

A simple solution to a great issue: Validating a 'mesh' technique for BC ABR in Infants

Australasian Newborn Hearing screening Conference
Canberra 2025

Florencia Montes, Sydney Children's Hospital Randwick

Outline:

- Middle ear dysfunction in infants
- Factors influencing BC measurement
- Options for BC coupling
- ‘Mesh’ technique validation study: results and conclusions

Middle ear dysfunction in infants

One of the most common reasons why newborns do not pass UNHS

Incidence in ICU 57 to 67%

In our Clinic around 20 % of the babies we test have CHL

Reported as one of the barriers in achieving diagnosis by 3 m of age

Abnormal tympanometry is not sufficient to confirm that the hearing loss is caused by the middle ear problem

Middle ear dysfunction can continue through the first year of life, waiting for resolution is not an option



Bone Conduction ABR

- BC ABR can overcome the middle ear dysfunction
- Feasible and reliable diagnostic tool in testing infants, for determining the type of hearing loss and cochlear thresholds
- Validity and reliability affected by standardization of the reference level, masking procedure, variability of thickness and structure of skin and bone, and the pressure exerted by the vibrator on the head and placement.



Effect of coupling force

- Von Bekesy (1960): sound pressure changes as large as 30 dB at 100 Hz to near 0 dB at 7 KHz, with varying forces.
- Yang (1991): studied the effect of bone vibrator pressure/force of 225, 325, 425 and 525 g at intensities of 30 and 15 dB in 20 newborns. The V-wave latencies were affected by pressure variations of less than 200 g. The pressure applied on the vibrator affected response recordings, producing better responses at weak intensities with the effective vibrator placement, which occurred when the pressure was between 425 and 525 g. The authors suggested that pressure between 400 and 450 g be applied for bone-conducted BAEP in newborns.
- Kờng (1957): similar observations with static forces ranging from 150 to 1.500 g.
- Lau (1986): static forces similar to those used in BC audiometry, threshold variations were larger at low frequencies than at high frequencies
- Toll (2011): 4 headstrap conditions, varied static forces (2.4-5.4N). In 75% of the cases the difference between the highest and lowest mean threshold was within 1 dB and the largest difference was 1.7 dB. Not clinically significant

Placement

- Yang et al. (1987) investigated bone-conducted BAEP in children and placed the bone vibrator in frontal, occipital and temporal areas. The results indicated that vibrator placement in temporal areas produces significantly shorter V-wave latencies than in frontal or occipital positions. For this reason, the authors recommended placing the bone-conducted BAEP vibrator on the temporal bone when the test was performed with newborns.
- Stuart, Yang and Stenstrom (1990) studied the effect of V-wave latency on newborns with bone vibrator placement in three positions in the temporal area. The results showed significant changes in V-wave latency, not only by changing the frontal, occipital and temporal position, but also by alterations around the temporal area. They suggest that the BAEP test be applied to newborns using the bone-conducted stimulus and that bone vibrator placement in the temporal region remains consistent.

Challenges

- Space to place the BC transducer (hairy babies)
- Can't use the spring steel metal headband, handholding with finger pressure recommended technique
- Unknown force
- Placement
- Maintaining position
- Comfort/risk of waking up the baby
- Multitasking: holding BC+collecting results+settling baby
- Untrained parents holding the BC



BSA: Recommended Procedure Auditory Brainstem Response (ABR) Testing in Babies Date: February 2019

- 4.5 Placement of bone vibrator The bone vibrator should be placed on the mastoid approximately 1 finger's width above the electrode. If possible, move hair away from where the bone vibrator is to be placed. The bone vibrator lead should be kept away from the electrode and electrode lead. This placement gives a higher stimulus level when compared to a forehead placement in young babies (Webb 1993). A mastoid location also takes full advantage of the inter-aural attenuation which is at least 20dB for clicks in babies under 12 weeks corrected age (Webb 1993). Placement on the temporal bone slightly posterior to the upper part of the pinna may be a good alternative where the mastoid is difficult due to proximity of the electrode (Small, Hatton, and Stapells 2007).
- 4.6 Pressure to apply to bone vibrator A moderate force ('finger pressure') should be applied to the bone vibrator, but the exact force is not critical - tests on an artificial mastoid have demonstrated an error of no more than 2dB over a wide range of applied forces (Webb 1993). It is not good practice to ask the parent or carer to hold the bone vibrator as this may lead to an inconsistent pressure or changes in position.

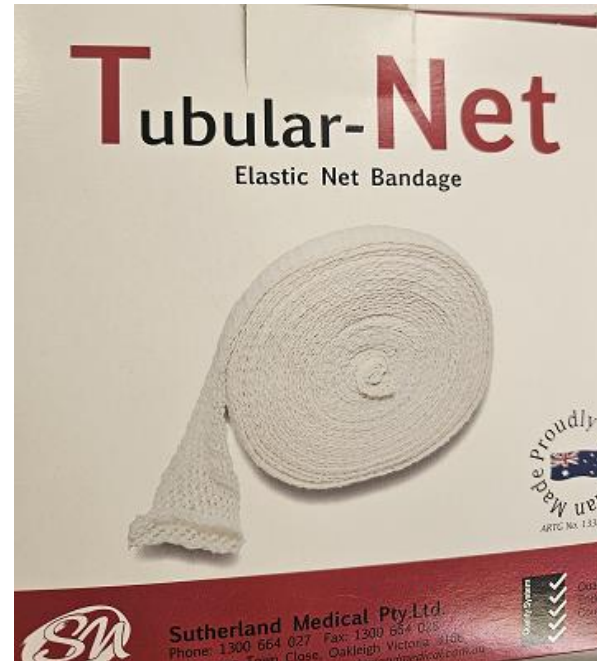
Options for BC coupling

- Adjustable elastic headband (Amband)
 - BC aids elastic headband
- *Expensive for single use (infection control)
- Finger



And the mesh!

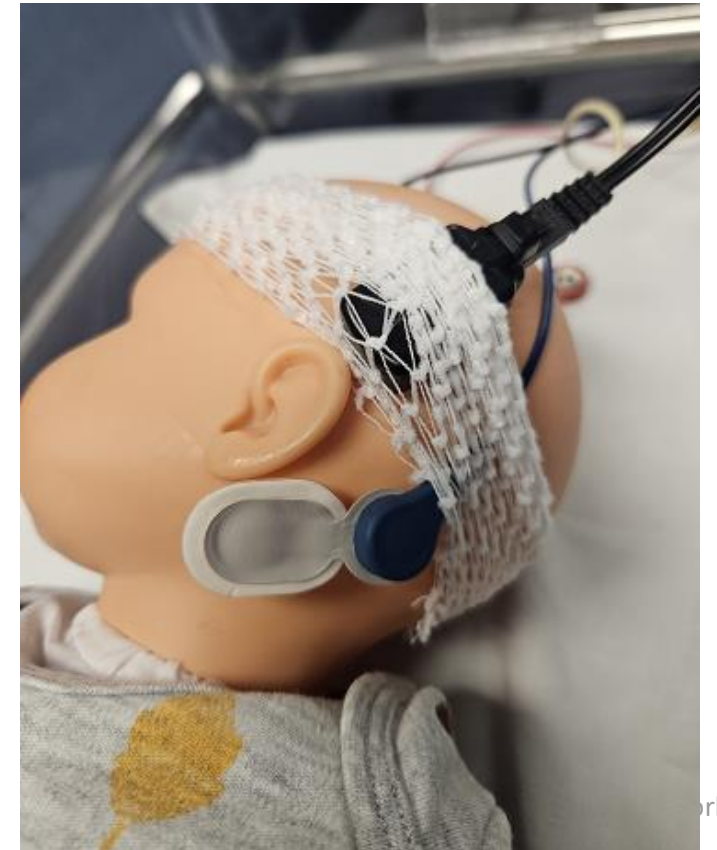
- Tubular-Net .Elastic net bandage: content Nylon, Elastodine
- Comes in different sizes. Size 3 fits most baby's heads (arm/leg)
- Dot with Velcro stacked to the BC transducer (comes with Amband)



Validating the mesh technique

- Aim

To validate the use of the mesh for BC in infants, comparing the amplitude of the response (nV) against the 'finger pressure' accepted technique.



Methodology

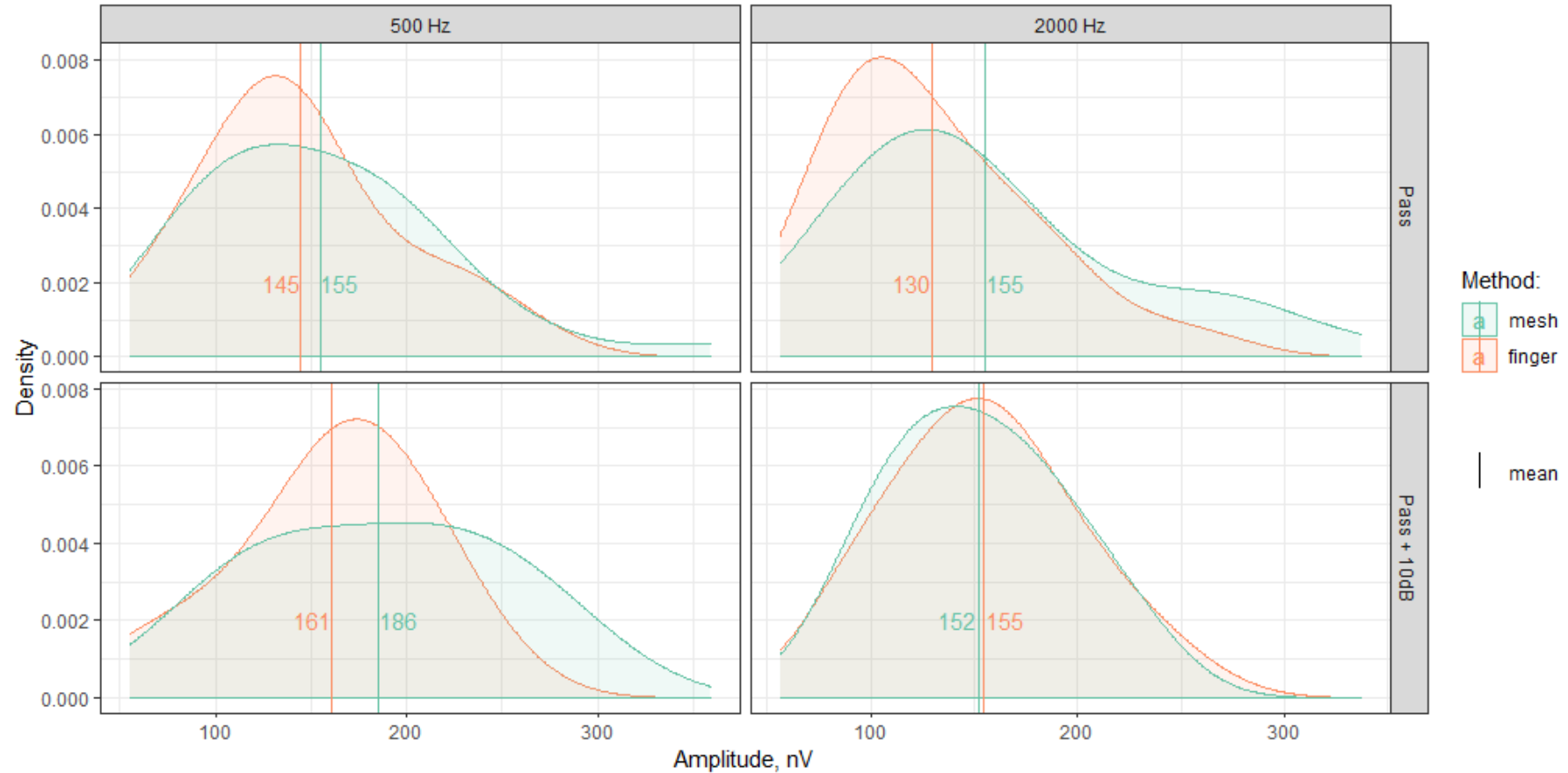
- BC was calibrated with the Velcro dot at the back of the transducer
- ABR Normal hearing
- Mesh first. Control 'finger' second
- Placement of the BC: superior-posterior temporal bone position
- Intensity tested: 25 dB nHL for 2 KHz (20 eHL) and 15 dB nHL for 500 Hz (20 eHL). Some ears tested at pass level +10
- Two replicated added waveforms were used for calculations
- Collection was stopped when residual noise target was achieved ($\leq 25\text{nV}$)
- Filters 1000 Hz/50 Hz
- Wave V trough (marked as the lowest point in the waveform following Wave V)
- Inserts kept in the ear for both conditions: mesh-finger

Results:

Frequency	Intensity	Mean Finger	Mean Mesh
500 Hz (32 ears)	15 dBnHL	144.7650	154.9144
2000 Hz (39 ears)	25 dBnHL	129.8486	155.3174
500 Hz (13 ears)	25 dBnHL	160.6715	185.6723
2000 Hz (18 ears)	35 dBnHL	154.8271	152.1582

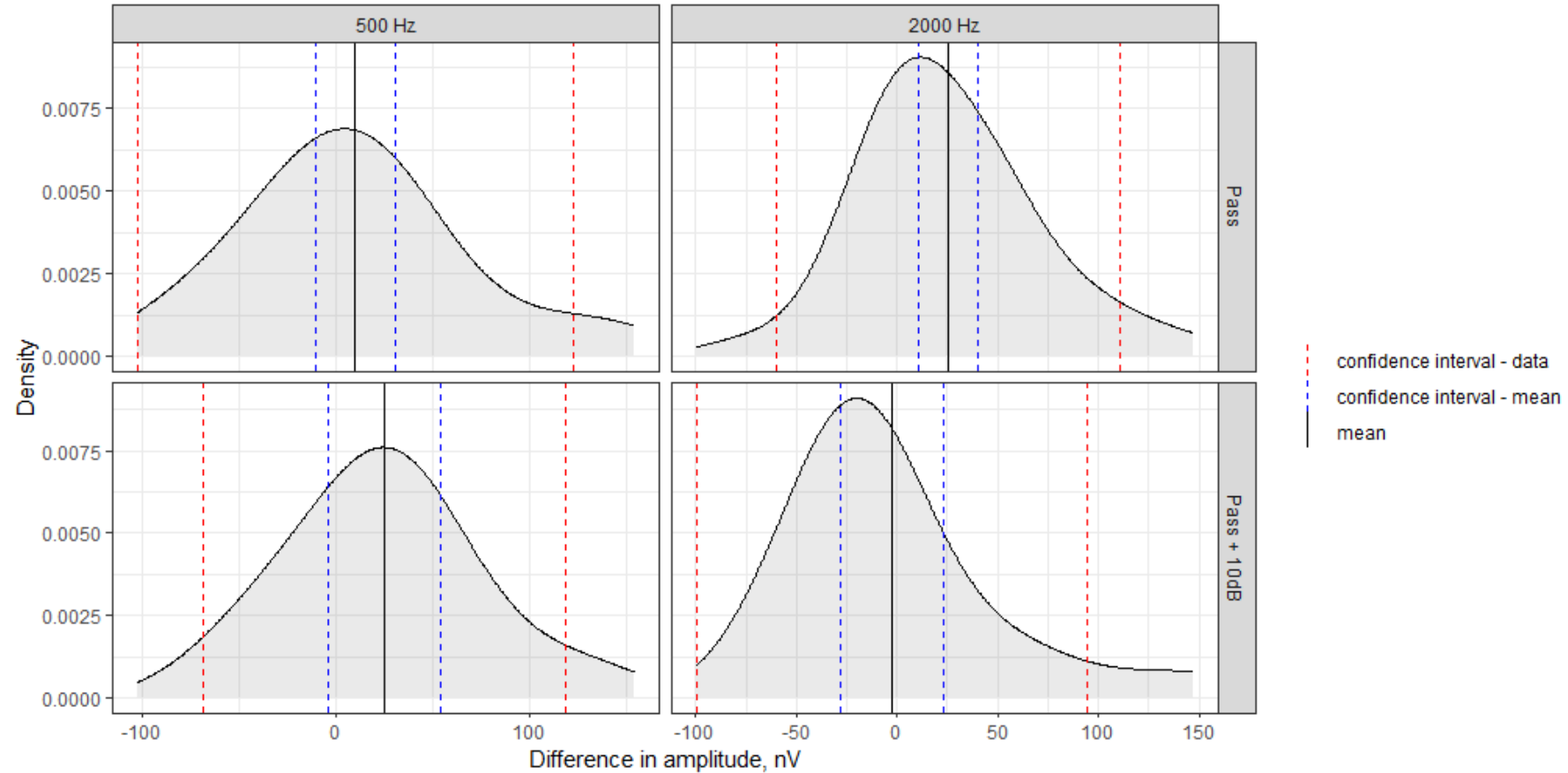
Frequency	Intensity	Mean_Difference	lower 95 CI	upper 95 CI	P value
500 Hz	pass	10.1	-10.6	30.9	0.325
2000 Hz	pass	25.5	10.9	40.0	0.001
500 Hz	pass+10	25.0	-3.9	54.0	0.084
2000 Hz	pass+10	-2.7	-28.2	22.8	0.827

Comparison of mesh and finger methods



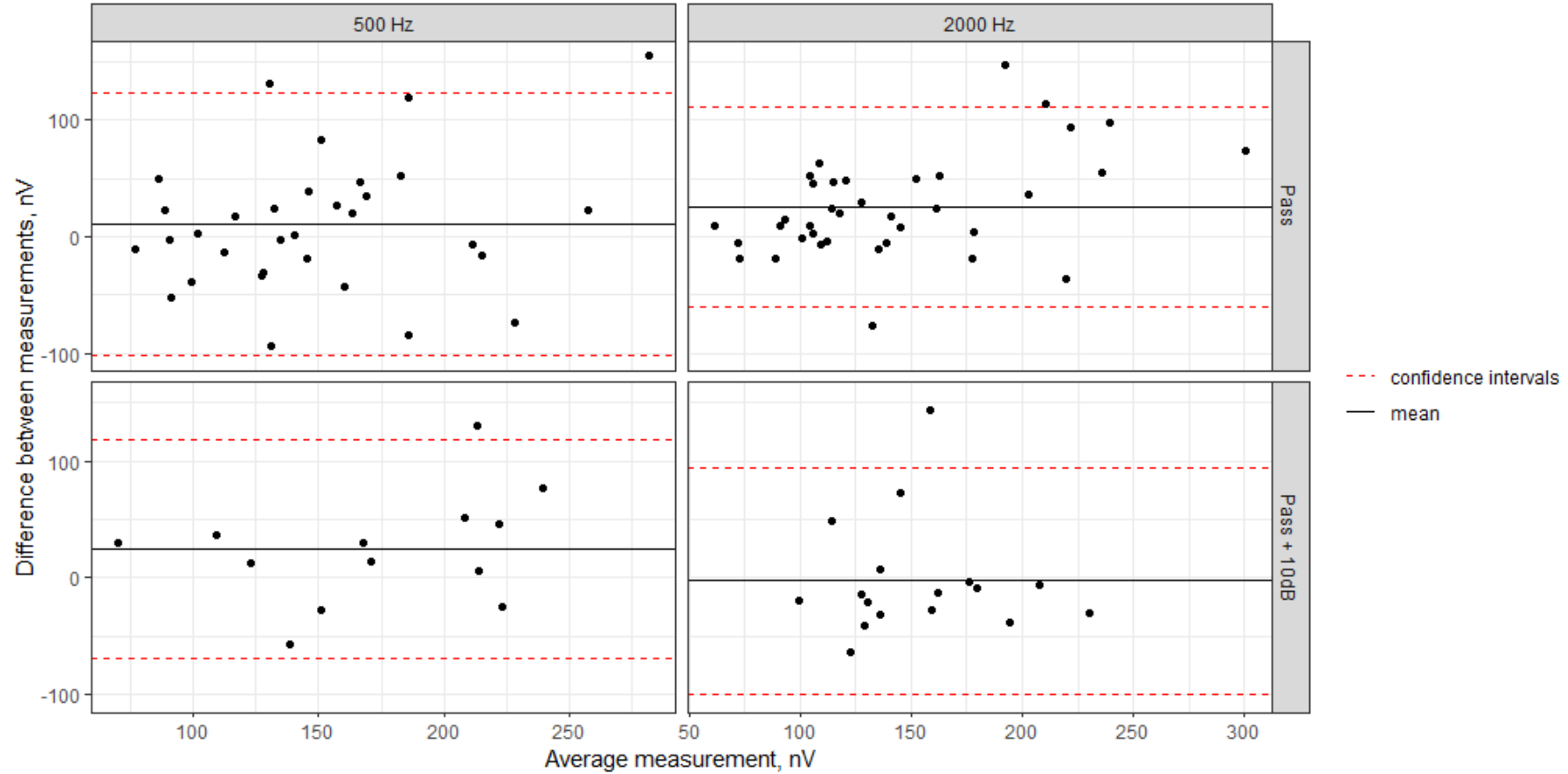
Data from Sydney Children's Hospital Randwick, 2024-2025

Comparison of mesh and finger methods



Data from Sydney Children's Hospital Randwick, 2024-2025

Bland-Altman Plot



Data from Sydney Children's Hospital Randwick, 2024-2025

• Conclusions

- Mesh as effective as holding the BC with finger pressure. No significant difference.
- Intersubject variability in amplitude of the BC response, with both finger and mesh
- Able to record a response at pass levels for all babies with both techniques.

Advantages of using the mesh:

- Less disturbance to baby, mesh can be fitted at the biggening of the appointment
- No extra hand required; audiologist can concentrate in collecting /analysing waveforms
- Stable coupling arrangement/consistent force and placement
- It can be 'adjusted' to different head sizes and pressure force can also be adjusted by number of folding
- Disposable/cheap option
- Added benefit, helps keeping electrodes in place
- BC testing easier for the Audiologist!





The Sydney
children's
Hospitals Network