

Quantifying separability of ablation outcome regions from rotor trajectory kinematics using residence threshold labelling in persistent atrial fibrillation

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Introduction: Rotor-guided ablation in AF assumes that rotor behaviour contains actionable cues for identifying effective ablation targets. However, the utility of basic rotor trajectory kinematics (such as displacement, duration and velocity) in discriminating effective from ineffective ablation regions remains unclear. This study investigates whether these kinematic parameters can reliably differentiate rotors linked to positive or negative ablation outcomes using residence-threshold

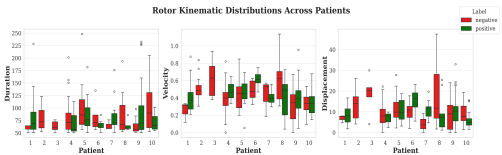


Figure 1: Boxplots of rotor kinematics

labelling. **Method:** Patient-specific ablation outcome regions were delineated on the left atrial surface and classified as positive or negative based on clinical response. Phase singularities were tracked over time to reconstruct rotor trajectories. Each rotor was labelled based on its residence within the outcome regions, positive if $\geq 70\%$ of its lifetime was within positive region and negative if $\geq 70\%$ was within negative region. Rotors not meeting either criterion were excluded. The Ordinary Least Squares (OLS) regression analysis was used to model the association between rotor kinematics and rotor labels. The OLS regression estimated the effect size (β), 95% confidence intervals (CI), and p-values for each parameter. **Results:** Significant interpatient variability was observed in displacement, duration and velocity. In most patients, positive and negative rotors showed overlapping distributions: duration (positive: 82.99 ± 39.27 s, negative: 83.06 ± 35.55 s), velocity (0.41 ± 0.16 mm/s, vs 0.42 ± 0.20 mm/s) and displacement (9.63 ± 5.89 mm, vs 10.59 ± 7.77 mm), with outliers present in both groups. The OLS regression confirmed no significant association between rotor label and kinematics duration: ($\beta = -0.06$, 95% CI -8.85 to 8.73, $p = 0.989$), velocity: ($\beta = -0.01$, 95% CI -0.06 to 0.03, $p = 0.527$), or displacement: ($\beta = -0.96$, 95% CI -2.58 to 0.66, $p = 0.244$). **Conclusion:** Rotor kinematics remained largely descriptive and patient-specific and did not offer a common standalone signature of effective and ineffective regions of ablation.