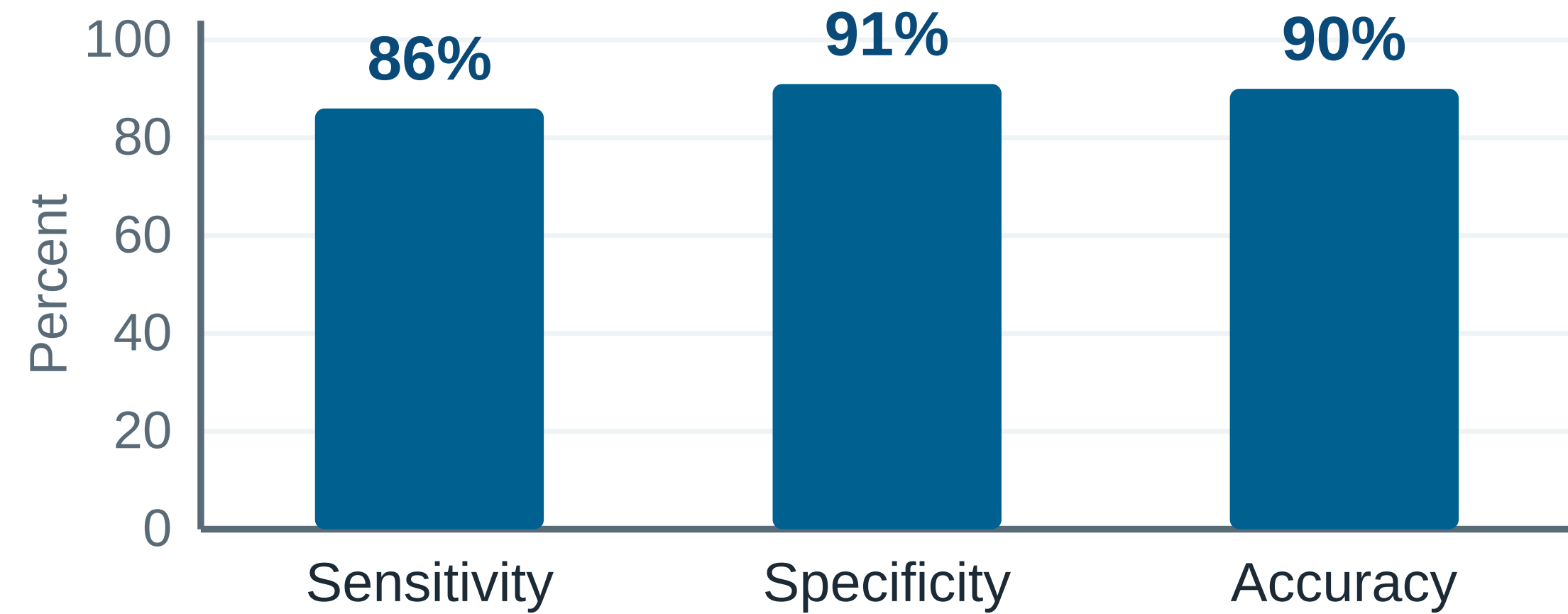
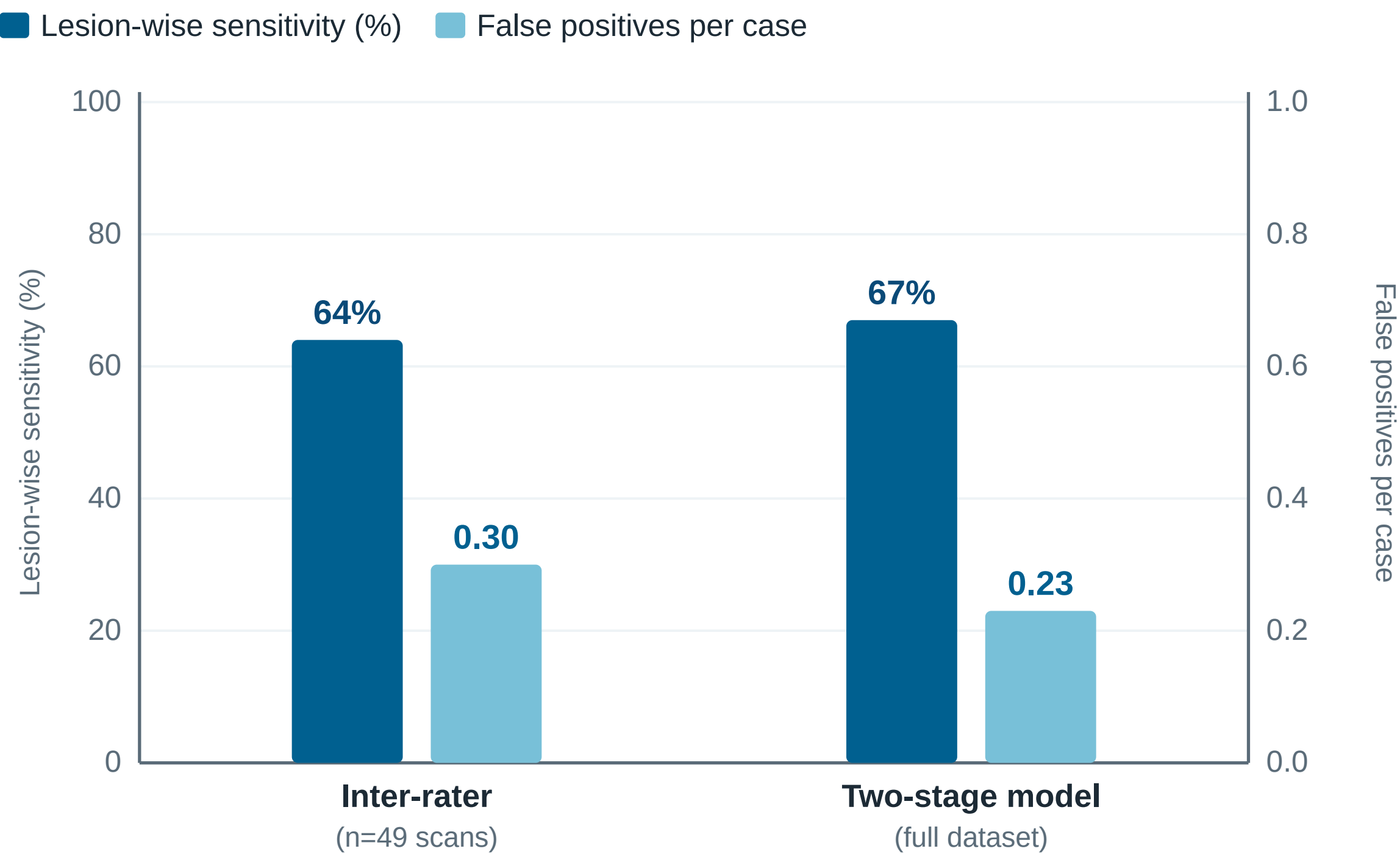


Figure 1. Example of a cerebral microbleed visible on T2* (arrow) with corresponding FLAIR image.

Case-based Performance of the Two-Stage Model



Model Performance Compared With Inter-rater Agreement



★ KEY FINDING

The automated model achieved case-based performance comparable to inter-rater agreement of experienced radiologists, while maintaining low false-positive rates in heterogeneous routine MRI data.

5 CONCLUSIONS

- ✓ A two-stage deep learning framework enables reliable automated detection of cerebral microbleeds on routine MRI.
- ✓ Performance comparable to expert inter-rater agreement supports its use as a clinically relevant decision-support tool.

Clinical impact

Standardized, scalable support for routine CMB assessment and ARIA-related imaging evaluation.

6 CONTACT

Correspondence: Roland Opfer

✉ info@jung-diagnostics.de

🌐 www.jung-diagnostics.de

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