Title: Robotic Arm Based Elastic Fusion: Enhancing Precision and Safety in MRI-Ultrasound Guided Prostate Biopsy

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Introduction: Multiparametric magnetic resonance imaging (mpMRI)-targeted biopsy is now established as a critical component of prostate cancer pathways, as endorsed by the latest NCCN and EAU guidelines. Traditional rigid fusion systems often struggle to maintain registration accuracy due to prostate deformation caused by ultrasound probe pressure. This study explores the technical advantages and clinical outcomes of "Robotic Arm Based Elastic Fusion," a sophisticated approach that combines non-linear warping algorithms with robotic precision to optimize the detection of clinically significant prostate cancer.

Results: Robotic arm based systems utilizing elastic fusion (EF) significantly outperform conventional rigid fusion (RF) methods in targeting accuracy. By employing a robotic arm with multiple degrees of freedom (e.g., the Mona Lisa system), the procedure achieves a mechanical accuracy within 1.0mm. The elastic registration algorithm further enhances this by compensating for real-time gland deformation through surface registration and elastic interpolation. Furthermore, the integration of a transperineal (TP) approach via robotic guidance has shown a superior detection rate for anterior and apical lesions (~60-70%) while drastically reducing the incidence of post-biopsy sepsis. The system's ability to automatically offset and correct for minor patient movements under local anesthesia ensures high procedural reliability and patient tolerability.

Conclusion: Robotic arm based elastic fusion represents the next generation of prostate biopsy technology. By merging advanced elastic registration with the stability and precision of robotic arm positioning, this system minimizes human error and maximizes diagnostic yield. The shift toward robotic-assisted transperineal elastic fusion not only improves cancer detection rates but also aligns with global initiatives for safer, infection-free biopsy procedures, marking a significant advancement in personalized urological care.