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Title of Study: Analysis of Tremor during Grasp Using Ultrasound Imaging
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STATISTICAL DESIGN

A. Tremor Model Accuracy.

Hypothesis: The data-driven and ultrasound-based tremor prediction model improves wrist angle prediction during tremor compared to the use of accelerometers.

Statistical Plan. Primary endpoint is the patient-level mean NRMSE of wrist angle prediction during tremor, computed by averaging trial NRMSEs within subject. We will perform a within-subject comparison of the data-driven with ultrasound enhanced model versus the accelerometer-only baseline using the Wilcoxon signed-rank test (two-sided $\alpha=0.05$), reporting the Hodges–Lehmann median paired difference and 95% bootstrap CIs; if >2 models are included, we will first run a Friedman test with Holm–Bonferroni–adjusted post-hoc pairwise tests.

B. Ultrasound Imaging based Tremor Frequency Prediction

Hypothesis: Tremor frequency derived from ultrasound features (e.g., tissue displacement) is equivalent to tremor frequency measured with an accelerometer or electromyography.

Statistical Plan. Primary endpoint is tremor frequency (Hz) per trial/site, summarized as the subject-level mean across trials. For each comparison (US-derived frequency vs accelerometer or EMG), we will test statistical equivalence using TOST with margin $\Delta=0.5$ Hz by computing the 90% CI of the mean paired difference via a paired t-test; equivalence is concluded if the entire CI lies within $[-0.5, +0.5]$ Hz (two-sided $\alpha=0.10$). Analyses will be conducted separately by muscle/site (e.g., ECR, FCR) and then pooled across sites; we will report mean differences and 90% CIs along with equivalence conclusions.

C. Tremor Suppression

Hypothesis. Afferent stimulation effectively suppresses tremor compared to baseline tremor with no stimulation

Statistical Plan. Primary endpoint is the within-subject tremor suppression ratio, defined as the percent reduction in RMS wrist tremor amplitude during stimulation compared to baseline. Differences across stimulation frequencies will be tested using a one-way repeated-measures ANOVA (within-subject factor: Frequency); if assumptions are not met, the Friedman test will be applied. Upon a significant omnibus result, pairwise frequency comparisons will be performed with Holm–Bonferroni correction, and we will report mean differences with 95% CIs.