Robotic Bone Drilling Assessment
Checkpoint Presentation

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Project Summary

Mastoidectomy procedures

- Sensitive anatomy near surgical site

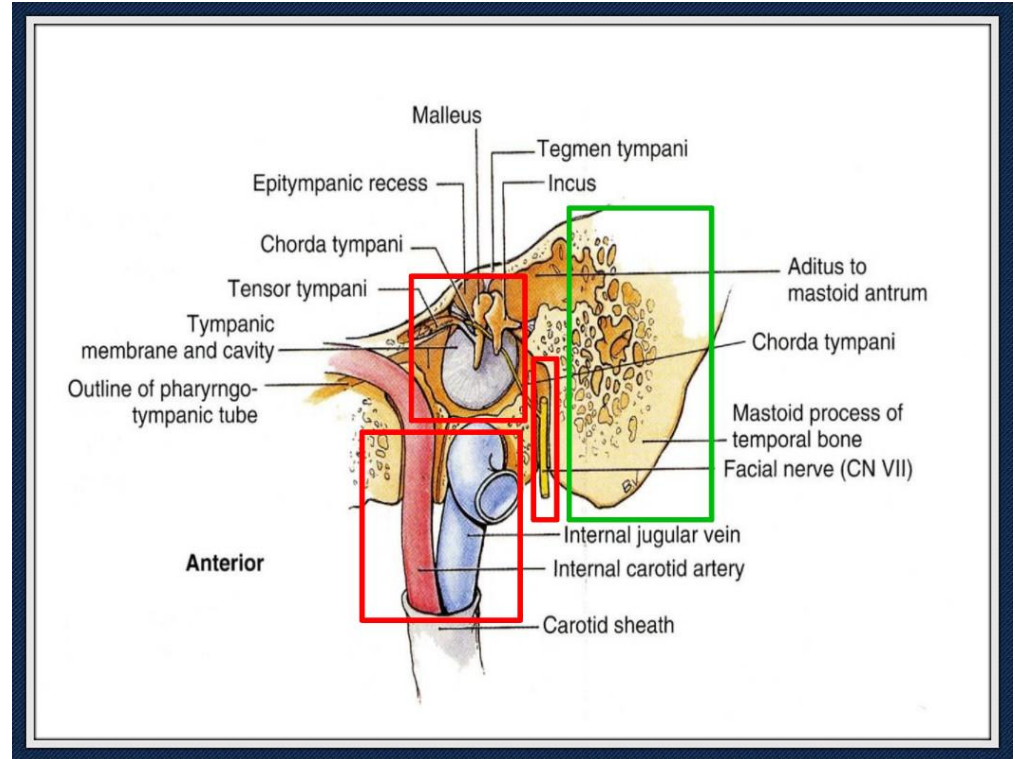- Risk of facial nerve damage at 1~3% in initial surgery, 4~10% in revision surgery

Image from StudyBlue flashcards
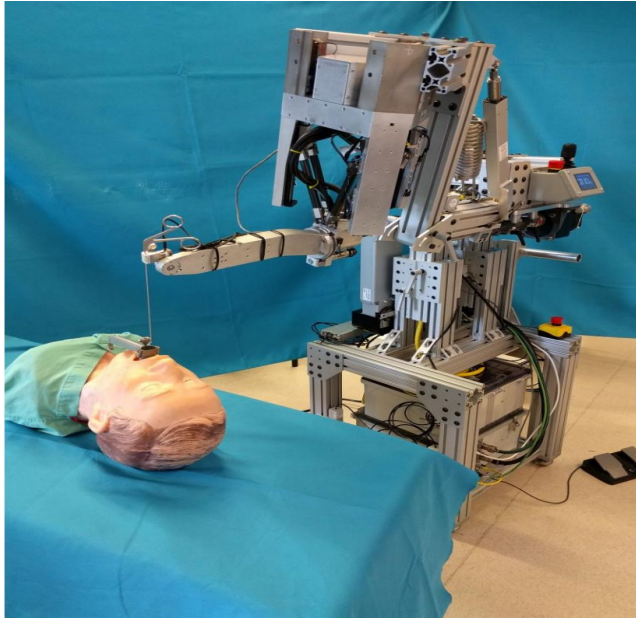
Project Summary

Galen Robot

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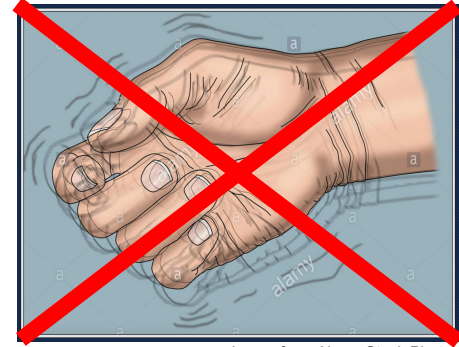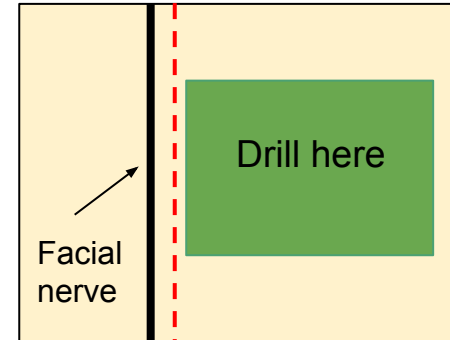
Reduce hand tremors

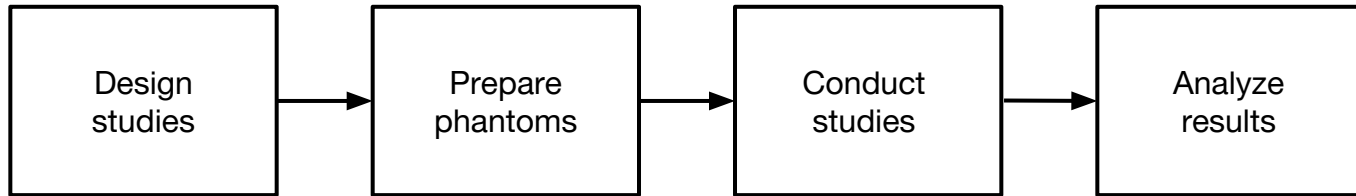Image from Alamy Stock Photos

Virtual fixtures

Drill here

Facial nerve

Project Summary

Goal: Design and conduct experiments to evaluate the performance of the Galen System in the bone drilling procedure

| Design studies | → | Prepare phantoms | → | Conduct studies | → | Analyze results |

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~~
  - ~~Conduct studies~~

- Maximum Deliverable
  - ~~Write evaluation report~~
  - ~~Develop virtual fixture mode~~
  - Preliminary studies
  - Recruit volunteers

- Summer Deliverable
  - Conduct studies
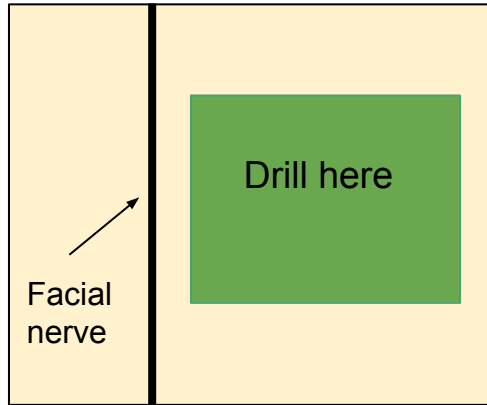 - Write evaluation report

Design of Study
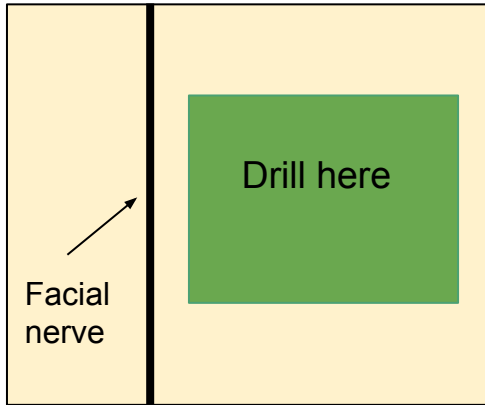
Evaluation
- Safety
  - Determine whether drill entered forbidden regions
  - Measure closest distance drill approached facial nerve
- Effectiveness
  - Determine extent of under-drilling/over-drilling
- Speed
  - Record time taken to perform procedure
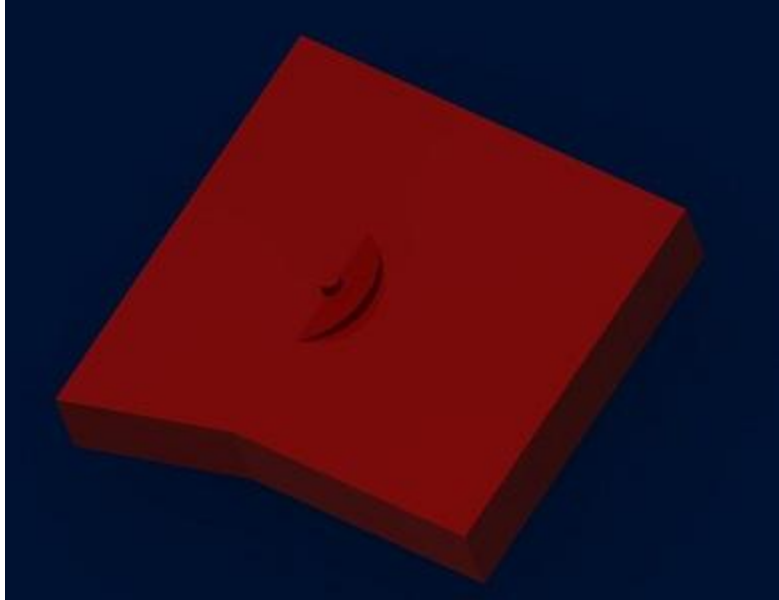
Facial nerve

Drill here

Design of Study

Three levels of robotic assistance:
- No assistance
- Hand tremor elimination
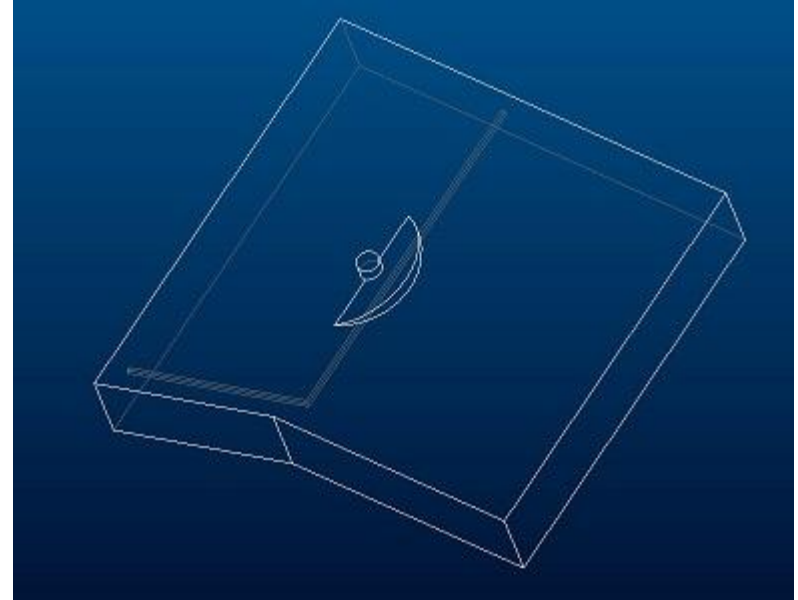- Hand tremor elimination and virtual fixtures

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

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

- PHACON temporal bone model

- Drill away a portion of it

- Replace with 3D-printed insert

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

Facial nerve
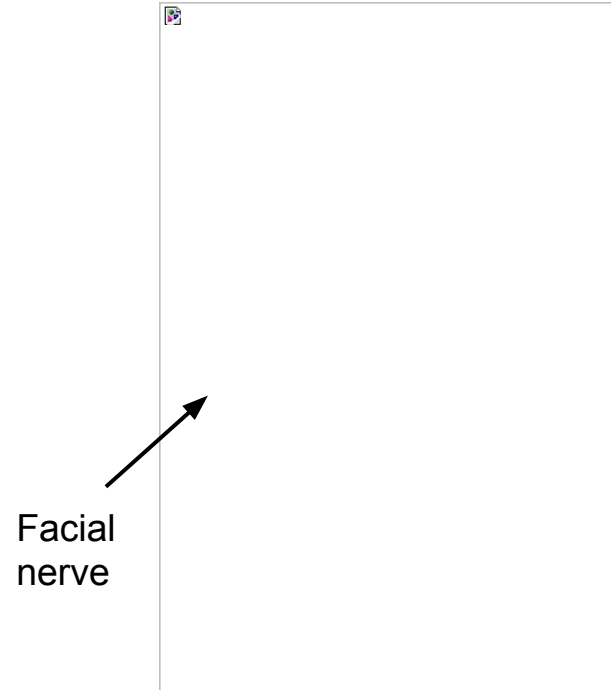
Dependencies

- 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)

	April				May	
Minimum Deliverables						
Detailed study design document approved by mentors	▓	▓				
Finalized phantom design approved by mentors	▓	▓				
Fabrication of phantoms			▓	▓		
Expected Deliverables						
Develop virtual fixtures	▓	▓	▓	▓		
IRB approval	▓	▓	▓	▓	▓	▓
Maximum Deliverables						
Preliminary studies				▓	▓	▓
Recruit voluteers					▓	▓