Gynecologic Brachytherapy in AMIGO: A collaboration between Radiology and Radiation Oncology

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Segmentation for Gynecologic Brachytherapy (Kapur)
2011-2013
Today…

Gynecologic Cancer and Treatment

Previous Work in 0.5T MR-Guided Brachytherapy
- Prostate Cancer
- Gynecologic Cancer

Advanced Multimodality Image-Guided Operating (AMIGO) Suite

Gynecologic Brachytherapy in AMIGO
Gynecologic Anatomy and Cancers

- 500,000 cases per year worldwide: Cervical, Uterine, Vaginal, Vulvar, Ovarian
- 4th leading cause of death in women in the US
- External beam radiation, chemo followed by brachytherapy
Brachytherapy

Radioactive sources that deliver very high doses of radiation are placed directly inside cancerous tissue.
Step 1: Applicator Placement
Hollow applicators are placed inside the cancerous tissue.

Interstitial

Tandem and Ring

Tandem and Ovoids
Step 2: Treatment Delivery

- A cable is connected to the applicator through which radiation sources travel.
- The radiation source (Iridium-192) is housed in a computer-guided afterloader that directs the source into the treatment catheters.
- The source travels through each catheter in discrete steps or "dwell" positions.
- The distribution of radiation and dose is determined by the dwell positions and the length of time it dwells there.

Nucletron Microselectron Afterloader
Imaging

Computed Tomography (CT)

Magnetic Resonance Imaging (MRI)

2002-2011

2002-2006  0.5T

2011-     3.0T

Akila Viswanathan, MD, MPH
History
0.5T Open Magnet (GE SP Signa) 1997-2006

Clinical Programs

- Neurosurgery
- Abdominal Tumor Ablation
- Prostate Brachytherapy
Pelvic Brachytherapy in 0.5T MRI

- Pioneered MR-guided Pelvic brachytherapy
  - 1997
- Prostate Cancer
  - 1997-2006
  - Clinical Service with 450+ cases
- Gynecologic Cancer
  - 2004-2006
  - Prospective clinical trial with 25 cases
Pelvic Brachytherapy in 0.5T MRI

Clare Tempany, MD
Radiology

Robert Cormack, PhD
Radiation Oncology

Anthony D'Amico, MD
Radiation Oncology

Akila Viswanathan, MD
Radiation Oncology


Advanced Multimodality Image Guided Operating Suite (AMIGO)
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BRIGHAM AND WOMEN’S HOSPITAL
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National Center for Image Guided Therapy (NCIGT) P41EB015898 (Jolesz, Tempany) 2005-2015
Precise Localization of Tumor Boundaries for Therapy and Biopsy

MRI Room
Operating Room
With Cardiac Catheterization, Navigation, Ultrasound
PET/CT Room
183 AMIGO Procedures Performed
(August 30, 2011-September 1, 2011)

58 Cryoablation treatments (liver, kidneys)
  • Kemal Tuncali, Servet Tatli

41 Brain surgeries and laser ablations
  • Alexandra Golby, Ed Laws, Ferenc Jolesz

32 Prostate treatments and biopsies
  • Kemal Tuncali, Paul Nguyen, Clare Tempany

28 Gynecologic Brachytherapy
  • Akila Viswanathan, Clare Tempany

10 Soft tissue biopsies
  • Kemal Tuncali, Servet Tatli, Paul Shyn

7 Cardiac ablations
  • Greg Michaud, Ray Kwong

3 Breast lumpectomies
  • Mehra Golshan, Eva Gombos
Investigators

Radiology  
Computer Science  
MRI Physics  
Mechanical Design  

Radiation Oncology  
Radiation Physics  

Clare Tempany, MD  
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Ehud Schmidt, PhD  
Sam Song, PhD  
Tobias Penzkofer, MD  
Wei Wang, PhD  

Akila Viswanathan, MD, MPH  
Robert Cormack, PhD  
Antonio Damato, PhD  
Jorgen Hansen, MS
Gyne Brachytherapy in AMIGO

Clinical Workflow and Technologies Developed
- MR and Ultrasound
- MR Imaging and Post-processing centric view

Akila Viswanathan, MD, MPH and Jorgen Hansen, MS
Sounding under Ultrasound in OR

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Initial Applicator Placement in OR

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Transfer to MR room

Akila Viswanathan, MD, MPH and Jorgen Hansen, MS
Inspect patient position

Akila Viswanathan, MD, MPH and Jorgen Hansen, MS
Begin MR Imaging

Akila Viswanathan, MD, MPH and Jorgen Hansen, MS
Fat suppressed 3DFSE (SPACE, CUBE, VISTA) 1.2 mm sw, ~5 min

3D fat suppressed balanced SSFP (FISP, FIESTA, bFE) 1.6 mm sw, ~1.2 min

Ehud Schmidt, PhD
bSFFP MR Images for Needle Tip Localization

Fat suppressed 3DFSE (SPACE, CUBE, VISTA)
1.2 mm sw, ~5 min

3D fat suppressed balanced SSFP (FISP, FIESTA, bFE)
1.6 mm sw, ~1.2 min

Ehud Schmidt, PhD
Post-Processing Using 3D Slicer iGyne

• “Bedside” Project: tight integration of algorithm and software development

• iGyne key features
  – Software workflow that matches clinical workflow
  – (robust) DICOM transfer from MR
  – Model-to-model registration of applicator CAD model to image
  – Simulation of needle trajectories
  – Novel needle detection and labeling
  – Reformatting of MRI along needle trajectory
Applicator Registration

Model-to-Model Registration

- CAD model of Applicator
- Auto detected landmarks
- Surface segmentation using GrowCut
- Iterative Closest Points Algorithm for point cloud registration
Needle Planning and Virtual Needle Placement

Image Processing for MR-guided Gynecologic Interstitial Brachytherapy in AMIGO
Xiaojun Chen, Jan Egger et al. in Proceedings of 9th International IMRI Symposium, 2012.
Needle Detection

Novel Algorithm

- Relies on needle tips provided by user
- Finds an optimized path in a ‘needleness’ image, computed using a Hessian filter
- Fits a Bézier curve (polynomial regression) to obtain bent needles

Needle Labeling for Interstitial Gynecological Brachytherapy.

Needle labeling for Image-Guided Brachytherapy, Masters thesis (in preparation)
Guillaume Pernelle, Technical University Munich and Ecole Centrale Marseille
Deflected Needle Detection

Needle Labeling for Image-Guided Brachytherapy, Masters Thesis (in preparation)
Guillaume Pernelle, Technical University Munich and Ecole Centrale Marseille
Iterative Imaging and Post-Processing
Iterative Needle Placement
Iterative Needle Placement
Iterative Needle Placement
Iterative Needle Placement
Iterative Needle Placement
3D Slicer iGyne

DICOM Transfer
From MR Scanner

Applicator Registration

Needle Detection

- Input: Needle tips
- Output: Needle 3D Models

Ex. 1
Ex. 2

Exploring the result

- Reformating
- Detected vs CAD Needles
- Distance Transform

Guillaume Pernelle, Technical University Munich and Ecole Centrale Marseille
iGyne Future Directions

Within 6 months
- Validate detected needle geometry (vs. CT)
- Export needle geometry for treatment planning
- Integrate real-time imaging sequence

Within 12 months
- Integrate needle trackers (Endoscout Inc, Symbow Inc, in-house)
- Biopsy needle identification and tracking (with Junichi Tokuda)

1 year+
- Integrate real-time dosimetry (with Robert Cormack)
- MR-Ultrasound registration (with Sandy Wells)
The OR and MR rooms of AMIGO

Thank you

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Ferenc Jolesz, MD
Clare Tempany, MD