Robotic Bone Drilling Assessment

Checkpoint Presentation

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Mastoidectomy procedures

- Sensitive anatomy near surgical site

- Risk of facial nerve damage at 1~3% in initial surgery, 4~10% in revision surgery
Project Summary

Galen Robot

Image from Joseph Peine's presentation: Integration of Galen for Otology Applications

Reduce hand tremors

Image from Alamy Stock Photos

Virtual fixtures

Drill here

Facial nerve
Goal: Design and conduct experiments to evaluate the performance of the Galen System in the bone drilling procedure.
Previous Deliverables

- **Minimum Deliverable**
  - Design study
  - Design and fabricate phantoms

- **Expected Deliverable**
  - IRB approval
  - Recruit volunteers
  - Conduct studies

- **Maximum Deliverable**
  - Write evaluation report
  - Develop virtual fixture mode
Updated Deliverables

● Minimum Deliverable
  ○ Design study
  ○ Design and fabricate phantoms
  ○ Prepare phantom

● Expected Deliverable
  ○ IRB approval
  ○ Develop virtual fixture mode
  ○ Recruit volunteers

● Maximum Deliverable
  ○ Write evaluation report
  ○ Develop virtual fixture mode
  ○ Preliminary studies
  ○ Recruit volunteers

● Summer Deliverable
  ○ Conduct studies
  ○ Write evaluation report
Design of Study

**Evaluation**
- **Safety**
  - Determine whether drill entered forbidden regions
  - Measure closest distance drill approached facial nerve
- **Effectiveness**
  - Determine extent of under-drilling/over-drilling
- **Speed**
  - Record time taken to perform procedure
Three levels of robotic assistance:
- No assistance
- Hand tremor elimination
- Hand tremor elimination and virtual fixtures

Three groups of subjects will be tested:
- Laymen (no prior surgical experience): 4
- Surgeons in training: 2
- Senior surgeons: 2
Design of Previous Phantom

1st Iteration - Rendered

1st Iteration - Wireframe
Design of Previous Phantom (1st Iteration)

- Simple, low-cost phantom developed for mastoidectomy
- 3D printed
  - Demo model in ABS
  - Drillable model in PLA
- Outer ear and jawline are simulated
  - Outer landmarks for facial nerve
- Channel within phantom
  - Simulated facial nerve fed through channel
- Fiducials prefabricated onto phantom
Design of Previous Phantom (2nd Iteration)

- Similar to 1st iteration
- Phantom has two parts
  - Outer undrillable “frame”
    - Contains jawline and fiducials
  - Inner drillable insert
    - Contains outer ear and facial nerve
- Inner insert is 3D printed
  - Minimizes printing material used

Development halted once Phacon phantoms became available
PHACON Phantom

- PHACON temporal bone model
- Drill away a portion of it
- Replace with 3D-printed insert

Images from PHACON and Joseph Peine’s presentation: Integration of Galen for Otology Applications
PHACON Phantom

Design of insert

- Based on CT scan of pre-drilled Phacon
- Different color to represent pre-defined portion that needs to be drilled away
- Wire to simulate facial nerve
Dependencies

- Budget for phantom fabrication
- PHACON phantoms
- CT scanner
- Access to Galen System/surgical drills/robot software
- Microscope with video recording capability
- Human Subjects Research Training
- IRB approval
- Recruitment of volunteers for study (laymen, surgeons in training, and senior surgeons)
- Scheduling of mock operations
# Updated Timeline (4/1/2017)

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<th>Minimum Deliverables</th>
<th>April</th>
<th>May</th>
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<tr>
<td>Detailed study design document approved by mentors</td>
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<td>Finalized phantom design approved by mentors</td>
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<td>Fabrication of phantoms</td>
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