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Vanderbilt Audiology's Journal Club: Effects of Hearing Preservation for Cochlear Implant Outcomes

Presented by:

René Gifford, Ph.D.

Moderated by:

Gus Mueller, Ph.D.

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Effects of Hearing Preservation for Cochlear Implant Outcomes

René H. Gifford, PhD

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AAA Annual

TRIVIA BOWL XXIV

A few examples of "Bill's Bar"

What's the connection between "Bill's Bar" and audiology?

A. Standard for the highest background noise SPL allowed on space shuttle
B. Bony shelf which is landmark in nVIII surgery
C. Narrow strip of the amygdala important for processing speech-in-noise
D. The term "BILL processing" (for hearing aids) was coined in Chicago's Bill's Bar
E. C.C. Bunch and Ray Carhart did Fuzzy Navel shots together in Chicago's Bill's Bar

The real "Bill's Bar"

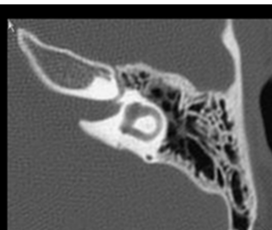

Fig. 1: CT, axial. Internal auditory canal. The beak-shaped structure protruding into its anterior fundus at this level is "Bill's bar" named after Dr. William House. The facial nerve canal starts just anterior to Bill's bar, and the short canal for the

Photo from 1981

Ben Hornsby: 20 Years at Vandy!

Has René experienced the “Hornsby Effect?”

THEN

NOW

VANDERBILT AUDIOLOGY JOURNAL CLUB

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Effects of Hearing Preservation for Cochlear Implant Outcomes

René H. Gifford, PhD

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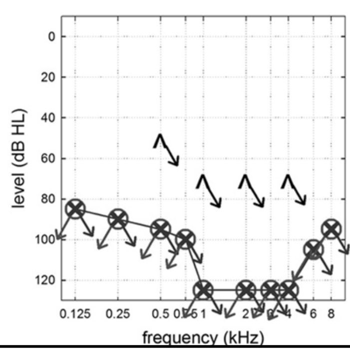
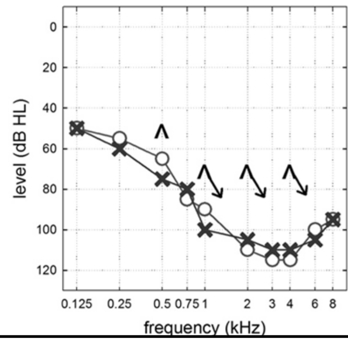
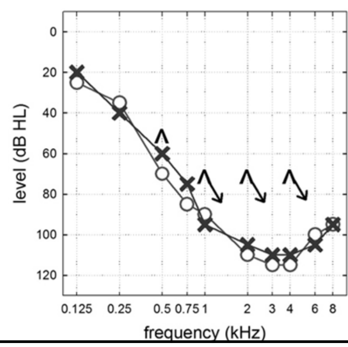
Early CI Patient



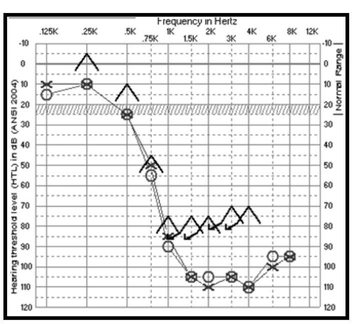
Modern CI Patient



Modern CI Patient?

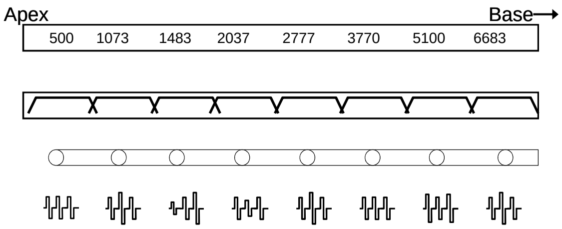


HA? CI? MEI? EAS/Hybrid?

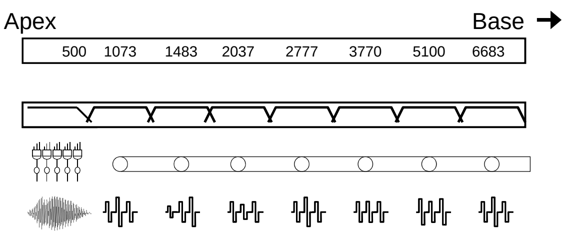


- difficult to fit
- Vinay & Moore (2007):
- 592 ears
- For thresholds > 70 dB HL, 59% had dead regions

Conventional Cochlear Implant



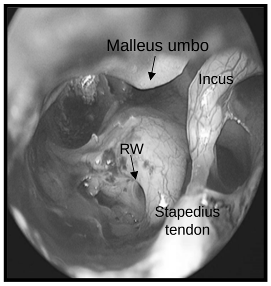
Combined Electric and Acoustic Hearing



Cochlear Implants: Hearing Preservation

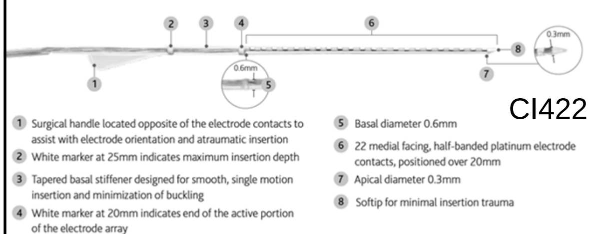
- Traditionally, any residual hearing would have been sacrificed during surgery.
- We are now seeing significant hearing preservation both with short and long electrode arrays.

Minimally traumatic surgery



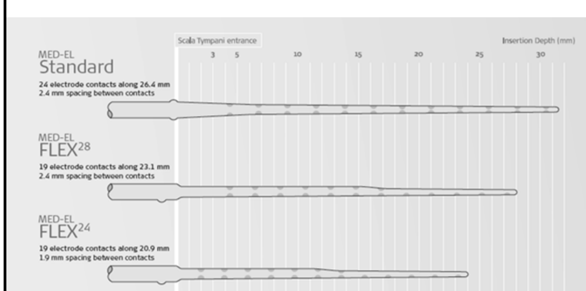
- Cochleostomy location & size
- RW insertion
- Opening endosteum
- Hyaluronic acid (**Healon**®)
- Perilymph
- Insertion force and speed
- Steroids
  - Pre-, peri- and/or post-implant

Atraumatic electrodes

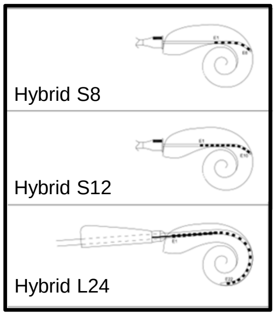


CI422

Atraumatic electrodes



Atraumatic electrodes



Skeptics

Hearing preservation doesn't matter because…

- The hearing is useless anyway.
- My patients do well.
- Surgery takes more time...
  - and it's more difficult.
- Patients will lose hearing over time.
- We are setting ourselves up for failure.

Research Questions

Does HP improve speech recognition in realistic listening environments (e.g., diffuse noise and reverberation)?

Speech Perception With Combined Electric-Acoustic Stimulation and Bilateral Cochlear Implants in a Multisource Noise Field

Tobias Rader,[1,2] Hugo Fastl,[2] and Uwe Baumann[1]

Objective: The aim of the study was to measure and compare speech perception in users of electric-acoustic stimulation (EAS) supported by a hearing aid in the unimplanted ear and in bilateral cochlear implant (CI) users under different noise and sound field conditions. Gap listening was assessed by comparing performance in unmodulated and modulated Comité Consultatif International Téléphonique et Télégraphique (CCITT) noise conditions, and binaural interaction was investigated by comparing single source and multisource sound fields.

Methods: Speech perception in noise was measured using a closed-set sentence test (Oldenburg Sentence Test, OLSA) in a multisource noise field (MSNF) consisting of a four-loudspeaker array with independent noise sources and a single source in frontal position (S_0N_0). Speech simulating noise (Fastl-noise), CCITT-noise (continuous), and OLSA-noise (pseudo continuous) served as noise sources with different temporal patterns. Speech tests were performed in two groups of subjects who were using either EAS (n = 12) or bilateral CIs (n = 10). All subjects in the EAS group were fitted with a high-power hearing aid in the opposite ear (bimodal EAS). The average group score on monosyllable in quiet was 68.8% (EAS) and 80.5% (bilateral CI). A group of 22 listeners with normal hearing served as controls to compare and evaluate potential gap listening effects in implanted patients.

Results: Average speech reception thresholds in the EAS group were significantly lower than those for the bilateral CI group in all test conditions

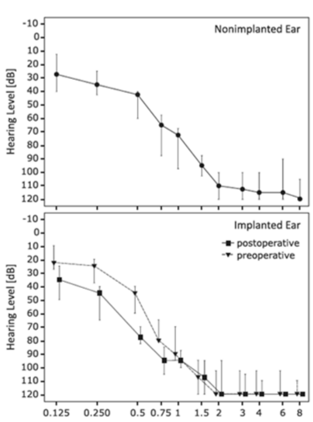
INTRODUCTION

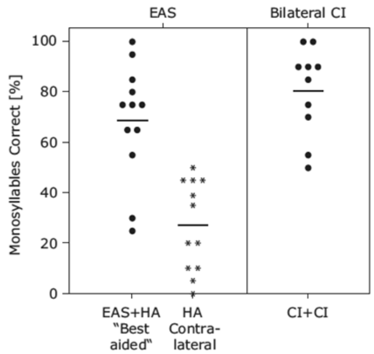
Electric-acoustic stimulation (EAS) with hearing preservation in the implanted ear is a well-accepted therapeutic treatment for subjects with profound ski-slope hearing loss (Baumann & Helbig 2009, von Ilberg et al. 2011). This technique was introduced by von Ilberg et al. (1999) as a consequence of groundbreaking surgical approaches that enabled hearing preservation with optimized electrode designs. These combined techniques minimize trauma to the delicate structures of the Basilar membrane, and preserve the acoustic low-frequency hearing in the majority of subjects after implantation (Gstoettner et al. 2009). EAS users show improved speech intelligibility compared with cochlear implant (CI) users who receive only electrical stimulation (Kiefer et al. 2002, review in Dorman & Gifford, 2010).

An alternative treatment option for bilateral, precipitously sloping high-frequency hearing loss is a standard CI with a fully inserted electrode array. Patients can thus receive electric stimulation from the implanted ear and acoustic stimulation from the contralateral ear (bimodal stimulation). Similar to EAS patients who have hearing preservation in the implanted ear, patients with bimodal stimulation have the opportunity to benefit from the combination of electric and acoustic stimulation (Gifford et al. 2007).

Rader et al. (2013). Ear Hear. 34:324-32.

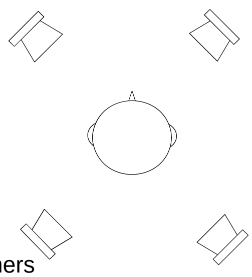
- n = 44
- Normal-hearing control (n = 22)
- Bilateral CI (n = 10)
- Hearing preservation (n = 12)
  - 11 FLEX^eas
    - Now marketed as the Flex 24
  - 1 FLEX 20
  - straight electrodes



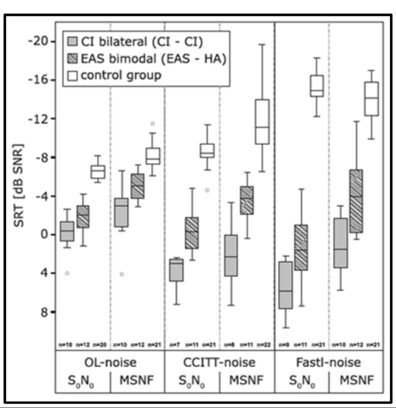


Experimental details

- 2 noise conditions
  - S_0N_0
  - multi-source noise field
    - MSNF
    - 4-loudspeakers
    - ±45º and ±135º



- Noise fixed:
  - 75 dB SPL for NH listeners
  - 65 dB SPL for CI listeners



LIMITATIONS

- Only tested the “best” condition for the EAS subjects
  - Did they need the hearing in the CI ear to achieve this level of performance?
- Small sample of both bilateral and EAS subjects

Research Questions

Does HP improve speech recognition in realistic listening environments (e.g., diffuse noise and reverberation)?

If so, what underlying mechanism may be responsible for the HP-related benefit?

Cochlear Implantation With Hearing Preservation Yields Significant Benefit for Speech Recognition in Complex Listening Environments

René H. Gifford,[1] Michael F. Dorman,[2] Henryk Skarzynski,[3] Artur Lorens,[3] Marek Polak,[4] Colin L. W. Driscoll,[5] Peter Roland,[6] and Craig A. Buchman[7]

Objective: The aim of this study was to assess the benefit of having preserved acoustic hearing in the implanted ear for speech recognition in complex listening environments.

Design: The present study included a within-subjects, repeated-measures design including 21 English-speaking and 17 Polish-speaking cochlear implant (CI) recipients with preserved acoustic hearing in the implanted ear. The patients were implanted with electrodes that varied in insertion depth from 10 to 31 mm. Mean preoperative low-frequency thresholds (average of 125, 250, and 500 Hz) in the implanted ear were 39.3 and 23.4 dB HL for the English- and Polish-speaking participants, respectively. In one condition, speech perception was assessed in an eight-loudspeaker environment in which the speech signals were presented from one loudspeaker and restaurant noise was presented from all loudspeakers. In another condition, the signals were presented in a simulation of a reverberant environment with a reverberation time of 0.6 sec. The response measures included speech reception thresholds (SRTs) and percent correct sentence understanding for two test conditions: CI plus low-frequency hearing in the contralateral ear (bimodal condition) and CI plus low-frequency hearing in both ears (best-aided condition). A subset of six English-speaking listeners were also assessed on measures of interaural time difference thresholds for a 250-Hz signal.

Results: Small, but significant, improvements in performance (1.7–2.1 dB and 6–10 percentage points) were found for the best-aided condition versus the bimodal condition. Postoperative thresholds in the implanted ear were correlated with the degree of electric and acoustic stimulation (EAS) benefit for speech recognition in diffuse noise. There was no reliable relationship among measures of audiometric threshold in the implanted ear nor elevation in threshold after surgery and improvement

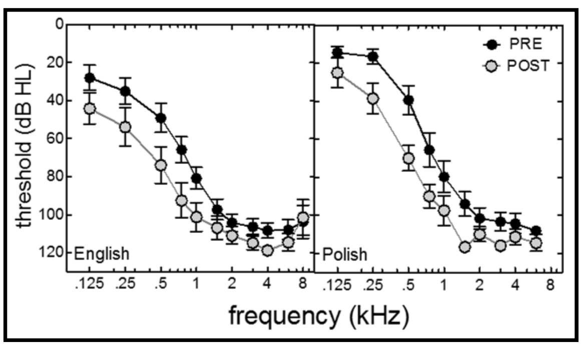
INTRODUCTION

There is increasing interest in preservation of acoustic hearing with cochlear implantation and multiple reports have demonstrated that this is feasible both with short electrodes and shallow insertion (e.g., Büchner et al. 2009; Gantz et al. 2009; Lenarz et al. 2009; Woodson et al. 2010) and longer electrodes with deeper insertion depth (e.g., Gstoettner et al. 2008, 2009; Arnoldner et al. 2010; Carlson et al. 2011; Helbig et al. 2011; Skarzynski et al. 2009, 2011; Obholzer & Gibson 2011). Degree of hearing preservation has been to shown to be somewhat dependent on the insertion depth of the array. Mean threshold elevation after cochlear implantation ranges from 10 to 25 dB for shorter electrode arrays (10 mm; Gantz et al. 2005, 2009; 16 mm; Lenarz et al. 2009) and 10 to 40+ dB for longer electrode arrays (16– to 30+ mm; Gstoettner et al. 2008, 2009; Arnoldner et al. 2010; Carlson et al. 2011; Helbig et al. 2011; Skarzynski et al. 2009, 2011; Obholzer & Gibson 2011).

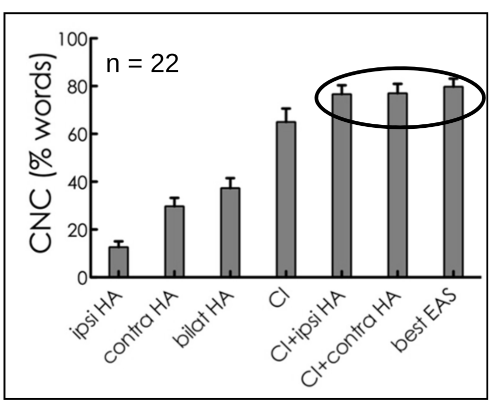
In the aforementioned articles, however, there are reports of complete hearing preservation with both long and short electrodes as well as complete loss of residual hearing with both long and short electrodes thresholds. Many variables are thought to be associated with hearing preservation, including drug delivery, surgical approach, electrode arrays and dimensions, individual inflammatory response to trauma, etc. (e.g.,

Gifford et al. (2013). Ear Hear.

- n = 54
- Normal-hearing control (n = 16)
- Polish speaking (n = 17)
  - 17 Med El EAS
- English speaking (n = 21)
  - 2 Med El Sonata H
  - 2 Med El EAS
  - 10 Hybrid (6 S8, 4 L24)
  - 7 Nucleus 24 series or later [CI24RCA, CI24RE(CA), CI512]
  - Both short and long electrodes



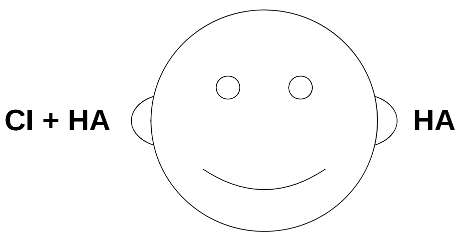
LF PTA: 20-dB loss for both groups



Experiments

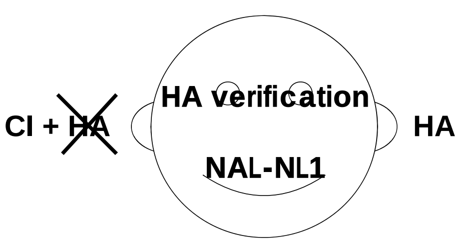
- Restaurant simulation (8 loudspeakers)
  - Adaptive SNR, noise at 72 dBA
  - Fixed level SNR (+6 and +2 dB)
    - Polish: PMST
    - English: HINT
- Reverberant sentence recognition
  - 0.6 sec
  - AzBio & PSMT at 60 dBA
- ITD thresholds, acoustic only
  - f_s = 250 Hz

Listening Conditions

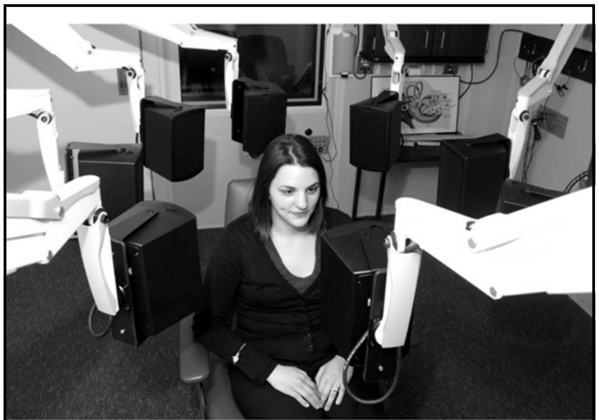


Best aided EAS

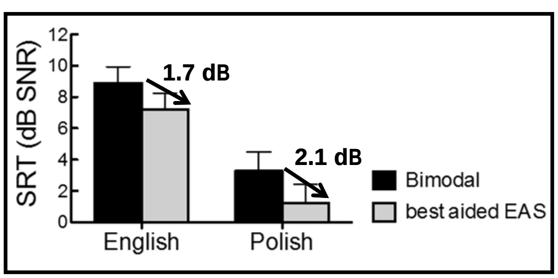
Listening Conditions



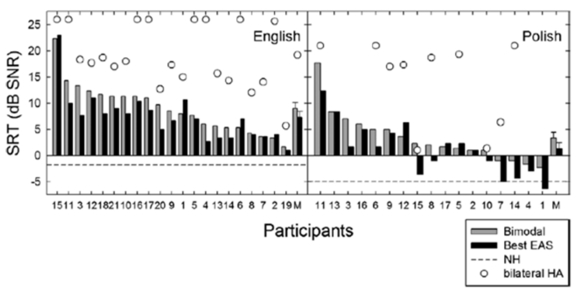
Bimodal

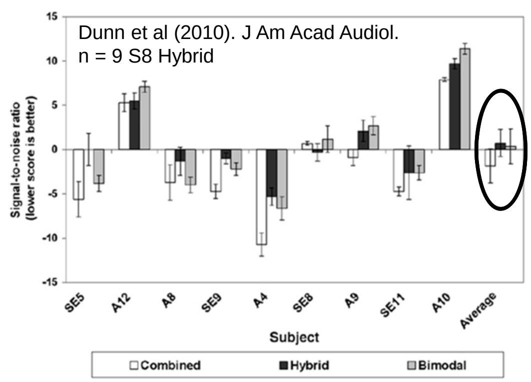


Adaptive SNR
Speech reception threshold (SRT)



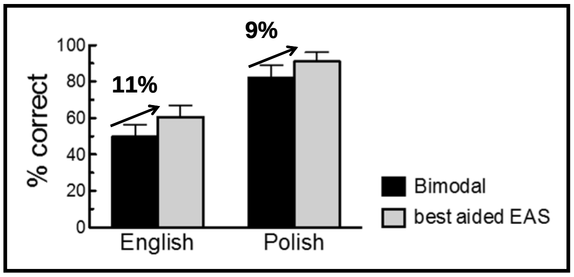
$F_{(1, 37)} = 21.1$ $p < 0.001$





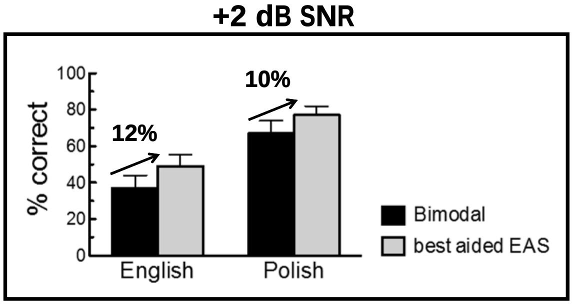
Fixed SNR, +6 and +2 dB
% correct

+6 dB SNR



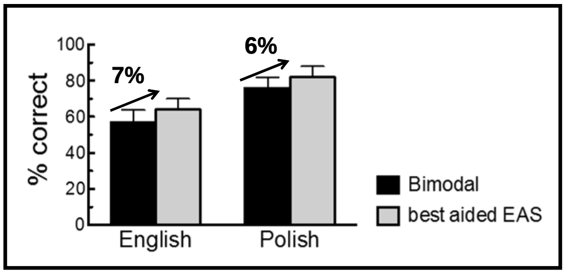
$X^2_{(1)} = 16.9, p < 0.001$

+2 dB SNR



$X^2_{(1)} = 8.1, p = 0.005$

Reverberant Speech Recognition
RT60 = 0.6 sec
% correct



$F_{(1, 37)} = 15.5, p < 0.001$

Summary: noise & reverberation

- Preservation of acoustic hearing →

  significant benefit
- ~ 2.0 dB improvement in SNR for SRT
  - 6- to 12-percentage points
    (fixed-level noise & reverberation)

What is the underlying mechanism
for the EAS-related benefit?

Preservation of both hearing
and binaural cues?

Interaural time differences (ITDs)

- most prominent < 1500 Hz

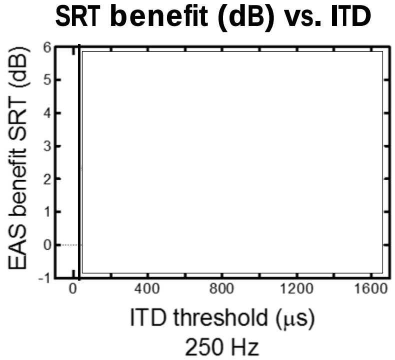
Do hearing preservation patients have preserved ITD cues?

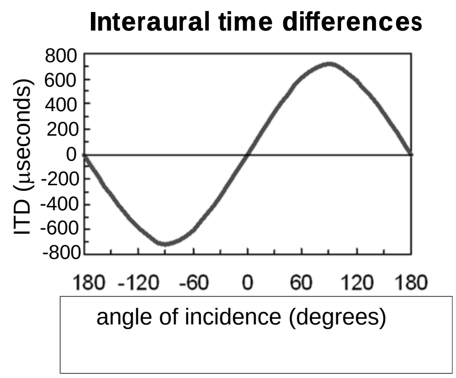
ITD thresholds

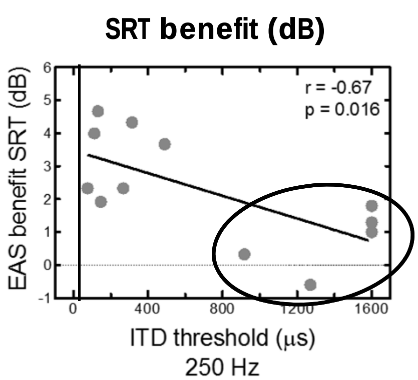
- f_s = 250 Hz
  - 200 ms
- level = 90 dB SPL (10 to 40 dB SL)
- 2 down, 1 up tracking
  - 70.7% correct
- TASK: lateral position change

6 subjects in paper
12 subjects run to date!

SRT benefit (dB) vs. ITD

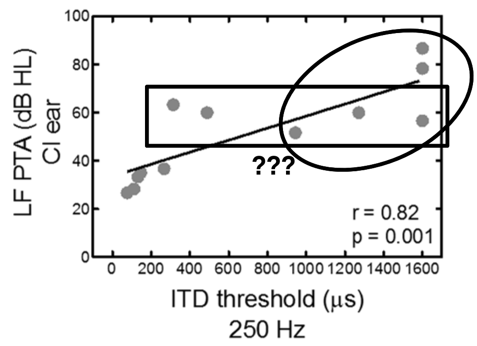


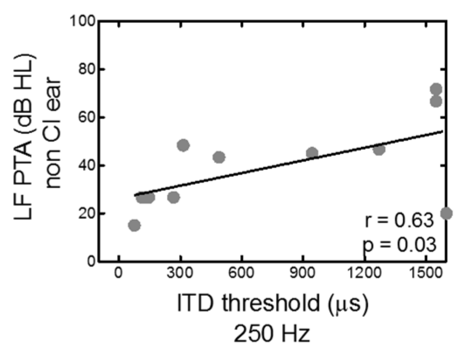




Is it a simple answer?

Do those with the best preserved hearing have the best ITD thresholds?





Multiple regression

Dependent variable: ITD threshold

Independent variables: LF PTA in CI ear and non CI ear

multiple regression

Which variables contribute?

LF PTA CI ear (r^2 = 0.67): t = 3.04, p = 0.014

LF PTA non-CI ear (r^2 = 0.39): t = 0.92, p = 0.38

Those with better preop hearing tend to have the best preserved hearing and:

- Lowest (best) ITD thresholds
- Greatest degree of HP-related benefit

LIMITATIONS

- bimodal condition with CI ear occluded was an acute condition
- Small sample for subjects in the ITD experiment

What needs to be done to ensure best hearing preservation?

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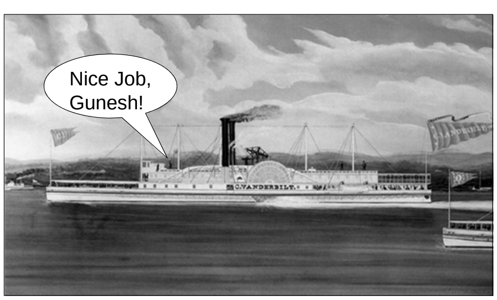
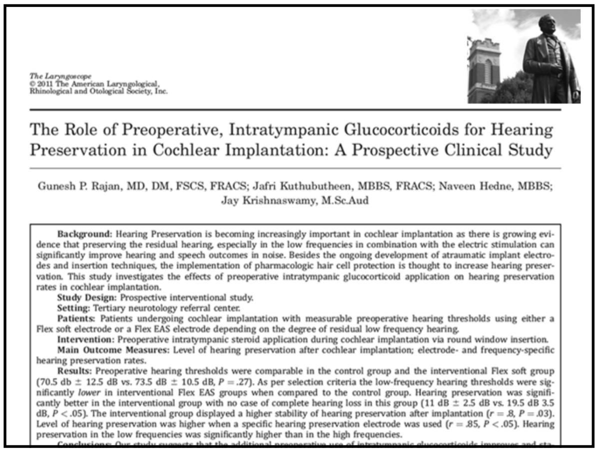
Commodore Award

Brought to you by AudiologyOnline

Commodore Cornelius Vanderbilt

Commodore Vanderbilt Steamship (circa 1860)





The Laryngoscope

The Role of Preoperative, Intratympanic Glucocorticoids for Hearing Preservation in Cochlear Implantation: A Prospective Clinical Study

Gunesh P. Rajan, MD, DM, FSCS, FRACS; Jafri Kuthubutheen, MBBS, FRACS; Naveen Hedne, MBBS; Jay Krishnaswamy, M.Sc.Aud

Background: Hearing Preservation is becoming increasingly important in cochlear implantation as there is growing evidence that preserving the residual hearing, especially in the low frequencies in combination with the electric stimulation can significantly improve hearing and speech outcomes in noise. Besides the ongoing development of atraumatic implant electrodes and insertion techniques, the implementation of pharmacologic hair cell protection is thought to increase hearing preservation. This study investigates the effects of preoperative intratympanic glucocorticoid application on hearing preservation rates in cochlear implantation.

Study Design: Prospective interventional study.

Setting: Tertiary neurotology referral center.

Patients: Patients undergoing cochlear implantation with measurable preoperative hearing thresholds using either a Flex soft electrode or a Flex EAS electrode depending on the degree of residual low frequency hearing.

Intervention: Preoperative intratympanic steroid application during cochlear implantation via round window insertion.

Main Outcome Measures: Level of hearing preservation after cochlear implantation; electrode- and frequency-specific hearing preservation rates.

Results: Preoperative hearing thresholds were comparable in the control group and the interventional Flex soft group (70.5 db ± 12.5 dB vs. 73.5 dB ± 10.5 dB, $P = .27$). As per selection criteria the low-frequency hearing thresholds were significantly *lower* in interventional Flex EAS groups when compared to the control group. Hearing preservation was significantly better in the interventional group with no case of complete hearing loss in this group (11 dB ± 2.5 dB vs. 19.5 dB 3.5 dB, $P < .05$). The interventional group displayed a higher stability of hearing preservation after implantation ($r = .8$, $P = .03$). Level of hearing preservation was higher when a specific hearing preservation electrode was used ($r = .85$, $P < .05$). Hearing preservation in the low frequencies was significantly higher than in the high frequencies.

Rajan et al. (2012). Laryngoscope, 122: 190-195

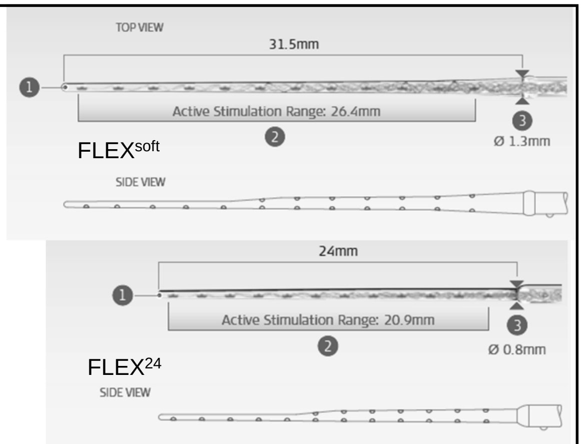
- Prospective interventional study
- n = 34
  - All patients presenting for CI with measurable audiometric thresholds
- FLEX^{eas} (n = 9) or FLEX^{soft} (n = 25)
  - 12 of the 25 FLEX^{soft} were in the "interventional" group

<u>CONTROL group</u>

- intravenous dexamethasone 4 mg
- Minimally traumatic surgery
- RW insertion

<u>INTERVENTIONAL group</u>

- intravenous dexamethasone 4 mg
- Minimally traumatic surgery
- RW insertion
- After intubation: transtympanic injection of 0.6 mL of methylprednisolone into the middle ear.
- Everything else consistent



Rajan et al. (2012)

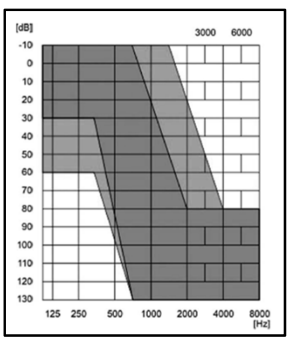
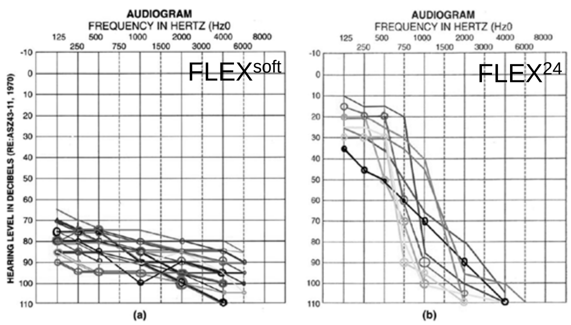
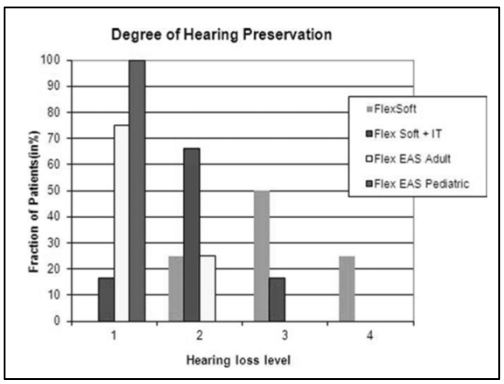


TABLE II.
Our Proposed Classification System to Categorize Postoperative Hearing Preservation Rates for Comparison.

Loss of Hearing after Implantation (Bone Conduction in dB)	Level of Hearing Preservation
<10 dB	Level 1 (Complete Hearing Preservation)
10–30 dB	Level 2 (Partial Hearing Preservation)
>30 dB	Level 3 (Minimal Hearing Preservation)
Complete loss of Hearing	Level 4 (Failure)



Preoperative audiograms



LIMITATIONS

- Study not conducted as a RCT
- Relatively small sample

CONCLUSIONS

- Hearing preservation → better performance in complex listening environments
- degree of preserved hearing impacts degree of EAS benefit
- Intratympanic steroid use → better rates of hearing preservation

CONCLUSIONS

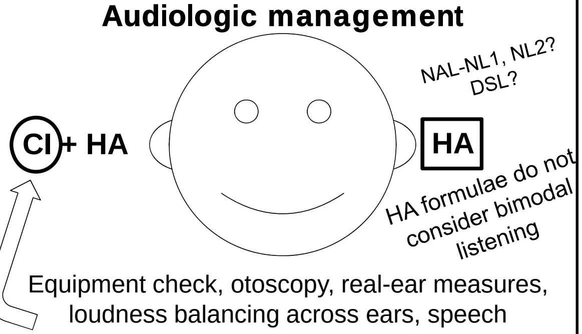
- patients with best hearing preservation also have preserved *binaural cues*
  - ITD cues
  - CI ear best explains ITD thresholds…
  - …but those with better non-CI ear hearing tend to have better CI ear hearing

QUESTIONS

- How much preserved hearing is needed?
- Amplified bandwidth?
  - More attention to LF amplification?
  - Targets for 125 Hz?
- Do patients really use binaural cues?
  - HA AGC → disrupt ILD and ITD cues?
  - Unilateral CI → disrupt ILD cues?
- Timing disruption b/tw electric and acoustic stimuli delivery?

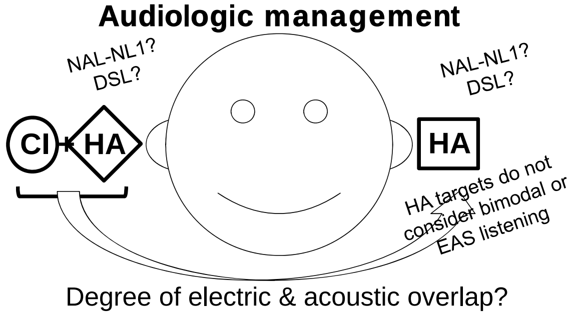
Audiologic management of individuals with hearing preservation

Audiologic management



Equipment check, otoscopy, real-ear measures, loudness balancing across ears, speech recognition, audiometry (if needed), device orientation counseling

Audiologic management



Degree of electric & acoustic overlap? Strictly judged by audiogram (slope/severity) or individual preferences?

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