Image-Guided TransOral Robotic Surgery (TORS)

Wen P. Liu
Oropharyngeal Cancer

HPV-positive cases, which had made up just 16 percent of oral cancer cases in the 1980s, comprised more than 70 percent in the 2000s.

~Dr. Maura Gillison, Journal of Clinical Oncology
Oropharyngeal Cancer

Standard of Care:

- Radiation
- Chemotherapy
- Open Surgery
  - Invasive techniques
  - long recoveries


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TransOral Robotic Surgery

In 2009 FDA approved the use of the Intuitive Surgical Inc. da Vinci robot for transoral intervention of select oropharyngeal cancer completely removing tumors while preserving speech, swallowing, and other key quality of life issues.

~Bert O’Malley Jr., MD, professor and chairman of Penn Medicines’ Department of Otorhinolaryngology

- Decrease morbidity relative to open surgical procedures
- Decrease swallowing dysfunction relative to chemoradiation
- Improve access and “teachability” relative to Transoral laser microsurgery (TLM)

Credit: Weinstein; O’Malley, Penn Medicine

~Bert O’Malley Jr., MD, professor and chairman of Penn Medicines’ Department of Otorhinolaryngology
Transoral Robotic Surgery
Left Base of Tongue Cancer

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Division of Head and Neck Surgery
Robotic Surgery

- Avoidance of disfiguring mandibulotomy
- Significantly less pain & Decreased need for chemotherapy & radiation therapy
- Avoidance of tracheostomy
- Quicker return to normal speech and swallowing
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- Avoidance of tracheостомия
- Более быстрое возвращение к обычной речи и глотанию
- Существенно меньше боли и уменьшение кровопотери
- Краткосрочное выздоровление и уменьшение времени пребывания в больнице

http://wiki.uiowa.edu/display/protocols/Transoral+Robotic+Surgery
Contraindications

- Inability to adequately visualize anatomy to perform the diagnostic or therapeutic surgical approach transorally
- Unresectability of involved neck nodes
- Mandibular invasion
- Radiologic confirmation of carotid artery involvement
- Fixation of tumor to the prevertebral fascia
- Medialized carotid artery lying adjacent to tonsil (contraindication for radical tonsillectomy, not tongue base resection)

http://wiki.uiowa.edu/display/protocols/Transoral+Robotic+Surgery
**Video-CBCT**

**Intraoperative Image-Guided TORS**

- **Advantages**
  - Up-to-date anatomical information
  - Assessment of surgical progress

- **Emerging Technologies**
  - CT, MR, ...
  - C-Arm Cone-Beam CT
  - Conely, et al. Comparison of Intraoperative Portable CT Scanners in Skull Base and Endoscopic Sinus Surgery
  - Skull Base Thieme eJournal 2011

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Nithiananthan, SPIE (2010)

Image-Guided TORS: Phantom Validation

- Preop CT/MR
- Intraop CBCT
- Phantom CBCT
- Segment & Plan
- Porcine Tongue w/tumor
- Updated Intra-operative Plan
- Register to da Vinci
- Overlay cisst/saw
- Video
- Manual/Rigid
Porcine Tongue Phantom (A)
Porcine Tongue Phantom (B)
Porcine Tongue Phantom (B)
Video to CBCT Registration
Reprojection Distance Error (RPD)

- Register CBCT to Endoscope by identifying registration fiducials with virtual cursor for point-based, rigid registration.
- 5 Poses, collected RPD, projection of 3 target fiducials points from both cameras
  - 3 zooms
  - pan left/right
Manual Registration, Kinematics-based tracking

RPD Error:
- Mean 1.82
- Median 1.99
- Max 3.63
- Stdev 0.92

3D TRE (L1 Norm)
- Mean 3.08
- Median 2.24
- Max 7.79
- Stdev 1.87
Image Acquisition: Porcine Phantom

- 3 x Tongues
  - 8 Targets (peas)
- 2 Image Sets:
  - 1 Preop (flat)
  - 1 Intraop (curved)
Experiment: Porcine Phantom

Tongue 1: No overlay, preop images
Tongue 2: No overlay, intraop images
Tongue 3: Overlay, intraop images
Experiment: Porcine Phantom
Results: Porcine Phantom
## Results: Porcine Phantom

### Image Data

<table>
<thead>
<tr>
<th>Phantom</th>
<th>Image Data</th>
<th>Overlay</th>
<th>TLE [mm]</th>
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<tbody>
<tr>
<td>1</td>
<td>Preop</td>
<td>No</td>
<td>4.92</td>
</tr>
<tr>
<td>2</td>
<td>Intraop</td>
<td>No</td>
<td>3.90</td>
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<tr>
<td>3</td>
<td>Intraop</td>
<td>Yes</td>
<td>1.70</td>
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Mean | STDDev | Max
---|--------|---
4.57 | 15.03 |
3.26 | 9.94  |
1.77 | 4.05  |

P-value: 0.048
Next Steps

• Intraoperative Deformable Registration (Ja)

• Depth Cue
  – Robot Registration
  – Shading
  – Volume

• Improve 3D TRE Video Registration
  – RPD: 1.8 +/- 0.9
  – 3D TRE: 3.1 +/- 1.9
  – Vision-based, 3D Reconstruction
3D Reconstruction (Phantom)