

## **The use of fractal dimension and lacunarity as a predictive radiomic variable of relapse in lung nodules**

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### **Keywords**

LUNG NODULES, FRACTAL DIMENSION, LACUNARITY

### **Purpose/Objective**

Radiomic features such as fractal dimension and lacunarity have shown promising results in tumor analysis, characterizing the structural complexity and internal heterogeneity of pulmonary nodules in CT images. However, select those providing relevant information without redundancy of the large number of available radiomic variables is necessary. This preliminary study investigates the predictive potential of fractal-dimension and lacunarity for early relapse in patients with pulmonary nodules treated with SBRT.

### **Material/Methods**

We retrospectively analyzed pre-treatment PET/CT images of patients with solitary pulmonary nodules, histologically confirmed or with high suspicion of lung cancer, treated with SBRT-Tomotherapy from 2013 to 2019. Tumor geometry and fractality related radiomic variables were extracted from CT images within the PET/CT studies. Four representative variables were chosen by combining correlation studies and classification tree (CRT) analysis to minimize redundancy and optimize predictive performance: median 2D fractal dimension across tumor slices, lacunarity in the slice with the largest tumor cross-section, the tumor volume-to-minimum bounding volume ratio, and the tumor surface area-to-volume ratio. Fractal dimension captures the structural complexity of the tumor, while grayscale lacunarity reflects textural heterogeneity, linked to density variability and tumor growth patterns. A predictive model was built using CRT with cross-validation, incorporating the selected variables to predict tumor relapse local (LR), pulmonary (P), locoregional (R), or distant (D).

### **Results**



Eighty-nine patients with segmented nodules were analyzed. At 12 months, relapse patterns were 6LR, 9P, 12R, and 3D. The model achieved a ROC AUC of 0.955, demonstrating excellent predictive performance, with a sensitivity of 93.8%, specificity of 86.3%, and overall accuracy of 89.3%. High lacunarity correlated with greater textural heterogeneity and relapse risk. Tumors with higher 2D fractal dimension values exhibited higher relapse probabilities, consistent with increased structural complexity. High values in geometric variables were also associated with higher recurrence rates, suggesting an irregular and extensive morphology, indicative of greater challenges for uniform radiotherapy penetration.

## **Conclusion**

This study suggests that an optimized selection of radiomic variables suffices to predict relapse in pulmonary nodules treated with SBRT, simplifying model interpretation and reducing complexity. Combining fractal dimension, lacunarity, and geometric variables offers a balance between complexity and robustness in tumor characterization. Given the retrospective nature and limited sample size, further research is necessary to validate these findings and explore their clinical applicability across diverse contexts.

## **References**

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