MRI Guided Needle Navigation in Prostate Cancer Targeting

Suljendic D. (1), Lee J. (1), Chopra S. (1), Kirilova A. (1), Publicover, J. (1), Abed J. (1), Haider M. (1), Galop D. (2), Elliott I. (2), Fichtinger G. (3), Brock K. (1), Menard C. (1)

(1) Princess Margaret Hospital, Toronto, Canada (2) Sentinelle Medical, Toronto, Canada (3) Queen's University, Kingston, Canada

Introduction: MRI holds promise in accurately depicting the boundaries of cancer burden within the prostate gland and mandates further refinement and validation. To achieve this task, MRI voxel-to-tissue co-localization is required. Online MRI needle guidance systems with accurate and responsive navigation may help better define cancer features on MRI and enable tumor-targeted diagnostics and therapeutics. Here we report on the technical development and clinical performance of a needle navigation system for MRI-guided prostate interventions.

Methods: The navigation system utilizes a dedicated MRI table assembly and a stereotactic transperineal template system with four embedded fiducial registration markers visible on MRI. The MRI-guided procedure currently involves multiparametric diagnostic imaging of the prostate gland, imaging and registration of the stereotactic system, navigation tools for needle guidance, and 3D needle verification imaging. Clinical performance of the navigation system was evaluated in three ways: 1) needle to MRI coordinate target accuracy, 2) needle-targeting accuracy after rigid correction for hardware movement, and 3) voxel-to-tissue co-localization accuracy using deformable image registration (MORFEUS) between the needle verification images and diagnostic images.

Results: 14 patients have been enrolled to date on a prospective clinical trial for MRI-guided prostate biopsy. The mean in-plane coordinate needle-targeting error for six patients analyzed to date was 2.4 mm. This error was reduced to 2.1mm after correction for hardware motion. The accuracy of MORFEUS was measured by comparing the observed and predicted displacement of embedded fiducials. The mean registration error for eight image sets of two biopsy patients is 0.6 mm in each direction.

Conclusions: A system for MRI-guided needle navigation in prostate cancer targeting has been developed and shows promise in early clinical evaluations of technical performance. The combination of accurate registration and management of patient motion are expected to enhance the technical performance of this approach. Ongoing developments include automated registration schemes as well as an imaging method to capture and adapt to motion of the prostate prior to needle insertion. The importance of 3D imaging to document the actual location of the needle in reference to prostatic anatomic boundaries cannot be overstated.