Bone Conduction Audiometry
The Good, The Bad and The Interesting

“my bone calibration is off”

Sherman G. Lord, Au.D.
e3 Midlantic Technologies Group
slor@midlantictech.com

What are the Goals of this presentation?

1. To increase your confidence in measured BC thresholds when they don’t seem to make sense.

2. To discourage “tampering” with the measured BC thresholds when the results don’t confirm to “the way it is supposed to be” (Studebaker 1962)
Learning objectives

After this course participants will be able to:

1. Describe at least two technical variables affecting bone conduction audiometry.
2. Describe calibration variables in bone conduction audiometry.
3. Describe the difference between forehead and mastoid placement of the bone oscillator and determine the best placement for his/her patient.

Topics

• Brief history of audiometric BC testing
• How we hear by BC
• Calibration of BC vibrators
• Variables affecting BC threshold measurement
• Positive and negative air/bone gaps
• Mastoid or forehead placement
History

Electronic instruments in medicine
- First audiometer 1919 in Germany
- First US made audiometer was in 1922 from Western Electric
  - A much smaller version soon became available (1923)
- Bone conduction was added to the device in 1928
- Reference levels for normal hearing not established until 1936
- First standard for audiometer calibration came in 1951 (ASA now ANSI) – air only

How we hear by bone conduction

**News flash...** when a BC oscillator is placed at any location on the skull, it causes vibration of the temporal bones and stimulates both cochleas.

Of course, you already knew that
- Unlike hearing via the AC pathway, BC hearing is much more complex
- Three modes of bone conduction hearing
  - Compression/distortion
  - Inertial
  - Osseotympanic
- Each contribute to BC hearing in a unique way affecting different frequency regions

Many physicians expect BC thresholds to equal air in the absence of a confirmed ME disorder
Compression/Distortion Mode

- Vibration of the skull compresses the otic capsule
- This causes distortion within the cochlear fluids and movement of the basilar membrane
- Occurs as a result of pressure differentials at the round window, vestibule, and semicircular canals
- This mode contributes to BC hearing in the high frequency range (>1.5KHz)

This is the only mode of BC hearing that DOES NOT involve the AC pathway

Inertial mode

- Newton’s first law of motion
- Involves the contribution of the ossicular chain to BC hearing
- At low frequencies (<1.5KHz) the skull moves as a rigid body
- Since the ossicles are loosely coupled to the skull, they lag behind the skull when it is vibrated
- As a result, the stapes footplate vibrates in the oval window
  - Creates a traveling wave
Osseotympanic mode

- Another non-cochlear influence on BC hearing
- Due to occlusion effect when testing bone and masking the non-test ear
- Skull vibration causes the ear canal walls to vibrate
- The normal AC hearing pathway is then activated
- Dominant in the low frequencies
- Not an issue when ears are not occluded during BC testing

Modes of BC Hearing – Bottom Line

- Bone conduction hearing levels are affected by non-cochlear sources using the air conduction pathways
- Vibration of the skull during BC testing does not totally bypass the external and middle ears
Audiometer calibration

- Voluntary standards are published by ANSI and ISO
  - Only required if written into a state or federal law
- Periodically reviewed by an appointed working group
  - The standard is either revised, reaffirmed or withdrawn
- Made up of industry representatives; very few clinicians
- International uniformity in the standard since the early 90’s

Audiometer calibration

Air conduction
- Supra-aural
  - TDH 39; TDH-49/50; DD45
- Circumaural
  - HDA200/300; DD450; HDA280; Koss HV/1A
- Insert earphones
  - ER3A; ER3C; IP30; EARTone 3A

All have different RETSPLs and may require a different calibration test coupler
Table 5 — Reference equivalent threshold sound pressure levels (RETSPLs) (dB re 20μPa) for supra-aural earphones in common use

<table>
<thead>
<tr>
<th>Frequency Hz</th>
<th>Earphone type*</th>
<th>IEC 60318-1</th>
<th>NBS 9A / IEC 60318-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>45.0</td>
<td>45.0</td>
<td>47.5</td>
</tr>
<tr>
<td>160</td>
<td>38.5</td>
<td>37.5</td>
<td>40.5</td>
</tr>
<tr>
<td>200</td>
<td>32.5</td>
<td>31.5</td>
<td>33.5</td>
</tr>
<tr>
<td>250</td>
<td>27.0</td>
<td>25.5</td>
<td>26.5</td>
</tr>
<tr>
<td>315</td>
<td>22.0</td>
<td>20.0</td>
<td>22.5</td>
</tr>
<tr>
<td>400</td>
<td>17.0</td>
<td>15.0</td>
<td>17.5</td>
</tr>
<tr>
<td>500</td>
<td>13.5</td>
<td>11.5</td>
<td>13.5</td>
</tr>
<tr>
<td>630</td>
<td>10.5</td>
<td>8.5</td>
<td>9.0</td>
</tr>
<tr>
<td>750</td>
<td>9.0</td>
<td>7.5</td>
<td>6.5</td>
</tr>
<tr>
<td>800</td>
<td>8.5</td>
<td>7.0</td>
<td>6.5</td>
</tr>
<tr>
<td>1000</td>
<td>7.5</td>
<td>7.0</td>
<td>6.0</td>
</tr>
<tr>
<td>1250</td>
<td>7.5</td>
<td>6.5</td>
<td>7.0</td>
</tr>
<tr>
<td>1500</td>
<td>7.5</td>
<td>6.5</td>
<td>7.5</td>
</tr>
<tr>
<td>1600</td>
<td>7.5</td>
<td>6.5</td>
<td>8.0</td>
</tr>
<tr>
<td>2000</td>
<td>7.5</td>
<td>9.0</td>
<td>10.0</td>
</tr>
<tr>
<td>2500</td>
<td>10.5</td>
<td>9.5</td>
<td>10.5</td>
</tr>
<tr>
<td>3000</td>
<td>11.5</td>
<td>10.0</td>
<td>9.5</td>
</tr>
<tr>
<td>3150</td>
<td>11.5</td>
<td>10.0</td>
<td>8.0</td>
</tr>
<tr>
<td>4000</td>
<td>12.0</td>
<td>9.5</td>
<td>10.5</td>
</tr>
<tr>
<td>5000</td>
<td>11.0</td>
<td>13.0</td>
<td>13.0</td>
</tr>
<tr>
<td>6000</td>
<td>16.0</td>
<td>15.5</td>
<td>20.5</td>
</tr>
<tr>
<td>6300</td>
<td>21.0</td>
<td>15.0</td>
<td>19.0</td>
</tr>
<tr>
<td>8000</td>
<td>15.5</td>
<td>13.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Speech</td>
<td>20.0</td>
<td>19.5</td>
<td>20.0</td>
</tr>
</tbody>
</table>

*Earphone type: TDH 39, TDH 49/50, DD45

---

**dB SPL --- Sound pressure Level**

**dB HL --- Hearing Level**

[Graph showing dB SPL and dB HL levels for different frequencies]
Audiometer calibration

Bone conduction
• Standard for BC first published (ANSI-1972)
  • Based on Beltone 5A artificial mastoid
• ANSI-1981 issued revised standards
  • Based on the B&K 4930
• Revised again in 1996 – unchanged since
• Force level is the reference, not SPL
• Calibration values reported in RETFLs (Reference Equivalent Threshold Force Levels)
  • BC vibrator force changed to an electrical signal
• Couplers are temperature and humidity sensitive

Recent findings bring into question the accuracy of the RETFL at 4KHz
Margolis et al (2013)
Altus et al (2018)
Margolis (2019)
**Key Point**

ANSI and ISO bone conduction values were obtained with 40dB EM in the contralateral ear. The standard assumes that a contralateral masking signal will be applied when performing clinical measurement of bone conduction thresholds.

### Table 8 — Reference equivalent threshold force levels ( RETFLs) for bone vibrators

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Mastoid (dB re 1μN)</th>
<th>Forehead (dB re 1μN)</th>
<th>Forehead minus mastoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>67.0</td>
<td>79.0</td>
<td>12.0</td>
</tr>
<tr>
<td>315</td>
<td>64.0</td>
<td>76.5</td>
<td>12.5</td>
</tr>
<tr>
<td>400</td>
<td>61.0</td>
<td>74.5</td>
<td>13.5</td>
</tr>
<tr>
<td>500</td>
<td>58.0</td>
<td>72.0</td>
<td>14.0</td>
</tr>
<tr>
<td>630</td>
<td>52.5</td>
<td>66.0</td>
<td>13.5</td>
</tr>
<tr>
<td>750</td>
<td>46.5</td>
<td>61.5</td>
<td>13.0</td>
</tr>
<tr>
<td>800</td>
<td>47.0</td>
<td>59.0</td>
<td>12.0</td>
</tr>
<tr>
<td>1000</td>
<td>42.5</td>
<td>51.0</td>
<td>8.5</td>
</tr>
<tr>
<td>1250</td>
<td>39.0</td>
<td>48.0</td>
<td>10.0</td>
</tr>
<tr>
<td>1500</td>
<td>36.5</td>
<td>47.5</td>
<td>11.0</td>
</tr>
<tr>
<td>1600</td>
<td>36.5</td>
<td>46.5</td>
<td>11.0</td>
</tr>
<tr>
<td>2000</td>
<td>31.0</td>
<td>42.5</td>
<td>11.5</td>
</tr>
<tr>
<td>2500</td>
<td>29.5</td>
<td>41.5</td>
<td>12.0</td>
</tr>
<tr>
<td>3000</td>
<td>30.0</td>
<td>42.0</td>
<td>12.0</td>
</tr>
<tr>
<td>3150</td>
<td>31.0</td>
<td>42.5</td>
<td>11.5</td>
</tr>
<tr>
<td>4000</td>
<td>35.5</td>
<td>43.5</td>
<td>8.0</td>
</tr>
<tr>
<td>5000</td>
<td>40.0</td>
<td>51.0</td>
<td>11.0</td>
</tr>
<tr>
<td>6000</td>
<td>40.0</td>
<td>51.0</td>
<td>11.0</td>
</tr>
<tr>
<td>8000</td>
<td>40.0</td>
<td>50.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Speech</td>
<td>55.0</td>
<td>63.5</td>
<td>8.5</td>
</tr>
</tbody>
</table>
Variables that may affect bone conduction thresholds and the air/bone gap

- Positioning of the BC vibrator on the mastoid process
- BC vibrator surface area
- Application force
- Occlusion effect
- Accurate air conduction thresholds
- Reference threshold levels and a normal distribution
Positioning of the BC oscillator

- On the bony mastoid prominence
- Should not be placed on hair
- Should not be touching the pinna
- Tab of headband on contralateral temple region
  - Ensures stability
- For smaller heads, may need to wrap top of headband

BC oscillator surface area

- B71 and B81 have a disk “protrusion”
- Contact/surface area is 175mm on B71 and B81
- Current models designed for uniformity across subjects
- Make sure as much of the disk surface area as possible contacts the mastoid
- Greater contact area yields better thresholds
Radioear B-81

- Higher maximum output
  - 250Hz – 1KHz
- Lower distortion in LFs
  - 25% less at 250Hz
  - 5% less at 500Hz and 1KHz

Application force

- BC headband static force of 5.4N +/- 0.5 when spread to 145 mm
  - This equals a pressure of 510 grams
- Studebaker (1962) measured the force of a BC headband on the mastoid at 322 g with a range of 142 grams
- Toll, Emanuel, & Letowski (2011) found mean thresholds within ±2dB across a range of static force levels (2.4N – 5.4N)
- Application force level appears to interact differentially across both frequency and vibrators (Dirks & Kamm 1975)
- Force level appears to have little effect on the reliability of BC thresholds
Table 5. Physical output in dB re 1 dyne for the B-70A and B-71 bone vibrators at static forces of 3.4 N and 5.4 N and differences in dB between the two force conditions. Measurements were made on the Bruel and Kjaer 4930 artificial mastoid with 0.1 v at vibrator terminals.

<table>
<thead>
<tr>
<th>Vibrator</th>
<th>Force (N)</th>
<th>0.25</th>
<th>0.50</th>
<th>1.0</th>
<th>2.0</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-70A</td>
<td>5.4</td>
<td>69.0</td>
<td>83.9</td>
<td>78.8</td>
<td>69.6</td>
<td>54.2</td>
</tr>
<tr>
<td></td>
<td>3.4</td>
<td>69.0</td>
<td>82.9</td>
<td>77.3</td>
<td>68.6</td>
<td>53.6</td>
</tr>
<tr>
<td></td>
<td>5.4 minus 3.4</td>
<td>0.0</td>
<td>1.0</td>
<td>1.5</td>
<td>1.0</td>
<td>0.6</td>
</tr>
<tr>
<td>B-71</td>
<td>5.4</td>
<td>74.5</td>
<td>83.3</td>
<td>77.2</td>
<td>71.0</td>
<td>66.2</td>
</tr>
<tr>
<td></td>
<td>3.4</td>
<td>74.4</td>
<td>81.3</td>
<td>76.2</td>
<td>69.2</td>
<td>65.4</td>
</tr>
<tr>
<td></td>
<td>5.4 minus 3.4</td>
<td>0.1</td>
<td>2.0</td>
<td>1.0</td>
<td>1.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Dirks and Kamm 1975

Figure 1. Mean BC thresholds as a function of frequency for each static force compared with P-3333 results for the test condition. Error bars represent ± 1 SD for P-3333.

Toll, Emanuel, Letowski 2011
Occlusion effect

- LF acoustic energy is “trapped” in the occluded ear
  - The trapped LF acoustic energy increases the SPL delivered to the cochlea
    - Osseotympanic mode
- Enhancing the measured hearing threshold (125Hz - 1KHz)
- Style of AC transducer affects the amount of OE
  - Supra-aural earphones create the largest OE
  - Insert phones with shallow insertion similar to SA
  - Circumaural, very little except at 250Hz
- Not present in CHL of 20dB or more

Table 1. Acoustic and psychoacoustic occlusion effects for six adult subjects. Occlusion effects were measured for insert earphones (Etymotic Research ER3) with full insertion (F) and partial insertion (P), circumaural earphones (Sennheiser HDA 200), and supra-aural earphones (Telephonics TDH-50 with Type 51 cushion).

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>0.25</th>
<th>0.5</th>
<th>0.75</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>3.0</th>
<th>4.0</th>
<th>6.0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Earphone/Acoustic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ER3 (F)</td>
<td>Mean</td>
<td>5.3</td>
<td>5.2</td>
<td>0.2</td>
<td>2.8</td>
<td>−0.5</td>
<td>−8.7</td>
<td>−2.5</td>
<td>−0.5</td>
</tr>
<tr>
<td></td>
<td>s.d.</td>
<td>4.1</td>
<td>3.3</td>
<td>4.5</td>
<td>4.4</td>
<td>2.5</td>
<td>2.7</td>
<td>4.4</td>
<td>2.4</td>
</tr>
<tr>
<td>ER3 (P)</td>
<td>Mean</td>
<td>10.5</td>
<td>10.3</td>
<td>7.2</td>
<td>9.8</td>
<td>4.2</td>
<td>−5.5</td>
<td>−2.7</td>
<td>−1.0</td>
</tr>
<tr>
<td></td>
<td>s.d.</td>
<td>6.1</td>
<td>3.0</td>
<td>6.0</td>
<td>5.6</td>
<td>3.1</td>
<td>3.2</td>
<td>3.1</td>
<td>2.2</td>
</tr>
<tr>
<td>HDA200</td>
<td>Mean</td>
<td>9.7</td>
<td>1.3</td>
<td>0.0</td>
<td>−1.8</td>
<td>−1.7</td>
<td>−0.5</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>s.d.</td>
<td>4.3</td>
<td>6.1</td>
<td>4.3</td>
<td>4.4</td>
<td>3.4</td>
<td>1.9</td>
<td>2.1</td>
<td>2.7</td>
</tr>
<tr>
<td>TDH50</td>
<td>Mean</td>
<td>18.2</td>
<td>13.0</td>
<td>3.2</td>
<td>5.0</td>
<td>1.5</td>
<td>−2.2</td>
<td>1.5</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>s.d.</td>
<td>8.2</td>
<td>6.1</td>
<td>8.3</td>
<td>10.4</td>
<td>6.6</td>
<td>8.0</td>
<td>5.0</td>
<td>5.9</td>
</tr>
<tr>
<td><strong>Earphone/Psychoacoustic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ER3 (F)</td>
<td>Mean</td>
<td>3.3</td>
<td>4.2</td>
<td>2.5</td>
<td>−0.8</td>
<td>−1.7</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>s.d.</td>
<td>6.1</td>
<td>7.4</td>
<td>5.2</td>
<td>5.8</td>
<td>4.1</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDA200</td>
<td>Mean</td>
<td>5.0</td>
<td>1.7</td>
<td>0.8</td>
<td>−0.8</td>
<td>0.8</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>s.d.</td>
<td>4.5</td>
<td>6.8</td>
<td>8.0</td>
<td>7.4</td>
<td>3.8</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDH50</td>
<td>Mean</td>
<td>16.0</td>
<td>15.0</td>
<td>8.0</td>
<td>3.0</td>
<td>−1.0</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>s.d.</td>
<td>4.2</td>
<td>3.5</td>
<td>2.7</td>
<td>4.5</td>
<td>2.2</td>
<td>2.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Accurate air conduction thresholds

- Properly placed supra-aural earphones
  - Can affect 4KHz, 6KHz, 8KHz (find reference)
  - Collapsing ear canal
- Condition of earphone cushions
  - Cracked and/or hardened cushions attenuate less ambient noise in LF
  - Should be replaced annually
- Properly fit insert earphones
  - Good acoustic seal (low frequencies can escape – venting)
  - Deep insertion (without discomfort)
    - Reduces occlusion effect
- Circumaural headphones
  - Easier to place
  - Little or no occlusion effect

MX41/AR
Needs Replaced

New MX41/AR
Cushions

Model 51
Reference threshold levels and a normal distribution

- BC thresholds are more variable than AC thresholds
- ABG is a normally distributed variable based on the variability between two threshold measurements that form the difference (AC & BC)
- Assuming a 5dB SD of the ABG, a 0dB ABG would only occur about 38% of the time (Studebaker 1967)
- Does the sample population used to generate reference threshold levels represent the patient population being tested?
  - If so, you would expect that same variability in the outcomes

<table>
<thead>
<tr>
<th>Measured AC-BC Relationship</th>
<th>Actual AC-BC Relationship</th>
<th>Percentage in Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20 or more</td>
<td>-20 or greater</td>
<td>0.02</td>
</tr>
<tr>
<td>-15</td>
<td>-17.5 to -12.5</td>
<td>0.60</td>
</tr>
<tr>
<td>-10</td>
<td>-12.5 to -7.5</td>
<td>6.06</td>
</tr>
<tr>
<td>-5</td>
<td>-7.5 to -2.5</td>
<td>24.17</td>
</tr>
<tr>
<td>0</td>
<td>-2.5 to +2.5</td>
<td>38.29</td>
</tr>
<tr>
<td>+5</td>
<td>+2.5 to +7.5</td>
<td>24.17</td>
</tr>
<tr>
<td>+10</td>
<td>+7.5 to +12.5</td>
<td>6.06</td>
</tr>
<tr>
<td>+15</td>
<td>+12.5 to +17.5</td>
<td>0.60</td>
</tr>
<tr>
<td>+20 or more</td>
<td>+20 or greater</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Other variables affecting PT air & bone thresholds

Affect air & bone similarly
- Sensori-neural sensitivity
- Attention
- Fatigue
- Experience

May affect air & bone differently
- Efficiency of the middle ear
- Length and shape of EAM
- Thickness of skin and subcutaneous tissue
- Head shape and size

Tester Bias and the ABG

- **Confirmation bias**—evaluating evidence that supports one’s preconceptions differently from evidence that challenges these convictions (Kaptchuk 2003)
- **Diagnostic suspicion bias**—occurs when knowledge of the subject’s past history influences the outcome of a diagnostic process (Margolis et al 2016)
- **Previous opinion bias**—occurs when a previous diagnostic procedure influences the administration and result of a subsequent measurement (Margolis et al 2016)
- "**Interpretation is never completely independent of a scientist's beliefs, preconceptions, or theoretical commitments**" (Kaptchuk 2003)
- Expectation of outcome influences judgement and recording of results
Tester Bias and the ABG


- Results obtained via manual testing compared to automated testing
- Manual audiology databases show significant levels of positive skew, indicating an under-representation of negative ABGs
  - Translation – audiologists were not reporting bone conduction thresholds as measured in the presence of a negative ABG
- How can tester bias be documented?
  - Compare thresholds measured manually to those measured using an automated approach

Distributions of air and bone conduction thresholds that would occur on repeated testing of an individual patient with normal hearing or sensorineural hearing loss with an air-bone gap of 0 dB

Distribution of air-bone gaps based on the air and bone conduction threshold distributions in Figure 2. The figure shows the variation in air-bone gaps that are expected on repeated testing of an individual patient when the average air-bone gap is zero.
Tester Bias and the ABG

Distribution of air-bone gaps for a set of audiograms on patients with sensorineural hearing loss. Air-bone gaps from manual audiometry (squares) by an expert audiologist and the predicted distribution from Figure 3 (triangles) are shown. There are more air-bone gaps of 0 and 5 dB and fewer of -5, -10, and -15 in the manually-obtained audiograms compared to the predicted distribution.

Margolis 2008

Tester Bias and the ABG

Figure 9. Average air-bone gaps for 11 patients with sensorineural hearing loss with manual audiometry and an unbiased automated method (AMTAS). The aberrant air-bone gaps at 4 kHz are larger with the automated procedure.

Margolis 2008
Tester Bias and the ABG

[Margolis et al (2016)]

The findings...
1. ABGs are normally distributed (confirms Studebaker findings)
2. The ABG SD for manual testing was 6dB; for automated testing it was 8.1dB (includes all frequencies)
   a. Smaller SDs for manual testing reveal effect of tester bias on variance of results
3. Fewer negative ABGs recorded during manual testing
4. Tester bias may cause misinterpretation of audiometric results
   a. ABGs in cases of vestibular pathology (LVA, SCD)
5. The more knowledge the clinician has about the patient, the greater the potential bias
   a. Recording of BCT influenced by having already measured ACT

The dreaded 4KHz ABG

• A fairly common occurrence in clinical testing
• Different theories advanced
  • Collapsed canals
  • Acoustic radiation
  • Accuracy of the calibration value at 4KHz
  • Audiometer out of calibration at 4KHz
  • Could it really be conductive in nature
    • Change in ME transmission that is age-related
  • Size of ABG may be related to degree of SNHL
    • ABG increases as AC threshold increases in ears with normal ME function
The dreaded 4KHz ABG

Collapsed canals:
- Occurs when the pressure from SA headphones cause a more narrow canal to collapse
  - More common in older patients
  - Does not occur if IE or CA headphones used
- Collapsed canals in about 4% of patients (Lynn 1989)

Acoustic radiation:
- A popular explanation...
- Numerous studies revealed little (1-4dB) or no improvement in BC thresholds
  - Compared BC thresholds measured with the ear unoccluded and occluded
  - B71 and B71A bone vibrators
- ALTHOUGH...
- SPL readings of acoustic energy from a BC suggest otherwise...take a look
The dreaded 4KHz ABG

Calibration RETFL at 4KHz
• Accuracy is questioned based upon studies conducted in the 1950's and 1960's
  • Force levels measured based on BC thresholds obtained
  • But not on the B&K 4930
• Current RETFLs based on three studies
  • Force levels measured on B&K 4930
• Could the questionable RETFL at 4KHz be related to the calibration device?

What to do?
• Nothing – but understand that this may be the reason an unexplained ABG occurs at 4KHz in patients with SNHL and a normal middle ear
  • Educate physicians
• Add a correction factor
• Change the calibration RETFL
  • Ask your calibration company to reduce the output of the bone vibrator
  • Be prepared to justify this adjustment with peer-reviewed articles
  • This may violate federal and state regulations
• Don’t test bone conduction at 4KHz

Margolis et al (2019)
The dreaded 4KHz ABG

- Could it be a true conductive or mixed loss?
  - Unlikely if it’s just at 4KHz; but...
  - But changes in ME transmission properties occur with age
    - So could this change be related to the air conduction threshold?
    - Nixon and Glorig (1962) found just that; others studies have not supported their finding
- Degree of SNHL affects the ABG at 4KHz
  - As SNHL increases so does the size of ABG
  - Range is from 10dB to 22.1dB (normal to severe HL)

Mastoid or Forehead

- Over 90% of audiologists use mastoid placement
  - Need more force applied at the forehead to reach threshold
  - Hearing threshold is less (better) with mastoid placement
  - Higher maximum output attained
    - B81 bone vibrator – increases overall maximum output in the low to mid frequencies
    - Closer to the cochlea being tested
    - It’s how most audiologists are trained

But we also know the potential problems associates with mastoid placement...

- Smaller surface area on which to place bone vibrator
- Shifts in the position during testing will cause larger changes in BC threshold
- Middle ear contributes to BC thresholds
Advantages of forehead placement

- Larger surface area – slight shift in location has little effect on threshold
- Better test-retest reliability
- Reduced intra-subject variability
- Less contribution from the ME
- Use of circumaural headphones eliminates
  - The occlusion effect
  - The need to reposition the bone vibrator when switching ears, and
  - Saves time

![Mean Standard Deviations - Forehead and Mastoid Bone Conduction Thresholds](image_url)

Standard deviations for each test frequency for bone conduction thresholds averaged for the left and right ears. The right most bars show SDs averaged across frequencies and subjects for the two locations.

Questions?
References


Jacob S. That doesn’t make sense! – The practical realities of bone conduction testing. www.e3diagnostics.com


