Robotic Bone Drilling Assessment

Seminar Review:
Study Design and Phantom Design

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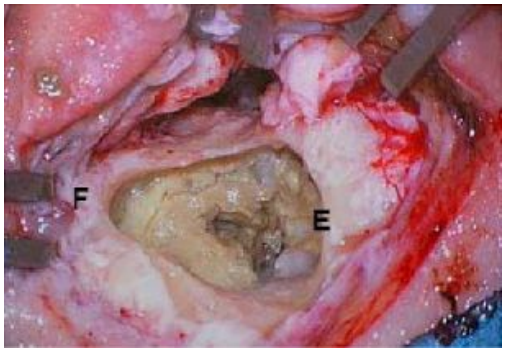
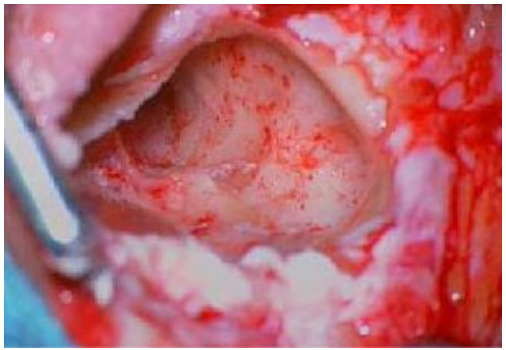
Project Overview

Mastoidectomy: Surgery that involves the removal of a portion of the mastoid bone



Cholesteatoma

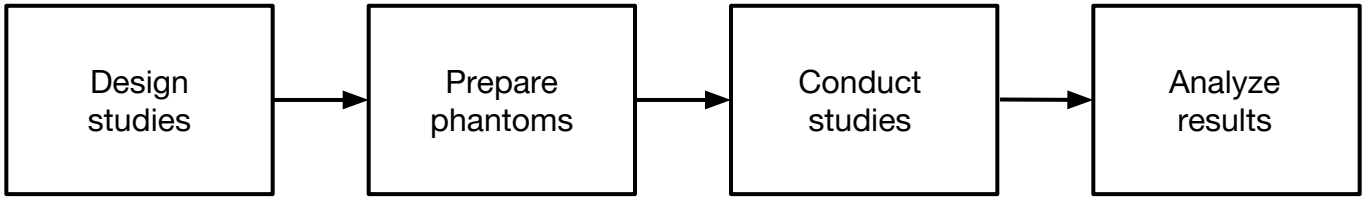


Treated surgical site

Images from *First Clinical Evaluation of the Navigated Controlled Drill at the Lateral Skull Base* (Hofer et al.)

Project Overview

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



The Navigation-Controlled Drill in temporal bone surgery: A feasibility study

Gero Strauss, MD; Kirill Koulechov, PhD; Mathias Hofer, MD; Elmar Dittrich; Ronny Grunert; Hendrick Moeckel; Eva Muller; Werner Korb, PhD; Christos Trantakis, MD; Thomas Schulz, MD; Juergen Meixensberger, MD, PhD; Andreas Dietz, MD, PhD; Tim Lueth, PhD

ElePhant - An anatomical Electronic Phantom as simulation-system for otologic surgery

R. Grunert, G. Strauss, H. Moeckel, M. Hofer, A. Poessneck, U. Fickweiler M. Thalheim, R. Schmiedel, P. Jannin, T. Schulz, J. Oeken, A. Dietz , W. Korb

The influence of various registration procedures upon surgical accuracy during navigated controlled petrous bone surgery

Hofer M, Dittrich E, Baumberger C, Strauss M, Dietz A, Lüth T, Strauss G.

Device Evaluated

Navigation-controlled (NC) drill

- Preoperative determination of workspace in CT record
- Drill switches off automatically once borders of workspace are reached

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ElePhant (Electronic Phantom)

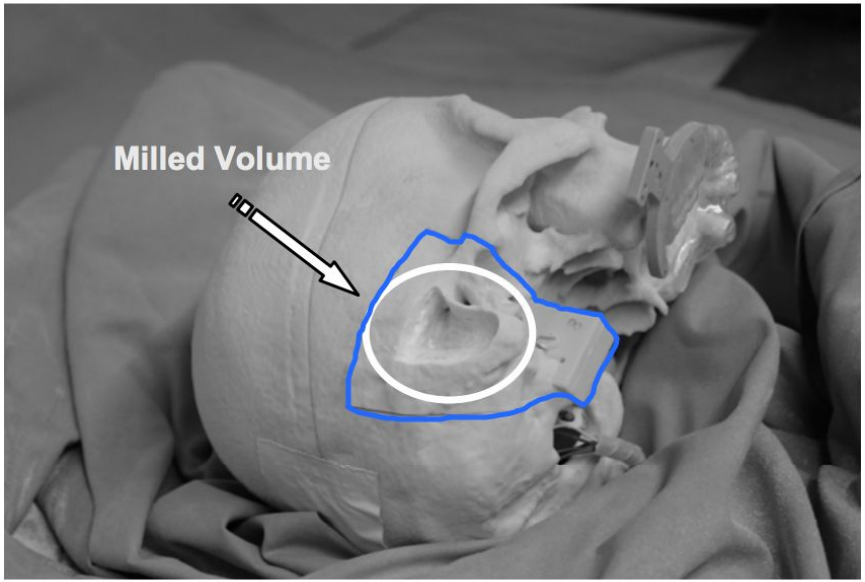

Image from *ElePhant - An anatomical Electronic Phantom as simulation-system for otologic surgery* (Grunert et al.)

- Based on CT data record
- 3D printed with 3D printer Z^{TM}510
- Material: plaster infiltrated with polyurethane and acetone

ElePhant (Electronic Phantom)

- Metal cable: sigmoid sinus, horizontal semicircular canal
  - Alloy (lead, bismuth, tin)
  - Tip of structures connected with analogue output (0.5V) and input channel of data acquisition card
  - Drill connected with ground of DAQ-card
- Optical fiber: facial nerve
  - LED provides light through fiber optic a photodiode at the other end detects the light intensity
  - Photodiode is connected with an input channel of the DAQ-card

Test Subjects

Group	Number	Mode
Surgeons inexperienced in otologic surgery	5	With Navigated Control
Surgeons experienced in otologic surgery	5	Without Navigated Control (could view navigation information)
		With Navigated Control

Evaluation Criteria

Evaluation Criteria	Procedure for Measurement
Time	Record time
Deviation from planned volume	3D reconstruction using CT data, compare with predetermined workspace
Number of injuries to high-risk structures	Record counts
Extent of injury to facial nerve	Light intensity of fiber-optic detector
Minimal distance to high-risk structures	Evaluation of CT images

Summary of Results

Group	Time	Speed of resection	Deviation to planned volume	Number of injuries
Experienced w/o NC	715 s	9.62 mm^3/s	-39.9%	1 facial nerve injury
Experienced + NC	817 s	10.08 mm^3/s	-34%	0

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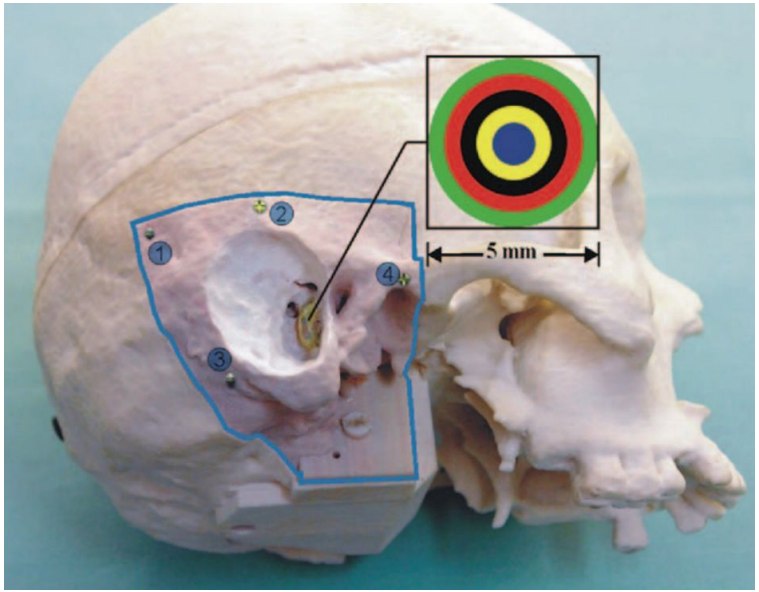
Phantom

Color-coded model

- Model based on CT data record
- Printed with Spectrum Z510
- Color-coded damage identification of facial nerve



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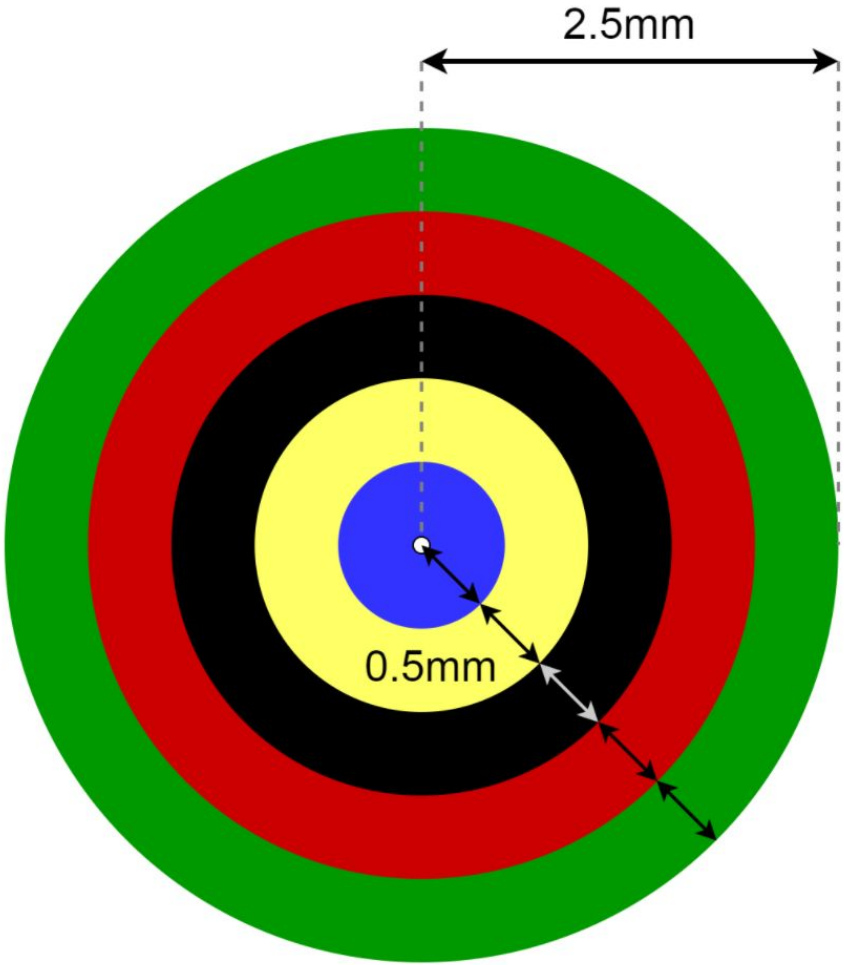
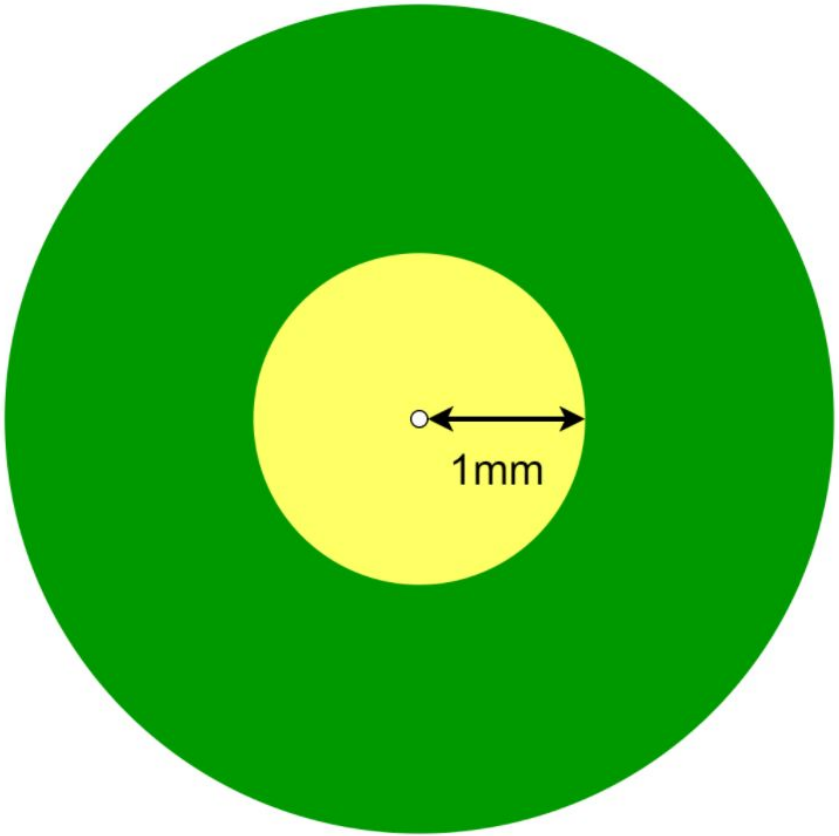
Phantom

Color-coding of facial nerve



Phantom

Target workspace comes in direct contact with the border of the nerve



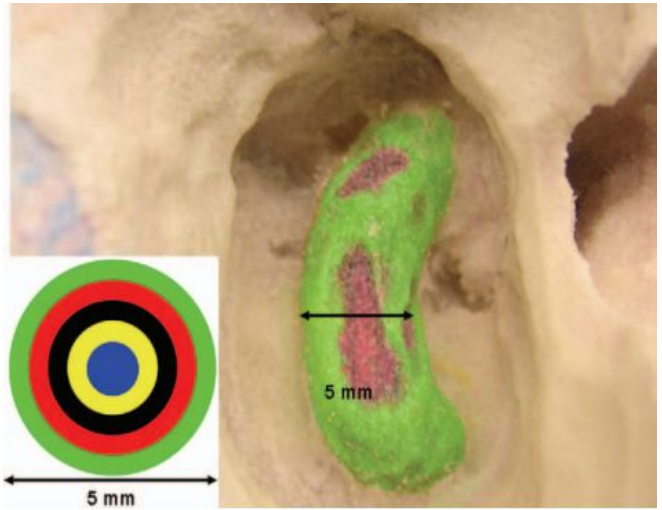
Test subjects

- 10 medical students without surgical experience
- Instructions
  - Drill out cavity until drill comes to a stop
  - Subjects not informed of location and significance of facial nerve
  - Subjects not informed of significance of color-coding

Evaluation Criteria

- Record deviation of drill from facial nerve
  - Evaluated by 5 jurors
  - Models examined with three- to seven-fold magnification under microscope

Image from *The influence of various registration procedures upon surgical accuracy during navigated controlled petrous bone surgery* (Hofer et al.)



Outside facial nerve				**Within facial nerve**	
>1.5 mm	Green 1.5 to 1 mm	Red 1 to 0.5 mm	Black 0.5 to 0 mm	Yellow 0 to -0.5 mm	Blue -0.5 to -1.5 mm

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