นิพนธ์ต้นฉบับ

A study of cross hearing in unilateral sensorineural deafness.

Parinya Luangpitakchumpon*
Pachada Luangpitakchumpon*

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Objective : *To study Cross hearing in unilateral sensorineural deafness*

Design : *Prospective*

Setting : *Otoneurologic Clinic, Department of Otolaryngology, Faculty of Medicine, Chulalongkorn University*

Subjects : *Fifty two unilateral sensorineural deafness with age range 20-50 years were recruited in this study. The hearing level in deaf ear is more than 90 dBHL and the air conduction threshold (ACT) in normal hearing ear is less than 25 dBHL at any test frequency. They are out patient department cases of ENT Clinic, Chulalongkorn Hospital. We selected cases and collected data in this study for two years.*

Main outcome measure : *We studied cross hearing level via air and bone conduction. The stimuli in this study were speech and pure tone signal. The lowest intensity level of the signals which cross over from deaf ear to normal hearing ear were recorded and analysis of statistical data by mean.*

Reprint request : Luangpitakchumpon P, Department of Otolaryngology, Faculty of Medicine,Chulalongkorn University,Bangkok 10330,Thailand.

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* Department of Otolaryngology, Rajvithi Hospital, Ministry of Public Health.

Results : *Mean of cross hearing level for speech signal is 71 ± .88 dB. Mean of cross hearing level for pure tone air conduction are 69.25 ± 1.57, 74.81 ± 1.14, 75.74 ± 1.31, 76.48 ± 1.09, 74.81 ± 1.19, 74.81 ± 1.21, 74.53 ± 1.54, 79.72 ± .77, 84.90 ± 1.98 and 82.03 ± 2.16 dB. Mean of cross hearing level for pure tone bone conduction are 28.75 ± 1.37, 27.50 ± 1.26, 26.52 ± 1.39, 24.28 ± 1.57, 28.57 ± 1.18, 27.61 ± 1.09, 27.77 ± 1.70 and 25.29 ± .60 dB.*

Conclusion : *We found the cross hearing phenomenon had occured to every one who has one ear is normal hearing and the other ear is sensorineural deafness. The bone cross hearing level had occured close to the bone conduction threshold (BCT) in normal hearing ear, those differences are not more than 10 dB at the same test frequency. And pure tone air cross hearing level are not closed to the ACT in normal hearing ear, the cross hearing level are more than 50 dB at the same test frequency. Finally, while we are testing on the poorer ear, masking method is necessary for hearing evaluation by presenting the noise into the better ear.*

Key words : *Cross hearing, Unilateral sensorineural deafness.*

ปริญญา หลวงพิทักษ์ชุมพล, พัชดา หลวงพิทักษ์ชุมพล. ศึกษาการได้ยินเสียงข้ามฟากในผู้ป่วยหูหนวกข้างเดียวและอีกข้างปกติ. จุฬาลงกรณ์เวชสาร 2539 ส.ค.; 40(8): 641-55

วัตถุประสงค์ : *เพื่อศึกษาระดับความดังของเสียงที่ข้ามฟากจากหูข้างหนวกไปยังหูข้างปกติทำให้หูข้างปกติได้ยินเสียงนั้นแทน*

รูปการวิจัย : *การศึกษาไปข้างหน้า*

สถานที่ : *คลินิคโสตประสาทวิทยา ภาควิชาโสต นาสิก ลาริงซ์วิทยา คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย*

ผู้เข้าร่วมการศึกษา : *การศึกษานี้ได้ทำการศึกษาการได้ยินในผู้ป่วยที่หูหนวกหนึ่งข้างอีกข้างปกติ ในหูข้างหนวกมีระดับการได้ยินเกิน 90 เดซิเบลทุกความถี่ ในหูข้างปกติมีระดับการได้ยินไม่เกิน 25 เดซิเบลทุกความถี่ที่ทดสอบเช่นกัน คัดเลือกโดยการตรวจการได้ยินแบบปกติ ซึ่งเป็นผู้ป่วยที่มารับการตรวจที่แผนกคนไข้นอกของภาควิชาโสต นาสิก ลาริงซ์วิทยา ร.พ.จุฬาลงกรณ์ มีอายุระหว่าง 20-50 ปี จำนวน 52 ราย ระยะเวลาในการทดสอบและเก็บข้อมูล 2 ปี*

การวัดผล : *ทดสอบหาระดับความดังของเสียงที่ใส่เข้าหูข้างหนวก โดยเพิ่มความดังขึ้นเรื่อยๆ จนทำให้ความดังของเสียงนั้นข้ามไปได้ยินในหูข้างปกติ ซึ่งทำการทดสอบทั้งทางช่องหูและทางกระดูกหลังใบหู เสียงที่ใช้ในการทดสอบเป็นเสียงบริสุทธิ์และเสียงพูด แล้ววิเคราะห์ข้อมูลเป็นค่าเฉลี่ยแบบมัชฌิมเลขคณิต*

ผลของการศึกษา : *จากการศึกษาพบว่า ระดับความดังของเสียงที่ข้ามฟากจากหูข้างหนวกไปทำให้หูข้างปกติได้ยินแทนนั้น มีดังนี้ ระดับความดังเฉลี่ยของเสียงพูดที่เกิดการได้ยินข้ามฟาก คือ 71.85 $\pm$ .88 เดซิเบล ระดับความดังของเสียงบริสุทธิ์ที่ทดสอบโดยปล่อยเสียงผ่านทางช่องหู แล้วเกิดการได้ยินข้ามฟากในแต่ละความถี่ที่ทดสอบ คือ 69.25 $\pm$ 1.57, 74.81 $\pm$ 1.14, 75.74 $\pm$ 1.31, 76.48 $\pm$ 1.09,74.81 $\pm$ 1.19, 74.81 $\pm$ 1.21, 74.53 $\pm$ 1.54, 79.72 $\pm$ 77, 84.90 $\pm$ 1.98 และ 82.03 $\pm$ 2.16 เดซิเบล และระดับความดังของเสียงบริสุทธิ์ที่ทดสอบผ่านทางกระดูกหลังใบหูแล้วเกิดการได้ยินข้ามฟากในแต่ละความถี่ที่ทดสอบคือ 28.75 $\pm$ 1.37, 27.50 $\pm$ 1.26, 26.52 $\pm$ 1.39, 24.28 $\pm$ 1.57, 28.57 $\pm$ 1.18, 27.61 $\pm$ 1.09, 27.77 $\pm$ 1.70 และ 25.29 $\pm$ 60 เดซิเบล*

วิจารณ์และสรุป : *ผลของการศึกษาพบว่า เมื่อปล่อยเสียงที่มีความดังระดับหนึ่งเข้าในหูข้างที่หนวกทั้งทางช่องหูและทางกระดูกหลังใบหู ความดังของเสียงระดับหนึ่งจะข้ามฟากไปกระตุ้นในหูข้างปกติทำให้ผู้ป่วยได้ยินเสียงนั้นได้ และพบว่าปรากฏการณ์นี้จะเกิดกับผู้ป่วยทุกรายที่มีระดับการได้ยินระหว่างหูทั้งสองข้างแตกต่างกัน ฉะนั้นการตรวจการได้ยินจะต้องระมัดระวังเมื่อพบว่าผู้ป่วยมีระดับการได้ยินของหูทั้งสองข้างไม่เท่ากัน หลักการป้องกันการเกิดการได้ยินเสียงข้ามฟาก คือ การใส่เสียงรบกวนเข้าหูข้างที่ไม่ได้ทดสอบในขณะที่กำลังทดสอบการได้ยินในหูอีกข้างหนึ่ง*

Cross hearing is the phenomenon of signal hearing in the better ear when the signal is presented to the poorer ear. It is the reception of the sound signal at the opposite ear under test.[1-5] There are two ways in which cross hearing occurs. These are air and bone conduction. Signals presented to the poorer ear (test ear: TE) may reach sufficient intensity levels to cross over to the opposite ear (nontest ear: NTE). When the signals (speech and pure tone) are presented through an earphone receiver or bone conduction vibrator to the ear, it is logical to assume that if the hearing sensitivity is considerably better in one ear than the other ear, it is possible that before the threshold of the poorer ear is reached the intensity of the signal may be great enough for sound to escape from beneath the earphone into the room and be heard by the better ear.[6] For bone conduction tests, because there is rarely a way of knowing for certain which inner ear has been stimulated by a bone conduction tone, regardless of where the bone conduction vibrator is placed, cross hearing is always a posibility.[7-10] Thus, cross hearing for bone conduction should be suspected whenever the BCT on TE and NTE are different. Synonymous terms for cross hearing include "cross over," "transcranial hearing" and "shadow hearing".[6] Whenever cross hearing is suspected, it is necessary to remove the NTE from the test procedure by masking. Masking is the introduction of a noise into the NTE to eliminate cross hearing.[11,12] Minimum effective masking level[13], minimum effective masking (EM)[14], or minimum masking level[15] refers to the minimum amount of masking signal needed to prevent the NTE from hearing a cross hearing test signal.[16] There were two types of masking noise in this study, white noise and narrow-band noise. White noise is used for speech audiometry. Because speech is a broad spectrum signal, speech masking noises must consist of a broad band of frequencies. Because it is a broad spectrum noise,it masks speech satisfactorily but is slightly less intense in the low frequencies.[17] Masking noise for pure tone audiometry in this study is narrow band noise. Narrow band noises are preferred for pure tone test procedures because of their masking efficiency and it has been proven that the masking of a pure tone is most effecient.[18,19]

Methodology

Three testing methods were used in this study. They were speech reception threshold (SRT), ACT and BCT. They were performed by a clinical audiologist. The procedures in this study were:

1. SRT testing was first. Spondiac words are the most commonly used stimuli for establishing the SRT.[20] We presented RAMA I and RAMA II spondee words, and these were presented from live voice through an earphone to measure the hearing threshold in:

1.1 the deaf ear without masking

1.2 the good ear without masking

1.3 the deaf ear with minimum EM

The masking noise in this testing was white noise. The SRT is the point at which the listener can respond correctly 50% of the time. We recorded the results on a data sheet.

2. The second step was ACT testing. Threshold testing procedure began at 1000 Hz. Once the threshold was found at 1000 Hz, similar searches

were undertaken at 1500, 2000,3000,4000,6000 and 8000 Hz. Threshold findings at 1000 Hz were repeated as a reliability check,followed by testing at 750, 500, and 250 Hz.[21,22] We presented pure tones through an earphone to measure the hearing threshold in:

2.1 the deaf ear without masking

2.2 the good ear without masking

2.3 the deaf ear with minimum EM

Test frequencies for ACT testing were 250, 500, 750, 1000, 1500,2000, 3000, 4000, 6000 and 8000 Hz. The lowest hearing level at which the frequency can be detected were referred to as the ACT. The masking noise in this testing was narrow band noise and we again recorded the results on a data sheet.

3. The last testing was BCT testing. The bone conduction vibrator was placed on the mastoid area of the TE.[23] Threshold testing procedures were same as in 2. Pure tones at frequencies of 250, 500, 750, 1000, 1500, 2000, 3000 and 4000 Hz. were presented through the bone conduction vibrator to measure the hearing threshold in:

3.1 the deaf ear without masking

3.2 the good ear without masking

3.3 the deaf ear with minimum EM

Masking noise in this testing was narrow band noise. We again recorded the results on a data sheet.

Population

We selected subjects for this study by determining their pure tone audiogram to isolate subjects in which one ear had good hearing and the other ear had sensorineural deafness. They are OPD cases in ENT Clinic of Chulalongkorn Hospital who complainted cannot hear anything in one ear. Normal hearing ear showed a hearing threshold of less than 25 dB HL at the test frequency and the hearing threshold of the deaf ear was over 90 dB HL at the test frequency. There were 52 cases of unilateral sensorineural deafness in our study. Their age ranges were between 20-50 years old in both sexes.

Instrumentation

The instruments in this study were a soundproof room and a clinical audiometer. The soundproof room prevents noises from outside from entering. All that is necessary in clinical audiometry is to keep the noise level within the soundproof room below the level of masking when the door is closed. The ambient noise level in the soundproof room was checked by using a sound level meter. It compared to ANSI S3.1-1991 criteria for permissible ambient noise during audio-metric testing. The dimensions of the soundproof room were 2 x 2.5 x 2 meters. The audiometer was a Beltone model 2000, which is a clinical two-channel audiometer. The intensity ranged from -10 dBHL to 110 dBHL at 500 to 6000 Hz and -10 dBHL to 90 dBHL at 250 and 8000 Hz. This is through a TDH-50 earphone for ACT testing and ranges from-10 to 70 dBHL through the B-71 bone conduction vibrator for BCT testing. For SRT testing, we presented RAMA I and RAMA II spondee words through an earphone to both the good ear and the deaf ear. The range of intensity was -10 to 110 dBHL.

Table 1. Shows the mean of speech hearing level in 52 cases.

	Mean ± SE	95 % CI
Good ear	16.48 ± .70	17.89 - 15.07
Deaf ear	103.98 ± .46	104.91 - 103.04
Cross hearing	71.85 ± .88	73.62 - 70.08
Effective masking	82.03 ± .74	83.52 - 80.54

Results

1. Cross hearing in speech testing

This study found that the mean of the SRT in the normal hearing ear was 16.48 ± .70 dB; the mean of cross hearing of the SRT was 71.85 ± .88 dB and the mean of the SRT in the deaf ear with effective masking was 103.98 ± .46 dB. The mean difference between SRT in normal hearing ear and the cross hearing level was 55.37 dB; between the SRT in the normal hearing ear and the SRT in the deaf ear with effective masking was 87.50 dB; and between the SRT in the deaf ear and cross hearing was 32.13 dB. (Table 1)

2. Cross hearing via bone conduction

The mean of BCT in the normal hearing ear at test frequency were: (250-4000 Hz) 21.59 ± 1.34 dB, 22.39 ± .94 dB, 23.18 ± 1.24 dB, 20.68 ± 1.25 dB, 23.91 ± 1.38 dB, 25.47 ± 1.16 dB, 21.38 ± 1.17 dB and 21.17 ± 1.56 dB.

An average mean of BCT in the normal hearing ear was 22.47 ± 1.06 dB. The mean of cross hearing via bone conduction from the deaf ear to the normal hearing ear at the test frequencies were 28.75 ± 1.37 dB, 27.50 ± 1.26 dB, 26.52 ± 1.39 dB, 24.28 ± 1.15 dB, 28.57 ± 1.18 dB, 27.61 ± 1.09 dB, 27.77 ± 1.70 dB and 25.29 ± .60 dB. An average mean of cross hearing was 26.85 ± .97 dB. And the threshold of bone conduction in deaf ear, we could not obtain a threshold at the maximum intensity level at any test frequency. (Figure 1)

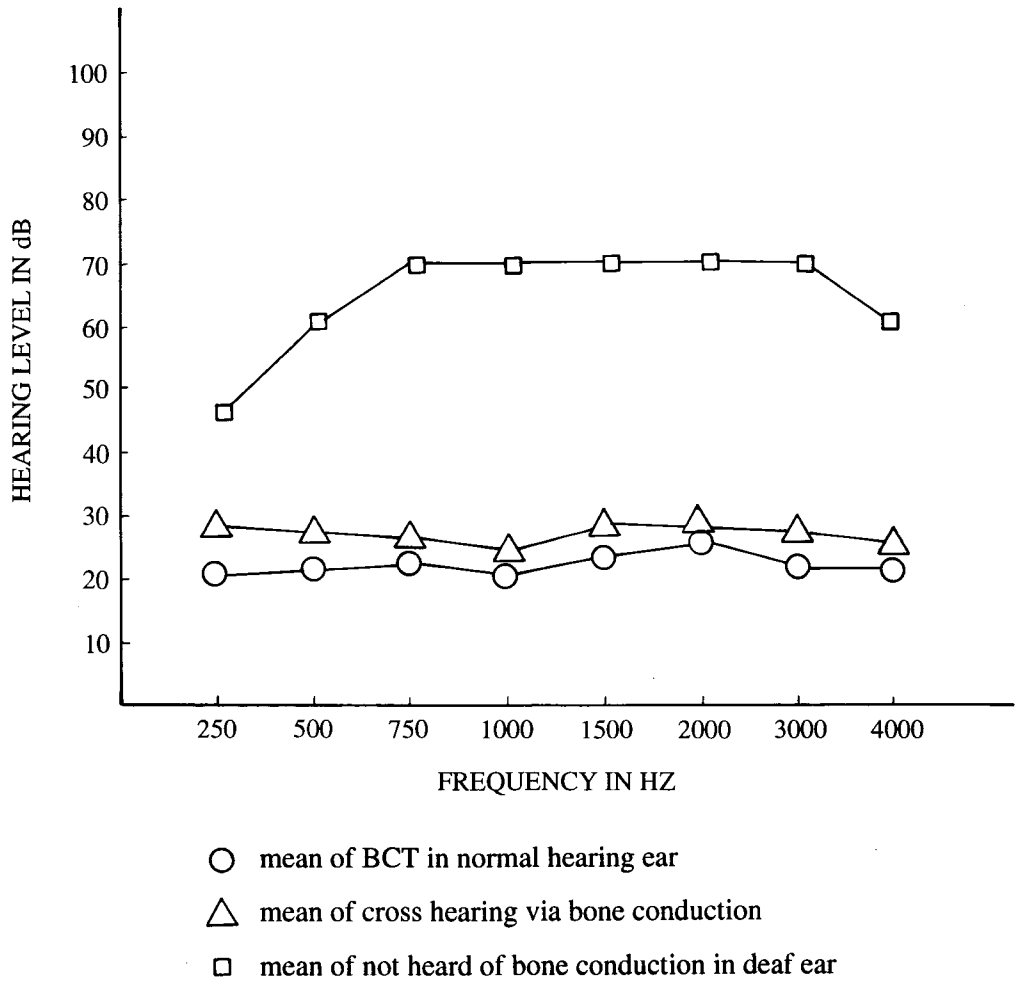

Figure 1. Shows mean of bone cross hearing level, normal BCT and BCT in deaf ear in 52 cases.

3. Cross hearing via air conduction

The mean of ACT in the normal hearing ear at the test frequencies (250-8000 Hz) were 17.14 ± .66 dB, 17.88 ± .91 dB, 16.73 ± 1.24 dB, 15.57 ± .90 dB, 15.76 ± 1.09 dB, 13.07 ± .97 dB, 12.69 ± 1.50 dB, 14.80 ± 1.45 dB, 14.6 ± .78 dB and 10.93 ± 1.19 dB. An average mean of ACT in the normal hearing ear was 14.92 ± 1.07 dB. The mean of cross hearing threshold at the test frequencies (250-8000 Hz) were: 69.25 ± 1.57 dB, 74.81 ± 1.14 dB, 75.74 ± 1.31 dB, 76.483 ± 1.09 dB, 74.81 ± 1.92 dB, 74.81 ± 1.21 dB, 74.53 ± 1.54 dB, 79.72 ± .77 dB, 84.90 ± 1.98 dB and 82.03 ± 2.16 dB. An average mean of cross hearing by air conduction was 76.70 ± 1.40 dB.

And the mean of ACT on the deaf ear with EM were: 83.46 ± 1.43 dB, 99.62 ± 1.35 dB, 106.34 ± .66 dB, 106.48 ± .82 dB, 107.03 ± .89 dB, 108.11 ± .76 dB, 108.37 ± .76 dB, 109.37 ± .42 dB, 107.52 ± .82 dB and 97.54 ± .59 dB. An average mean of the ACT on the deaf ear was 103.38 dB. The mean difference between ACT in the normal hearing ear and cross hearing threshold was 61.78 dB. The mean difference between ACT in the normal hearing ear and ACT in the deaf ear was 88.46 dB. And the mean difference between cross hearing threshold and ACT in the deaf ear was 26.68 dB. (Figure 2)

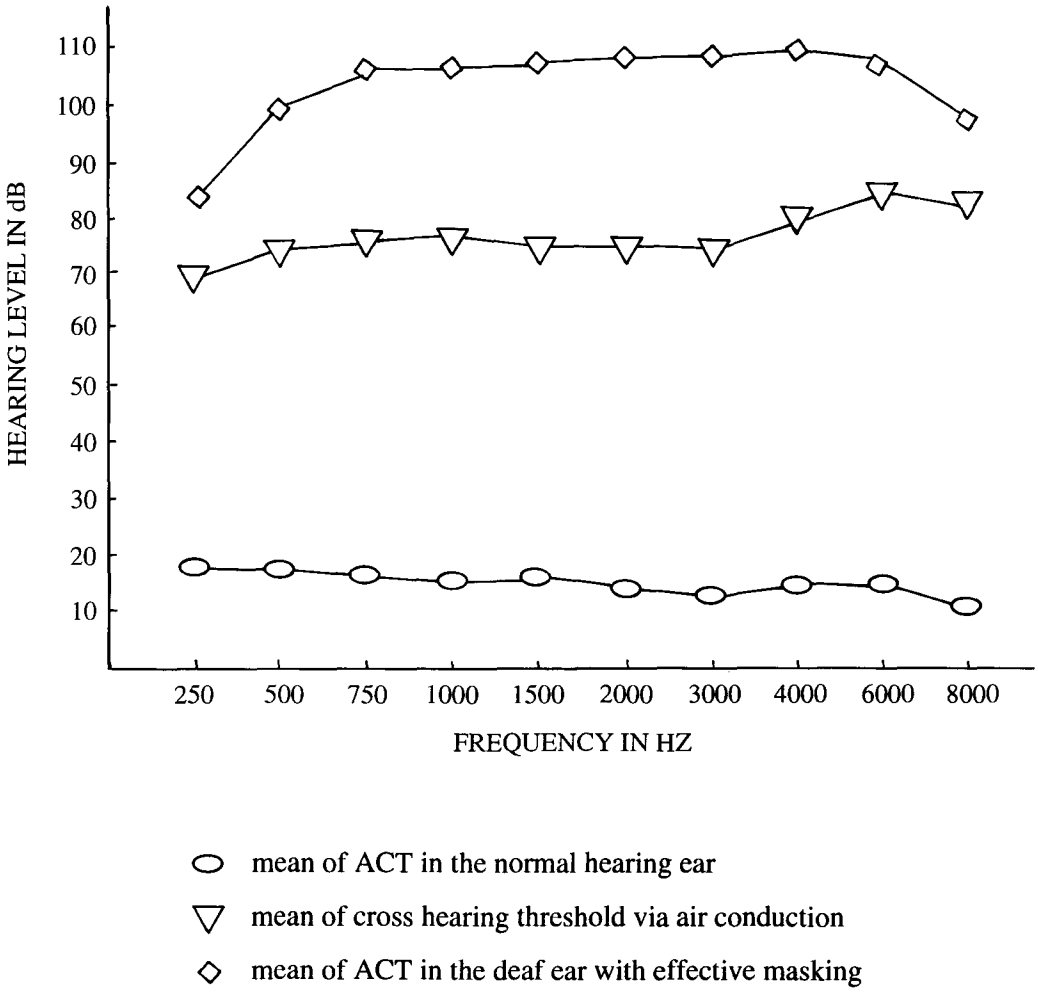

Figure 2. Shows mean of air cross hearing level, normal ACT and ACT in deaf ear with EM level in 52 cases.

4. Effective masking (EM) level

The mean EM for SRT in this study was 82.03 ± .74 dB. The mean EM for ACT at the test frequencies were 76.85 ± 1.06 dB, 81.85 ± .87 dB, 80.37 ± 1.02 dB, 78.14 ± .85 dB, 76.66 ± 1.00 dB, 78.33 ± .93 dB, 75.74 ± .91 dB, 77.03 ± .83 dB, 77.77 ± .98 dB and 74.25 ± .98 dB. And the average mean of EM for air conduction testing was 77.69 ± .94 dB. The mean of the EM level for BCT were 61.90 ± .66 dB, 71.13 ± .90 dB, 73.40 ± .82 dB, 70.68 ± 1.08 dB, 63.63 ± 1.08 dB, 61.80 ± 1.28 dB, 62.64 ± 1.43 dB and 62.05 ± 1.22 dB. The average mean of EM level for bone conduction testing was 65.90 ± .88 dB. (Figure 3)

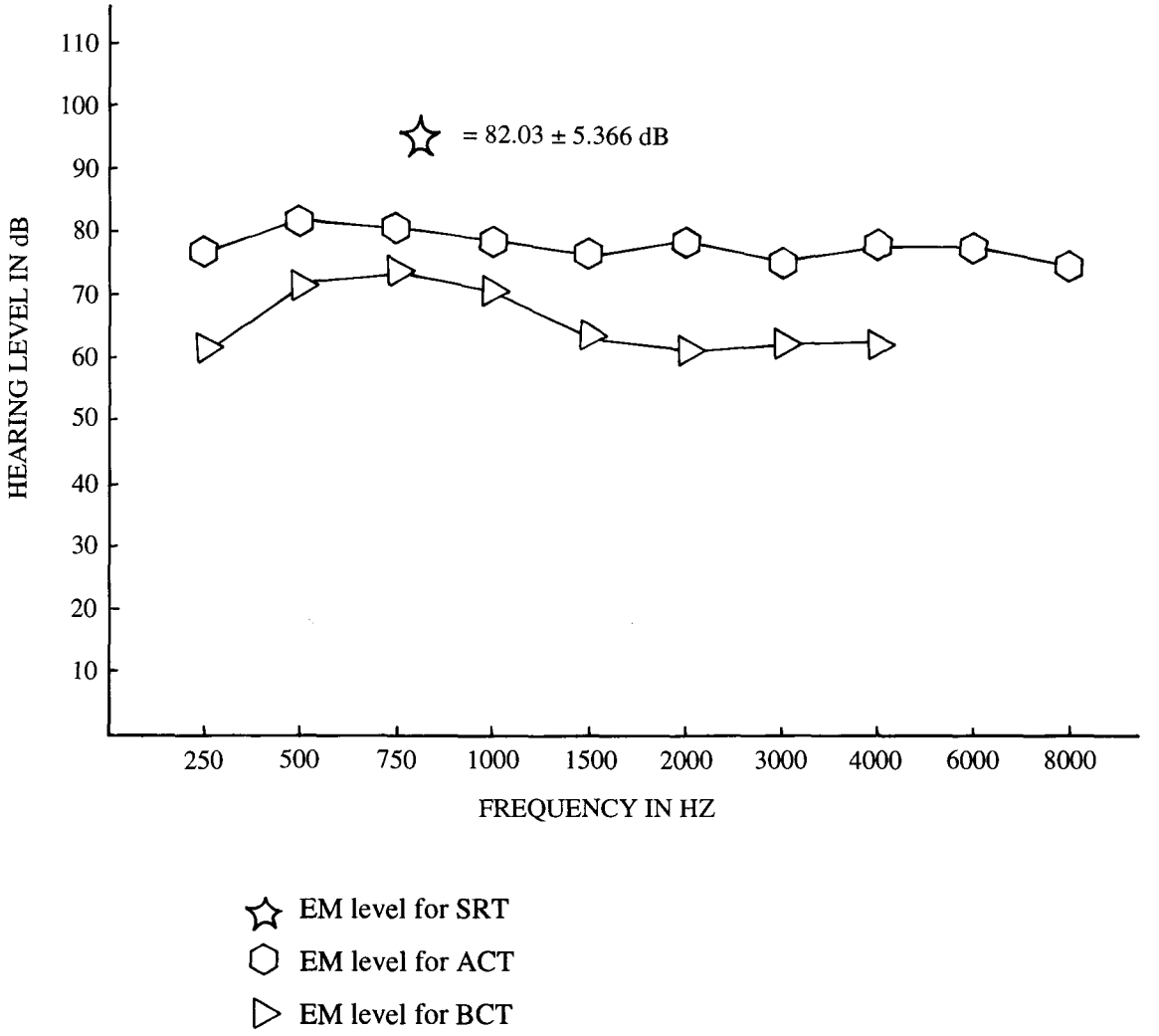

Figure 3. Shows mean level of EM for SRT, ACT and BCT in 52 cases.

Discussion

Chaiklin, 1967; and Martin & Blosser, 1970 found that sounds introduced by air conduction actually cross from one side of the head to the other primarily by means of bone conduction.[6,24] It is probable that whenever the intensity is raised to a high enough level, the air conduction receiver vibrates sufficiently to cause deformations of the skull giving rise to bone conducted stimulation. If the level of signal thus generated is above the BCT of the NTE during air conduction audiometry or speech audiometry, the subject will respond, signalling that the tone has been heard before the auditory threshold of the TE had been reached. This phenomenon is called cross hearing.

As sounds travel from one side of the head to the other, a certain amount of energy is lost in transmission. This loss of intensity of a sound introduced to one ear and heard by the other is called interaural attenuation (IA). IA for air conduction and speech varies with the frequency and from one individual to another.

Cross hearing in speech testing is the reception of speech sounds during SRT testing in the ear opposite the ear under test. The difference between the SRT of the TE and the lowest BCT of the NTE exceed the minimum IA found when speech sounds are contralateralized (40 dB). Because speech sound is a complex signal, and BCT are obtained with pure tones, it must be determined which frequency to use in computation. Martin and Blythe (1977) found that frequencies surrounding 250 Hz did not contribute to the recognition of spondees presented to the opposite ear, until levels were reached that considerably exceeded normal IA values.[25] Their research confirmed the recommendations made by ASHA (1988) that the SRT of the test ear should be compared to the lowest (best) BCT of the NTE at 500 1000, 2000 or 4000 Hz.[26]

The posibility of cross hearing for SRT is SRT_{te} - IA >/= Best BC_{nte} or SRT_{te} - Best BC_{nte} >/= IA or SRT_{te} >/= IA + Best BC_{nte}.

The results of our study (Table 1,3 and Figure 1) is agree with Martin and Blythe (1977) and ASHA (1988) also. They found that SRT_{te}-IA >/= Best BC_{nte}.

Because the difference in threshold between the two ears is 87.50 dB, which is more than 40 dB, cross hearing has occurred. We found the mean level of cross hearing in speech testing from the deaf ear to the normal hearing ear was (71.85 - .88) 70.97 dB up to (71.85 +.88) 72.73 dB (Table 1). These levels are over the mean of BCT in normal hearing ears or NTE (70.97 - 22.47) 48.50 dB to (72.73 - 22.47) 50.26 dB (Figure 1). The values of >/= 48.50 dB to 50.26 dB considerably exceeded normal IA (ENIA) of unilateral sensorineural deafness patients. So it may be concluded and stated as the following formula for a speech malingering test:

$[ENIA \pm_{srt} + Best\ BC_{nte}]$ cross hearing has occurred -> patient's response.

ENIA = The intensity of the suprathreshold of normal IA for speech or spondee words.
The minimum intensity is 48.50 dB.
The maximum intensity is 50.26 dB.

Best BC_{nte} = The intensity of average BCT

Malingering test procedure:

1. In testing for BCT in the better ear, the Modified Hughson-Westlake ascending/descending method should be used. This means that for every positive response, the intensity decreases by 10 dB. When the patient does not respond, the intensity is increased in 5 dB steps until the patient again responds. Then average the BCT level.

2. Using the formula as a non-organic screening test.

For example: ACT on the better ear is 10 dB and
ACT on patient's professed poorer ear is 100 dB.
Best BC_{nte} or good ear = 20 dB
ENIA = 48.50 dB to 50.26 dB

$[ENIA + Best\ BC_{nte}]$ cross hearing has ocuurred -> patient's response

method :

a) Adding the intensity level of IA $\pm$ srt and Best BC_{nte} together, the result is (48.50 + 20) 68.50 dB

b) Present speech signals or spondee words at a level of 68.50 dB to the poorer ear without masking.

c) Observe the patient's response.

If the patient responds to the signal in the better ear at this level, which crosses over from the poorer ear, the loss of the poorer ear is real and the malingering test is negative.

If the patient does not respond, raise the level in 5 dB steps and continue until the patient reaches a level where he or she responds to the signals.

The range of SRT level at which the patient responds in this case varies from 68.50 - 70.26 dB.

d) If there is a lack of response to the signals, the patient heard but will not admit having heard the louder speech signal in the professed poorer ear. This is a positive malingerling test. So this method can be used to detect hearing in case of malingering of unilateral sensorineural deafness. If the patient does not show cross hearing to speech testing at any intensity, he does not have unilateral sensorineural deafness. And of course we found that the level of cross hearing was (71.85 ± .88 dB, Table 1), less than the level of EM. The EM for speech testing was 82.03 ± .74 dB. (Table 1 & Figure 3)

Table 2. Shows mean ($\bar{X}$ ± SE) of air & bone conduction testing in 52 cases.

	250	500	750	1000	1500	2000	3000	4000	6000	8000	Mean
ACT good ear	17.14 ± .66	17.88 ± .91	16.73 ± 1.24	15.57 ± .90	15.76 ± 1.09	13.07 ± .97	12.69 ± 1.50	14.80 ± 1.45	14.64 ± .78	10.93 ± 1.19	14.92 ± 1.07
ACT deaf ear	83.46 ± 1.43	99.62 ± 1.35	106.34 ± .66	106.48 ± .82	107.03 ± .89	108.11 ± .76	108.37 ± .76	109.37 ± .42	107.52 ± .82	97.54 ± .59	103.38 ± .85
Cross hearing in AC	69.25 ± 1.57	74.81 ± 1.14	75.74 ± 1.31	76.48 ± 1.09	74.81 ± 1.19	74.81 ± 1.21	74.53 ± 1.54	79.72 ± .77	84.90 ± 1.98	82.03 ± 2.16	76.70 ± 1.40
Minimum EM for AC	76.85 ± 1.06	81.85 ± .87	80.37 ± 1.02	78.14 ± .85	76.66 ± 1.00	78.33 ± .93	75.74 ± .91	77.03 ± .83	77.77 ± .98	74.25 ± .98	77.69 ± .94
BCT good ear	21.59 ± 1.34	22.39 ± .94	23.18 ± 1.24	20.68 ± 1.25	23.91 ± 1.38	25.47 ± 1.16	21.38 ± 1.71	21.17 ± 1.56			22.47 ± 1.06
BCT deaf ear	45 ±	60 ±	70 ±	70 ±	70 ±	70 ±	70 ±	60 ±	X ± = no response		
Cross hearing in BC	28.75 ± 1.37	27.50 ± 1.26	26.52 ± 1.39	24.28 ± 1.57	28.57 ± 1.18	27.61 ± 1.09	27.77 ± 1.70	25.29 ± .60			26.85 ± .97
Minimum EM for BC	61.90 ± .66	71.13 ± .90	73.40 ± .82	70.68 ± 1.08	63.63 ± 1.08	61.80 ± 1.28	62.64 ± 1.43	62.05 ± 1.22			65.90 ± .88

For pure tone bone conduction testing, the test frequencies in this study were 250, 500, 750, 1000, 1500, 2000, 3000 and 4000 Hz. We found that the mean of cross hearing via bone conduction from the deaf ear to the normal hearing ear at test frequencies were 27.38-30.12 dB, 26.24-28.76 dB, 25.23-27.91 dB, 23.13-25.43 dB, 27.39-29.75 dB, 26.52-28.70 dB, 26.07-29.47 dB and 24.69-25.89 dB. The average of cross hearing was 26.85 dB (Figure 1) which is not far from the average BCT in a normal hearing ear (22.47 dB). Cross hearing in bone conduction testing easily occurs because the minimum IA for bone conduction should be considered to be 0-10 dB.

For pure tone air conduction testing, the test frequencies in this study were 250, 500, 750, 1000, 1500, 2000, 3000, 4000, 6000 and 8000 Hz. We found the mean level of cross hearing in ACT at the test frequencies were 67.68-70.82 dB, 73.67-75.95 dB,74.43-77.05 dB, 75.39-77.57 dB, 73.62-76.00 dB, 73.60-76.02 dB, 72.99-76.07 dB, 78.95-80.49 dB, 82.92-86.88 dB, and 79.87-84.19 dB (Figure 2). These levels are higher than the mean of the BCT in normal hearings ear or the NTE (Figure 1). They are 47.43-47.89 dB, 52.22-52.62 dB, 52.49-52.63 dB, 55.64-55.96 dB, 51.09-50.71 dB, 49.29-49.39 dB, 52.98-53.32 dB and 57.76-59.34 dB. As the following:

Using the formula $[ENIA + BC_{nte}]$ cross hearing has occurred -> the patient's response, method and interpretation are the same as for the SRT malingering testing.

We found that the average mean level of cross hearing for pure tones was 76.70 ± 1.40 dB (Figure 2) and the effective masking for air conduction testing was 77.69 ± .94 dB (Figure 3.)

Table 3. Shows mean (95% CI), of normal IA level for pure tone from this study.

Frequency	IA ± in this study
250 Hz	47.43-47.89 dB
500 Hz	52.22-52.62 dB
1000 Hz	55.64-55.96 dB
2000 Hz	49.29-49.39 dB
4000 Hz	57.76-59.34 dB

Conclusion

Whenever the intensity of signals presented to the professed poorer ear are raised to the norms of cross hearing in this study, the danger of cross over presents itself.

If the patient indicates hearing the stimulus in the better ear, and the audiogram obtained is a shadow-gram, it shows that the patient is co-operat-

ing and displays unilateral sensorineural hearing deafness. However, this is only one of the battery of tests. Identification of a functional hearing loss may be ruled out by many audiological testings.

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