Detection of Aberrant Anterior Tibial Artery on Knee MRI Using Deep Learning

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Introduction

The aberrant anterior tibial artery (AATA) is a rare anatomical variant with an increased risk of injury during orthopedic procedures such as high tibial osteotomy, revision total knee arthroplasty, lateral meniscal repair, posterior cruciate ligament reconstruction, and tibial tubercle osteotomy screw fixation. Accurate preoperative detection of the AATA on knee magnetic resonance imaging (MRI) can guide surgical planning and reduce complications

Hypothesis

A deep learning algorithm trained on axial T2-weighted knee MRI can reliably detect the AATA with high sensitivity and specificity.

Methods

A retrospective dataset from a unified multi-center institution was acquired after IRB approval. The dataset comprised 70,260 axial T2-weighted images from 2,315 MRI exams (1,441 without AATA and 874 with AATA). The dataset was split into training (42,488 images; 866 non-AATA/562 AATA), validation (13,865 images; 286 non-AATA/182 AATA), and testing (13,907 images; 289 non-AATA/166 AATA) folds.

The dataset was annotated by five musculoskeletal radiologists with 1 to 7 years of MSK experience, under the supervision of a musculoskeletal radiologist with 24 years of expertise. Preprocessing involved pixel normalization between the 0.25th and 99.75th percentiles. A deep learning model (architecture: ResNet-based custom CNN) was trained to identify the presence of AATA, with metrics computed at the patient level. The model was developed using Python version 3.8.10 and PyTorch version 2.0.1.

Results

A slice-level analysis achieved an F1-score of 0.838, while patient-level classification applied a probability threshold of 0.172, yielding F1-scores of 0.966 on the validation set and 0.979 on the test set. AUC for the test set was 0.99.

Conclusion

This deep learning algorithm shows promise for automating the detection of the aberrant anterior tibial artery on knee MRI, potentially improving preoperative risk assessment and surgical outcomes. Further validation in larger, diverse datasets is warranted.

Figure(s)

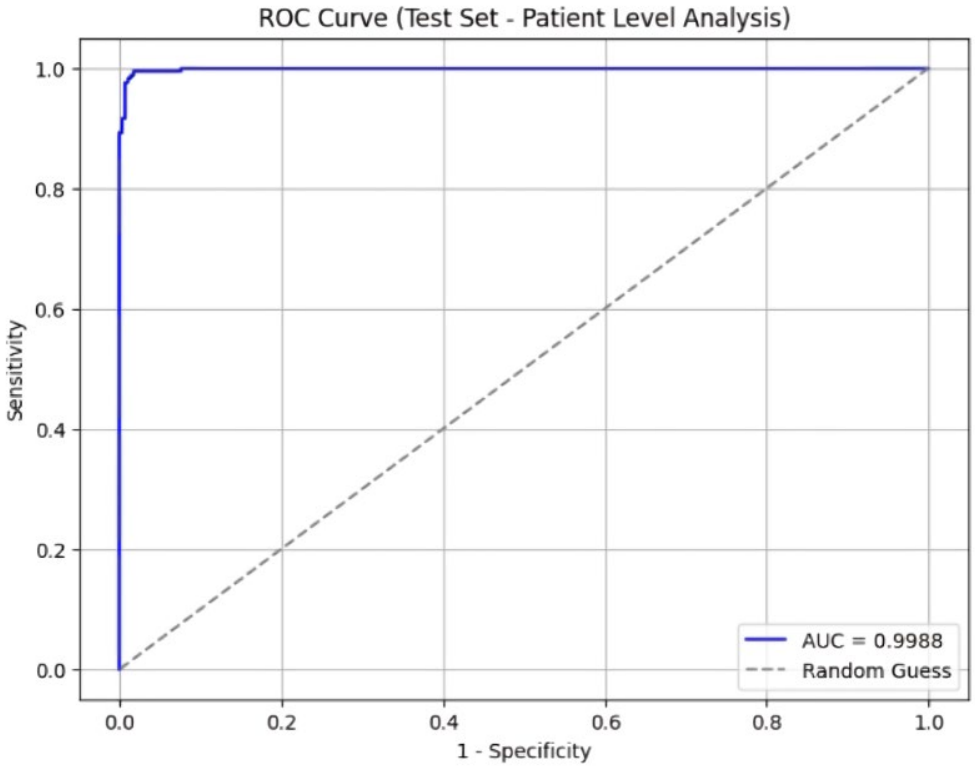

Figure 1. ROC curve for patient-level analysis on the test set.

Keywords

Artificial Intelligence/Machine Learning; Clinical Workflow & Productivity; Imaging Research; Quality Improvement & Quality Assurance