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Automatic tracing of the cochlear duct shape on clinical CT images

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Size does differ

- Large inter-patient variability in cochlear size and morphology exists

  - Diameter

    - Long: 8.85 mm (SD 0.45)
    - Short: 6.58 mm (SD 0.40)

- Gender

  - ♂: 3.0 – 4.4% (p < 0.001)
  - ♀: 3.3 – 5.5% (p < 0.001)

  - Ratio long/short = 1.32 (NS)

Size does matter

Cochlear implantation

- 12% of variance in insertion depth can be explained by cochlear size alone.

Vertical trajectories do differ

- 12% of variance in insertion depth can be explained by cochlear size alone.
Unravelling cochlear morphology

Ex vivo
- Histology
- Micro-CT
- Rotational tomography
- Orthogonal-plane fluorescence optical sectioning microscopy (OPFOS)

→ more/accurate details

In vivo
- X-ray
- CT
- MRI

→ patient tailored evaluation
→ large cohort analysis
- Surgical outcomes
- Hearing outcomes

Our study

- Novel, automatic method for determining the cochlear walls and the floor of the scala tympani
- Based on voxel density differences
- From multiplanar reconstructions (MPRs) from clinical preoperative CT-images
- From the center of the round window (RW) up to a cochlear angle of 720 degrees (2 cochlear turns), with 1-degree intervals

Study population

- 479 inner ears (from 242 CI patients)
- Implanted between January 2011 – December 2014
- Normal cochlear morphology
  - Excluded were:
    - Obliterated cochlear lumens by fibrosis or ossification
    - Cochlear/fenestral otosclerosis (obscuring RW anatomy)

MPRs clinical CT scans

- Application of 3-dimensional coordinate system

Automatic tracing procedure

Demonstration

Results
Radial distance outer and inner wall

Results
Cochlear duct size

Results
Vertical trajectory

• Large variation, especially within the first 270 degrees
  • 3 categories
    - Rise & fall within the basal turn
    - Late steep rising (with a preceding fall or flat course)
    - Constant rising

Conclusions & clinical application
• Succeeded to automatically trace the first and second cochlear turn
• Detailed description: 720 measurements
• Patient-tailored surgical planning
  - Risk profile for insertion trauma (%)
  - Implant design
  - Expected surgical and hearing outcomes
• Valuable information for implant design manufacturers
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References