# The Effect of site of tympanic membrane perforation on hearing

***Alyaa Farouk Al- Omari, **Fadhila Shahwan Al-Doski.**
**Department of medical Physiology, College of Medicine, University of Mosul, Mosul, Iraq**

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## Abstract

Tympanic membrane(TM) perforation is one of the most common causes of hearing impairment. Apart from conduction of sound waves across the middle ear, the tympanic membrane, also sub-serves a protective function to the middle ear cleft and round window niche. The aim of the study is to determine the effect of the site of the tympanic membrane perforation on hearing. Seventy-eight patients with perforated tympanic membranes were included in the study.They all have TM perforation due to recurrent or chronic otitis media. Patients with traumatic TM perforation were excluded from the study. There were 47 males (46.5%) and 54 females (53.5%). Twenty patients had left ear perforation, 35 patients had right ear perforation, and 23 patients had bilateral perforations. Each ear was taken as a case, so the total number of the perforated ear drums was 101. The age ranged from 13- 56 with the mean of age was (31.64 ± 13.249) years. The TM perforation was examined and photo image was taken with the aid of the endoscope. Controls were 55 patients with a mean age 30.73 ±12.09 (range 14-53) years. Male controls were 34 (61.8%), and 21 female controls (38.2%). There is a positive correlation between site of TM perforation and hearing level, air bone gap, low frequency hearing level and high frequency hearing level. As a conclusion, there is a positive relationship between the site of TM perforation and hearing level being more in the posterior-superior and inferior parts.

***Key words: Tympanic membrane(TM) perforation, hearing level, air-bone gap, low frequency, high frequency.***

الخلاصة

ان ثقب غشاء الطبلة هو احد اهم الاسباب شيوعا لضعف السمع . ان الهدف من هذه الدراسة هو تقييم تأثير موقع الثقب على السمع. تم تضمين ثمانية وسبعين مريضا في هذه الدراسة ، وكانو مصابين بثقب غشاء الطبلة نتيجة الالتهاب المكرر او المزمن في الاذن الوسطى . وقد تم استبعاد المرضى المصابين بثقب الطبلة الرَضْحِيّ . من المرضى كان الذكور حوالي 47 مريضا (46%)، وحوالي 56 مريضا كانوا من الاناث (53%) . عشرون مريضا كان لديهم ثقب في غشاء الطبلة في الاذن اليسرى ، و 35 مريضا كان لديهم ثقب الطبلة اليمنى، وفي 23 مريضا لديهم ثقب في كلتا الاذنين. كل اذن تم دراستها كحالة مستقلة وبذلك يصبح المجموع الكلي 101 حالة. العمر تراوح من 13-56 سنة مع متوسط العمر (31,64 سنة). تم فحص وتصوير غ شاء الطبة باستخدام الناظور. وكانت المجموعة الضابطة تتكون من 55 مريضا مع متوسط العمر (30,73 سنة)، حيث تراوح العمر من 14-53 سنة. شكل الذكور 34 مريضا(61%)، والاناث 21 مريضا(38%). كان هناك علاقة قوية وايجابية بين موقع الثقب ومستوى السمع و الَغْرَةٌ العَظْمِيَّةٌ الهَوائِيَّة حيث ان هما يزيدان في حالة ثقب الطبلة في المنطقة الخلْفِيّةٌ العُلْوِيةٌ و السفلية .

## Introduction

Tympanic membrane (TM) perforation is one of the most common causes of hearing impairment. Infection is the principle cause of TM perforation. It may be acute or chronic. Perforations due to acute infections usually heal if treated timely. Perforation of TM is frequent manifestation of injury and may be due to instrumentation injuries such as ear picking habits, probing, syringing, post ventilation tube insertion etc. and with compression forces such as in slapping, diving, head injuries, blast injuries etc. Most of these perforations cause conductive hearing loss except some due to head injury; blast injuries etc. may cause inner ear injury and SNHL[1]. Apart from conduction of sound waves across the middle ear, the tympanic membrane, also sub-serves a protective function to the middle ear cleft and round window niche. Intact tympanic membrane protects the middle ear cleft from infections and shields the round window from direct sound waves which is referred to as (round window baffle)[2]. This shield is necessary to create a phase differential so that the sound wave does not impact on the oval and round windows simultaneously. This would dampen the flow of sound energy being transmitted in a unilateral direction from the oval window through the perilymph[3,4]. A perforation on the tympanic membrane reduces the surface area of the membrane available for sound pressure transmission and allows sound to pass directly into the middle ear. As a result, the pressure gradient between the inner and outer surfaces of the membrane virtually becomes insignificant[5]. The location of the perforation is believed by some schools of thought to have a significant effect on the magnitude of hearing loss. For instance, posterior quadrant perforations are believed to be worse than the anterior ones because of the direct exposure of the round window to sound waves and perforations at or near the site of tympanic membrane attachment to manubrium have more severe effects than those of comparable size at different sites [6.7]. However, some workers believe that there is no significant effect associated with location of the perforation [6, 8]. Previously, Bordley and Hardy in [1937], Payne and in [1951] and Mcintire and Benitez in [1979] have studied the effect of experimentally induced tympanic membrane perforations on auditory function in the cat. Payne and Githler showed that the pattern of auditory impairment was dependent on the location of the perforation and that there was a quantitative relationship between the area of the perforation and loss in auditory sensitivity. In an audiometric study of perforations due to ear disease in man, Anthony and Harrison in [1972] confirmed the importance of area and location of the perforation in determining the degree of hearing loss[9]. Ahmad and Ramani in [1979] studied tympanic perforations in young, otherwise healthy adult males who had been referred for closure of perforations which had resulted from trauma or infection. These authors examined affected ears under the operating microscope, noted the location of the perforation and measured its area with techniques more sophisticated than those that had been used hitherto (if they considered it necessary, Ahmad and Ramani used photography and planimetry)[6]. In this study, we used the Hopkins rod endoscope to have a video capture of the TM.

## Patients and Methods

It is a prospective case control study, which was conducted between

March 2011 and march 2012 with a target patient seen in the Ear Nose and Throat (ENT) clinic of the AL-Jamhori Teaching Hospital. Seventy-eight patients with perforated tympanic membranes were included in the study. There were 47 males (46.5%) and 54 females (53.5%). Twenty patients had left ear perforation, 35 patients had right ear perforation, and 23 patients had bilateral perforations. Each ear was taken as a case, so a total number of 101 perforated ear drums were examined. The age ranged from 13- 56 with the mean of age was (31.64 ± 13.249) years. Each patient was interviewed with a pre tested structured questionnaire and examined clinically to assess the features of the tympanic membrane perforation. Video endoscopy of the perforated TM was done in each patient using a Hopkins rod endoscope attached to a camera and a tuner ((Easycap, model BA0362 ZI-8-A02)) to the laptop. Programmed capture of the TM picture was taken and saved. Patients with traumatic perforation of the TM were excluded from the study to avoid the possible sensorineural element from the trauma. The TM was divided into 4 parts to identify the effect of the site on the hearing level. According to the findings on endoscopy, the perforations were categorized into 9 groups depending on the sub sites involved:

1- Anterior superior.
2- Anterior inferior .
3- Posterior inferior .
4- Posterior superior.
5- Anterior superior and inferior.
6- Posterior superior and inferior.
7- Anterior inferior and posterior inferior.
8- Posterior superior and inferior with anterior inferior.
9- Subtotal.

See figure 1.

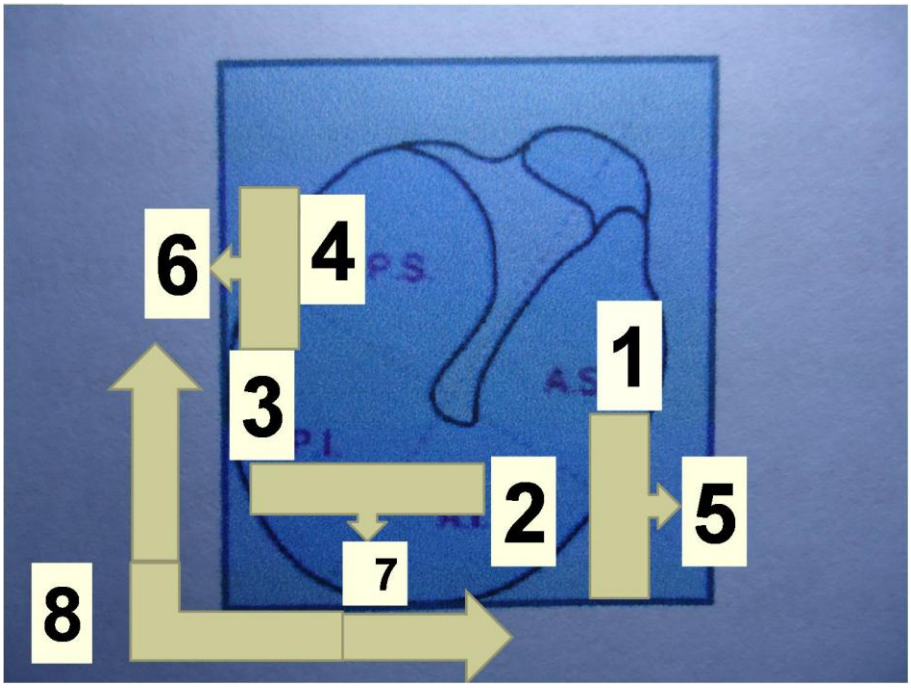


**Fig.(1):- Descriptive categories of the sites of the perforation.**

All patients had tuning fork ( Rinne'S and Weber'S) 512 Hz forks in most instances which gives Rinne'S negative in conductive deafness if

more than 25dB ,14% had positive Rinne'S and 86 %were negative .Weber'S give lateralization to the affected site ,10% central ,51% shift to the right and 39% shift to the left . Similarly Pure Tone Audiometry (PTA) was carried out in each case to confirm that the hearing loss was of conductive type and to determine its extent. PTA was done using audiometer. Patients with sensorineural element of hearing loss were excluded from the study. Controls were 55 patients with a mean age 30.73 ±12.09 (range 14-53) years. Male controls were 34 (61.8%), and 21 female controls (38.2%).

## Statistical analysis

These were carried out with computer software Statistical Package for Social Sciences (version 17; SPSS). The sites of the tympanic membrane perforations were correlated with the magnitude of hearing losses through Pearson's correlation test. The t-test was applied were appropriate .and Chi square test.

**Results**

The results of the data analysis are presented as follows:

1- By using Chi -Square test we see there is a positive association between site of TM perforation and hearing level, air bone gap, low frequency hearing level and high frequency hearing level.( $P \leq 0.0001$,$P \leq 0.003$ ,$P \leq 0.023$ ,$P \leq 0.007$) respectively. See Table (1).

**Table (1):- Shows a significant association between site of perforation and studied parameter.**

| Parameters | $\chi^2$(calculated) | p-value≤ |
|---|---|---|
| hearing level | 75.425 | 0.0001 |
| air bone gap | 33.347 | 0.003 |
| low frequency | 35.870 | 0.023 |
| high frequency | 49.574 | 0.007 |

**Table (2):-Show the relationship between site of TM perforation and hearing level.**

| Site | No | Normal | Mild | moderate | Moderately severe |
|---|---|---|---|---|---|
| 1 | 2 | 100% | 0 | 0 | 0 |
| 2 | 16 | 38% | 44% | 12% | 6% |
| 3 | 7 | 14% | 57% | 29% | 0 |
| 4 | 7 | 0 | 100% | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 |
| 6 | 23 | 17% | 39% | 31% | 13% |
| 7 | 16 | 0 | 88% | 12% | 0 |
| 8 | 12 | 0 | 33% | 50% | 17% |
| 9 | 18 | 0 | 6% | 44% | 50% |

This table shows the relationship between sites of TM perforation and hearing level we found that the worst perforation is at site number 6, 8 and 9.

**Table (3):-Shows the relationship between site of TM perforation and air bone gap.**

| Site | No | Normal | Mild | Moderate | Moderately severe |
|---|---|---|---|---|---|
| 1 | 2 | 0 | 100% | 0 | 0 |
| 2 | 16 | 0 | 31% | 69% | 0 |
| 3 | 7 | 0 | 14% | 86% | 0 |
| 4 | 7 | 0 | 71% | 29% | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 |
| 6 | 23 | 0 | 35% | 39% | 26% |
| 7 | 16 | 0 | 44% | 56% | 0 |
| 8 | 12 | 0 | 42% | 25% | 33% |
| 9 | 18 | 0 | 6% | 44% | 50% |

This table shows the relationship between site of TM perforation and air bone gap we found that the worst perforation is at site number 6, 8 and 9.

**Table (4):-Shows the relationship between sites of TM perforation and low frequency hearing level.**

| Site | No | normal | Mild | Moderate | Moderately severe | Severe |
|---|---|---|---|---|---|---|
| 1 | 2 | 0 | 0 | 100 | 0 | 0 |
| 2 | 16 | 0 | 19% | 37% | 44% | 0 |
| 3 | 7 | 0 | 14% | 57% | 29% | 0 |
| 4 | 7 | 0 | 29% | 57% | 14% | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 23 | 0 | 9% | 26% | 48% | 17% |
| 7 | 16 | 0 | 0 | 31.25% | 68.75% | 0 |
| 8 | 12 | 0 | 17% | 17% | 58% | 8% |
| 9 | 18 | 0 | 0 | 17% | 50% | 33% |

This table shows the relationship between site of TM perforation and low frequency hearing level. We found that the worst perforation is at site number 6, 8 and 9.

**Table (5):-Shows the relationship between site of TM perforation and high frequency hearing level.**

| Site | No | normal | Mild | Moderate | Moderately severe | Severe |
|---|---|---|---|---|---|---|
| 1 | 2 | 0 | 100% | 0 | 0 | 0 |
| 2 | 16 | 12% | 13% | 56% | 0 | 19% |
| 3 | 7 | 0 | 14% | 86% | 0 | 0 |
| 4 | 7 | 0 | 43% | 57% | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 23 | 4% | 26% | 39% | 31% | 0 |
| 7 | 16 | 6% | 31% | 44% | 12% | 7% |
| 8 | 12 | 0 | 41% | 8% | 51% | 0 |
| 9 | 18 | 0 | 17% | 22% | 50% | 11% |

This table shows the relationship between site of TM perforation and high frequency hearing level we found that the worst perforation is at site number 2, 7 and 9.

2- To compare between patients and control group, by using t – test we found that there is statistical significant difference between patients and control group regarding hearing level, air bone gap, low frequency and high frequency hearing loss ($p \leq 0.0001$).table (6).

**Table (6):-Shows comparison between patiens and controls in studied parameters**

| PARAMETERS | Patients | | Control | | P-value ≤ |
|---|---|---|---|---|---|
| | No. | X±SD | No | X±SD | |
| Hearing level | 101 | 39.77±13.736 | 55 | 19.55±7.628 | 0.0001 |
| Air bone gap | 101 | 31.61±9.184 | 55 | 12.4±2.780 | 0.0001 |
| Low frequency | 101 | 44.31±10.771 | 55 | 20.45±6.256 | 0.0001 |
| High frequency | 101 | 35.79±13.743 | 55 | 14.96±7.219 | 0.0001 |

## Discussion

Tympanic membrane perforation descriptors can conceivably correlate with hearing level as a result of four basic dysfunctions, directly by impairing the impedance matching mechanism due to reduction in membrane area, secondly due to impaired matching due to reduction of the 'baffle' effect on the fenestra rotunda, and thirdly indirectly as indicants of underlying middle ear pathology, which also affect the functioning of the tympano-ossicular mechanism[8]. Perforation-induced changes in transmission result primarily from changes in driving pressure across the TM and that perforation-induced change in the structure of the TM and its coupling to the ossicles contributes a substantially smaller component [10, 11]. Although tympanic membrane perforations are common, there have been few systematic studies of the structural features determining the magnitude of the resulting conductive hearing loss. It has been suggested that perforations in anterior versus posterior quadrants showed no significant differences in air-bone gaps at any frequency, although anterior perforations had, on average, air-bone gaps that were smaller by 1 to 8 dB at lower frequencies)[12]. Although various studies proposed that the site of TM perforation has no effect on hearing [7, 8], we found in our study with the statistical results a positive correlation between the site of TM perforation and other variables including, hearing level, air-bone gap, low frequency and high frequency hearing levels and air bone gaps. In this study, the site of acute perforation doesn't correlate with hearing level; on the contrary, they observed that the location of the perforations correlate positively with magnitude of hearing loss in ears with chronic TM perforations. The posterosuperior segment was most outstanding in this regard [10, 11, 12]. In our study, we dealt with the cases of perforations of the TM associated with chronic or recurrent otitis media, and we excluded cases of traumatic perforations which are categorized as acute perforations and the results agrees with the above mentioned studies. This is in agreement with the earlier observations by Ahmad and Ramani.[6], Payne and Gither [13], that the position of the TM perforations affects the magnitude of hearing loss. However the effect of direct impaction of sound energy into the middle ear leading to the loss of "round window baffle", as they suggested; may not be the only reason bearing in mind the complex mode of sound transmission across the middle ear as shown by recent models on sound-energy transmission through TM into the middle ear[14,15,16].

## Conclusion

As a conclusion, there is a positive relationship between the site of TM perforation and hearing level being more in the posterior-superior and inferior parts. And because this current study dealt with chronic perforation of the TM, there was a positive correlation between

the perforation and the variables included in the study (hearing level ,air bone gap, low and high frequency hearing level).

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