

# Radiomics and Machine Learning for Preoperative Prediction of Pituitary Macroadenoma Consistency

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## Background

- Pituitary macroadenoma consistency strongly influences surgical complexity, extent of resection, and operative risk.
- Firm tumors are associated with higher rates of residual or recurrent disease, while soft tumors are more amenable to gross-total removal.
- Conventional MRI features are unreliable predictors of tumor consistency.
- Radiomics extracts quantitative MRI features (texture, intensity, heterogeneity), and machine learning applies computational models to predict consistency.
- Together, radiomics and ML offer a non-invasive approach to guide preoperative planning and patient counseling.

## Methods

A PRISMA-based review identified five studies published between 2020 and 2025 that evaluated radiomics and ML models for preoperative prediction of pituitary adenoma consistency.

Extracted data included study design, radiomics pipelines, ML classifiers, diagnostic performance metrics, interpretability methods, and readiness for clinical integration.

## Results

**Performance:** A dual-center clinicoradiological–radiomics ML model achieved an **AUC of 0.87** for predicting firm versus soft pituitary macroadenomas, substantially outperforming conventional MRI assessment.

**Interpretability:** The model incorporated Shapley Additive Explanations (SHAP), assigning feature-level importance to MRI-derived metrics (for example, entropy, intensity, heterogeneity), enabling transparent case-level predictions of tumor firmness.

**Feature Correlates:** Four additional single-center retrospective studies showed that radiomic features—including **entropy, gray-level co-occurrence texture metrics, and volumetric heterogeneity**—correlate with intraoperative tumor firmness.

**Comparative Accuracy:** Across all five studies, ML classifiers consistently outperformed expert radiologist interpretation using standard MR protocols in discriminating firm from soft macroadenomas.

## Key Radiomic Features and Model Performance

- Dual-center clinicoradiological–radiomics ML model: **AUC  $\approx$  0.87** for firm vs soft macroadenomas.
- **High-value features** across studies: entropy, gray-level co-occurrence texture metrics, intensity-based heterogeneity, and volumetric measures.
- **ML classifiers** (random forests, gradient boosting, deep learning) consistently outperform expert radiologist assessment based on conventional MRI alone.
- **SHAP** and related attribution methods highlight which radiomic features most strongly push a case toward “firm” or “soft,” enabling case-level interpretability.

## Take-Home Messages

- **Clinical Need:** Tumor consistency is a major determinant of pituitary macroadenoma surgical risk, yet conventional MRI is an unreliable predictor.
- **AI Advantage:** Radiomics and machine learning models outperform expert visual assessment and enable non-invasive preoperative stratification of tumor firmness.
- **Trust and Transparency:** Interpretability tools such as SHAP translate complex ML outputs into feature-based explanations that mirror surgical image reasoning.
- **Clinical Integration:** Embedding these models into MRI workstations and radiology reports can refine counseling, approach selection, and operative planning.

Study (year)	Design / key features	AUC
Clinicoradiological–radiomics ML model (2025)	Dual-center; clinical + conventional MRI + radiomics; SHAP interpretability	$\sim$ 0.9
T2-weighted MRI radiomics (2020)	Single-center; T2 texture radiomics	up to $\sim$ 0.99
Multiparametric MRI radiomics (2021)	Single-center; T1/T2/mpMRI radiomics	$\sim$ 0.86–0.9
MRI-based radiomics in pituitary adenoma review (2024)	Systematic review of MRI radiomics applications	many models $\geq$ 0.85
ML models for PA consistency meta-analysis (2026)	Systematic review/meta-analysis of radiomics-ML studies	pooled AUC high 0.8–0.9

## Conclusions

Radiomics and ML provide a promising, non-invasive approach to predicting pituitary macroadenoma consistency and directly informing surgical strategy. Interpretability techniques such as SHAP are essential for clinical adoption because they expose the model’s reasoning in a way that parallels how surgeons weigh imaging features in differential diagnosis. This transparency builds clinician confidence, aligns AI outputs with preoperative planning, and strengthens the role of ML as a decision-support tool rather than a black box.

## Future Directions and Clinical Implications

- Integration of radiomics-based consistency prediction into MRI workstations and radiology reports within the next 3 years, with automated tumor segmentation and firmness scores.
- Prospective multi-center validation and incorporation into multidisciplinary pituitary tumor boards for risk stratification and patient counseling.
- Use of consistency predictions to tailor surgical approach, instrumentation, and backup strategies for firm tumors.
- Positioning radiomics-ML pipelines as a bridge toward fully AI-enabled, image-informed robotics and navigation in skull base surgery.

## References:

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