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Explainable Machine Learning Using Preoperative X-ray Radiomics and Clinical-Radiographic Features for Predicting Rotator Cuff Retear

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Introduction and Background

Retear is a major complication after arthroscopic rotator cuff repair (ASRCR). Although numerous artificial intelligence models have been proposed to predict postoperative retear, prediction using preoperative X-ray radiomics and clinical-radiographic features has not been evaluated. To address this gap, we developed an explainable machine learning model based on these features to predict retear after ASRCR.

Material and Method

This retrospective study included 315 cases who underwent ASRCR by a single surgeon between April 2020 and December 2024. Radiomics features were extracted from three regions of interest (greater tuberosity, lesser tuberosity, and subacromial spur), yielding 4,119 features. Radiomics features were then pre-filtered using univariate tests ($p < 0.01$), resulting in 587 features used for subsequent modeling. Along with the radiomics, clinic-radiographic features consisting of 37 original variables and 89 feature-engineered variables from clinical data and preoperative X-ray measurements were included into the model. The dataset was split into training (80%) and test (20%) sets. Final feature selection was performed using least absolute shrinkage and selection operator regularization. Logistic regression, random forest, XGBoost, and LightGBM models using selected features, were trained, and tested via 5-fold stratified cross-validation.

Results

Of the 315 cases, 27 experienced retear (8.6%). Logistic regression achieved the highest performance with a validation AUROC of 0.976 and a test AUROC of 0.940. Random forest, XGBoost, and LightGBM also demonstrated high performance, with test AUROCs ranging from 0.870 to 0.905. SHAP analysis identified several major contributors to model predictions, including radiomics texture features, age, acromial index, superior migration indicator combined with upward migration index, double-circle radius ratio, acromiohumeral interval.

Conclusions

Integrating preoperative X-ray radiomics with clinical-radiographic features enabled strong and explainable prediction of retear after arthroscopic rotator cuff repair. These findings suggest that retear risk can be estimated preoperatively using simple X-ray imaging and basic clinical information.

Figure & Table 1.