

# Audiometric Assessment of Adolescents and Adults with Tympanic Membrane Perforation in Benin City



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## Abstract

**Background:** The degree of hearing loss is directly proportional to the size of tympanic membrane (TM) perforation. However, there is dearth of information on correlation between severity of hearing loss and location of perforation on the tympanic membrane

**Objective:** To determine the hearing level of adolescent and adult patients with tympanic membrane perforation.

**Patients and Methods:** A cross sectional study at the ENT Clinic, University of Benin Teaching Hospital (U.B.T.H), Benin City. Consecutive patients with TM perforations were examined with "Firefly video-otoscope", and subsequently had pure tone audiometry. The contralateral intact TMs in individuals with unilateral TM perforation and the ears of students and staff of Institute of Health Technology UBTH were used as control. Data was analyzed using statistical package for social sciences (SPSS) version 20 and Image J software. P-value  $\leq 0.05$  was considered statistically significant [1-3].

**Results:** Two hundred ears from 148 patients with TM perforation in either or both ears were studied. Conductive hearing loss (CHL) had the highest prevalence; 64.3% and 55.9% in the right and left ears respectively. Slight CHL; 67.5% was more common [4-7]. However, the severity of hearing loss increased with the size and also varied with the location of TM perforation.

**Conclusion:** The hearing level among adolescent and adult patients with TM perforation showed a significant association with the size and the location of the perforation on the TM.

**Key words:** Hearing level; Tympanic membrane; Perforation; Adolescents; Adults

## Introduction

The tympanic membrane is a thin elliptical shaped pearly grey membrane. It is placed obliquely at the boundary between the external auditory canal and the middle ear, and as a result, its postero-superior part is more lateral than its antero-inferior part [8]. The total area of the tympanic membrane is about 85mm<sup>2</sup>, out of which almost 2/3<sup>rd</sup> (55mm<sup>2</sup>) is the vibrating area [9]. It is divided into two parts; the pars tensa and pars flaccida. The pars tensa forms the larger part of the tympanic membrane. Tympanic membrane perforation is a condition where the tympanic membrane has a tear or a hole in it [10]. This can arise from middle ear infection, ear trauma or iatrogenic causes such as ear syringing, foreign body removal, myringotomy with grommet insertion [11]. The tympanic membrane does not only function as a barrier which helps in preventing infection from spreading to the middle ear from the external ear, but more importantly, it plays a role in the hearing process [12]. Perforation on the tympanic membrane may be single or multiple, with variation in sizes, shapes and locations on the tympanic membrane. .

The type of hearing loss attributed to tympanic membrane perforation is usually conductive hearing loss (CHL), and this seldom exceeds 15 decibel (dB) hearing loss [1]. This is due to the disruption of sound pressure gain at the tympanic membrane which helps in amplification of sound for onward transmission to the inner ear chamber [6,13]. Larger conductive hearing losses are however caused by total perforation or associated ossicular pathology [1]. Individuals with tympanic membrane perforation may present with symptoms depending on the size and location of the perforation and the causative factors [14] including hearing loss, ear discharge and tinnitus. There may or may not be ear pain or vertigo.

Most TM perforations are diagnosed using standard otoscopy, however extremely small perforations may require oto-microscopy or middle ear impedance studies for definitive diagnosis [1,15]. The advent of computer based video-otoscopy has to a large extent made evaluation of tympanic membrane

diseases more reliable and objective [16,17]. This has helped in reducing observer errors associated with standard otoscopy [11]. Tympanic membrane perforation could be managed conservatively if the perforation is small with the edges in close proximity to each other as it is the case with traumatic perforation, or following acute suppurative otitis media. Larger perforations would require surgery (myringoplasty) to improve hearing and prevent recurrence of middle ear infection [12]. This study was aimed at determining the hearing level associated with the size and location of TM perforation.

**Patients and Method**

The study was carried out between July 2014 and May 2015 at the Ear Nose and Throat (ENT) Clinic of the University of Benin Teaching Hospital (UBTH), Benin City, Nigeria. After obtaining ethical approval from UBTH Ethics and Research committee, consecutive patients (10-64years) presenting at the ENT clinic of UBTH, Benin City during the study period had their ears examined by ENT surgeons with a battery powered otoscope (professional LED fibre-optic) to determine eligibility. Each of the patients was duly briefed on the aim and objectives of the study and an informed written consent obtained before he/she was recruited in the study. The ear of each participant with tympanic membrane perforation was assessed using a Firefly DE 550 handheld USB video-otoscope, and images saved on the computer for determination of the size of the tympanic membrane perforation and location of the perforation on the tympanic membrane [18]. The system described comprises a video-otoscope (capable of generating still and video images of the tympanic membrane) adapted via a wireless model to a computer screen. Saved images were analyzed using the Image J (version 1.35 of Wayne Rasband, National Institute of Health, USA) geometrical analysis software package. The area of the tympanic membrane perforation (P), and the area of entire tympanic membrane (T) were calculated and percentage of perforation (P/T x 100/1) obtained (Figure 1a and 1b). The number of TM perforations was categorized into the different segments of the TM.

Pure tone audiometry (PTA) was done on every participant in a sound proof booth at the audiometry laboratory in ENT clinic of UBTH, using Otoproton diagnostic audiometer (EN 60645-1 Class 2, EN 60645-2 Class B-E, 'Germany'); calibrated according to international standard reference ISO 8253-1:1989. The results were charted on an audiogram. The pure tone average for each ear was then calculated; this was the average of thresholds for air conduction at 500Hz, 1000Hz, 2000Hz and 4000Hz i.e. the sum of the thresholds at these frequencies divided by 4 [19].

The pure tone average for each ear was used to determine the level of hearing for that ear. Air-bone gap was also calculated; this is the difference between the average air conduction threshold and the average bone conduction thresholds. Usually, four (4) frequency threshold over 500Hz, 1000Hz, 2000Hz and 4000Hz are recommended, as the air-bone gap is greatest

at these frequencies [20]. The diagnosis of CHL was when air-bone gap was  $\geq 15$ dB and sensorineural hearing loss if air-bone gap was less than 15dB. It was mixed hearing loss if air-bone gap was  $\geq 15$ dB with the bone conduction level was impaired [21]. Hearing loss was classified using the WHO grading system [19]; normal hearing  $\leq 25$ dB hearing level (HL), slight hearing loss=26-40dBHL, moderate hearing loss=41-60dBHL, severe hearing loss=61-80dBHL and profound hearing loss $\geq 81$ dBHL. Tympanometry was done for each ear of the control subjects (i.e. intact tympanic membranes) to establish normal middle ear function before proceeding to have audiometry.

**Results**

A total of 200 ears from 148 patients with tympanic membrane perforation in either or both ears were studied. Ages ranged from 10 - 64 years, with a mean age range 34.5 $\pm$ 15.7 years (Table 1). A high proportion of the participants; 98 (66.3%) were within the younger age group of 10-39 years. There were 67 (45.3%) males and 81 (54.7%) females; ratio of 1:1.2.

**Table 1:** Socio-demographic Characteristics.

Variable Age (years)	Frequency (n = 148)	Percent
10 - 19	22	14.9
20 - 29	47	31.8
30 - 39	29	19.6
40 - 49	25	16.9
50 - 59	16	10.8
60 - 69	9	6.0
<b>Sex</b>		
Male	67	45.3
Female	81	54.7
<b>Mean age = 35.4 + 16.8 years</b>		

The conductive hearing loss had the highest prevalence; 63 (64.3%) and 57 (55.9%) in the right and left ears of the study ears respectively (Figure 2). The slight conductive hearing loss accounted for more of the hearing loss in the study and control ears; 81 (67.5%) and 14 (87.5) respectively (Table 2). The larger the size of TM perforation, the severity of the hearing loss increased. This was statistically significant (p= 0.000) (Table 3). The pure tone average increased with an increase in the size of TM perforation. This was statistically significant (p=0.000) (Table 4). There was a positive relationship between the size of perforation and pure tone average, with a Pearson's correlation coefficient of 0.690. This finding was also statistically significant (p=0.000) (Table 4). The subtotal and the marginal TM perforations recorded more severe forms of hearing loss; 12.5% of profound hearing loss and 100% severe hearing loss within the groups respectively. This was statistically significant (p =0.004) (Table 5).

**Table 2:** Severity and Type of Hearing Loss.

Severity (dB)	CHL n (%)	MHL n (%)	CHL n (%)	MHL n (%)
Slight (26 - 40)	81 (67.5)	5 (8.5)	14 (87.5)	4 (33.3)
Moderate (41- 60)	34 (28.3)	27 (45.7)	1(6.25)	8 (66.7)
Severe (61- 80)	5 (4.2)	19 (32.2)	1(6.25)	0 (0.0)
Profound (≥ 81)	0 (0.0)	8 (13.6)	0 (0.0)	0 (0.0)
<b>Total</b>	<b>120 (100.0)</b>	<b>59 (100.0)</b>	<b>16(100.0)</b>	<b>12 (100.0)</b>

**Table 3:** Size of TM Perforation vs. Severity of Hearing Loss.

Size (% Area)	Test statistic	p value						
	Slight (26-40dB) n (%)	Moderate (41-60dB) n (%)	Severe (61-80dB) n (%)	Profound (> 81dB) n (%)	Total n (%)			
Small (1-25)	64 (79.0)	15 (18.5)	2 (2.5)	0 (0.0)	81 (100.0)	$\chi^2 = 90.159$	0.000*	
Medium (26-50)	18 (34.6)	28 (53.8)	5 (9.6)	1 (1.9)	52 (100.0)			
Large (51-75)	3 (8.6)	12 (34.3)	14 (40.0)	6 (17.1)	35 (100.0)			
Subtotal (>76)	1 (9.1)	6 (54.5)	3 (27.3)	1 (9.1)	11 (100.0)			
<b>Total</b>	<b>86 (48.0)</b>	<b>61 (34.1)</b>	<b>24 (13.4)</b>	<b>8 (4.5)</b>	<b>179 (100.0)</b>			

**Table 4:** Pure Tone Average and Size of TM Perforation.

PTA (dB)	Size of TM Perforation (% Area)					T test	P value
	Small (1-25)	Medium (26-50)	Large (51-75)	Subtotal (76-100)	Total		
11 - 20	12 (100)	0 (0.0)	0 (0.0)	0 (0.0)	12 (100)	$r^2 = 0.473$	0.000*
21 - 30	47 (87.0)	7 (13.0)	0 (0.0)	0 (0.0)	54 (100)		
31 - 40	27 (63.0)	12 (28.0)	3 (7.0)	1 (2.0)	43 (100)	$P = 0.690$	
41 - 50	12 (26.0)	22 (26.0)	7 (15.2)	5 (11.0)	46 (100)		
51 - 60	3 (23.0)	4 (30.8)	5 (38.5)	1 (7.70)	13 (100)		
61 - 70	0 (0.0)	5 (41.7)	7 (58.3)	0 (0.0)	12 (100)		
71 - 80	2 (15.5)	0 (0.0)	8 (61.5)	3 (23.0)	13 (100)		
81 - 90	0 (0.0)	0 (0.0)	4 (80.0)	1 (20.0)	5 (100)		
≥ 91	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	2 (100)		
<b>Total</b>	<b>103(51.5)</b>	<b>51(25.5)</b>	<b>35(17.5)</b>	<b>11(5.5)</b>	<b>200(100)</b>		

**Table 5:** Site of TM Perforation vs. Severity of Hearing Loss.

Site of TM Perforation	Test statistic	p value				Total n (%)		
	Slight (26-40dB) n (%)	Moderate (41-60dB) n (%)	Severe (61-80dB) n (%)	Profound (> 81dB) n (%)				
Central	30 (40.5)	29 (39.2)	12 (16.2)	3 (4.1)	74 (100.0)	$\chi^2 = 34.694$	0.004*	
Central anterior	49 (60.5)	24 (29.6)	5 (6.2)	3 (3.7)	81 (100.0)			
Central posterior	5 (83.3)	1 (16.7)	0 (0.0)	0 (0.0)	6 (100.0)			
Subtotal	2 (12.5)	7 (43.8)	5 (31.2)	2 (12.5)	16 (100.0)			
Marginal	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)	2 (100.0)			
<b>Total</b>	<b>86 (48.0)</b>	<b>61 (34.1)</b>	<b>24 (13.4)</b>	<b>8 (4.5)</b>	<b>179 (100.0)</b>			

\*Significant

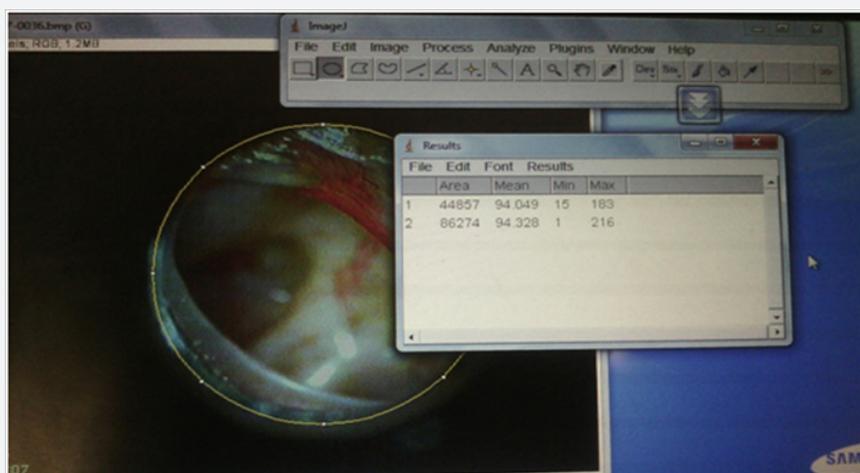
**Discussion**

This study set out to review the correlation between hearing level and the size of TM perforation amongst adolescent and adult patients. The predominant age group was 10 to 39 years; 66.3%. This suggests that the youths were more socially active and aware of the social implications of hearing loss [22]. In a previous study in Ibadan [23], 45.5% of the study population was within the same age bracket. The female preponderance was similar to previous Nigerian studies, suggesting a better health seeking attitude by females [18,23]. Conductive hearing loss is known to be the commonest type of hearing loss associated with TM perforation due to loss of the TM surface area responsible for amplification of sound waves [3,24]. Conductive hearing loss accounted for the highest cases of hearing loss among the studied ears; 64.3% and 55.9% in the right and left ears respectively (Figure 1a & 1b). In a study among patients that underwent Type 1 tympanoplasty in Benin City [12], CHL accounted for virtually

all the cases of hearing loss. Other studies [8,25,26] also noted similar high prevalence of CHL in patients with TM perforation. The mixed hearing loss was second to CHL; 26.5% and 32.3% in the right and left ears respectively. This shows that CHL is not the only type of hearing loss associated with TM perforation. This finding was also noted in other studies [24,26]. The occurrence of mixed hearing loss may be as a result of diffusion of bacterial exotoxins through the oval and round windows to the cochlea in patients with CSOM [27]. Also, the ubiquitous age related hearing loss may not be completely ruled out in older adults with TM perforation. There was however no isolated case of SNHL recorded in both the study and control ears. Perhaps the selection criteria may have excluded those individuals with background ototoxicity and noise induced hearing loss. However in another study [28], SNHL was recorded in a few patients with TM perforation from CSOM associated with attico-antral disease probably from damaging effects of cholesteatoma on the labyrinth.



**Figure 1a:** Outline of area of TM perforation and the entire TM.



**Figure 1b:** Area measurement of TM perforation and the entire TM.

Slight hearing loss accounted for the most frequent form of hearing loss among the study ears; 48%, while the profound hearing loss accounted for the lowest degree of hearing loss;

4.5% (Table 2). In similar studies [2,3], mild hearing loss was the predominant degree of hearing loss reported. The severity of hearing loss increased with an increase in the size

of TM perforation, with the large and subtotal TM perforations accounting for 74.3% and 81.8% of moderate to severe hearing loss respectively (Table 3). The pure tone average hearing threshold; a measure of the severity of hearing loss, was largely dependent on the size of TM perforation with a positive Pearson's correlation coefficient of 0.690 (Table 4). This was statistically significant ( $p=0.000$ ). Other related studies [25,29] showed that there was an increase in severity of hearing loss with increase in size of TM perforation. A contrary observation

is yet to be reported. A summary of the of pure tone average to the size of TM perforation shown in (Figure 3). Because of the amplification provided by the surface area ratio between the TM and oval window, any reduction in the size of TM by perforation will affect this ratio, with a subsequent decline in amplification [30,31]. The association between the severity of hearing loss and size of TM perforation was statistically significant ( $p= 0.000$ ) (Table 3).

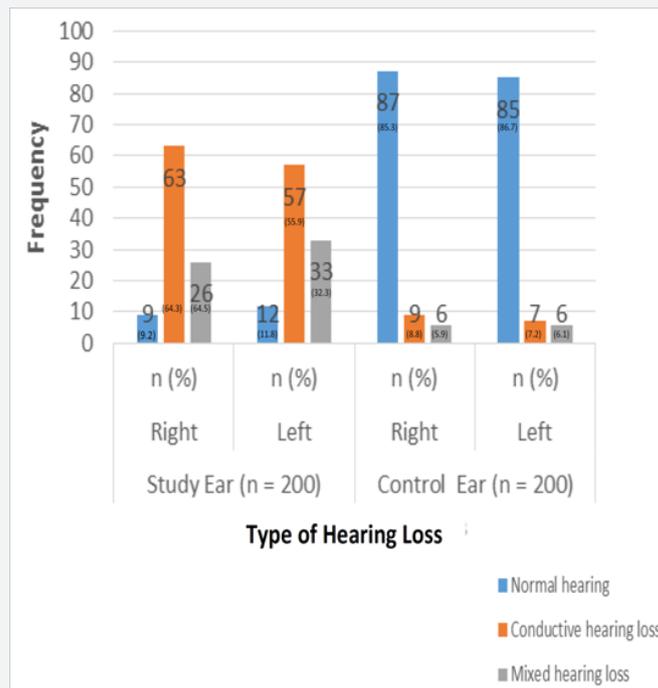


Figure 2: Types of Hearing Loss.

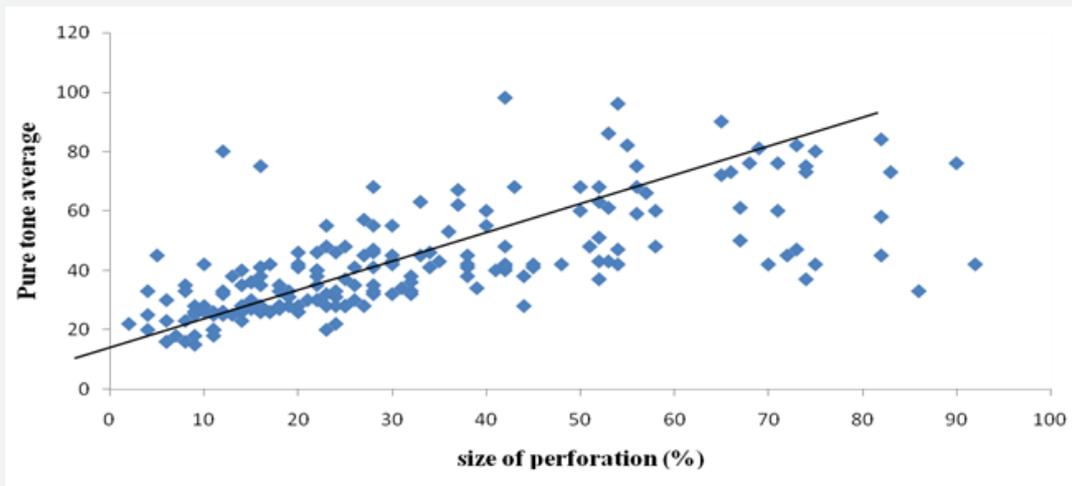


Figure 3: Scatterplot of Pure Tone Average (dB) vs. Size of TM Perforation (%).

In conclusion, the hearing level among the study population showed that conductive hearing loss is the predominant type of hearing loss associated with TM perforation, the severity of which increased with an increase in the size of TM perforation. The severity of hearing loss is also dependent on the site of TM perforation with the subtotal and marginal types associated with more severe hearing loss. There is therefore the need for continuous enlightenment among the populace on proper ear hygiene and the importance of early presentation to the Ear, Nose and Throat surgeon in the event of any ear discomfort.

## Ethical Considerations

- A. Ethical clearance for this study was obtained from the Research and Ethics Committee of University of Benin Teaching Hospital, Benin City.
- B. Consent (written, informed) was obtained from each participant that met the inclusion criteria after the nature of the study was explained in the language that he or she understood.
- C. The aim and objectives of the study, benefits to be obtained, confidentiality of participants and results, the voluntary nature of participation and free will to withdraw from the study without penalty were clearly spelt out to participants.
- D. Adequate professional steps were taken to ensure the protection of the right and dignity of each participant according to the provisions of the second declaration of Helsinki (1964) on research involving human beings.

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## Conflict of Interest

This research is devoid of any conflicts of interest.

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