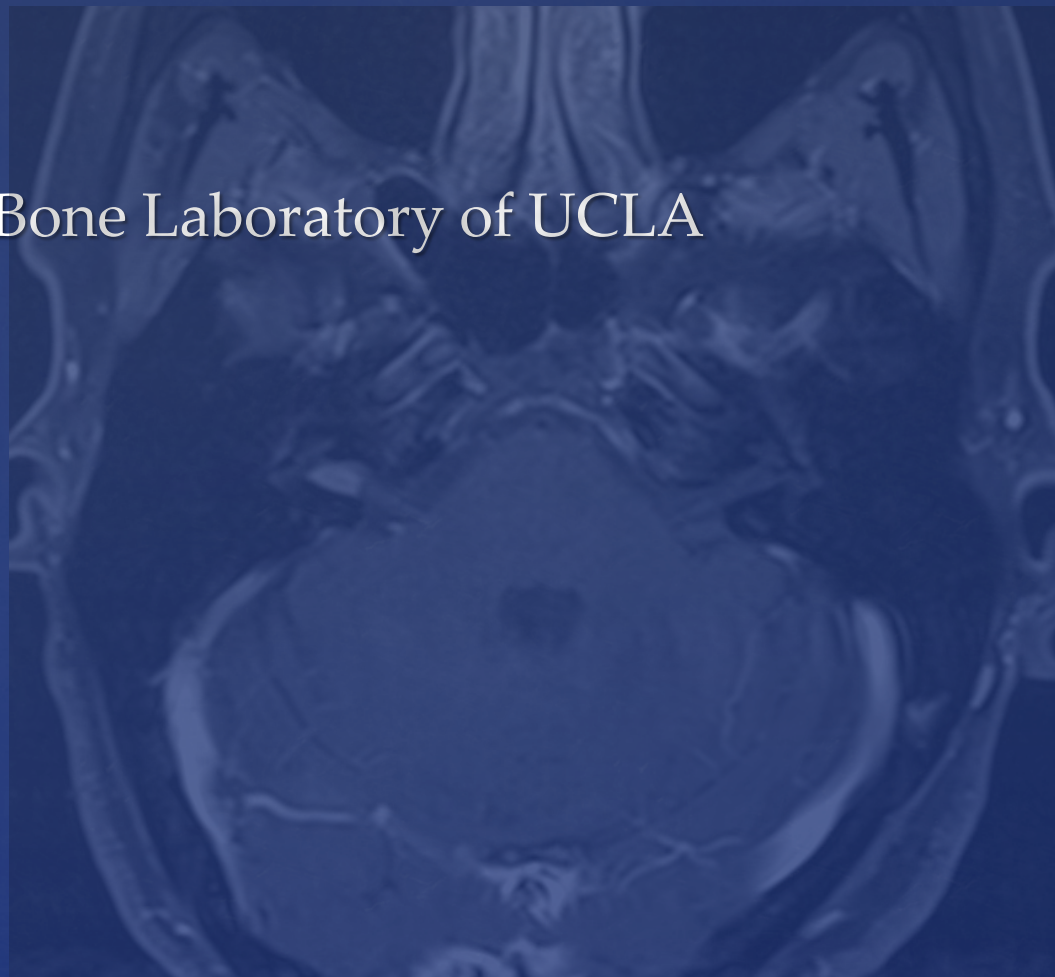
Hearing Preservation and Restoration in the Treatment of Acoustic Neuromas

Mia E. Miller, MD

House Clinic
NIDCD National Temporal Bone Laboratory of UCLA
September 22, 2017



Disclosures

- The authors have nothing to disclose.

Overview

- Approaches for resection of acoustic tumors
  - Translabyrinthine
  - Middle Fossa
  - Retrosigmoid
- Hearing Preservation
  - Middle fossa and retrosigmoid approaches
  - Radiosurgery
- Hearing Restoration
  - Solutions for single-sided deafness
  - Cochlear Implantation
  - Auditory Brainstem Implant

Natural History of AN

- Observation is an important consideration in AN management.

- Sughrue et al., 2010:

  Systematic review of 982 tumors < 2.5 cm

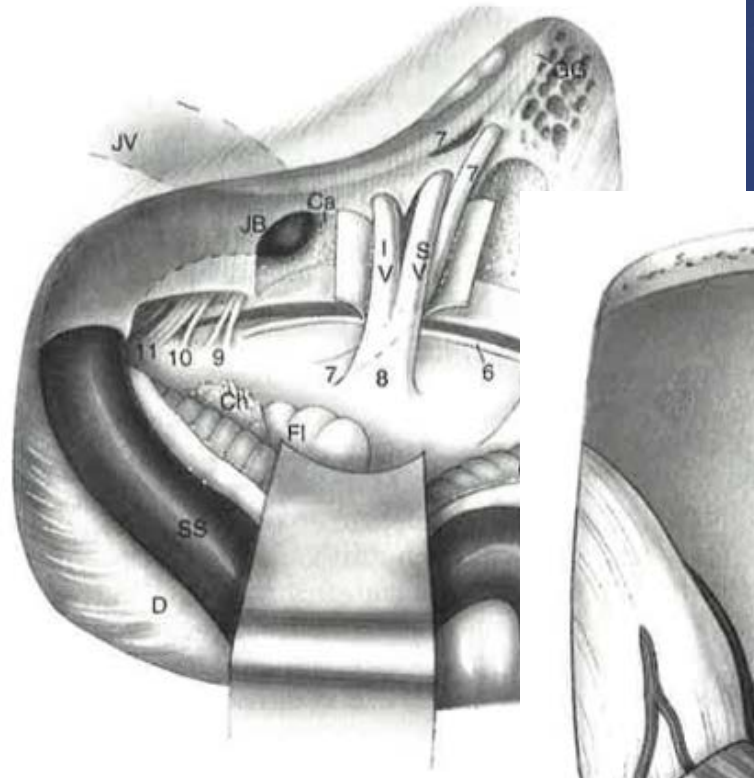
  - Growth rate relates to hearing preservation.
  - Average growth rate of < 2.5 mm/year is favorable.

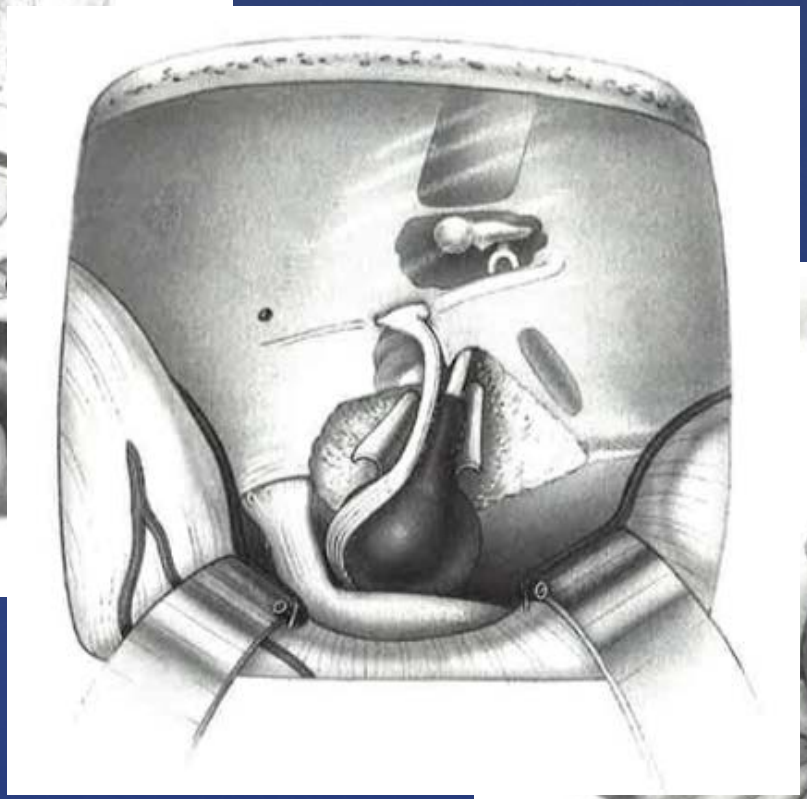
- Sughrue et al., 2011:

  Prospective study over 22 years

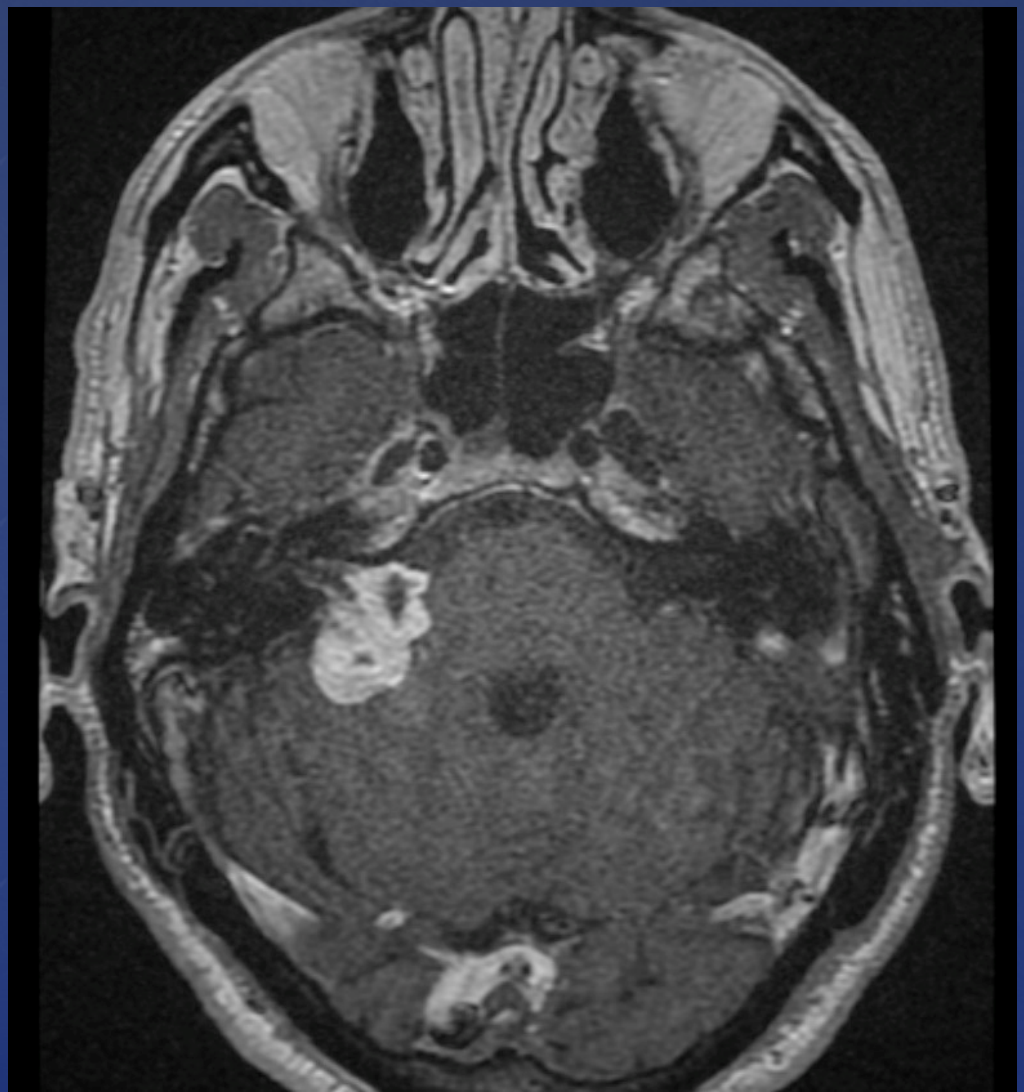
  - Median time to hearing loss was 7.0 years in those patients with tumor growth rate > 2.5 mm/year compared to 14.8 years in the other patients ($p < 0.0001$).

Approaches

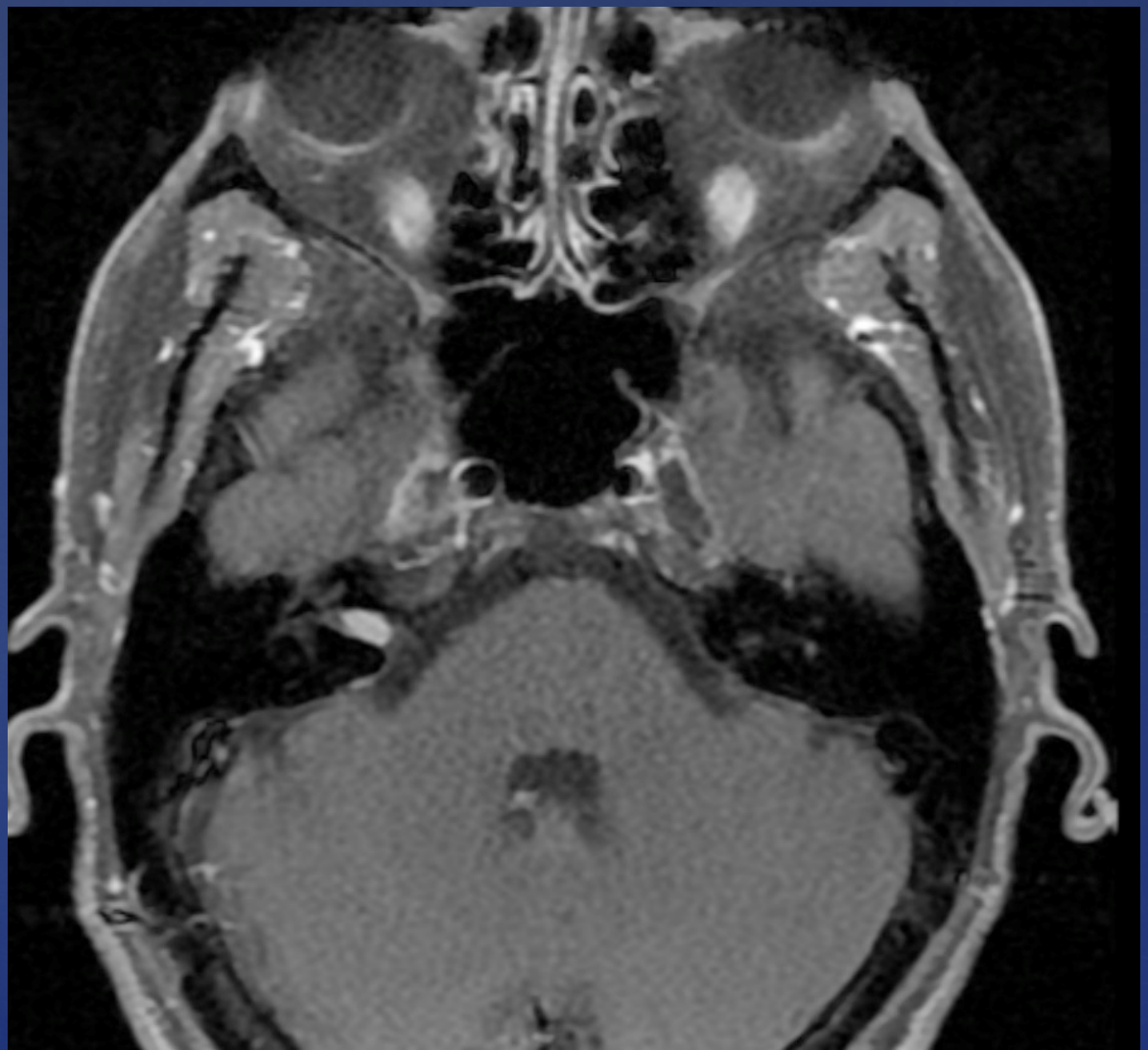




Translabyrinthine



Middle Cranial Fossa



Hearing Preservation: MF

Slattery, Brackmann, Hitselberger, 1997

- Study of 150 patients undergoing MF:
  - 68% had hearing preservation
  - 52% within 15 dB and 15% discrimination of preoperative levels.

Hearing Preservation: MF

Goddard et al., 2010: 101 patients 2006-2009

- Patients with fundal fluid had a higher rate of postoperative measurable hearing (77.6%) compared with those without fundal fluid (52%).

Hearing Preservation: MF

TABLE 2. *Postoperative hearing outcome measures*

Group	Definition
Preserved hearing	Change in PTA ≤15 dB and SDS ≤15%
Serviceable hearing[a]	PTA ≤50 dB and SDS ≥50%
Measurable hearing	PTA ≤90 dB and any SDS

[a]Equivalent to American Academy of Otolaryngology–Head and Neck Surgery class A or B.

PTA indicates pure-tone threshold average at 500, 1,000, 2,000, and 3,000 KHz; SDS, speech discrimination score.

rative American ck Surgery hearing f patients in each tive class

lass

Total n	Percentage
65	64.4%
27	26.7%
4	4.0%
5	5.0%

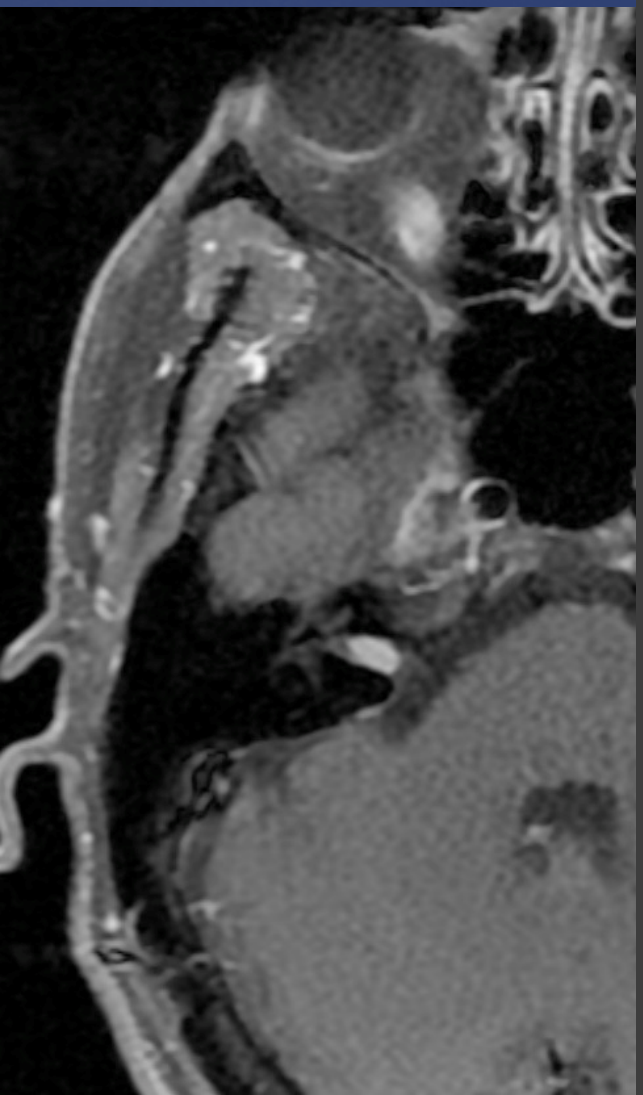
Total n	27	29	5	40
Percentage	26.7%	28.7%	5.0%	39.6%

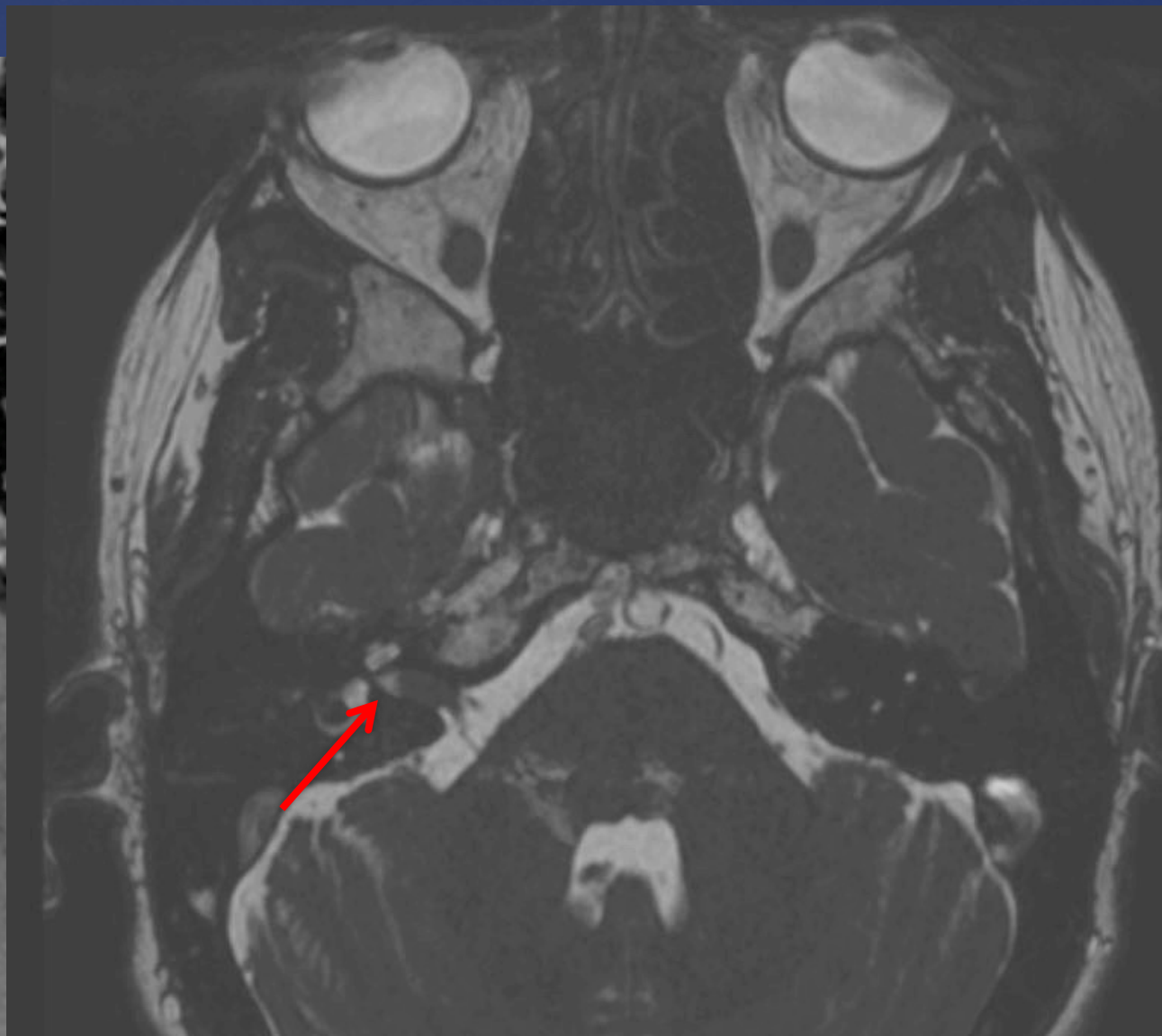
Classification based on the Committee on Hearing and Equilibrium guidelines for the evaluation of hearing preservation in vestibular schwannoma, 1995.

55% Class A or B postoperatively.

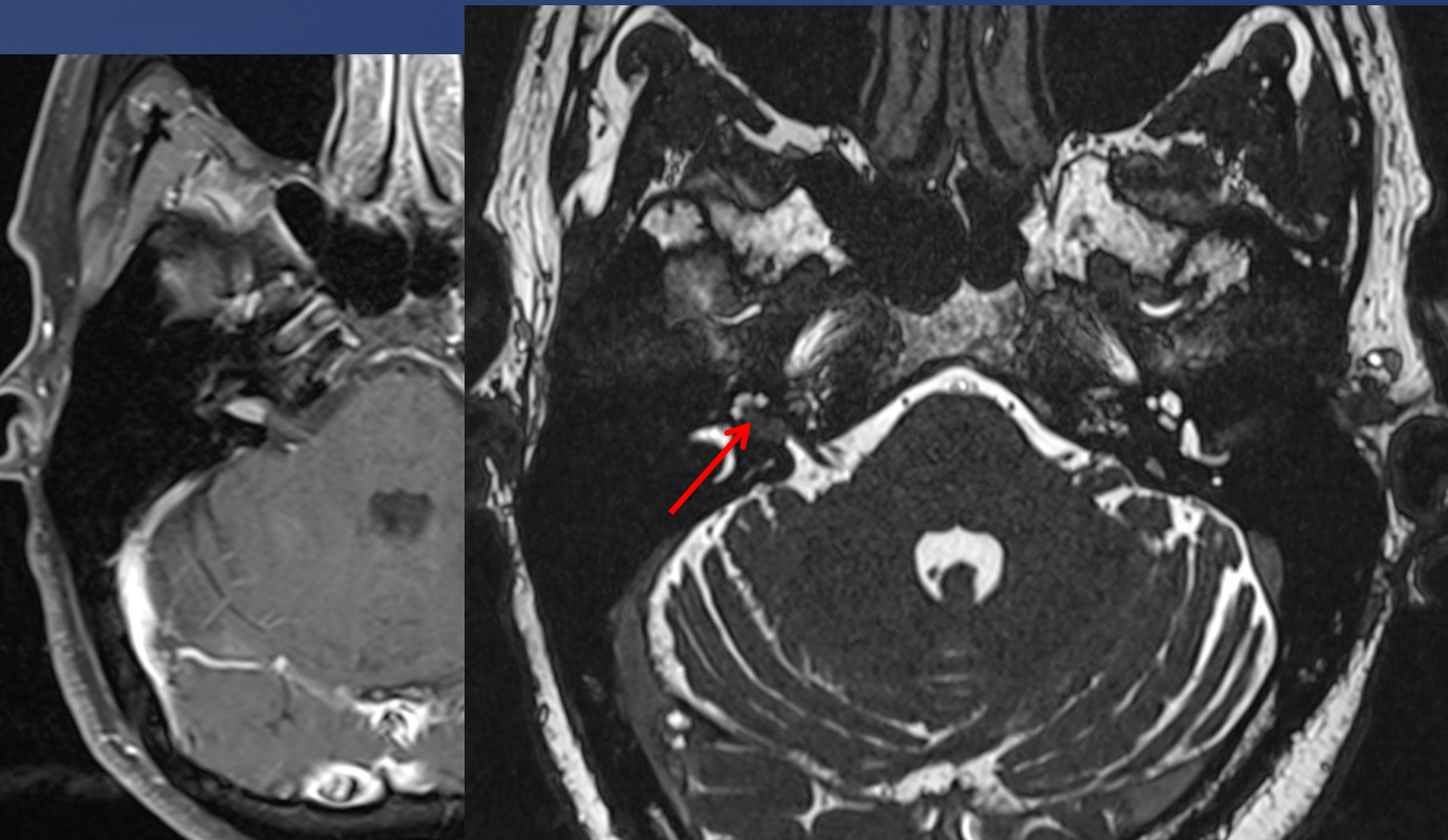
Goddard et al., 2010

Middle Cranial Fossa





Middle Cranial Fossa



Hearing Preservation: MF

Goddard et al., 2010: 101 patients 2006-2009

- Tumors arising from the superior vestibular nerve were associated with a higher rate of preserved, serviceable, and measurable hearing.

- The combination of the presence of fundal fluid and superior nerve tumor had a significantly better chance of hearing preservation than either factor alone.

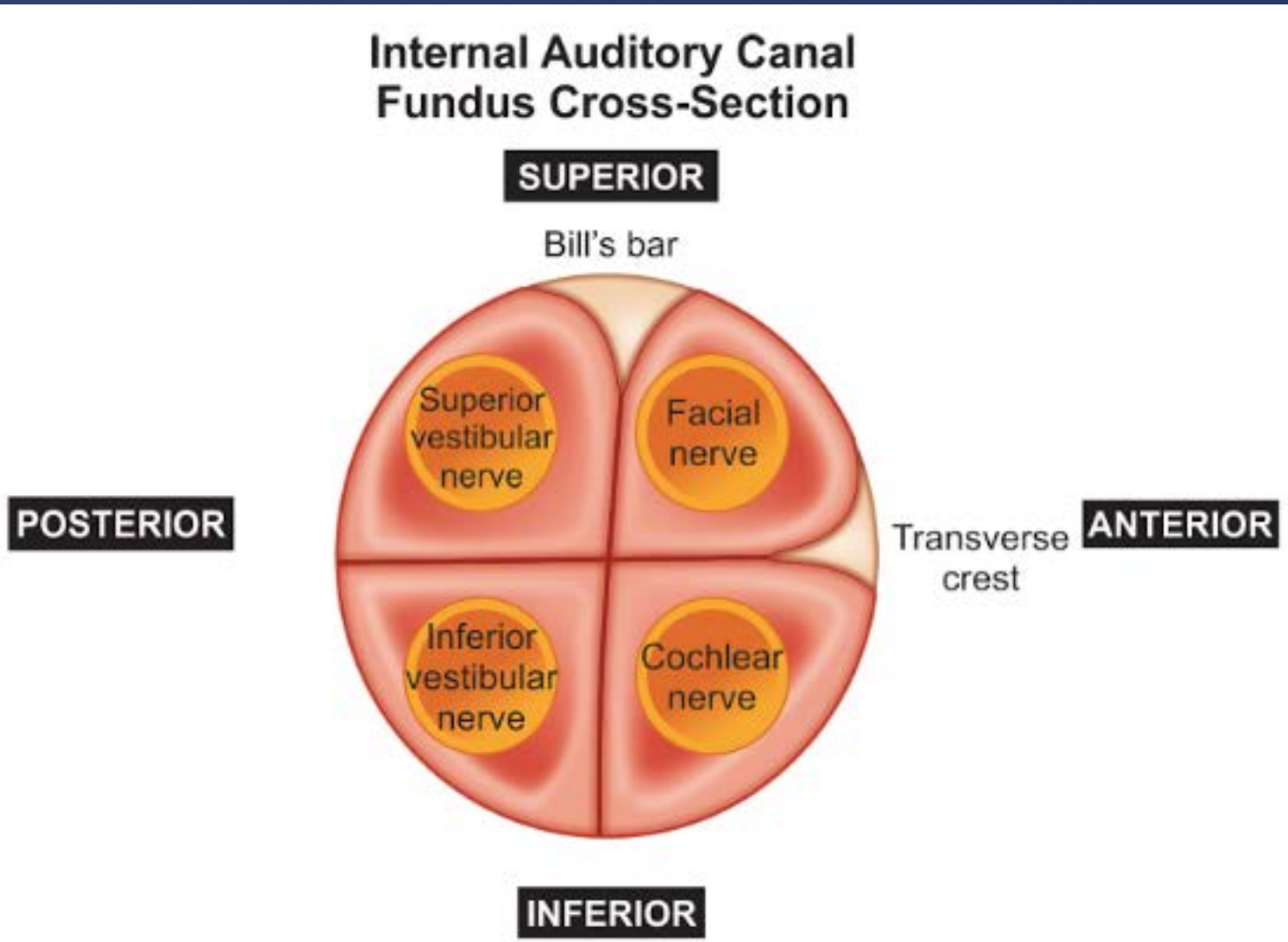
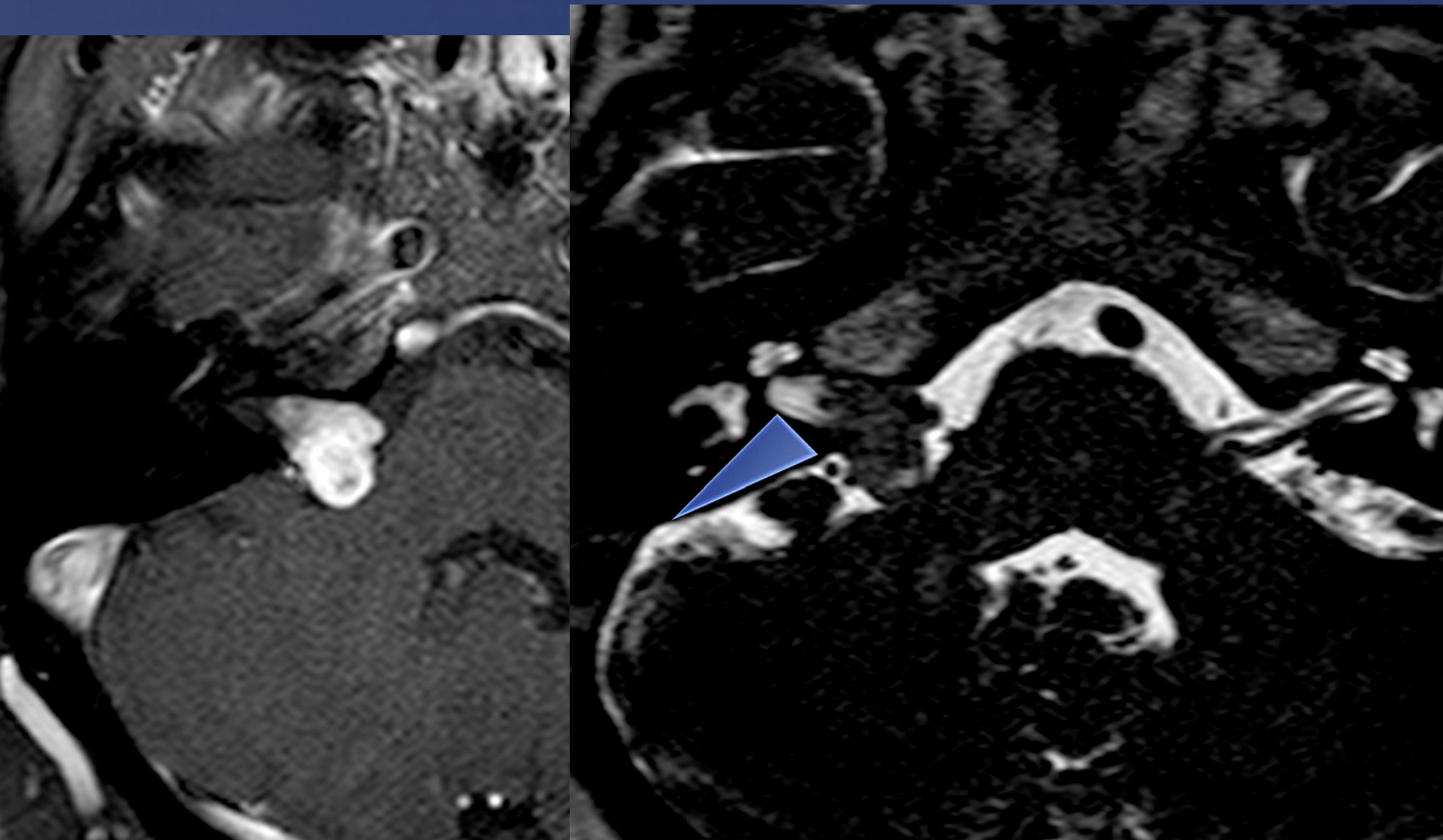


Figure 9.4: Internal auditory canal fundus.

Gopen. *Fundamental Otology*, p. 209.

Retrosigmoid



Direct Eighth Nerve Monitoring

- Hearing outcomes of RS approach are variable.
- 71% hearing preservation in RS cases with DENM vs. 41% with ABR alone for tumors < 1cm (Danner, Mastrodimos, Cueva, 2004).

MF vs. RS

- Wilkinson et al., 2016 found that in 377 patients undergoing MF or RS resection of AN, MF had superior hearing outcomes when controlling for tumor size.

- Sanna's group found in a review of 90 MF cases and 86 RS cases that there was no difference in hearing outcome, but facial nerve complications were more prevalent in MF group (de Freitas et al., 2012)

Radiosurgery

- Yang et al., 2010: systematic review of Gamma knife (Gk) outcomes (4324 patients).
  - Serviceable hearing in 51% at 44.4 months.
- Carlson et al., 2013: 44 patients after Gk, follow-up 9.3 years.
  - Durable hearing preservation after low-dose SRS occurs in less than 25% patients.

Radiosurgery

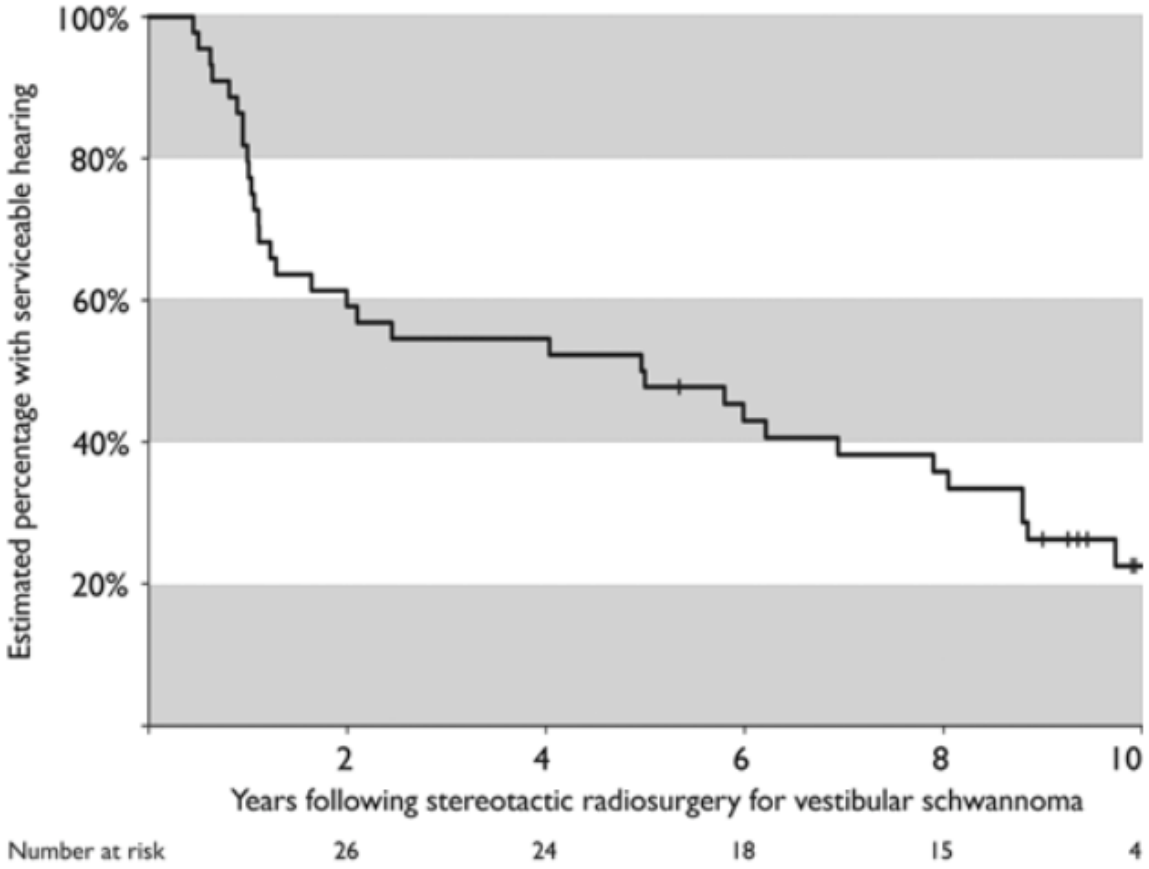


FIG. 1. Kaplan-Meier graph showing estimated rates of serviceable hearing among 44 patients with unilateral VS treated with low-dose SRS.

Carlson et al., 2013

Radiosurgery

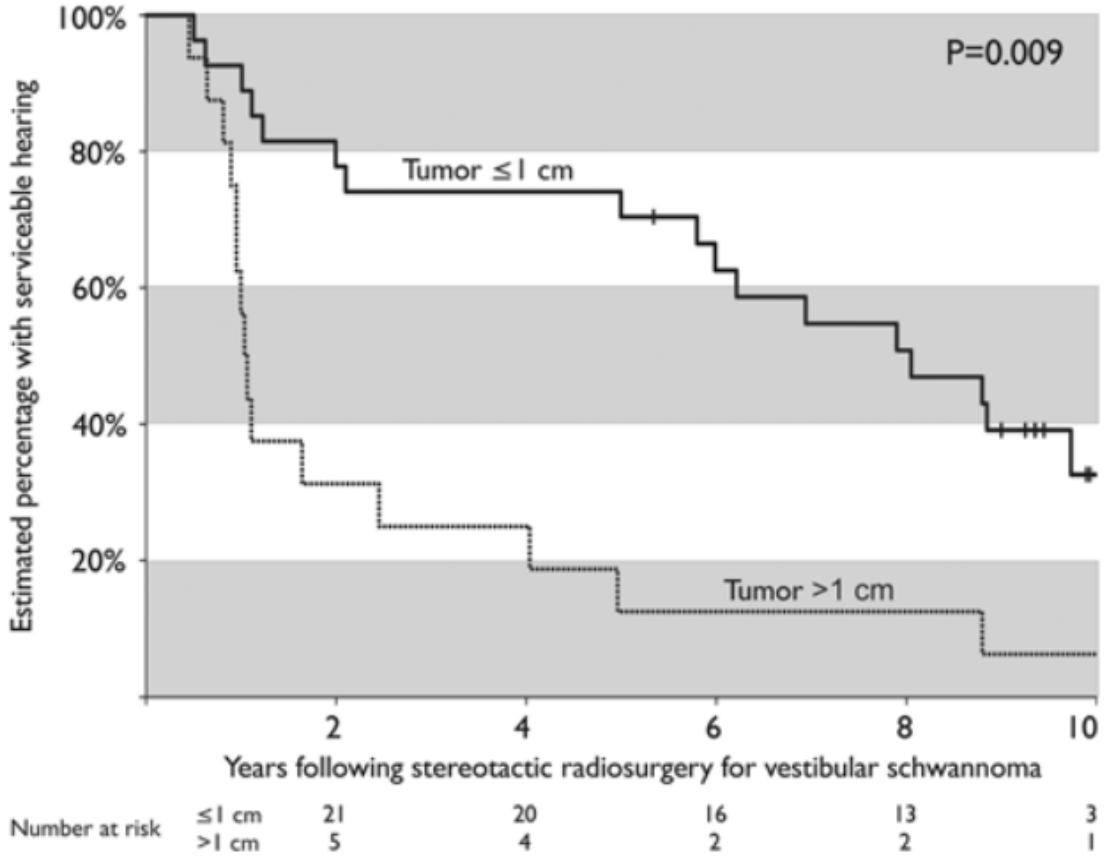


FIG. 3. Kaplan-Meier graph showing estimated rates of serviceable hearing comparing patients with sporadic VSs ≤ 1 cm and tumors > 1 cm.

Carlson et al., 2013

Hearing Restoration

- Contralateral Routing of Sound (CROS)
- Bone-anchored hearing aid (BAHA)
- Cochlear implant
- Auditory Brainstem Implant

CROS and BiCROS

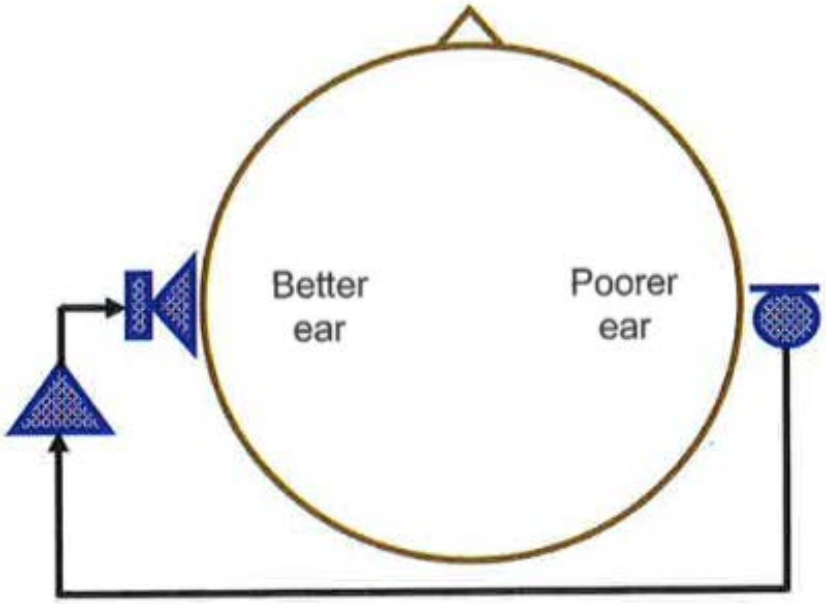


Figure 17.1 Block diagram of a CROS hearing aid system, viewed from above the head.

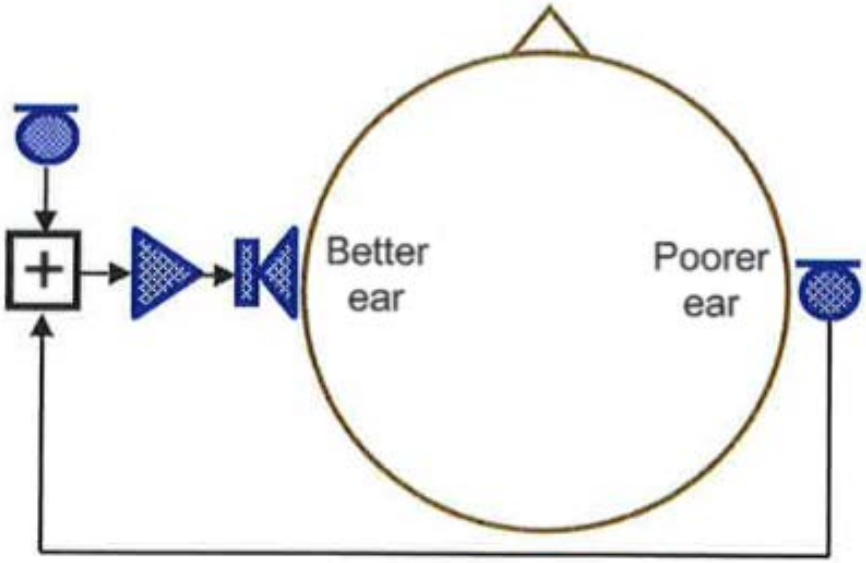


Figure 17.4 Block diagram of a BICROS hearing aid system.

Dillon H. 2012. *Hearing Aids*. Sydney, Boomerang Press, pp. 514-18.

The Baha Connect System with the abutment

The Baha Attract System as shown through the skin

BAHA Attract artifact

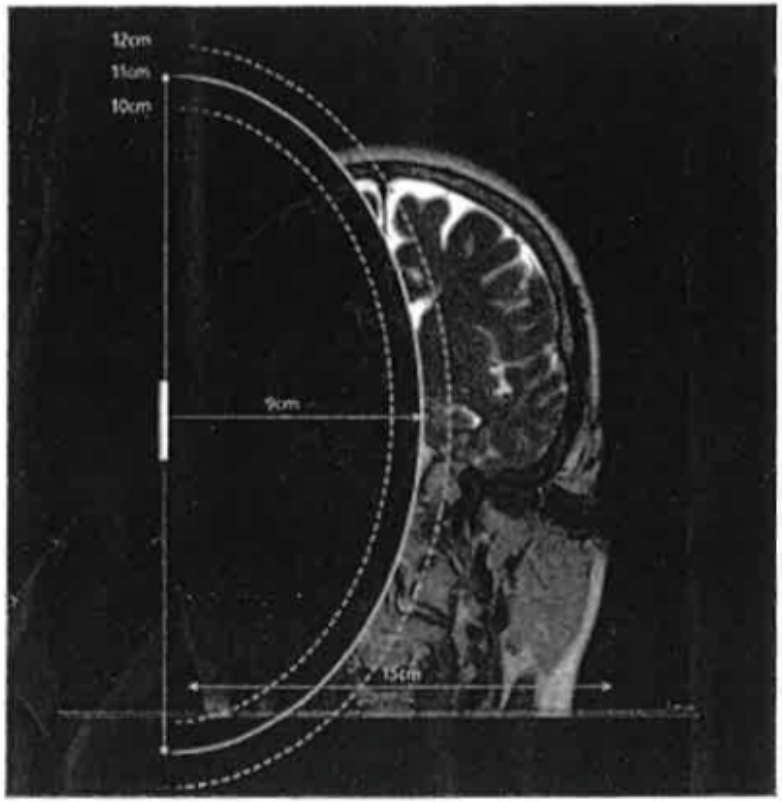


Figure 3: MRI of Baha Attract with implant magnet present

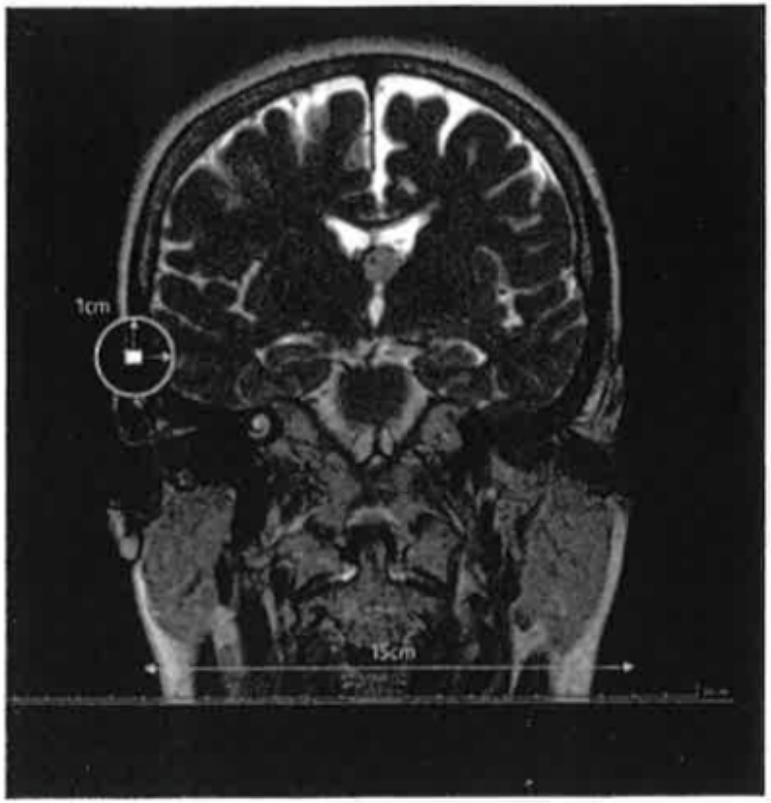


Figure 4: MRI of Baha Attract with the implant magnet removed

Cochlear Implantation

- CI is the only method of restoring binaural hearing patients who have lost hearing after treatment of sporadic AN.
- Binaural hearing allows sound localization, improved speech understanding and QOL, treats tinnitus.

CI Limitations for AN

- CI for single-sided deafness is not FDA approved.
- CI after AN treatment does not reach performance level of standard CI users (Lassaletta et al., 2016).
- CI in SSD demonstrates benefits of localization and speech understanding, but subset are nonusers.

Cochlear Implantation

- CI can be performed after AN resection (Hassepass et al., 2016)
- CI can be performed simultaneously with AN removal (Sanna et al, 2016)
- Controversy: Lack of reliable intraoperative monitoring of the to determine whether CN VIII would be suitable to conduct electrical stimuli.

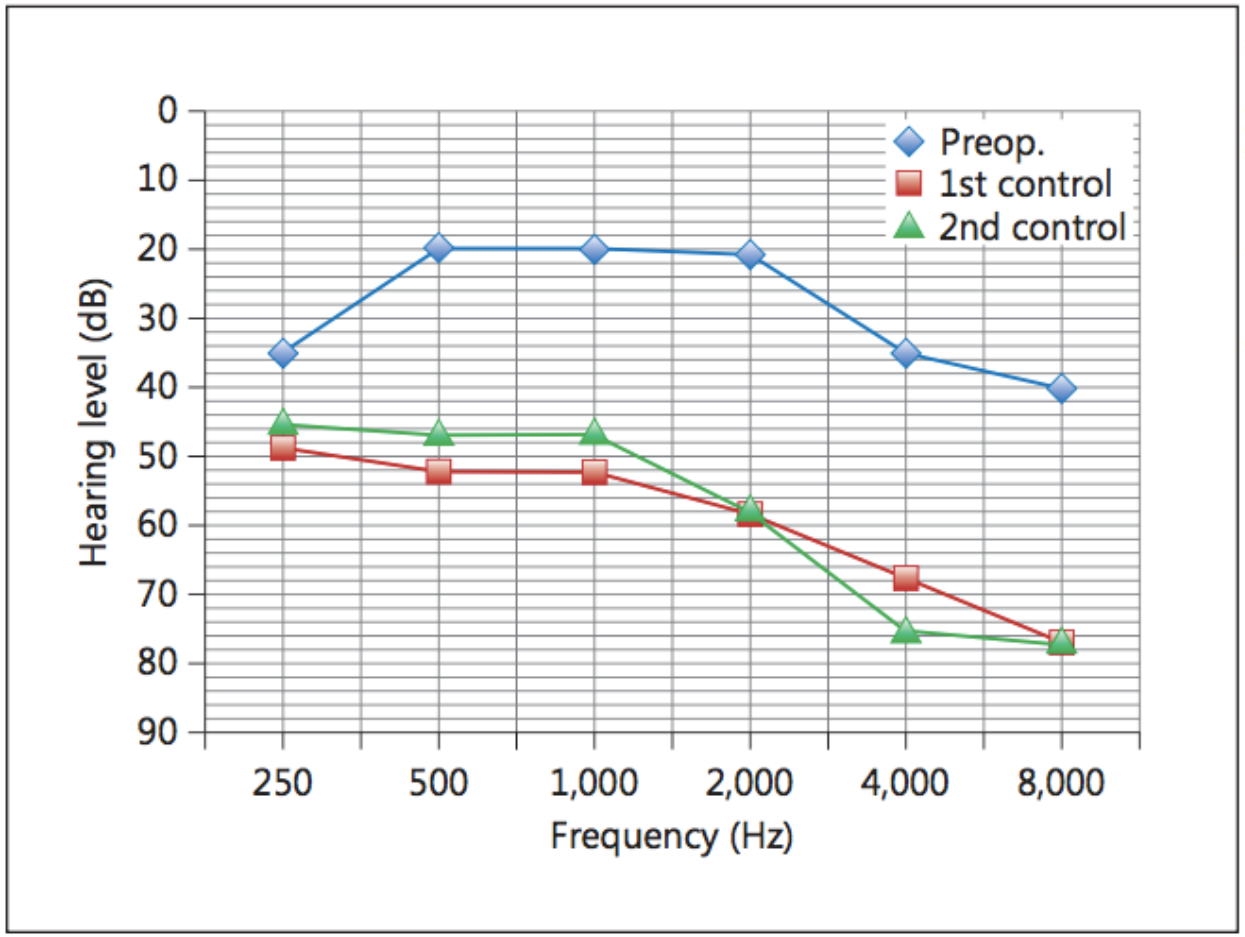
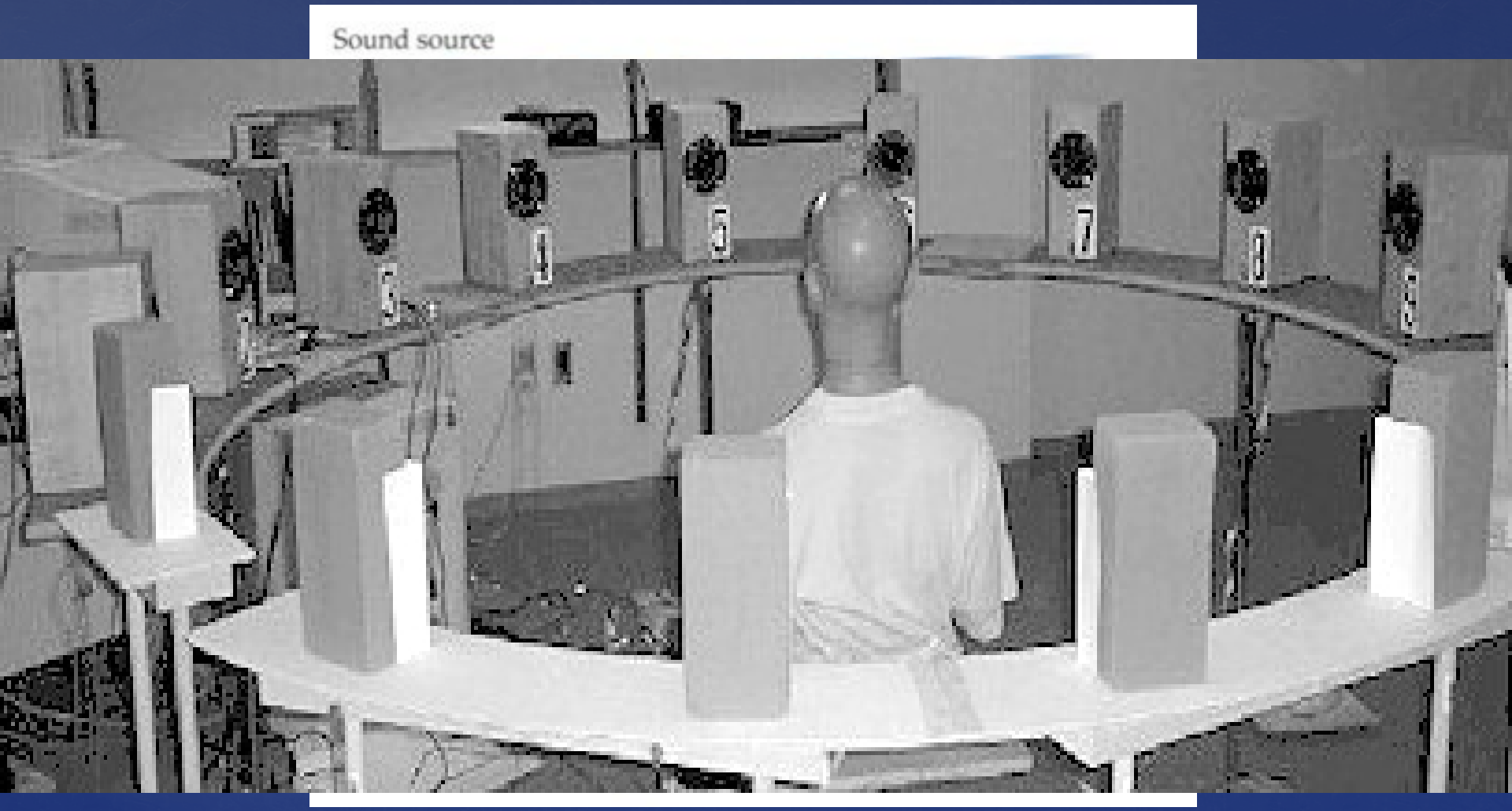


Fig. 1. Pure-tone audiogram showing CI performance in the monaural condition (masking on the normal-hearing side) preoperatively (preop.) and at 6 and 12 months.

Sanna et al., 2016

Sound Localization

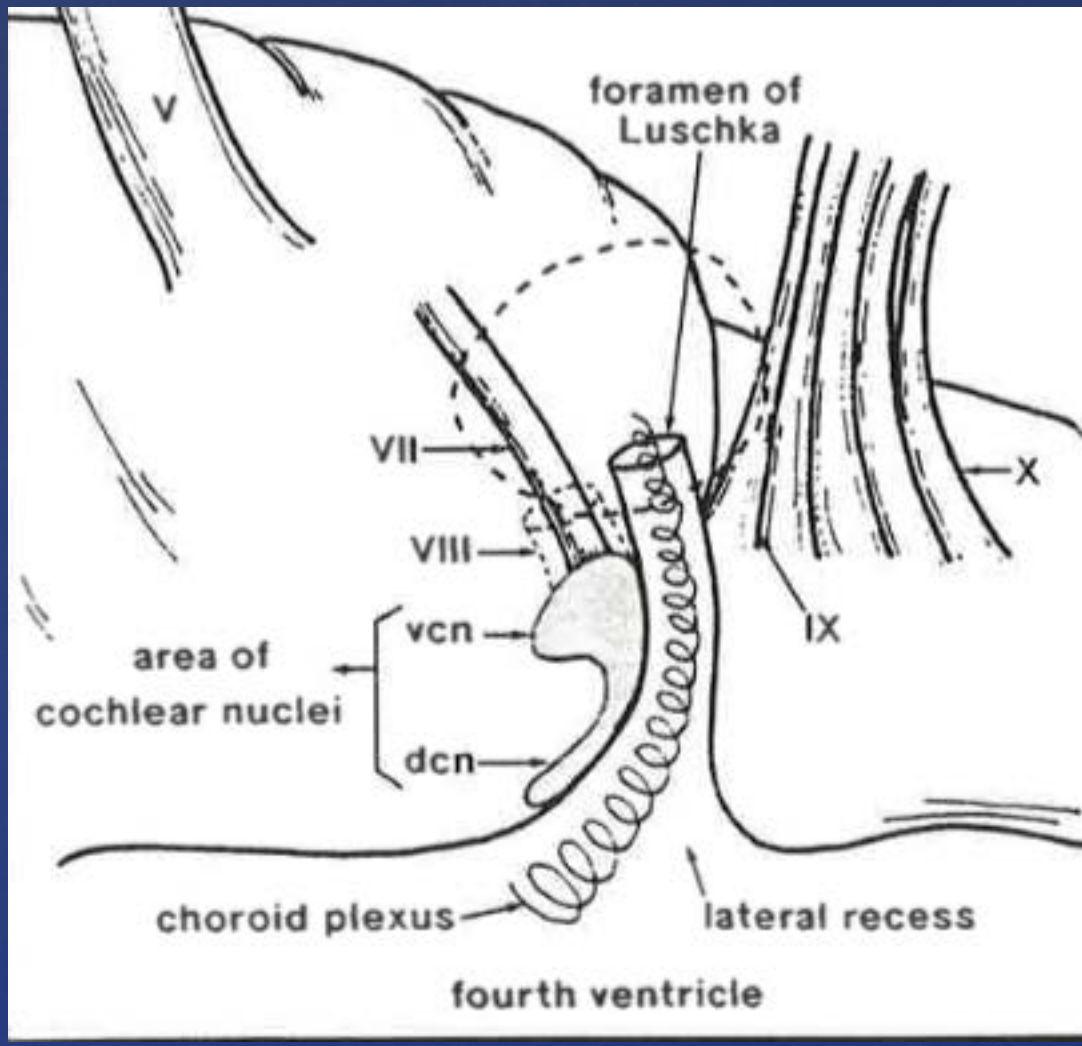


Head Shadow Effect

http://www.ssc.education.ed.ac.uk

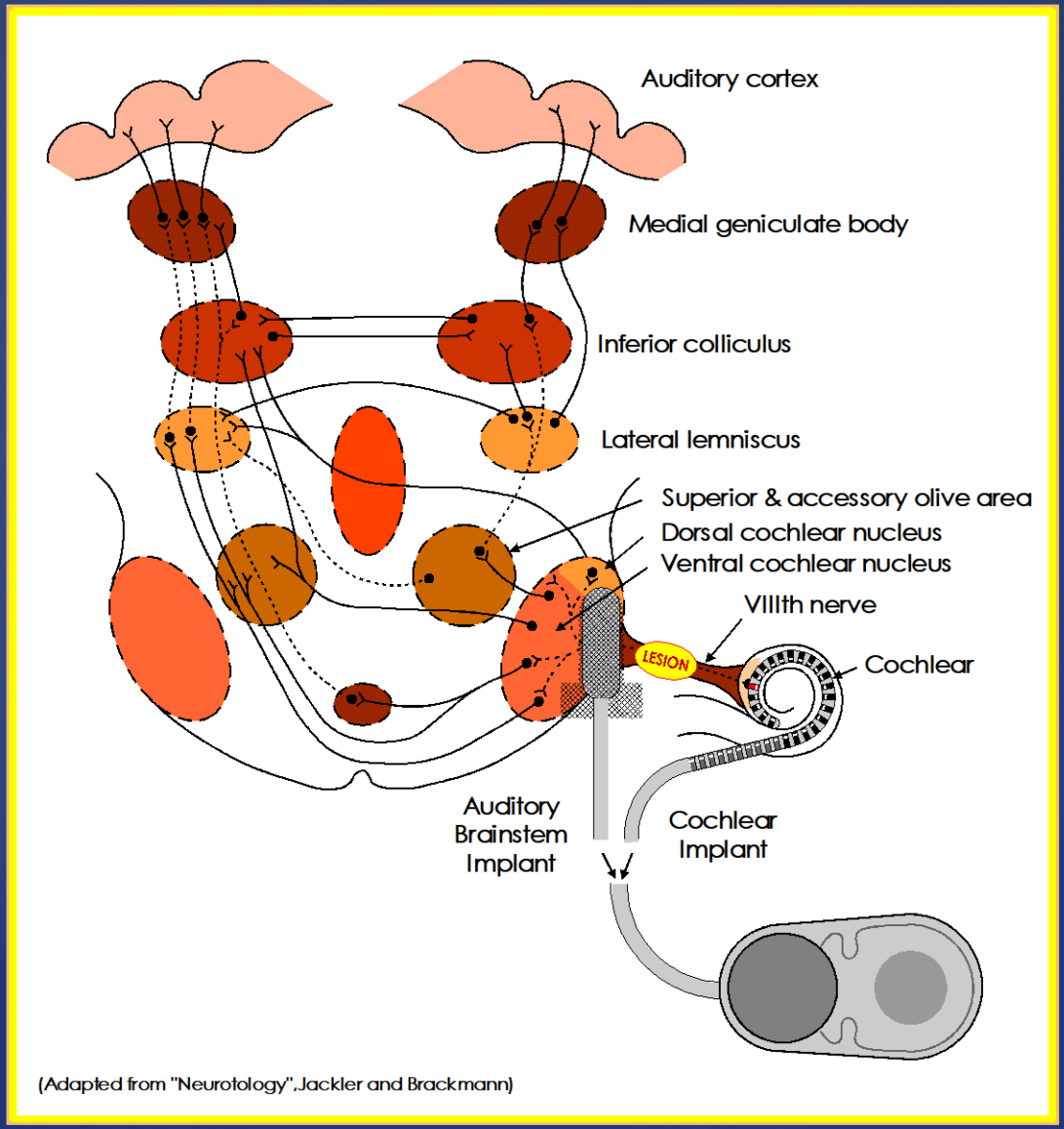
ABI

- Enter lateral recess of fourth ventricle (foramen of Luschka)
- ABI electrode array is positioned within the recess and activates the ventral and dorsal cochlear nuclei.
- Deep/shallow placements or poor contact of electrodes can result in nonauditory sensations with device use (tingling).
- ABI programming can turn off specific electrodes.

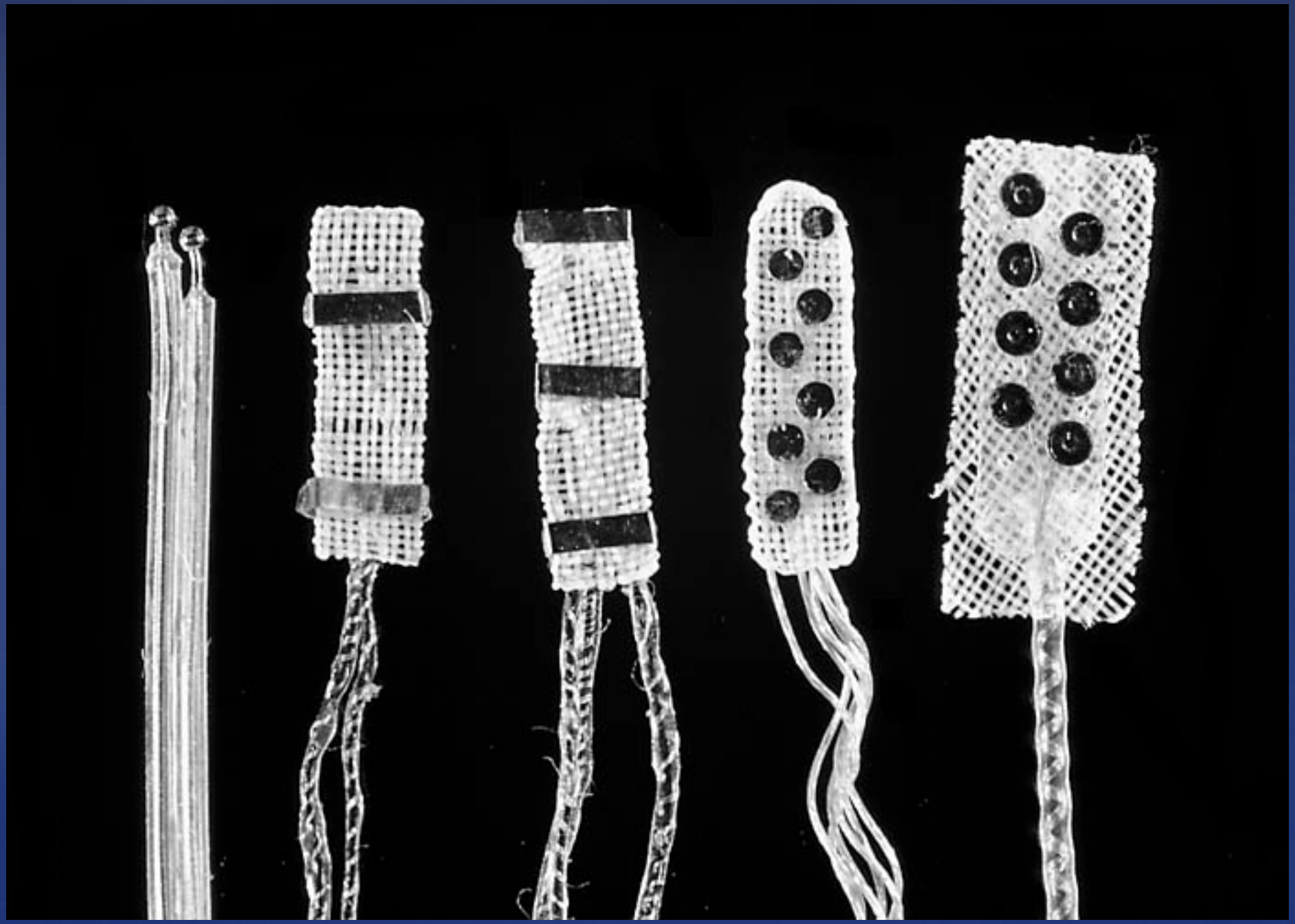


Jackler, Brackmann. *Neurotology*, p. 1324.

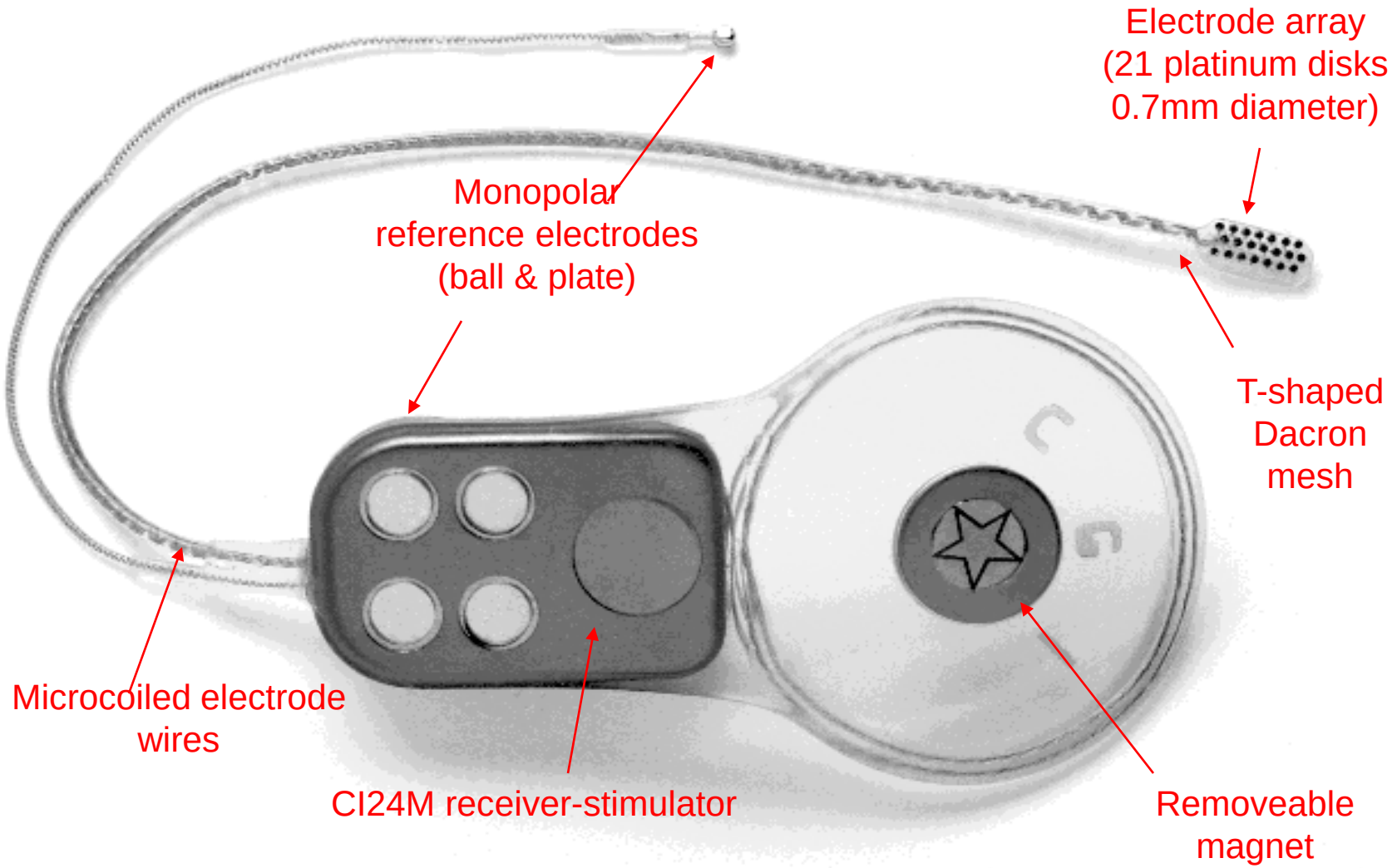
The Auditory Pathway



Relative positions of a cochlear implant and an auditory brainstem implant



Nucleus 24 ABI



Regulatory Status of the Device

- Initial ABI at HRI in 1979
- Cochlear Corp helped design/manufacture multichannel ABI 1993
- Nucleus 24 ABI submitted to FDA in March 2000
- ENT Advisory Panel recommended Nucleus 24 ABI for use by individuals with NF2
- ABI PMA approval in October 2000 (PMA No P000015) (>12y)

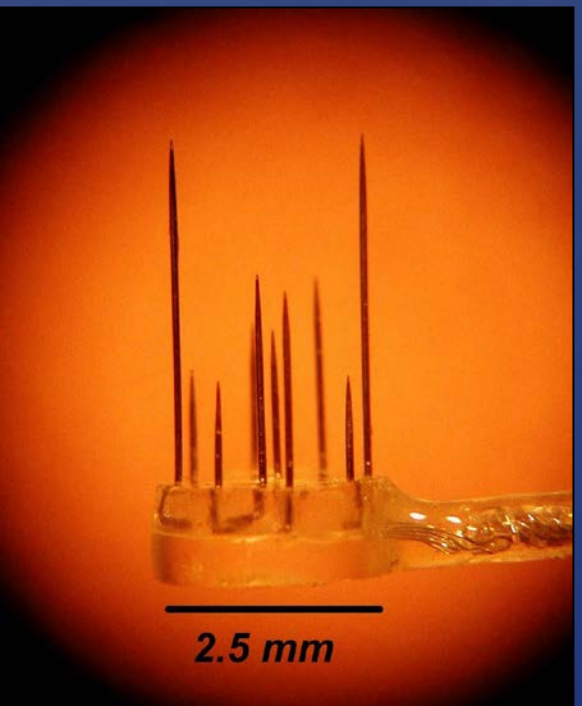
ABI function

Recent systematic review ABI in NF2 (Lloyd et al., 2017):

- Mean scores
  - Word: ABI and lip reading 72.9%
  - Word: ABI alone 35.3%
  - Sentence: ABI and lip reading 57.7%
  - Sentence: ABI alone 12.3%
- 11.6% had open set speech.
- Auditory benefit from ABI continues to improve over several years.
- Best performers >30% speech recognition (26/84 NF2 patients) (Behr et al., 2014)

Penetrating ABI (PABI) -- Goals

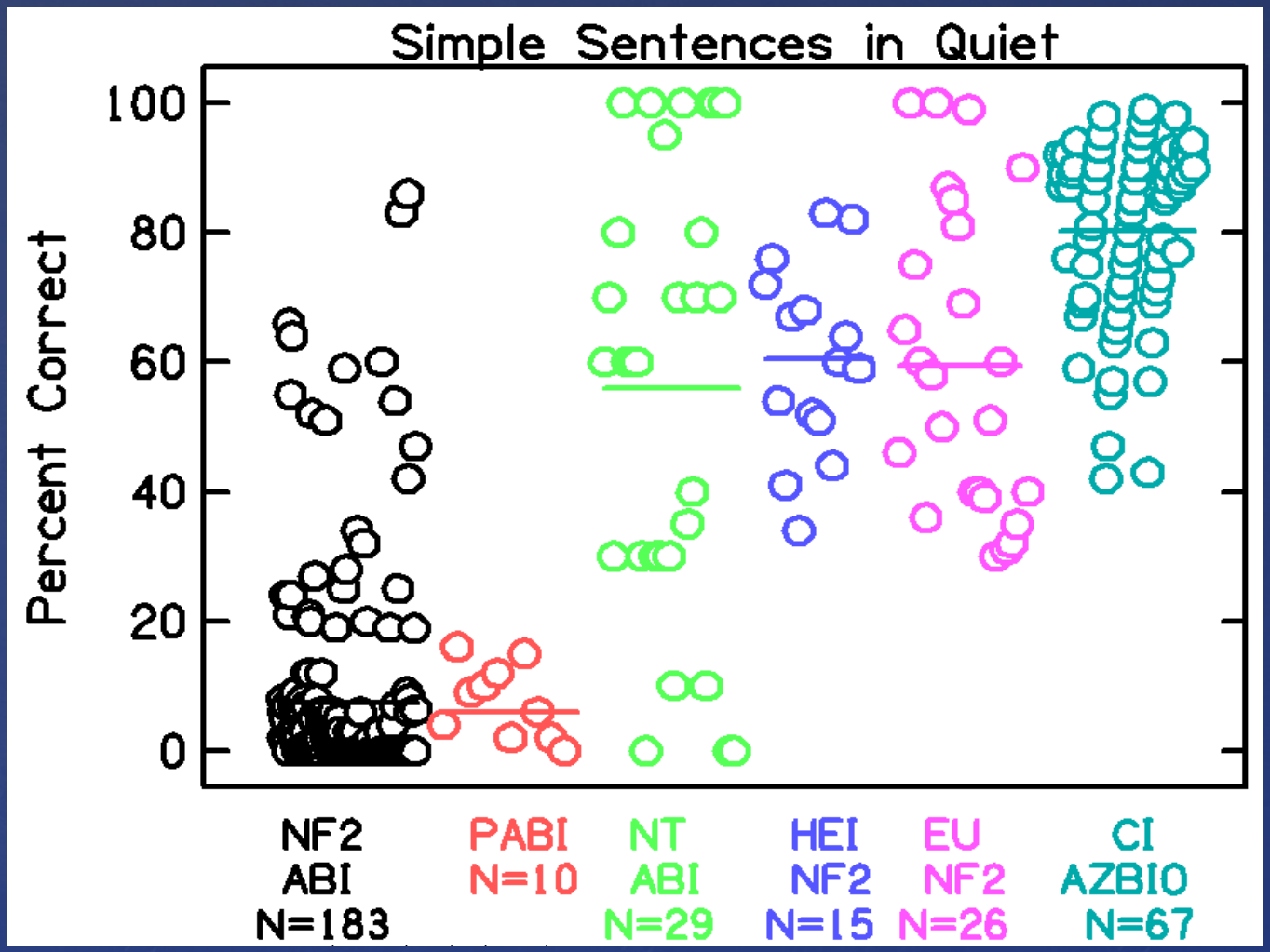
- Improve electrode selectivity
- Decrease threshold current levels
- Improve access to tonotopic organization within the cochlear nucleus
- Improve speech recognition



Otto et al., 2008: PABI met the goals of lower threshold, increased pitch range, and high selectivity, but these properties did not result in improved speech recognition.

Nuclear Profile ABI541

Nucleus Profile ABI541


Simple Sentences in Quiet
Percent Correct
100
80
60
40
20
0
NF2
ABI
N=183
PABI
N=10
NT
ABI
N=29
HEI
NF2
N=15
EU
NF2
N=26
CI
AZBIO
N=67

Summary

- Middle Fossa
  - 68% hearing preservation
  - 52% within 15 dB and 15% discrimination of preop levels.
- Retrosigmoid
  - Best hands, similar hearing preservation to MF.
- Radiosurgery
  - Poor long-term hearing preservation.
- Hearing Restoration
  - It is better to preserve hearing!
  - CI is the only modality to restore sound localization.
  - CROS HA and BAHA most widely used.

Thank you!