Innovation in Image Guided Surgery

David W. Kennedy, M.D., FRCSI
Rhinology Professor, University of Pennsylvania
Disclosures

• Partnership
  • AcceptEnt (Instrumentation)

• Consultant
  • Sinuwave
  • Sinopsys
  • Fiagon
  • Medtronic
  • NeurEnt

• Royalties
  • Medtronic-Xomed
Computer Image Guided Surgery

- Started work with Jim Zinreich in 1989 with rigid arm
- Endoscopic sinus surgery ideal candidate
- Rigid bony framework
- Very variable anatomy
- Critical anatomic relationships
- Subsequently chair of radiology at Penn suggested the potential use of digitizers (then used for making ship propellers)
Early Electro-Magnetic Device
c. 1989

Errors from dental fillings, OR tables, instruments etc.
Laser Digitizers in Image Guidance

Stan Baum M.D. (Chair of Radiology at Penn) recognized the potential for digitizers in patient head registration.
- Utilized for ships propellers
- Invited a originator for a presentation
- Surface recognition era developed
Optical Devices (BrainLab and LandMarX)

• Largely replaced with electromagnetic
• Line of site issues make surgery challenging
Computer Image Guided Surgery

- Becoming more surgeon friendly
- Wider range of instruments
- Less intrusive
- Improved registration
- Very little evidence it reduces complications
- Outstanding teaching tool
- Improves surgeon confidence
More Recent Systems

- Multiple receivers, one in the tip
- Flexible wire, malleable probe
- 0.6 mm wire for balloon utilization
- Receiver module can be attached to other instruments
- Transmitter in headrest
Fine Malleable Probes Are Preferable to Suction for Anatomy Confirmation
Photoregistration

- Three photos of head and reference frame taken with I-pad
- Penn Clinical Study - surface registration vs photoregistration
Forty five patients undergoing endoscopic sinus surgery for inflammatory or benign neoplastic disease (severe polyposis excluded)

Some spiral CT, some cone beam CT

Underwent both surface and photoregistration (approx. ½ of each performed 1st)

ET tube taped to lower lip, eyes not taped until registrations completed

All registrations performed by DWK

Accuracy and registration time measured
### Photo-registration vs. Surface Registration

<table>
<thead>
<tr>
<th>Location</th>
<th>Mean Photo Registration Accuracy (SD)</th>
<th>Mean Surface Registration Accuracy (SD)</th>
<th>Mean Difference (95% CI)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTH</td>
<td>0.47 mm (0.65 mm)</td>
<td>0.90 mm (0.75 mm)</td>
<td>0.45 mm (0.17-0.69 mm)</td>
<td>p=0.002</td>
</tr>
<tr>
<td>MTA</td>
<td>0.33 mm (0.59 mm)</td>
<td>0.73 mm (0.60 mm)</td>
<td>0.40 mm (0.19-0.60 mm)</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>SS</td>
<td>0.39 mm (0.49 mm)</td>
<td>0.79 mm (0.63 mm)</td>
<td>0.40 mm (0.20-0.60 mm)</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>NT</td>
<td>0.36 mm (0.54 mm)</td>
<td>0.59 mm (0.59 mm)</td>
<td>0.23 mm (0.13-0.44 mm)</td>
<td>p=0.04</td>
</tr>
</tbody>
</table>

MTH = Middle Turbinate Head; MTA = Middle Turbinate Apex; SS = Sphenoid Sinus; NT = Nasal Tip; SD = Standard Deviation; 95% CI = 95% Confidence Interval

P-values derived from paired t-tests

Significance considered at threshold of 0.01 due to Bonferroni correction
Photo-registration vs. Surface Registration

- No significant difference in registration time between the two techniques using the prior system
- Photoregistration significantly more accurate
- Subjective opinion – photoregistration is easier and requires less skill
- New system appears much more accurate
The New Photoregistration System

• Much easier, Much faster
• Appears to significantly improve accuracy
The New Photoregistration System

How long does it take to register a patient?

19.23 seconds!
• Ability to review triplanar display greatest value
• Scrolling through CT images:
  - Enables surgeon to develop 3-dimensional concept
  - Refine 3-D conceptualization during surgery
• Instrument tracking of less importance to skilled surgeon
Portable Low Dose Irradiation Intraoperative CT

- Provides a real time image while patient still asleep
- Enables CT image guidance to be updated
Preoperative and intraoperative images
Image Guided Surgery

Summary

• Assimilation into the surgical suite and workflow continues to improve
• Photo registration is more accurate than surface registration
• Speed and accuracy of registration continues to further improve
• Ability to scroll triplanar images preoperatively is invaluable (now possible with I-Pad)
• 3-D reconstruction surgical planning is evolving rapidly
• Malleable image guided probe is my favorite instrument and should be applicable to otology