INTRODUCTION

Progressive hearing loss is defined in several ways. Based on the variable nature of hearing loss in pediatric populations, some definitions of progression may provide a more accurate representation than others. For example, the Occupational Safety and Health Administration (OSHA, 2001) definition for noise exposure emphasizes higher frequencies (2, 3, 4 kHz) and requires a minimum average threshold shift of 10dB across these frequencies. In contrast, the GENDEAF definition targets lower frequencies (0.5, 1, 2 kHz) with standard deviations across those frequencies being set at 30dB. Lower frequencies are more often tested in pediatric patients (Mazzoli et al., 2003). The American Speech Hearing Association (ASHA, 1994) criteria, requiring a change of 20dB at one frequency or 10dB at any two adjacent frequencies, may be a more flexible definition that captures patients who do not meet the frequency and threshold shift criteria of other definitions.

The purpose of this study was to apply existing definitions of progressive hearing loss and modified forms to a small pediatric dataset (1) to develop methods for examining progressive hearing loss in a larger dataset (AudGenDB, 2) to determine how many cases of progressive sensorineural hearing loss (SNHL) were identified by each definition and (3) to address challenges and limitations of definitions in pediatric applications.

METHODS

Subjects: Subjects were derived from a pediatric dataset being developed for a multi-centered Audiological and Genetics Database (AudGenDB). Only ears with pure SNHL were included, resulting in 51 right ears and 58 left ears for the present analysis.

Data Source and Extraction: A REDCap database was created to extract and record audiological patient information. From the Vanderbilt University clinical records for eventual inclusion into AudGenDB, a pediatric database designed as a resource for audiological and genetic pediatric hearing health research.

Audiograms with pure tone air conduction (AC) and bone conduction (BC) thresholds, middle ear immittance measures, and/or speech recognition test scores were extracted, resulting in a total of 570 subjects and 2754 individual test dates (range of audiograms/subject was 1-13). Subjects with only one test date were eliminated.

Ears with pure SNHL were identified using the following exclusion criteria yielding 51 right and 58 left ears remaining above:

- Normal bone conduction thresholds defined as 15dB HL or better
- No AC or BC loss
- Air-bone gaps greater than 10dB HL

To analyze progression, test date pairs had to meet the following minimum requirements:

- Present bone conduction thresholds at three or more frequencies.
- For a given pair of test date pairs, AC thresholds for both test dates and BC thresholds for at least the latter test date.
- This resulted in a total of 168 test date pairs (80 right ear pairs, 88 left ear pairs).
- AC thresholds for right and left ears were not significantly different and thus were pooled for the remaining analysis.

Analysis of progression:

- Shifts, defined as threshold differences between the first and second test dates in each test date pair, were calculated for AC frequencies from 25-6 kHz and BC frequencies from 0.5-4 kHz. Time between tests was not analyzed at this time.
- Average threshold shifts were obtained for 0.5, 1, and 2 kHz.
- Progressive hearing loss definitions, shown below, were applied to each test date pair, yielding 23 right ear pairs and 23 left ear pairs that met at least one of the definitions. All subjects were first enrolled at ≤21 years. Mean age at the progressive cohort was 14.85 years (range 11 months to 51 years).

<table>
<thead>
<tr>
<th>Name</th>
<th>Frequency</th>
<th>Threshold Shift Definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF2/10</td>
<td>Any Frequency</td>
<td>20dB at one freq/10dB at two freqs</td>
<td>ASHA (ototoxicity)</td>
</tr>
<tr>
<td>AF2/15</td>
<td>Any Frequency</td>
<td>15dB at one freq/20dB at two freqs</td>
<td>Modified ASHA</td>
</tr>
<tr>
<td>LF10</td>
<td>2/3/4kHz</td>
<td>10dB average</td>
<td>OSHA (noise exposure)</td>
</tr>
<tr>
<td>HF10</td>
<td>2/3/4kHz</td>
<td>10dB average</td>
<td>Modified GENDEAF</td>
</tr>
<tr>
<td>LF&gt;15</td>
<td>Any Frequency</td>
<td>15dB average</td>
<td>Modified GENDEAF (non-syndromic hearing loss)</td>
</tr>
<tr>
<td>HF&gt;15</td>
<td>Any Frequency</td>
<td>15dB average</td>
<td>Modified GENDEAF</td>
</tr>
<tr>
<td>LF15</td>
<td>2/3/4kHz</td>
<td>15dB average</td>
<td>Modified GENDEAF</td>
</tr>
<tr>
<td>HF15</td>
<td>2/3/4kHz</td>
<td>15dB average</td>
<td>Modified GENDEAF</td>
</tr>
</tbody>
</table>

RESULTS

Table 2. Test date pairs (listed in the left vertical column) showing progression according to at least one definition (shown in the six remaining columns across the top) are noted in green for 10dB criteria and orange for >15dB criteria.

Distribution of Test Date Pairs by Progressive Hearing Loss Definition (m=66)

Figure 1. Audiometric data for subjects with progressive hearing loss indicated wide variation in hearing sensitivity with mean losses slightly sloping and generally in the moderate range. Mean and standard deviation (s.d.) are shown for (1a) pure tone thresholds for Test 1 (red) and Test 2 (blue) and (1b) threshold shift (m=46 test pairs).

Figure 2. This figure indicates the percentage of test date pairs meeting each of the six definitions of progressive hearing loss. The AF2/10 and AF2/15 definitions most often defined progression in our cohort. Less than one-third of cases of progressive hearing loss were identified using the stricter LF15-15 or HF15-15 criteria. The LF10 and LF15 definitions identified higher percentages (56.5%, 32.6%) of progression in this cohort than the HF10 and HF15 definitions (45.7%, 26.1%).

Modifying definitions to incorporate a lower intensity cut-off (10dB) and lower frequencies (0.5, 1, 2 kHz) identified higher numbers of cases (58.5%) of progressive hearing loss. Further modification to include an average of 0.5, 1, and 4kHz had little effect on the number of test pairs identified as progressive (47.8% at 10dB and 28.2% at >15dB).

DISCUSSION

The conclusion among approaches used to define progressive hearing loss suggests that challenges may be greater in pediatric populations where hearing loss configurations may be more variable. In this study, a greater percentage of subjects with progressive hearing loss were identified using lower frequency targeted definitions. Modified forms to the definitions in these younger populations, including low frequency emphasis and greater likelihood of fluctuating conductive overlays, must be considered when establishing a formal definition of progression.

REFERENCES


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