Transient evoked otoacoustic emission in Thai adults: a preliminary report

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Objective: To present the transient evoked otoacoustic emission data in normally hearing adults

Design: Descriptive study, cross section

Setting: Department of Otolaryngology, Faculty of Medicine, Chulalongkorn University

Subjects: Thirty-one normally hearing adults with age range of 21-63 (mean ± SD = 37.1 ± 13.33) years

Main outcome measure: Transient evoked otoacoustic emission response in each frequency in normally hearing adults

Results: Transient evoked otoacoustic emission were presented in all normally hearing ears (62 ears) and the amplitude of them varies inversely to frequencies. (12.6 dB at 1KHz compares with 3.72 dB at 5KHz) They showed no sex predirection, age difference or difference between right and left ear, and the test time was very short (58.34 ± 4.06 seconds, 95% CI)

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Conclusion: The preliminary result shows some benefits of TEOAEs. They use shorter test time and present in all normally hearing ears, and most useful in neonatal screening programmes.

Key words: Transient evoked otoacoustic emission, Cochlear response, Hearing test.
เพื่อศึกษาค่าฝีหูซึ่งไม่ได้ใช้ในทางการคุ้มครองยาวนาน ที่มีความถี่ในผู้ใหญ่ที่มีระดับการได้ยินปกติ : รายงานเบื้องต้น. วุฒิศิริยากร จุฬาลงกรณ์มหาวิทยาลัย

วัตถุประสงค์ : เพื่อศึกษาค่าฝีหูซึ่งไม่ได้ใช้ในทางการคุ้มครองยาวนาน ที่มีความถี่ในผู้ใหญ่ที่มีระดับการได้ยินปกติ

รูปแบบการวิจัย : การศึกษาเชิงพรรณนา

สถานที่ : ภาควิชาโสตทัศนศาสตร์วิทยาคณะแพทยศาสตร์จุฬาลงกรณ์มหาวิทยาลัย

ผู้เข้าร่วมการศึกษา : การศึกษาได้คัดเลือกผู้มีการตรวจพบฝีหูไขริด ขนาดระหว่าง 31 ราย ช่วงอายุระหว่าง 21-63 ปี (ค่าเฉลี่ย ± ค่าเบี่ยงเบนมาตรฐาน = 37.1 ± 13.33)

การวัดผล : เปรียบเทียบค่าฝีหูซึ่งไม่ได้ใช้ในทางการคุ้มครองยาวนาน ในผู้ที่มีการได้ยินอยู่ในระดับปกตินั้นว่าจะมีความต่างกันมั้ย

ผลการศึกษา : มีการวัดและสถิติที่ไม่มีการได้ยินปกติในผู้ที่มีการได้ยินปกติ (31 ราย, 62 ยุค) และความถี่ของการใช้ฝีหูซึ่งไม่ได้ใช้ในทางการคุ้มครองยาวนานที่มีความถี่ของเสียงที่ตรวจวัด (12.6 เดือน) มีกิโลเฮิร์ทส์เทียบกับ 3.72 เดือน (ที่ความถี่ 5 กิโลเฮิร์ทส์) ไม่มีความแตกต่างระหว่างผู้สูงอายุ หรือผู้ที่มีการได้ยินขจัดออกจากการตรวจวัด (58.34 ± 4.06 วินาที, 95% ความเชื่อมั่น)

วิจารณ์และสรุป : ผลการศึกษาเบื้องต้นแสดงถึงประโยชน์ของฝีหูซึ่งไม่ได้ใช้ในทางการคุ้มครองยาวนาน ที่มีความถี่ เช่น ใช้เวลาในการทดสอบน้อย พบทุกรายที่มีระดับการได้ยินปกติ เหมาะอย่างยิ่งในการทดสอบระดับการได้ยินขจัดในทางระดับ
Otoacoustic Emissions (OAEs) are audio frequencies that are generated by outer hair cells (OHCs) in the cochlea and transmitted to the middle ear, tympanic membrane and into the external ear canal.\(^{(1,4)}\) OAEs were first detected by Dr. David T. Kemp in 1978 and he proposed them as a clinical test.\(^{(5,6)}\) After that, other researchers in Europe and America supported this view and concluded that OAEs consume less time, and are a simple, reliable, and non-invasive method for neonatal and infant hearing screening.\(^{(2,4,7-9)}\) OAEs can be separated into two general categories.\(^{(1,3,5,10)}\)

1. Spontaneous Otoacoustic Emissions (SOAEs) They occur in the absence of any stimuli and can be detected in about 50% of normally hearing ears. They may be present at only one frequency or multiple frequencies, but there is no significant relation to tinnitus. SOAEs have little clinical usefulness.

2. Evoked Otoacoustic Emissions (EOAEs) They occur in response to acoustic stimuli and are detected in almost all normally hearing ears. According to the sound stimuli, EOAEs can be divided into three different subtypes.

2.1 Transient Evoked Otoacoustic Emissions (TEOAEs) TEOAEs are elicited by an acoustic transient such as a click or tone burst. They can be detected in all normally hearing ears but are absent if the hearing threshold is above 30-40 dB. Many studies have reported TEOAE response in different conditions and concluded their clinical applications.

2.2 Distortion-product Otoacoustic Emissions (DPOAEs) To evoke DPOAE, two stimulus pure tones separated in frequency, are presented to the ear. The strongest DPOAE occur at a frequency of 2F1-F2, in which F1 represents the low frequency and F2 the high frequency stimuli. The F2/F1 ratio is about 1.22. They appear in all normally hearing ears but are negative in ears which the hearing threshold is above 50 dB.

2.3 Stimulus-Frequency Otoacoustic Emission (SFOAEs) They are similar to TEOAE but are evoked with continuous pure tones instead of click stimuli. SFOAEs and their stimuli are the same frequency so it is difficult to separate which is the response. Because the detection of SFOAEs is more complicated than the measurement of TEOAEs, SFOAEs have not been studied so much for clinical tests of cochlear function.

In Thailand OAEs are used as recently advanced technology for testing cochlear function and there is little information available. Therefore so that they can be used for reference of Thai adults in the future, we studied the TEOAEs in 31 adults with normally hearing ears.

Material and Methods

Subjects

Thirty one persons, 62 ears divided, consisting of 6 males and 25 females with an age range of 21-63 years (mean = 37.1, SD = 13.33). They came to ENT department, outpatient service for hearing screening programme. All had normal ENT examinations, no history of noise trauma, normal middle ear function (type A tympanogram, positive stapedial reflexes) and their audiological records showed pure tone thresholds of < 20 dB SPL for frequencies of 0.5 K, 1K, 2K, 3K, 4K and 6 KHz inclusively.
Methods

The probe was provided with the ILO88 generator and it incorporated a low noise microphone and one earspeaker. The stimulus was a non-linear click of 80 us duration. The Click rate was 50/sec and the analysis time was 20 microseconds. The number of responses to be averaged was set at 260.

Table 1. Means, standard deviations and 95% CI of TEOAE data from 62 normally hearing ears.

<table>
<thead>
<tr>
<th></th>
<th>Mean (X)</th>
<th>SD</th>
<th>SE</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>test time (seconds)</td>
<td>58.34</td>
<td>16.00</td>
<td>2.03</td>
<td>54.36 - 62.32</td>
</tr>
<tr>
<td>canal noise (dB SPL)</td>
<td>41.61</td>
<td>1.34</td>
<td>0.17</td>
<td>41.28 - 41.94</td>
</tr>
<tr>
<td>stimulus peak (dB SPL)</td>
<td>83.58</td>
<td>1.95</td>
<td>0.25</td>
<td>83.09 - 84.07</td>
</tr>
<tr>
<td>TEOAE (dB SPL)</td>
<td>13.44</td>
<td>3.75</td>
<td>0.48</td>
<td>12.50 - 14.38</td>
</tr>
<tr>
<td>wave reproducibility(%)</td>
<td>91.84</td>
<td>5.08</td>
<td>0.65</td>
<td>90.57 - 93.11</td>
</tr>
</tbody>
</table>

Table 2. TEOAEs response in each frequency.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 KHz</td>
<td>12.60</td>
<td>4.80</td>
<td>0.61</td>
<td>11.40 - 13.80</td>
</tr>
<tr>
<td>2 KHz</td>
<td>12.24</td>
<td>4.06</td>
<td>0.52</td>
<td>11.22 - 13.26</td>
</tr>
<tr>
<td>3 KHz</td>
<td>7.21</td>
<td>5.16</td>
<td>0.66</td>
<td>5.91 - 8.51</td>
</tr>
<tr>
<td>4 KHz</td>
<td>5.88</td>
<td>6.31</td>
<td>0.80</td>
<td>4.31 - 7.45</td>
</tr>
<tr>
<td>5 KHz</td>
<td>3.72</td>
<td>5.88</td>
<td>0.75</td>
<td>2.25 - 5.19</td>
</tr>
</tbody>
</table>

Results

From table 1, the average time to measure TEOAEs was (54.36-62.32, 95% CI). The test time per patient was not more than 5 minutes. The amplitude of the canal noise floor was 41.61 dB SPL (41.28-41.94, 95% CI) and the stimulus peak was 83.58 dB SPL (83.09-84.07, 95% CI) for geometric mean. The amplitude of TEOAEs in all frequencies was 13.44 dB SPL (12.50-14.38, 95% CI) and wave the reproducibility mean was 91.84% which was very high.
From Table 2, separate TEOAE amplitudes in each frequency from 1 KHz to 5 KHz shows that low frequencies had higher TEOAE amplitude than high frequencies.

Table 3 shows no difference between age, sex, and right or left ears.

**Table 3. Means, SD, P-value of TEOAEs response by age groups, gender, ears.**

<table>
<thead>
<tr>
<th>age group</th>
<th>N(ears)</th>
<th>Means</th>
<th>t</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>26</td>
<td>13.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-39</td>
<td>14</td>
<td>13.58</td>
<td>0.02</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>40-49</td>
<td>8</td>
<td>11.51</td>
<td>1.44</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>&gt; 50</td>
<td>14</td>
<td>14.07</td>
<td>-0.37</td>
<td>&gt; 0.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>gender</th>
<th>N(ears)</th>
<th>Means</th>
<th>t</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>male</td>
<td>12</td>
<td>13.76</td>
<td></td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>female</td>
<td>50</td>
<td>13.36</td>
<td>0.34</td>
<td>&gt; 0.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ears</th>
<th>N(ears)</th>
<th>Means</th>
<th>t</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>31</td>
<td>13.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>31</td>
<td>13.53</td>
<td>-0.01</td>
<td>&gt; 0.05</td>
</tr>
</tbody>
</table>

**Discussion**

TEOAEs are OAEs that are evoked by clicks. Many studies have shown that TEOAEs are present in almost all normally hearing subjects but could not be detected if the hearing threshold was more than 30 dB.\(^{(1,2,8)}\) Some studies reported that TEOAE amplitudes were larger in infants and neonates and decreased in adults and the elderly.\(^{(1,2,13)}\) When compared between males and females, and right and left ears, the studies showed that TEOAE amplitudes were stronger in females and in the right ear.\(^{(2)}\) In our study, only 62 years were tested, and all of them showed no significant difference in the presence of TEOAE for females and males or for right and left ear. \((p>0.05)\) the TEOAE response varied with age (Table 3). Variations of the TEOAE response observed among our subjects younger than 40 years old were not statistically different \((p>0.05)\). Between 40-50 years of age, TEOAEs threshold decreased in amplitude, however the response increased in those of age more than 50 years. This result was different from other studies perhaps of the small number of subjects (62 ears) in our trials. When compared between frequencies \((1, 2, 3, 4, 5 \text{ KHz})\) low frequencies had larger TEOAE amplitude than high frequencies and
some ears had no response at high frequency (4 at 4KHz, 12 at 5KHz). They can mean that higher frequencies shows asymptomatic hearing loss before lower frequencies.

Robinette described that in normally hearing persons there are 5 different types of TEOAE patterns.\(^{(1)}\)

1. Wide spectrum (Figure 1). It is the most common type of TEOAE. It shows large amplitude in all frequencies from 1000-5000 Hz.

2. Notched emission (Figure 2). Its characteristics are similar to the wide spectrum type except that gaps of no response more than 500 Hz wide occur between 1500-3500 Hz.

![Figure 1. Wide spectrum.](image1)

![Figure 2. Notched emission.](image2)

3. Spiked or multiple peaked echo (Figure 3) TEOAE amplitudes show multiple peaked echoes with gaps but not as wide as the notched emission

4. Weak TEOAEs (Figure 4) show low amplitude in all frequencies despite normal hearing by audiometry tests.
5. Figure 5 shows the least common type of TEOAE response. Only mid-frequency ranges elicit TEOAE response despite normal hearing sensitivity through 8000 Hz. Therefore when interpreting TEOAE data, the presence of emissions suggests normal or nearly normal hearing, but no emissions does not rule out normal hearing in that frequency.
In conclusion, we found TEOAEs present in all normally hearing ears and the amplitude of the responses decreased from low to high frequency. The presence of emissions suggests normal or near normal hearing (threshold < 30 dB). This test has many advantages such as objective less time consuming and specific for outer hair cells.\(^{2,7,8}\) It is very useful in hearing screening, especially in neonates.\(^{6,7,12}\) Also, TEOAEs can provide valuable diagnostic information in determining the site of involvement for some patients having hearing losses.

References