Assessment of quantitative hearing loss in relation to the morphology of central tympanic membrane perforations

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ABSTRACT

The objective of this study was to assess the extent of conductive hearing loss in relation to different sizes and sites of simple central tympanic membrane perforations. Total 100 cases attending ENT OPD, BPKIHS during period of April 2003 to Mar 2004 without any discrimination of sex, race and religion were taken for the cross sectional prospective study. Dry, clean central tympanic membrane perforations due to various causes like chronic suppurative otitis media–tubotympanic, post acute suppurative otitis media residual perforations or simple traumatic perforations with conductive hearing loss and without preexisting hearing loss were clinicoaudiologically evaluated and analyzed. Hearing loss was found to be directly proportional to the size of perforation irrespective of their cause, which was statistically significant. Hearing loss in the study was found to range from negligible to 53dB.Overall, perforations involving posterioinferior quadrant were found to have maximum hearing loss.

Keywords: Tympanic membrane, chronic suppurative otitis media, hearing loss,), audiogram.

INTRODUCTION

Tympanic membrane(TM) perforation is a condition as old as the evolution of human species.[1] It 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 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. Majority of post acute infection and traumatic tympanic membrane perforations however heal spontaneously or with conservative treatment.

The perforation as stated generally involves pars tensa, however can involve both pars tensa and pars flaccida or pars flaccida alone. Pars flaccida perforations are also known as attic perforations. Again if the perforations cross the annulus they are called marginal perforations. In case of CSOM generally the pars tensa perforations with intact annulus ring are called the tubotympanic type and the ones involving attic or annulus ring are called atticoantral disease, which may or may not be occluded by cholesteatoma, granulation tissue and may be associated with osteitis. Therefore, the hearing assessment in such perforations (e.g. attic, marginal, total) may not correlate directly with the progression of disease.[2,3] The pars tensa (central) perforations on the other hand can be better assessed are morphologically classified arbitrarily by the demarcation with the vertical line passing through the handle of malleus and the horizontal on passing perpendicularly to the first line through umbo into: (a) Anteriosuperior (b) Anterioinferior (c) Posteriosuperior (d) Posterioinferior[4]

According to size of the perforation, these are classified as: (a) Pin hole (1-2mm) (b) Small (area involving one quadrant) (c) Medium (area involving 2-3 quadrants) (d) Large (subtotal)

In general, larger the perforation, the greater is the hearing impairment, but this relationship is not constant and consistent in clinical practice.[2,5] Thus, the aim of the study is to correlate the quantitative hearing impairment in relation to the morphology of the central TM perforation.

Level of hearing can be divided into normal to hearing impairment in progressive order into minimal, mild, moderate, moderately severe, severe and profound hearing loss.[6]

MATERIALS AND METHODS

Total of 100 cases attending ENT OPD, BPKIHS during one year period from April 2003 to March 2004 were taken up for the study. All the cases taken up for the study were dry clean central TM perforations due to CSOM-tubotympanic, post residual perforations ASOM and simple traumatic perforations of age group 10-40 years. This was the cross sectional prospective study and was carried out without any discrimination of sex, race and religion.

Perforations with preexisting or congenital hearing loss and SNHL were not taken up for the study. Similarly, those with atticoantral diseases and actively discharging ears were excluded. Each ear was taken as a case. Age criteria were put between 10-40 years because younger children may not be able to understand the instruction during hearing assessment and in older group, presbyacusis itself may affect the exact assessment of hearing loss, hence excluded in the study.

After taking history, thorough otoscopic examination of ear were carried out to ascertain that the perforation was central and dry in addition to exclude the presence of cholestetomas, granulation tissues, osteitis etc. If the ears were discharging actively, they were treated accordingly i.e. by a course of antibiotics and/or decongestants for 2 weeks period and reassessed if they did fit into the inclusion criteria.

Tuning fork tests (Weber's and Rinne's) were carried out with 512 Hz forks in most instances which gives Rinne negative in conductive deafness of > than 25dB. 1024 and 256Hz forks were used wherever necessary. Weber test was done to detect the better hearing cochlea or the side where there is conductive component of hearing loss.[7]

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 by amplaid 460 model, audiometer in a sound proof room by the same audiologist.

X-rays of mastoid bones-Towne's and Lateral-Oblique views were done in selected cases to rule out atticoantral diseases and temporal bone fractures in some traumatic cases.

The data analysis was carried out using SPSS version 10.0. The p value <0.05 was considered statistically significant.

RESULTS

Study population: Out of 100 patients, which 84.0% patients fell under 30 years group i.e.45.0% of cases were between 10-20 years and 39.0% cases were of 21-30 years of age. Rest 16.0% fell into age 31-40 years age age group. Again, 55.0% cases were males and 45.0% being females.

Cause of perforations: Eighty five percent of the tympanic membrane perforations were due to CSOM. This was followed by trauma and ASOM in 8.0% and 7.0% cases respectively.

All cases observed in the study had CdHL irrespective of cause of perforation.

Hearing loss according to site of perforation: In frequencies <2000Hz,out of total 64cases involving posterioinferior quadrants 50.0% had mild, 39.0% had moderate and 11.0% had minimal hearing loss.

Similarly, in 62 cases of perforations involving anterioinferior quadrant 50.0% cases had mild, 29.0% had moderate and 21.0% had minimal hearing loss.

Again out of 28 cases involving posteriosuperior quadrants, 78.0% cases had moderate, and both the mild and minimal hearing loss were noted in 11.0% cases each.

In 24 cases involving anteriosuperior quadrant, 50% had moderate and 25.0% each had mild and minimal hearing loss.

However, out of 14 cases of perforations involving all 4 quadrants, 12 had moderate and 2 had mild conductive hearing loss with no any cases with minimal hearing loss (Table-1a).The differences were statistically significant ($p<0.05$).

In higher frequencies, overall hearing loss was less in all cases (Table-1b).

The differences were statistically significant ($p<0.05$).

Hearing loss according to size of perforation: Table-2a. shows all pinpoint perforations were seen to have minimal hearing loss. Of all 47 small perforations, 53.0% had minimal, 38.0% had mild and only 9.0% had moderate hearing loss. Similarly, out of 34 medium sized perforations, 53.0% and 44.0% had mild and moderate hearing losses respectively. Again, among 14 large perforations, 71.0% had moderate and 22.0% had mild hearing loss. The observations were all in speech frequency<2000Hz. The differences were statistically significant ($p<0.05$).

In higher frequencies too, hearing loss is proportional to the size of perforation but overall hearing level was better than in lower frequencies as shown in table 2b. The differences were statistically significant ($p<0.05$).

DISCUSSION

Tympanic membrane perforation, worldwide is a very common disease either due to sepsis or trauma and one of the common reasons of hearing impairment. It is estimated that at least 2/3rd of the world population of persons with disabling hearing impairment reside in developing countries.[8] In Nepal too 6.5% of male and 3.5% female have some degree of hearing loss.[9] So the proper examination and diagnosis of specific cause of hearing impairment with available resources can be vital for timely prevention and control of deafness.

Hearing loss in relation with size of perforation: In general, larger the perforation greater the hearing impairment. Austin reported this in 1978 in his study in sound conduction of the diseased ears. In the study, he had compared such findings with those of others and with the experimental animals.[10] Perforation size was found to be most important determination of

hearing loss by Voss SE *et al* in their various series in 2001.[11-13] They mentioned that the volume of middle ear space combined with the tympanic cavity and mastoid air volume is also an important parameter that determine the amount of hearing loss caused by perforation. Thus the smaller the middle ear air space volume results in greater air-bone gap.

Berger *et al* in 1997 carried out a prospective study if hearing loss in 120 cases with non explosive blast injury during 6 years period. They also found that the severity of conductive hearing loss to be proportionate with the size of perforation.[14]

In present study hearing loss was found to be directly proportional to the size of perforation, which is consistent with all above studies. In total, 14 cases were found to have large perforation with conductive hearing loss of 43 dB on average, while 34 medium, 47 small and 5 pinpoint perforations had 35dB, 24dB and 18 dB hearing loss on average respectively in speech frequencies i.e. below 2000Hz. This can be explained as the larger perforations result loss of more middle ear and mastoid volume and there is more chances of diminish in the phase effect as the perforation size increases due to direct exposure of sound pressure to the round and oval windows. However, Saeed and Ghadami in a series of 183 patients (1987-92) found122 having large perforation with average conductive hearing loss 25.3 dB, 21 medium sized perforation with 19.2 dB and 40 small perforation with 11,35 dB hearing loss. In their study surprisingly the number of large perforations is quite high and the hearing loss in their observation is shown to be significantly low, though hearing loss is proportionate to the size of perforations.[15]

Range of hearing loss in uncomplicated central perforations: In study carried out by Merchant *et al* (1997), the a-b gaps associated with tympanic membrane perforation can range from 0-40.[16] Likewise J. Lavy and friends in their too found that central tympanic membrane perforations, the audiology showing a 30-40dB a-b gap.[17] Clinical analysis of 145 patients with chronic supporative otitis media with central tympanic membrane perforation and intact mobile occicular chain was done pre and postoperatively by Durko and friends[18]. In perforations involving posterioinferior quadrant, the mean conductive deficit up to 30 dB was observed while in rest of central perforation average of 20 dB conductive hearing loss was found before the surgery.[18] Hearing loss in tympanic membrane perforations to be depending upon perforation size and size of middle ear space volume was found by Voss in 2001.[12] They also concluded that the loss of shielding effect in tympanic membrane perforation with the increase in acoustic coupling due to above effects and maximum conductive effect that can result will be up to 40-50 dB. Mc.Ardle *et al* also showed that perforation of the tympanic membrane causes hearing loss that can range from negligible to 50 dB. They assumed that the primary mechanism of conductive hearing loss caused by a perforation being a reduction in occicular coupling caused by a loss in sound pressure difference across the tympanic membrane.[19]

The present study also shows the conductive hearing loss in central tympanic membrane can range from negligible to 50dB range except in two cases with hearing loss 52 and 53 dB which was found in long standing chronic supporative otitis media with large perforations. The extent of hearing loss to such extent can be explained by one or more of the following effects: First, diminished surface of the tympanic membrane on which sound pressure is exerted, causing diminished excursions of ossicular chain. Secondly diminished middle ear and mastoid air volume. Thirdly, sound vibrations reaching both the windows without dampening effect of the intact tympanic membrane. The result was consistent with study by Voss *et al*[13] and Mc. Ardle and friends.[19]

Hearing loss in relation to site of perforations: One hundred forty five cases of chronic suppurative otitis media with central perforations and intact, mobile ossicles were clinically analyzed by Durko *et al*.[18] Hearing loss in perforations involving posterioinferior quadrant was found to be upto 30 dB while in rest of central perforations average of 20 dB conductive hearing loss was found. Berger *et al* in the same year in his study over 120 cases also found of all locations, perforations involving the posterioinferior quadrant of the ear drum were associated with largest a-b gap.[14] Audiometric assessment revealed that none of the patients suffered the ossicular chain damage. Likewise, posterior perforations having greater hearing loss than anterior ones were revealed by Yung MW (1983) in the study of 100 cases.[20] Admed and friends in 1979 studied 70 cases with similar results. They also noted that marginal and malleolar perforations having greater hearing loss than that of similar sized central and non-malleolar perforations.[21]

In present study out of 100 cases, 64 cases involving posterioinferior quadrant, 50.0% cases had moderate-41-53 dB conductive hearing loss and in remaining cases, 39.0% (25cases) had mild-26-40 dB and 11.0% (7cases) had minmal-16-25dB hearing loss. When the perforations overlies round window in posterioinferior quadrant the hydraulic advantage produced by tympanic membrane on oval window disappears, so that sound reaches both the windows more or less at the same time with equal force and at nearly equal time. The resultant cancellation of the vibratory movement of the cochlear fluid column produces the maximum hearing loss observed in even small perforations overlying posterioinferior quadrant. The result in the study is consistent with all above studies in frequencies below 2000Hz. However, Vose *et al* (2001) in their study do not agree the notion that the location of the perforation should not influence the resulting hearing loss in contradiction to all previous studies.[13] Their result is questionable because the perforations located in posterioinferior quadrant has been proved to result loss in sound transmission and magnitude and phase of the sound pressures acting at the oval window and round window in various previous studies.

Hearing loss was found to be directly proportional to the size of perforation irrespective of their cause, which was statistically significant. Conductive hearing loss in the study was found to range from negligible to 53 dB. Overall, perforations involving posterioinferior quadrant were found to have maximum hearing loss. At frequencies below 2000Hz,

the hearing losses were found to be more by 10-15 dB on average in comparison to 2000- 6000Hz, which is statistically significant.

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Table-1(a): Hearing loss according to site of perforation (<2000Hz)

Site	PTA			Total
	16-25dB	26-40dB	41-55dB	
AI	11	11	1	23
PI	6	12	2	20
PI, AI	1	14	4	19
All 4	-	2	12	14
PI, PS	-	1	8	9
AS	5	1	-	6
PS	2	-	1	3
AS, AI	-	3	-	3
PS, PI,AI			1	1
PS,AS,AI	1	-	-	1
AI,AS,PI	-	1	-	1
Total	26	45	29	100

AI-Anterioinferior, PI-Posterioinferior, AS-Anteriosuperior, PS-Posteriosuperior, All4-All 4 Quadrants

Table-1(b): Hearing loss according to site of perforation (2000-6000Hz)

Site	PTA			Total
	16-25dB	26-40dB	41-55dB	
AI	17	6	-	23
PI	16	2	2	20
PI,AI	8	10	1	19
All 4	-	2	12	14
PI,PS	-	3	6	9
AS	6	-	-	6
PS	2	-	1	3
AS,AI	-	3	-	3
PS,PI,AI	-	-	1	1
PS,AS,AI	1	-	-	1
AI,AS,PI	-	1	-	1
Total	50	29	21	100

AI-Anterioinferior, PI-Posterioinferior, AS-Anteriosuperior, PS-Posteriosuperior, All4-All 4 Quadrants

Table-2(a): Hearing loss according to size of perforations (<2000Hz)

Size	PTA			Total
	16-25dB	26-40dB	41-55dB	
Small	25	18	4	47
Medium	1	18	15	34
Large	1	3	10	14
Pin Point	5	-	-	5
Total	32	39	29	100

Table-2(b): Hearing loss according to size of perforations (2000-6000Hz)

Size	PTA (2000-6000Hz)			Total
	16-25dB	26-40dB	41-55dB	
Small	36	8	3	47
Medium	7	17	10	34
Large	2	4	8	14
Pin Point	5	-	-	5
Total	50	29	21	100

Fig. Endoscopic pictures showing small, medium and large sized central tympanic membrane perforations