EVALUATION OF SPEECH PERCEPTION IN PATIENTS WITH SKI SLOPE HEARING LOSS USING ARABIC CONSTANT SPEECH DISCRIMINATION LISTS

Mai El Ghazaly, Resident of Audiology
Mohamed Aziz Talaat, MD, PhD
Mona Mourad, MD, PhD
Audiology Unit.
Alex. University.
Ski slope hearing loss is a sharply falling configuration ≥30 dB loss between 2 successive high frequencies.

Low frequencies thresholds remain about normal.

Effect of high frequency slope on audition:

1. Patients with ski slope hearing loss often miss out consonants (especially fricatives) and have difficulties understanding speech in background noise.

2. Individuals with cochlear high frequency hearing loss may score (80-100%) on PB word lists and still have difficulty understanding conversation.

3. Pure tone thresholds and speech discrimination for PBWLs may under estimate communication difficulties.
Dead regions in the cochlea may be hidden in ski slope hearing loss where the inner hair cells and/or associated neurons function poorly.

Mechanical vibration at a particular region of the basilar membrane will not cause signal transduction into its electrical counterpart.
As a consequence, high frequency speech sounds are not transduced at their anatomical region. These sounds are still detected via neurons that are tuned to lower frequencies with a different CF. Edge frequency $fe$ is the CF of IHC and neurons adjacent to a dead region. This is a phenomenon called "off-frequency listening".
Evaluation of cochlear dead regions:

A. Suspect from the audiogram:

- Threshold > 90 dB at any high frequency
- Audiometric slope > 50 dB/octave with increasing frequency

B. Masking paradigm tests:

- Psychophysical Tuning Curves: A research set up lacks precision in bracketing a dead region.
- Threshold Equalizing Noise (TEN test): A clinical test has the merit of accurate bracketing a cochlear dead region.
Evaluation of cochlear dead regions:

C. Speech discrimination tests:

- **Consonants speech discrimination tests** will assess phoneme recognition difficulties for high frequency hearing loss listeners.

- **Cochlear dead regions** are expected to negatively influence performance on such speech tests.

Rehabilitation for ski slope hearing loss includes:

1. **Amplification by Conventional hearing aids as open fit, RIC hearing aids if dead regions are absent.**

2. **Amplification by Frequency transposition algorithm if dead regions are present.**

3. **Auditory nerve stimulation by Cochlear implant.**
Cochlear implant in patients with dead regions

- Patients with extensive dead regions may be candidates for CI versus hearing aid.

- Acoustic and electric stimulation may be a further consideration for ski slope losses.

- This poses crucial decisions of electrode insertion depth and frequency mapping.

Ski slope is a Hybrid candidate

Hybrid device
Aim of the work

1. Evaluate patients’ speech perception with ski sloping high frequency hearing loss on Arabic high frequency emphasis speech materials.

2. Evaluate the possible effect of high frequency dead regions on such performance.
The study was conducted on 20 patients:

**Selection criteria:**

- Literate adults.
- Bilateral steep sloping high frequency SNHL with:
  - Normal to moderate loss at 250-500 Hz.
  - Mild to moderately severe loss at 1000 Hz.
  - Severe to total loss at 2000 to 8000 Hz.
Each patient was subjected to the following:

1. History, PTA (AC&BC) and imittance measures.
2. TEN (HL) test for diagnosis of cochlear dead regions.
3. Monosyllabic phonetically balanced word lists.
4. Modified Arabic consonant speech discrimination lists.

**TEN (HL) test**

**Test procedure**

- Threshold is measured for puretone detection presented in ipsilateral broadband noise using a recorded CD.
- The signals from the CD → two-channel audiometer, noise on one channel & test tones on the other channel. Both channels are routed to one ear.
1-Pure tone thresholds are measured.

2-Then masked thresholds are measured in presence of broadband noise. Test tones are 500, 750, 1000, 1500, 2000, 3000 and 4000 Hz.

A dead region is BRACKETED when
- The masked threshold is at least 10 dB above the absolute threshold & 10 dB above the nominal noise level.

**Full version Arabic consonant discrimination lists**

- List #1: 120 sense-words.
- List #2: 156 non-sense words.
- Lists are constructed in multiple choice items for closed set response. Each set consists of four monosyllabic words. The syllabic structure is C V C.
- **Words of a given item differ only in one phoneme either in initial or final position.**
- All words were subjected to spectral analysis & tested on patients with high frequency hearing loss.
The modified Arabic Consonant Discrimination Lists

**SWL (50 words)**
- 24 for fricatives
- 18 for stops
- 4 for nasals
- 4 for laterals

**NSWL (52 words)**
- 26 for fricatives
- 18 for stops
- 4 for nasals
- 4 for laterals
The 2 lists were recorded separately & were introduced to the patient through MADSEN ASTERA audiometer.

A carrier phrase (بدد كلمة) precedes the tested word. The carrier phrase and the tested word occupy 5 seconds followed by 5 seconds of silence.

Each list took about 8.5 minutes.
The patient has to choose the word heard from a closed set of words that differ from the test word in only the test consonant either initial or final.

The test score was reported as a percentage of the correct responses.

Probability of error for a phoneme =
\[
\frac{\text{Total errors for a type of consonant across subjects}}{\text{Total stimuli for that consonant across subjects}} \times 100\% 
\]

Probability of error for each class of consonant =
\[
\frac{\text{Total errors for a class of consonant across subjects}}{\text{Total stimuli for that class across subjects}} \times 100\% 
\]
RESULTS
&
DISCUSSION

Mean audiogram of all ears

Intensity in dB HL

Frequency in Hz
Distribution of ears according to presence or absence of dead regions and the extent of dead regions if present.

No Dead Regions 18
Dead regions 22

DR at 4000Hz only 11
DR 2000-4000Hz 6
DR 1000-4000Hz 5

X,SD thresholds of ears with no dead regions
X,SD thresholds of ears with dead region(s)
Distribution of ears with dead region(s) according to frequency of occurrence across audiometric frequencies

![Bar chart showing distribution of ears with dead regions across different frequencies.](chart.png)

Comparison between ears with no dead regions and those with dead region(s) according to their total score on modified Arabic consonant discrimination lists and phonetically balanced discrimination lists

<table>
<thead>
<tr>
<th></th>
<th>NDR (n=18)</th>
<th>DR (n=22)</th>
<th>t₁</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arabic consonant discrimination lists</td>
<td>75.32 ± 10.70</td>
<td>61.54 ± 12.98</td>
<td>3.678*</td>
<td>0.001*</td>
</tr>
<tr>
<td>Phonetically balanced discrimination lists</td>
<td>80.0 ± 6.44</td>
<td>68.09 ± 10.19</td>
<td>4.301*</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>t₂</td>
<td>2.525*</td>
<td>2.871*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.022*</td>
<td>0.009*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Comparison between ears with no dead regions and those with dead region(s) as respect to percentage correct of scores on modified Arabic consonant discrimination lists

<table>
<thead>
<tr>
<th></th>
<th>NDR (n=18)</th>
<th>DR (n=22)</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fricatives</td>
<td>70.09±12.41</td>
<td>58.22±12.86</td>
<td>2.950*</td>
<td>0.005*</td>
</tr>
<tr>
<td>Stops</td>
<td>80.56±10.99</td>
<td>63.13±19.74</td>
<td>3.526*</td>
<td>0.001*</td>
</tr>
<tr>
<td>Nasals</td>
<td>72.22±26.97</td>
<td>64.77±16.65</td>
<td>1.023</td>
<td>0.315</td>
</tr>
<tr>
<td>Laterals</td>
<td>88.89±15.39</td>
<td>68.18±25.80</td>
<td>2.993*</td>
<td>0.005*</td>
</tr>
<tr>
<td>All</td>
<td>75.32±10.70</td>
<td>61.19±13.11</td>
<td>3.678*</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

Distribution of performance of ears with dead region(s) on Arabic consonant discrimination lists represented as percent correct according to the extent of dead region(s)
Comparison between ears with no dead regions and those with dead region(s) according to probability of error of each class of consonants

<table>
<thead>
<tr>
<th></th>
<th>NDR (n=18)</th>
<th>DR (n=22)</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fricatives</td>
<td>29.91±12.42</td>
<td>41.78±12.85</td>
<td>2.950*</td>
<td>0.005'</td>
</tr>
<tr>
<td>Stops</td>
<td>19.44±10.99</td>
<td>36.87±19.74</td>
<td>3.526*</td>
<td>0.001'</td>
</tr>
<tr>
<td>Nasals</td>
<td>27.78±26.97</td>
<td>35.23±16.65</td>
<td>1.023</td>
<td>0.315</td>
</tr>
<tr>
<td>Laterals</td>
<td>11.11±15.39</td>
<td>31.82±25.80</td>
<td>2.993*</td>
<td>0.005'</td>
</tr>
<tr>
<td>All</td>
<td>24.68±10.70</td>
<td>38.81±13.11</td>
<td>3.678*</td>
<td>0.001'</td>
</tr>
</tbody>
</table>

CONCLUSIONS
1. In this study, **speech tests** using consonant sounds have proved to be effective in determining the performance that reflects spectral regions affected by cochlear pathology.

2. **Masking techniques** were pioneering evaluation of cochlear reserves and dead regions but not highlighting the parallel speech perception.

3. Because rehabilitation options are increasing with technical development, rehabilitation decision should be based on **realistic measures**. The most important of which is evaluating speech perception that targets specific cochlear regions which may vary widely from very limited affection when dead regions affect very narrow cochlear partition to much degraded performance in extensive dead regions.
4. The realistic assessment is expected to display the shortcomings of the pathology that affects speech perception. In this respect masking techniques that uncover cochlear non-functioning areas together with high frequency emphasis speech tests are synergistic in bracketing one or more regions of the cochlea that are not functioning and their effect on speech perception.