MINIMAL HEARING LOSS IN CHILDREN:

Outcomes and Options
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Preview

Normal Hearing

• Between -10 and 15 dB for children
  (Clarke 1981; Diefendorf & Gravel, 1996)
• Between 0 and 20-25 dB for adults

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Minimal Hearing Loss

- PTA between 15 and 25 dB bilaterally
- High-frequency sensorineural loss = > 2 frequencies above 2 kHz in one or both ears
- Loss of any degree in one ear

Definition of minimal hearing loss is as much about configuration as it is about degree.

Prevalence

- ~1/1000 in the newborn period (Prieve et al., 2000) and ~3/100 in the school-age population (Bess et al., 1998)
- There are ~2.7 million children in the U.S. aged 6-16 with unilateral or slight-mild bilateral HL (Ross, 2005)
Psychoeducational Outcomes: Unilateral Hearing Loss

The early years...

Unilateral Hearing Loss

“...audiologists and otolaryngologists are not usually concerned over such deafness, other than to identify its etiology and assure the parents that there will be no handicap.”

Northern & Downs, 1978

Binaural Advantages

Head Shadow = 6 – 12 dB

Binaural Summation = 3 - 10 dB

Interaural Time and Intensity Differences

Localization ability

ITD

IID

Frequency in Hz

250 500 1000 2000 3000 4000
Pilot Study: Bess & Tharpe, 1986

- 60 children with UHL in middle Tennessee
- Age range of 6 – 18 years (M = 13 yrs)
- Medical and educational case history data obtained

Age of Identification:

Grade Failure Rate
62% of those with academic difficulty had hearing loss of the right ear.

Follow up study with 25 matched pairs (Bess, Tharpe, & Gibler, 1986)

- Auditory battery
- Localization ability
- Speech recognition in noise
- Speech/Language battery
- Cognitive battery
Teacher Behavior Rating Scale

Behavior problems include social withdrawal, inattention, distractibility, & aggression

Below Average Above
Percent Categories

UHL Normal hearing

Effect of UHL on Infants and Toddlers

- Average age for first words = 12.7 months (WNL)
- Average age for first 2-word utterances = 23.5 months (significant delay)

UHL and Speech-Language Scores

(Lieu, Tye-Murray, & Piccirillo, 2010)
- Sibling-controlled study of 6-12 y.o. with UHL
- n = 148
- Oral & Written Language Scales (OWLS)

Results:
- Children with UHL had poorer language comprehension, oral expression, and oral composite scores
- No right- or left-ear differences

Impact of Unilateral Conductive HL on Academic Performance

(Kesser, Knock, Gray, 2013)
- Case control survey
- School children with aural atresia
- None repeated a grade but 65% required resource help
- 47% had IEPs
- 45% received speech therapy
Psychoeducational Outcomes: Minimal/Mild Bilateral Hearing Loss

Target Screening Population

Permanent Sensory or Conductive 30-40 dB HL Less than 30 dB HL (JCIH, 2007)

JOHNSON ET AL., PEDIATRICS 2005


What they asked…

Does a 2-stage (OAE/AABR) newborn hearing screen miss babies with mild hearing loss?
N= 86,000 babies

Johnson et al., 2005

Results:

- 4% failed OAE and passed A-ABR
- 21 out of 973 infants (who failed OAE but passed A-ABR) were found to have permanent hearing loss
- 77% of those missed with PHL had mild HL (PTA ≤ 40 dB)
- 57% had unilateral HL
- 86% were sensorineural

MSHL IN SCHOOL-AGE CHILDREN (n= 1218)

<table>
<thead>
<tr>
<th>HL Category</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSNHL</td>
<td>12</td>
<td>1.0</td>
</tr>
<tr>
<td>HFSNHL</td>
<td>17</td>
<td>1.4</td>
</tr>
<tr>
<td>USNHL</td>
<td>37</td>
<td>3.0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>66</td>
<td>5.4</td>
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</tbody>
</table>

(Bess, Dodd-Murphy, & Parker, 1998)
What, if any, are the functional health effects of minimal hearing loss?

COOP CHARTS
- Screening tool for functional health
- Developed at Dartmouth
- Ten different domains

<table>
<thead>
<tr>
<th>DOMAINS USED IN COOP CHARTS</th>
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</thead>
<tbody>
<tr>
<td>Emotional feelings</td>
</tr>
<tr>
<td>School work</td>
</tr>
<tr>
<td>Social support</td>
</tr>
<tr>
<td>Stress</td>
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<tr>
<td>Family</td>
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</tbody>
</table>

COOP Results:
- For 6th graders -
  - Scores were higher (more dysfunction) for MSHL group in 9 of 10 domains
  - Significant difference found on energy domain
- For 9th graders –
  - Scores were higher for MSHL group in 9 of 10 domains
  - Significant differences found on stress and behavior domains
Children with MHL reported less energy than children with NH.

Where to go from here?

Listening Effort & Fatigue

Listening Effort

Attentional requirements necessary to understand speech

Assuming a limited effort capacity, will performance on a secondary task decrease when the primary listening task is made more difficult?

Bourland-Hicks & Tharpe, JSHLR, 2002.
Dual-Task Paradigm

- **Subjects**
  - 14 children with mild HL matched with NH children for grade level
  - Ages between 6 – 11 years

(Bourland-Hicks & Tharpe, 2002)

**Fatigue**

No commonly accepted definition – Can be physical or mental, subjective or objective (Hornsby, Naylor, & Bess, 2016)
Consequences of ongoing, severe, fatigue

- Inattention
- Poor concentration
- Distractibility
- Poor school achievement
- High absenteeism

Is fatigue a problem for adults with hearing loss? (Hornsby & Kipp, 2016)

Compared to POMS Normative data, older adults (55-94 yrs) with HL report:

- Similar fatigue
- Significantly lower vigor

Adults with HL are at increased risk for severe fatigue and vigor deficits

- More than 2 times as likely to report severe fatigue and
- More than 4 times as likely to report severe vigor deficits!
- Severe = >1.5 sd above mean

Degree of HL and fatigue

- No association between degree of HL and fatigue or vigor
- Strong relationship between high levels of hearing handicap (HHIE/A) and subjective fatigue

(Hornsby & Kipp, 2016)
Hornsby et al., 2014

What is the effect of hearing loss on subjective reports of fatigue in school-age children?

What they did…

• 10 children with hearing loss (CHL) and 10 age-matched peers with normal hearing (CNH)
• Subjective ratings of fatigue using the PedsQL Multidimensional Fatigue Scale
• All had normal non-verbal intelligence
• CHL had poorer language abilities than CNH

What they found…

Why is this important?

• The fatigue scores reported herein indicated more fatigue experienced by CHL than children with cancer, rheumatoid arthritis, diabetes, and obesity (Varni et al., 2002; 2004; 2009; 2010)
• These findings might underestimate the impact of HL on fatigue because the PedsQL does not include items for speech processing/listening effort
Full data set (n=43; 6-12 yrs)

Effect of HL

No association between fatigue ratings and degree of HL

Cognitive fatigue ratings are associated with language ability (CELF scores)
Conceptual model linking HL to fatigue and school performance

Hearing Technology Options for UHL
- Traditional hearing aids
- Contralateral Routing of Signal (CROS) hearing aids
- Frequency modulated (FM) systems
- Cochlear implants

Traditional Hearing Aids for UHL
- Unaidable hearing
  - Profound SNHL
  - Very poor word recognition
  - Marked intolerance for amplified sounds

(Valente et al., 2002)
Traditional Hearing Aids for UHL

- Binaural interference - decrease in bilateral performance when an individual is receiving asymmetric auditory input (Jerger et al., 1993)
- Evidence of BI for adults, but not children, when listening to asymmetrically-degraded speech (Rothpletz et al., 2004)
- No binaural advantage when listening to asymmetrically-degraded speech (Rothpletz et al., 2004)

CROS HAs for UHL

- CROS HAs are considered for those ineligible for other technology
- CROS HAs are not recommended for consideration until child is able to control his/her communication environment (AAA, 2003; Kenworthy et al., 1990)
- Useful for children who do not have access to FM or need assistance outside of school
Transcranial CROS Aids

- Quasi-transcranial – high level AC signal creates vibration of skull to stimulate opposite ear

- True transcranial – BC signal is transmitted from poor ear to opposite normal cochlea (eg, BAHA)

- BAHA can be considered at age 5 years and above; however, data from the pediatric population are lacking (AAA, 2003)

Cochlear Implantation for SSD

- Most work has been done on adults as tinnitus-reduction treatment

- Recent systematic review of literature (17 studies, Vlastarakos et al., 2013)
  - Post-lingually deafened adults and children only
  - Tinnitus improvement
  - Wider use of implantation in SSD

- Better outcomes with shorter length of deafness

Factors to Consider

- Audiological
- Developmental
- Communication
- Educational
- Parental preference
- Child preference

- More specific recommendations do not exist because there is no evidence to support amplification for all children with MHL

Children With Single-Sided Deafness

- 7 children (all boys) ages 1-14 yrs with unilateral deafness
- Congenital in 5 children, sudden in 2 children
- Data logs for between 2 and 6 visits
- On average, children wore their CIs 7.4 hr/day (range 3.5-11.2 hr/day)
- Use time did not vary with CI experience
- Use time linearly increased with age
Influence of External Ear Canal

The sound pressure level (SPL) at the eardrum will vary across individuals for the same HL level.

Variability in RECDs in Infants (2-6 mos)

(Buttono, Sewall, Scollie, & Tharpe 2006)
Importance of Monitoring

- As the child’s ear canal grows and changes, the acoustic properties change which impact hearing thresholds (dB HL)
  - Important to consider when monitoring hearing levels and considering intervention strategies
- Children in the first 3 years of life experience otitis media with effusion (OME) that can increase hearing thresholds
  - Include immittance measures in audiological monitoring protocol

Traditional HAs for Infants & Young Children with MBHL

- Consider acoustic modifications, shorter speaker-listener distance, and increased voice volume
- Will have large RECDs leaving only a few dB recommended gain across frequencies
- Counsel regarding need for amplification as RECD decreases
- Consider noise floor of HAs – typically not heard by those with greater degrees of HL

FM Fitting with MHL: The Problem

- Need for enhanced signal from teacher
- Need for communication with fellow students
  - Classroom discussions
  - Question/answer sessions
  - Other group or social interactions
Phonak MicroEar

**Earmold**
- skeleton
- open

**Configuration**
- monaural
- bilateral

(Tharpe, Ricketts, Sladen, 2004)

**Study Design**

- **Schedule**
  - baseline testing
  - 2 week acclimatization with each device followed by testing
  - Total of 6 weeks

(Tharpe, Ricketts, Sladen, 2004)

**HINT Results**

Summary of HINT Results:

- Significant improvement in FM vs. No-FM condition
- No effect of "teacher" location
- On average, 2 dB advantage with skeleton vs. open EM in monaural condition
- On average, 2.2 dB binaural advantage

(Tharpe, Ricketts, Sladen, 2004)
Newborn Hearing Screening Follow-Up: Factors Affecting Hearing Aid Fitting by 6 Months of Age

- Diagnosis of UHL was a strong predictor of late HA fitting and LTF
- No current best-practice guidelines concerning amplification for UHL (lack of outcomes data)

No difference in LTF based on degree of HL

Fitzpatrick et al. (2010). Clinical Practice for Children with Mild Bilateral and Unilateral Hearing Loss, Ear & Hearing

What factors influence consistency of hearing aid use within families?
• Subjects were mothers of 7 infants with mild to moderately severe bilateral HL, all referred from NBHS programs
• Structured interview – The Amplification in Daily Life Questionnaire (15 5-pt Likert scale items)
• Interviews conducted when infants were 10.5-12, 16.5, 22.5, and 28.5 months old

Mothers of children with mild HL reported difficulty accepting the need for amplification because their infants responded to many sounds with or without amplification

PREDICTORS OF HEARING AID USE TIME IN CHILDREN WITH MILD-TO-SEVERE HEARING LOSS


*Language, Speech & Hearing Services in the Schools*, v 44, 2013

What they asked…

What are the predictors of hearing aid use time in children with hearing loss? And, what are the challenges?
A little background…

• We now screen >95% of babies at birth (Russ et al., 2010)

• Early diagnosis of hearing loss leads to early intervention (hearing aid fitting) in many cases

• It is assumed that children who achieve consistent, full-time use of hearing aids will have better outcomes than children who do not – but this has not been explored

A little background…

• Some evidence that hearing aid use is inconsistent early in life, becoming more consistent with age (Moeller et al., 2009)

• Likely that some situations are more challenging than others and they vary by age

What they did…

Study 1:

• Part of the larger Outcomes of Children with Hearing Loss (OCHL) Study

• Parents of 272 children with permanent, bilateral, mild-to-severe HL

Methods:

• HA Use Questionnaire
  • Completed regularly for up to 4 yrs
  • 2x/year for children <2 yrs; 1x/year for those > 2 yrs

• Parents estimated average amount of time their child used HAs per day during the week and on weekends

• Parents rated how often child wore HAs in 8 different listening environments
Environments:

<table>
<thead>
<tr>
<th>Situation</th>
<th>Never (0)</th>
<th>Rare (1)</th>
<th>Sometimes (2)</th>
<th>Often (3)</th>
<th>Always (4)</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Car</td>
<td></td>
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<tr>
<td>2. Prechool/School</td>
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<tr>
<td>3. Daycare</td>
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<td>4. Mealtimes</td>
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<td>5. Play/Screening</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>6. Public areas</td>
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</tbody>
</table>

What they found…

- On average, parents reported children wore HAs ~ 10.5 hrs/day during week days and ~10 hrs/day during weekends
- Longer HA use time associated with older age, poorer hearing, and higher maternal education level

Parameter estimates indicated:

- For every 10-dB increase in better ear PTA, the average HA use time increased by .50 hr

- For every 10-mo increase in age, average HA use time increased by .71 hr

- Mothers who had obtained a college degree had children with the most HA use time compared to mothers with other educational backgrounds

58% of parents of infants responded that they used HAs in the car compared to 78% of parents of preschoolers and school-age children.

58% of parents of infants reported they "always" wore HAs at daycare compared to 79% of preschoolers and 76% of school-age children.
What they did...

Study 2:
• Examined accuracy of parental estimates of average HA use time for their children
• Compared parent report to objective datalogging measures
• Parents were unaware that the datalogging feature was being used

What they found...

• 84% of parents overestimated their child’s HA use time
• 16% either underestimated or were accurate in their estimations
• On average, parents reported 10.8 hrs/day of use and datalogging indicated 8.3 hrs/day
• The older the child was, the smaller the expected difference would be between parents’ estimates and datalogging
Why is this important?

• Counseling for parents of children with milder losses

• Providers should recognize that most parents will over estimate HA use time – datalogging might be helpful in monitoring use of HAs, especially with young infants and children

What they asked…

• Are there differences in outcomes for children with mild HL as a function of amount of daily HA use?

• Does cumulative auditory experience (e.g., age at HL confirmation, level of audibility) influence expressive and receptive vocabulary skills?

Results

• Children with mild HL experience longer delays in confirmation of HL and HA fitting than JCIH recommendations

• Approximately ½ qualified for EI services

• On average, children nonusers demonstrated lowest scores on language measures (even though nonusers had better unaided PTA compared to full-time and part-time users)

• But, language scores WNL – except for morphological markers
After one week of hearing aid use:

- ‘Mom! I can hear my footsteps now!’
- She asks for her hearing aids every morning and wears until bedtime
- Mother reports she is more socially connected and engaged
- Understands better on the phone and FaceTime
- Happier demeanor

Summary

- A significant portion of children with permanent MHL have been found to demonstrate difficulties observed
  - In academic settings
  - Under laboratory conditions
  - By parents and teachers
  - By the children themselves
How do we manage if some children with MHL have significant academic difficulties while others do not??? Must we treat them all the same?

What are the contributing stressors?

- Listening conditions?
- Listening effort?
- Lack of early or aggressive intervention?
- Lack of effective amplification?
- Concomitant otitis media?
- Etiology?

<table>
<thead>
<tr>
<th>Tool</th>
<th>Target</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Language Milestone Scale-II</td>
<td>Receptive &amp; expressive language</td>
<td>8-36 mos</td>
</tr>
<tr>
<td>Early Listening Function</td>
<td>Auditory detection</td>
<td>Infants &amp; toddlers</td>
</tr>
<tr>
<td>Pre-School SIFTER</td>
<td>Classroom listening behavior</td>
<td>3 yrs to K</td>
</tr>
<tr>
<td>SIFTER</td>
<td>Classroom listening behavior</td>
<td>Grade school</td>
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<tr>
<td>Communication &amp; Symbolic Behavior Scales</td>
<td>Language &amp; symbolic development</td>
<td>Infants &amp; toddlers</td>
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