Adjustable Sleeve Template Assembly Device for Joint MR/US-guided Diagnosis and Treatment of Prostate Cancer: Initial Design and Feasibility Evaluation

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Prostate Cancer (PCa)

• 30% incidence for men in their 50s, 80% for men in their 70s
  • 450,000 new cases in 2015
• Second most-common cause of cancer-related death in men
  • 1 of 10 men will die from prostate cancer
• Imaging: diagnosis, staging, treatment

Challenges: early and accurate detection, choice of treatment, delivery of treatment, active surveillance
Transrectal Ultrasound (TRUS)

- Everyday modality for prostate imaging
  - Biopsy guidance (non-targeted)
  - Brachytherapy
- Typically not effective for cancer localization
  - 40% cancers are isoechoic
- Advanced modes of operation
  - B-mode
  - Doppler
  - Contrast-enhanced (research)
  - Elastography (research)
  - RF-mode for tissue typing (research)

http://www.cancer.umn.edu/cancerinfo/NCI/glossary/CDR322891.html
Magnetic Resonance Imaging

- **State of the art:**
  - Multi-parametric (T2W, DCE, DWI, spectroscopy)
  - 3 Tesla magnet
  - endorectal coil

- Most effective modality for detection, staging, monitoring of response, focal treatment

- **IGT applications (clinical research):**
  - Biopsy
  - Brachytherapy
  - Focal therapy (eg HIFU)
TRUS + MR

- **TRUS**
  - Cheap
  - Basic operation is relatively easy to learn, use and maintain
  - Real-time
  - Widely used in clinic for biopsy and treatment guidance

- **MRI**
  - PCa localization: good sensitivity and specificity
  - PCa staging
  - Possibility for tumor grading
  - Anatomical and functional imaging

Research areas when used together:
- Joint MR/US tissue characterization
- Integration of multiparametric MRI into US-guided workflows
Adjustable Sleeve-Template Assembly

ASTA schematic drawing courtesy Wendy Plesniak
Adjustable Sleeve-Template Assembly

TRUS

MRI

BK Medical

HOLOGIC

sentinelle MEDICAL

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ASTA design considerations

- Accommodate MR (D=26 mm) and US (D=20 mm) probes
- Minimum device profile
- Diagnostic quality of the image
- No/minimal deformation of the surrounding tissue while exchanging probes
- Facilitate repeated imaging interchanging MR/US probes
Design

Endocavity balloon (Civco Medical Solutions, Kalona IA)
Implementation

Civco saline-filled endocavity balloon

BK 8848 transrectal probe (D=20 mm)

Polymethylpentene (TPX) sleeve
Outer D=29 mm
Layer thickness: 1.8 mm
Preliminary evaluation

Phantom studies:

1. Confirm acoustic coupling and transparency
2. Evaluate the setup workflow
3. Confirm imaging quality upon reinsertion
Preliminary evaluation
Preliminary evaluation
Preliminary evaluation
AMIGO Suite setup

Integration of the BK ProFocus US and orientation tracker with 3D Slicer enabled by Public software Library for UltraSound imaging research (PLUS) (PerkLab, Queens U.) and OpenIGTLink.
ASTA Research applications

- Improved MR-TRUS tissue/imaging correlation
  - Reduce or eliminate concerns of gland motion/deformation
- Improved validation of the MR-TRUS registration
  - Diagnostic MR $\rightarrow$ Intraprocedural MR $\rightarrow$ TRUS $\text{vs}$
  - Diagnostic MR $\rightarrow$ TRUS
Next steps

• Testing of MR imaging with Hologic rigid coil (pending clearance for integration with Siemens magnet)
• Refinement of the prototype, integration with the Hologic tabletop
• Design of the patient studies protocols
Acknowledgments

• BWH Radiation Oncology: Paul Nguyen, Emily Neubauer
• PLUS team and especially Andras Lasso (PerkLab, Queens U.)
• NIH support:
  – R01 CA111288
  – P41 EB015898
  – P01 CA067165