

## Transient evoked otoacoustic emission in Thai adults: a preliminary reports

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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  $\pm$  SD = 37.1  $\pm$  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  $\pm$  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 neonotal screening programmes.*

**Key words :** *Transient evoked otoacoustic emission, Cochlear response, Hearing test.*

เพิ่มทรัพย์ อธิปประดิษฐ์, เสาวรส อัครวิเชียรจินดา, ปริญญา หลวงพิทักษ์ชุมพล. การศึกษาค่าปกติของเสียงสะท้อนจากหูชั้นในที่ถูกกระตุ้นด้วยเสียงช่วงสั้น ๆ ที่มีหลายความถี่ในผู้ใหญ่ที่มีระดับการได้ยินปกติ : รายงานเบื้องต้น. จุฬาลงกรณ์เวชสาร 2539 ส.ค.;40(8): 657-65

**วัตถุประสงค์** : เพื่อศึกษาถึงค่าของเสียงสะท้อนจากหูชั้นในที่ถูกกระตุ้นด้วยเสียงช่วงสั้น ๆ ที่มีหลายความถี่ในผู้ใหญ่ที่มีระดับการได้ยินปกติ

**รูปแบบการวิจัย** : การศึกษาเชิงพรรณนา

**สถานที่** : ภาควิชาโสต นาสิก ลาริงซ์วิทยา คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

**ผู้เข้าร่วมการศึกษา** : การศึกษานี้ได้คัดเลือกผู้ที่มารับการตรวจที่แผนกผู้ป่วยนอก โดยที่มีระดับการได้ยินปกติ จำนวน 31 ราย ช่วงอายุระหว่าง 21-63 ปี (ค่าเฉลี่ย  $\pm$  ค่าเบี่ยงเบนมาตรฐาน =  $37.1 \pm 13.33$ )

**การวัดผล** : เปรียบเทียบค่าของเสียงสะท้อนจากหูชั้นใน ในผู้ที่มีการได้ยินอยู่ในระดับปกติในแต่ละความถี่

**ผลการศึกษา** : ตรวจพบเสียงสะท้อนจากหูชั้นในในทุกคนที่มีการได้ยินปกติ (31 ราย, 62 หู) และค่าความดังของเสียงสะท้อนจากหูชั้นในแปรผกผันกับความถี่ของเสียงที่ตรวจวัด (12.6 เดซิเบลที่ 1 กิโลเฮิร์ตเทียบกับ 3.72 เดซิเบล ที่ความถี่ 5 กิโลเฮิร์ต) ไม่มีความแตกต่างระหว่างเพศ อายุ หรือหูซ้ายกับหูขวา นอกจากนี้ใช้เวลาในการตรวจน้อย ( $58.34 \pm 4.06$  วินาที, 95% ความเชื่อมั่น)

**วิจารณ์และสรุป** : ผลการศึกษาเบื้องต้น แสดงถึงประโยชน์ของเสียงสะท้อนจากหูชั้นในที่ถูกกระตุ้นโดยใช้เสียงช่วงสั้น ๆ ที่มีหลายความถี่ เช่น ใช้เวลาในการทดสอบน้อย พบทุกรายที่มีระดับการได้ยินปกติ เหมาะอย่างยิ่งในการทดสอบระดับการได้ยินขั้นต้นในทารกแรกเกิด

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.<sup>(1-4)</sup> OAEs were first detected by Dr. David T. Kemp in 1978 and he proposed them as a clinical test.<sup>(5,6)</sup> 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.<sup>(2,4,7-9)</sup> OAEs can be separated into two general categories.<sup>(1-3,5,10)</sup>

**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  $2F_1-F_2$ , in which  $F_1$  represents the low frequency and  $F_2$  the high frequency stimuli. The  $F_2/F_1$  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.<sup>(10)</sup> The stimulus was a non-linear

click of 80 us.duration. The Click rate was 50/sec.<sup>(11)</sup> 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.

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

**Table 2.** TEOAEs response in each frequency.

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

## 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.<sup>(4,12)</sup> 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 frequency.

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.

	N(ears)	Means	t	P Value
age group				
20-29	26	13.61		
30-39	14	13.58	0.02	> 0.05
40-49	8	11.51	1.44	> 0.05
> 50	14	14.07	-0.37	> 0.05
gender				
male	12	13.76		> 0.05
female	50	13.36	0.34	> 0.05
Ears				
Right	31	13.34		
Left	31	13.53	-0.01	> 0.05

## 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.<sup>(1,2,8)</sup> Some studies reported that TEOAE amplitudes were larger in infants and neonates and decreased in adults and the elderly.<sup>(1,2,13)</sup> 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.<sup>(2)</sup> In our study, only 62 ears 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 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.<sup>(11)</sup>

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.

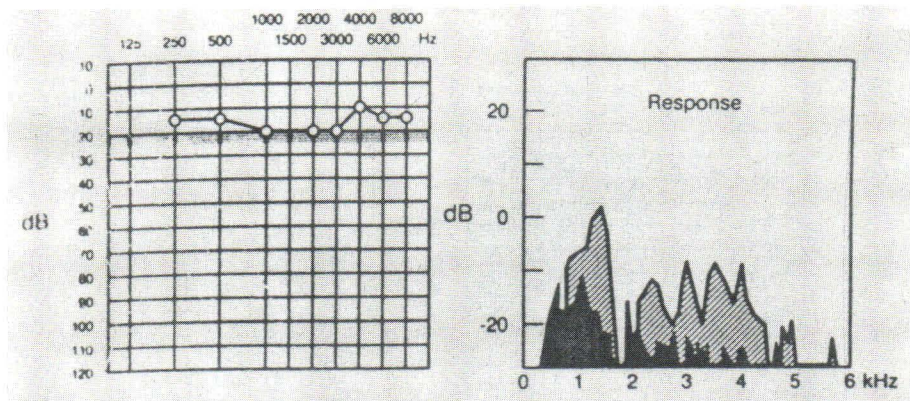


Figure 1. Wide spectrum.

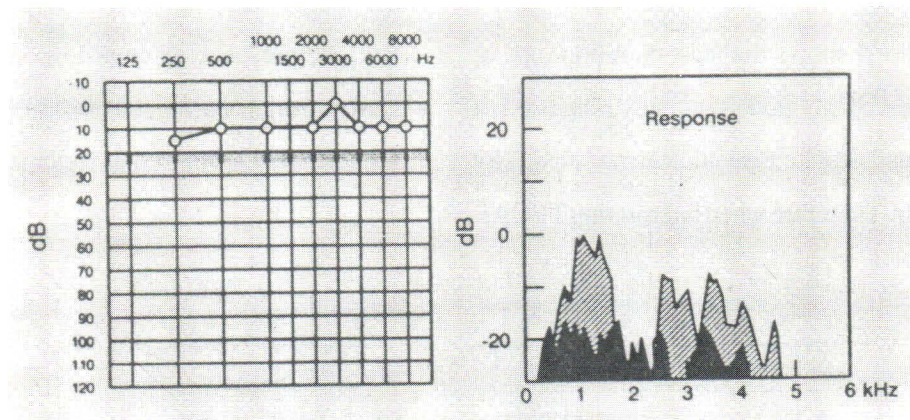


Figure 2. Notched emission.

3. Spiked or multiple peaked echo (Figure 3) TEOAE amplitudes show multiple peaked echos 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.

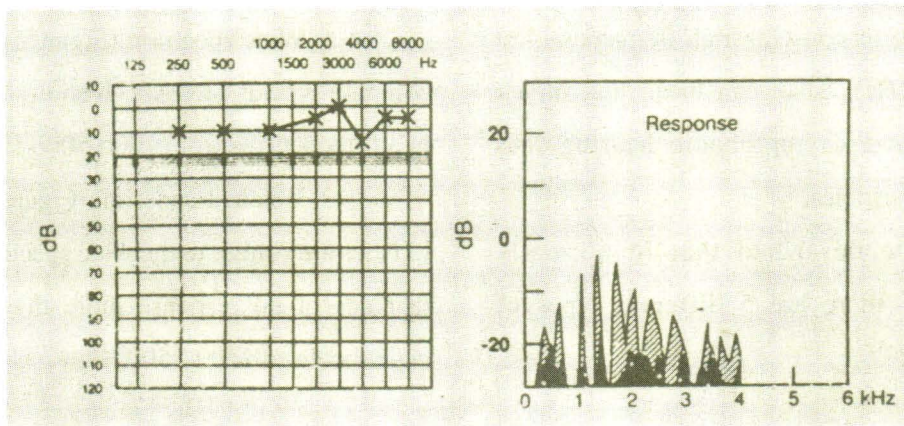


Figure 3. Multiple peaked echo.

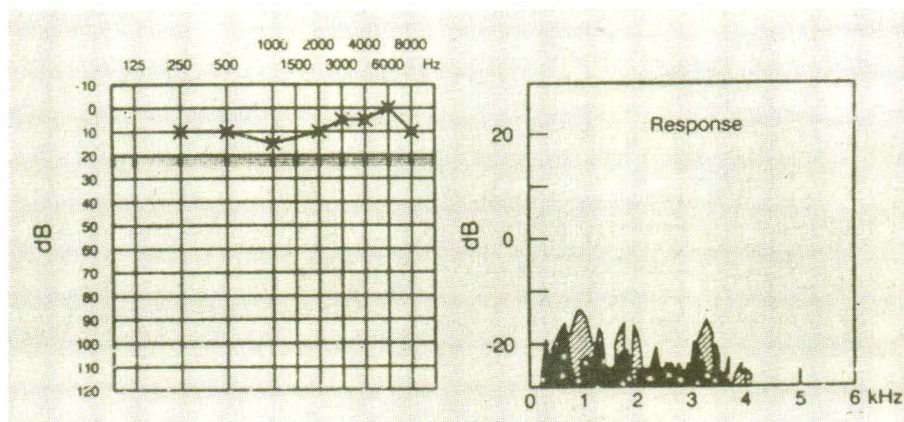


Figure 4. Weak TEOAEs.

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.

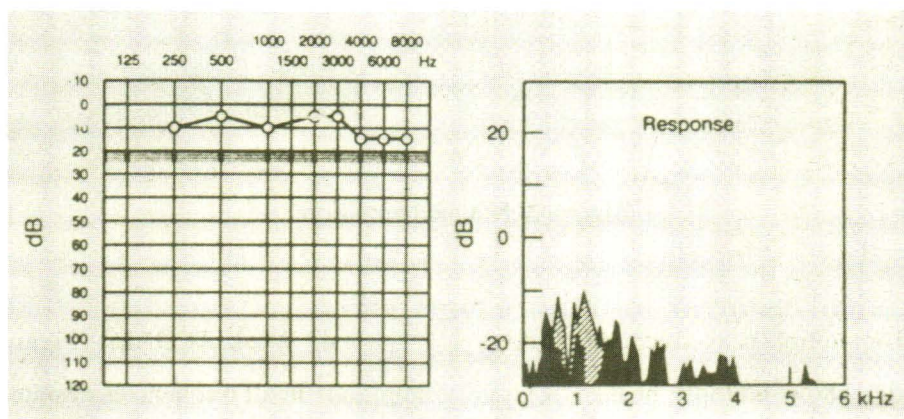


Figure 5. Least common.



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.<sup>(2,7,8)</sup> It is very useful in hearing screening, especially in neonates.<sup>(6,7,12)</sup> Also, TEOAEs can provide valuable diagnostic information in determining the site of involvement for some patients having hearing losses.

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