Cochlear surgery: the new frontier in otosurgery

Prof. Manuel Manrique

Inner Ear Surgery
Hybrid stimulation: CI + HA in the same ear
Inner ear surgery

- Cochlear implant surgery
- Diagnosis of SNHL:
  - Take samples
- Delivery of drugs and cells
  - Neurotrophines
  - Antioxidants
  - Stem cells
  - Etc
- Vestibular surgery

Atraumatic cochlear surgery means:
To act surgically on the structures of the membranous labyrinth without damaging its function.
HOW TO PERFORM THIS ATRAUMATIC SURGERY?

Research project milestones

• Study of the target area: Lateral wall of the cochlea

Acta Otolaryngol 2004; 124: 1–7

Morphometry of the Human Cochlear Wall and Implications for Cochlear Surgery*

FRANCISCO JAVIER CERVERA-PAZ¹, FRED H. LINTHICUM², MANUEL J. MANRIQUE³ and NICOLÁS PÉREZ¹
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36 temporal bones

Every cochlea have the same size and shape?
Research project milestones

- Drilling to expose the spiral ligament, does it provoke hearing loss?

Efecto acústico inmediato de la fístula coclear en el cobaya

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• Drilling to expose the spiral ligament, does it provoke hearing loss?

Study in guinea’s pigs
Efecto acústico inmediato de la fistula coclear en el cobaya

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15 animals: 30 ears. Place cochleostomy:
• 10 scala timpany
• 10 scala vestibuly
• 10 spiral ligament

Pre DPOAE

Cochleostomy 2° turn

Post DPOAE

DPOAE mean values

Drilling to expose the spiral ligament, does is provoke hearing loss?

Study in Macaca fascicularis
Cochleostomy in Macaca fascicularis

- Animals: 5 Macaca fascicularis
- Surgical procedure: Promontorial cochleostomy with preservation of spiral ligament
- Auditory evaluation: Pre and post OA and ABR(*)
- Follow-up: 23-25 months

Promontorial cochleostomy: Experimental procedure in animal model (Macaca fascicularis)
Cochleostomy: Experimental procedure in Macaca fascicularis (GEP5)

Posterior timpanotomy

Cochleostomy

Auditory Evaluation: OA y PEATC
Cochleostomy in Macaca fascicularis

- **MONKEY**  |  **FOLLOW-UP** |  **RESULTS**
- 8231 GPE2 (*)  |  26 months  |  OA- ABR 30dB
- 8071 GPE3  |  25 months  |  OA+ ABR 50dB
- 10011 GPE4  |  26 months  |  OA+ ABR 30dB
- 9043 GPE5  |  25 months  |  OA+ ABR 30dB
- 12161 GPE6  |  24 months  |  OA+ ABR 40dB

- No cases of total deafness
- 1 cases of partial hearing loss
- 3 cases of total hearing preservation
- (*) No cochleostomy: Control case

January 2008
Research project milestones

- Development of a micromanipulator to approach to the spiral ligament in the lateral wall of the cochlea

Atraumatic approach to the cochlea with a micromanipulator

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Atraumatic approach of the spiral ligament:
- It needs new surgical tools ⇒ Micromanipulator
- Increases level of atraumaticity and reproductibility
Stage ONE: Bone drilling

- Mainly two possible tools were considered for making the groove:
  - Laser beam
  - Drilling

- Possible global solutions for increasing the accuracy of the surgeon:
  - Teleoperation
  - Micromanipulators (manual or motorized)
  - Passive-controlled joint

Teleoperation system

- Precision
- Possibility of force feedback
- Not specific for a concrete task

- Controlled “by wire”
- Too sophisticated
- Training periods
- Expensive
**Commercial micromanipulators**

- Precision
- Commercial

- Low speed
- Sophisticated
- Expensive

**Passive-controlled joint suggested**

- Simple
- High Precision
- Surgeon keeps “the control of touch”
- Low cost

- Specific for this application
- Complex design of the joint
University of Navarre Micromanipulator

Compliant mechanism

Positioning mechanism

Attachment mechanism
University of Navarra Micromanipulator: Control in-depth movements

With the Z mechanism

With the compliant mechanism

University of Navarra Micromanipulator
18 Humans Temporal Bones:
In 15 cases ⇒ Total preservation of the spiral ligament
Endosteal approach with MM (HT1)

Future electrode concepts

Smart intra-cochlear electrodes

- Micro- and nano-structured stimulation contacts
  - Improved neural interfaces
- Transducers
  - Actuating and sensing perilymph flow
- ASIC integration
  - Reduce # of lead wires
  - Increase contact density
- Biocoatings
  - Reduce scar tissue growth
  - Encapsulation
  - Improved mechanical strength
- Sensors
  - Temperature, pH

Next generation of extra-cochlear electrodes

- Modiolus electrodes
- High density ABI electrodes
- Endosteal electrodes
Thank you!