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Original Research Article

A 3 years retrospective observational study of pure tone audiometry in a tertiary railway hospital

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ABSTRACT

Background: Pure tone audiometry (PTA) is the basic test to identify the type and severity of a hearing loss.
Methods: Retrospective "record-based" analysis was done on the PTA reports over 03 years from May 2018 to April 2021 and 1420 PTA were analyzed. The tests were done using Arphi digital audiometer 2001 and Proton Dx-5 audiometers.
Results: 905 (63.73%) were males and 515 (36.27%) were females. Till 50 years of age, mixed hearing loss (MHL) was the commonest type of hearing loss followed by sensorineural hearing loss (SNHL). Overall SNHL was the most common type of hearing loss followed by MHL, while conductive hearing loss (CHL) was the least common. Moderate hearing loss was the most common finding seen in 27.6% of patients in the right ear and in 25.1% of the left ears. This was followed by mild, moderately severe, severe and profound hearing loss in both the ears. The age group with the maximum number of patients was in the 7th decade with 444 (31.27%). The prevalence of presbycusis was 70.60% above 60 years of age.
Conclusions: PTA is a basic investigation to detect the type and severity of hearing loss. The prevalence of hearing loss increases with age and early detection is advisable for early rehabilitation which can delay the onset of dementia.

Keywords: Pure tone audiometry, Air bone gap, Hearing loss, Presbycusis, Carhart notch, Noise-induced hearing loss, Sensorineural hearing loss, Mixed hearing loss, Conductive hearing loss

INTRODUCTION

According to the National sample survey, "persons with disabilities in India" report, about 0.3% of the rural and 0.2% of the urban population have a hearing disability.[1] It is estimated that by 2050 over 700 million people – or one in every ten people – will have disabling hearing loss. 'Disabling' hearing loss refers to hearing loss greater than 35 decibels (dB) in the better hearing ear. Nearly 80% of people with disabling hearing loss live in low- and middle-income countries. The prevalence of hearing loss increases with age, among those older than 60 years, over 25% are affected by disabling hearing loss.[2] In other words about 2% of adults aged 45 to 54 have disabling hearing loss. The rate increases to 8.5% for adults aged 55 to 64. Nearly 25% of those aged 65 to 74 and 50% of those who are 75 and older have disabling hearing loss.[3] Hearing is an important tool of communication and is essential for emotional and mental health. A study by Shukla et al showed that hearing loss was associated with loneliness and isolation in older adults.[4] Providing hearing aids or other rehabilitative services for hearing impairment much earlier in the course of hearing impairment may stem the worldwide rise of dementia.[5]

METHODS

The study is a retrospective observational study conducted in the department of ear, nose and throat (ENT) in the Southern Railway Headquarters Hospital, Chennai, from

May 2018 to April 2021. A total of 1420 pure tone audiometry (PTA) were done during the above period with the following inclusion criteria: patients who complained of any hearing loss, including children, employees and dependents of railway employees; employees coming for periodical medical examination (PME); candidates coming for recruitment to the Indian railways; and all cases for whom PTA was advised by the ENT surgeon including cases of sudden SN hearing loss, pre-surgical assessment, post-surgical follow-up and other disorders of the ear.

PTA was done using Arphi digital audiometer 2001 and Proton Dx-5 audiometer by a qualified audiologist in a soundproof booth with an ambient noise level of 32-35 dB after clearing of wax and debris form the external canal.[6] Pure tone thresholds were determined using the modified Hughson-Westlake method. Masking was done using narrow-band noise presented to the non-test ear and threshold determined in the test ear. The magnitude of hearing impairment modified from Lloyd and Kaplan is used for describing the severity of hearing impairment in adults.[7]

Ethical approval

The study does not contain any experimental procedures and are in accordance with ethical standards of the institution.

The statistical analysis was done on Google sheets.

The calculations used in the study were based on the following definitions.

Conductive hearing loss

Conductive hearing loss (CHL) is present if the bone conduction thresholds are within normal limits, the air conduction thresholds are outside of the normal limits, that is greater than 25 dB HL and the air-bone gap is greater than 10 dB HL.[6,8]

Sensorineural hearing loss

Sensorineural hearing loss (SNHL) is present if the bone conduction thresholds are outside of the normal limits, that is, greater than 15 dB HL, no significant air-bone gaps are present (i.e. air-bone gaps do not exceed 10 dB), and the air conduction thresholds are outside of the normal limits, that is, greater than 25 dB HL.[9]

Mixed hearing loss

Mixed hearing loss (MHL) is present if the bone conduction thresholds are outside of the normal limits, that is, greater than 15 dB HL, significant air-bone gaps exceeding 10 dB are present, and the air conduction thresholds are outside of the normal limits, that is, greater than 25 dB HL.[9]

Noise-induced hearing loss

A SNHL produced by the damaging effects of overstimulation by high sound levels, usually over a long period of time, is called noise-induced hearing loss (NIHL).[6, 10-13]

Carhart notch

The mechanical advantage provided by the 2000 Hz resonance of the ossicular chain is altered by the ankylosis, which prevents the ossicles from vibrating normally. This results in an elevation of the bone conduction threshold at 2 kHz called Carhart notch.[14]

Presbycusis

Presbycusis is a term that describes the gradual loss of hearing sensitivity that occurs in most individuals as they grow older. Hearing loss due to aging typically causes a gently sloping high-frequency sensory hearing loss that tends to be slightly greater in men than in women.[15-17]

High frequencies are considered as frequencies above 1 kHz. The hearing loss at frequencies above 1 kHz (2 kHz, 4 kHz, and 8 kHz) is considered as high-frequency hearing loss (HFHL).[18]

RESULTS

A total of 1420 PTA done over 3 years were analyzed. Of which 905 (63.73%) were males and 515 (36.27%) were females. As shown in Table 1 the average age of male patients was around 57.92 (±SD 17.96) while the average age for females was 54.93 (±SD 17.39) and the overall average age was 56.83 (±SD 17.81). Patients were as young as 5 years and as old as 91 years with a median of 62 years for males and 57 years for females (Table 1).

Retired employees formed the largest group of patients with 402 (28.3%) individuals. Homemakers formed the next largest group with 377 patients (26.5%). A total of 222 (15.6%) patients had jobs in the Railway workshops that involved varying amounts of sound exposure like technicians and engineers. 164 patients (11.5%) were working at the stations in varying jobs like loco pilots, trackmen and had considerable exposure to noise. Railway protection force (RPF) personnel formed a cohort who had exposure to sounds at the stations, tracks and firing range. A group of 81 (5.7%) patients had office jobs like teachers, peons and clerks. Another cohort of 30 patients (2.1%) were hospital employees including doctors, nurses, and attenders. The last 2 groups of patients were not exposed to continuous or high decibel noise. Another 75 patients (5.3%) were candidates who wished to join the Indian Railways (Figure 1).

In the right ear, SNHL was the most common finding with 622 (43.8%) patients, followed by MHL in 470 (33.1%), only 19 patients (1.3%) had a CHL. Moderate hearing loss

was the commonest seen in 391 patients (27.5%) followed by mild hearing loss seen in 302 patients (21.3%). The Left ear also showed similar results. Sensorineural loss was the commonest with 643 (45.3%) patients, followed by MHL 455 (32.0%), conductive loss was seen in 19 patients (1.3%). Moderate hearing loss was the commonest and seen in 357 patients (25.1%) followed by mild hearing loss which was found in 315 (22.2%) patients (Table 2).

In children up to 10 years of age, moderate MHL was the commonest finding. Till about 50 years of age, MHL was the commonest type of hearing loss in both ears followed by SNHL. After the age of 50 years, SNHL was the commonest type of hearing loss. More than 72% of the total patients were above 50 years of age with a maximum number of 444 patients (31.27%) reporting in the seventh decade. The commonest hearing loss in this age group was SNHL, 52.25% on the right side and 54.95% on the left followed by MHL. The incidence of SNHL further increased in the eighth decade where the incidence in the right and the left ears were 71.9% and 71% respectively (Table 3).

Table 4 and 5 shows that most of the patients had reported to the OPD while having moderate hearing loss. Evaluation of the right ear findings showed that 21.8% of the cases had normal hearing and an almost similar number, 21.3%, had reported a mild hearing loss. Maximum number of patients (27.6%) reported a moderate hearing loss. Patients with moderately severe 15.6%, severe hearing loss 9.8%, and profound hearing loss formed only 3.9% of the cases respectively. Findings in the left ear also showed a similar pattern with 21.3% and 22.2% of patients having either normal or mild hearing loss respectively. The majority of the patients (25.1%) had reported moderate hearing loss. Moderately severe, severe, and profound hearing loss formed 16.6%, 10.8%, and 3.9% of the cases respectively. The number of patients with profound or severe hearing loss in either ear was the least, implying that most of the patients reported early without waiting for the hearing to deteriorate. Analyzing the type of hearing loss with gender, SNHL was the commonest problem in both males and females. The incidence of SNHL in males was 46.3% in the right ear and 49.3% in the left ear.

This was followed by a MHL where the incidence in males was 31.4% and 29.3% in the right and left ear respectively. While in females the incidence of SNHL was the commonest with 39.4% in the right ear and 38.3% in the left ear. This was followed by MHL which was 36.1% and 36.9% in the right and left ears (Table 6).

Table 7 and 8 shows the degree of hearing loss with reference to gender. In both males and females Moderate hearing loss was the commonest. In males, 257 (28.4%) patients on the right side and 253 (28.0%) on the left side had Moderate hearing loss. In females, 134 (26.0%) had a moderate hearing loss in the right ear and 104 (20.2%) had on the left side. This was followed by mild, moderately severe, severe and profound hearing loss in this order, in both the sexes.

High-frequency hearing loss was found in 193 (13.59%) patients in the right ear and 206 (22.76%) in the left ear. Bilateral high-frequency hearing loss was present in 101 patients (7.1%). The characteristic dip of NIHL seen at 4 kHz was present in 66 (4.65%) in the right ear and 79 (5.56%) in the left ear. A bilateral dip was seen in 23 patients (1.62%).

Right Carhart notch was seen in 50 patients (3.52%) while in the left ear 42 patients (2.96%) had Carhart notch and this phenomenon was seen bilaterally in 19 patients (1.34%). The present study shows (Table 9) a steady increase in the incidence of presbycusis with age. Above 60 years of age, presbycusis was seen in 550 patients (70.60%). The prevalence in the 7th decade was 65.91% which increased to 78.57% in the 8th decade and it was seen in 77.65% of patients above 80 years.

Table 1: The demographic details of patients.

Sex	No	Percentage	SD age	Average age	Average right loss dB	Average left loss dB	Least age	Max age
Males	905	63.73	17.96	57.92	45.96	45.74	5	91
Females	515	36.27	17.39	54.93	44.66	45.74	6	88
Total	1420	100.00	17.81	56.83	45.49	45.74	5	91

Table 2: Degree and type of hearing loss in right and left ear.

Degree of loss	Right ear (%)	Left ear (%)	Type of loss	Right ear (%)	Left ear (%)
Normal	309 (21.76)	303 (21.34)	Normal	309 (21.76)	303 (21.34)
Mild	302 (21.27)	315 (22.18)	SN	622 (43.80)	643 (45.28)
Moderate	391(27.54)	357 (25.14)	Conductive	19 (1.34)	19 (1.34)
Mod severe	223 (15.70)	236 (16.62)	Mixed	470 (33.10)	455 (32.04)
Severe	139 (9.79)	153 (10.77)			
Profound	56 (3.94)	56 (3.94)			
Total	1420 (100.00)	1420 (100.00)	Total	1420 (100.00)	1420 (100.00)

Table 3: Age distribution with type of hearing loss in the right and left ear.

Age in years	No	Normal right (%)	Sensorineural right (%)	Conductive right (%)	Mixed right (%)	Normal left (%)	Sensorineural left (%)	Conductive left (%)	Mixed left (%)
Upto 10	24	17 (70.83)	3 (12.50)	0 (0.00)	4 (16.67)	15 (62.50)	0 (0.00)	0 (0.00)	9 (37.50)
11- 20	22	12 (54.55)	6 (27.27)	1 (4.55)	3 (13.64)	9 (40.91)	9 (40.91)	1 (4.55)	3 (13.64)
21-30	131	80 (61.07)	17 (12.98)	3 (2.29)	31 (23.66)	72 (54.96)	19 (14.50)	1 (0.76)	39 (29.77)
31-40	100	51 (51.00)	15 (15.00)	7 (7.00)	27 (27.00)	55 (55.00)	17 (17.00)	4 (4.00)	24 (24.00)
41-50	120	44 (36.67)	28 (23.33)	3 (2.50)	45 (37.50)	50 (41.67)	28 (23.33)	5 (4.17)	37 (30.83)
51-60	284	57 (20.07)	111 (39.08)	4 (1.41)	112 (39.44)	63 (22.18)	117 (41.20)	6 (2.11)	98 (34.51)
61-70	444	43 (9.68)	232 (52.25)	1 (0.23)	168 (37.84)	35 (7.88)	244 (54.95)	2 (0.45)	163 (36.71)
71-80	210	3 (1.43)	151 (71.90)	0 (0.00)	56 (26.67)	4 (1.90)	149 (70.95)	0 (0.00)	57 (27.14)
81-90	84	2 (2.38)	58 (69.05)	0 (0.00)	24 (28.57)	0 (0.00)	59 (70.24)	0 (0.00)	25 (29.76)
Above 90	1	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)
Total	1420	309 (21.76)	622 (43.80)	19 (1.34)	470 (33.10)	303 (21.34)	643 (45.28)	19 (1.34)	455 (32.04)

Table 4: Age distribution with degree of hearing loss in the right ear.

Age in years	No	Normal (%)	Mild (%)	Moderate (%)	Moderately severe (%)	Severe (%)	Profound (%)
Up to 10	24	17 (70.83)	1 (4.17)	4 (16.67)	0 (0.00)	2 (8.33)	0 (0.00)
11- 20	22	12 (54.55)	1 (4.55)	6 (27.27)	0 (0.00)	2 (9.09)	1 (4.55)
21-30	131	80 (61.07)	17 (12.98)	13 (9.92)	9 (6.87)	6 (4.58)	6 (4.58)
31-40	100	51 (51.00)	21 (21.00)	19 (19.00)	4 (4.00)	2 (2.00)	3 (3.00)
41-50	120	44 (36.67)	38 (31.67)	14 (11.67)	13 (10.83)	8 (6.67)	3 (2.50)
51-60	284	57 (20.07)	69 (24.30)	72 (25.35)	46 (16.20)	33 (11.62)	7 (2.46)
61-70	444	43 (9.68)	99 (22.30)	147 (33.11)	73 (16.44)	57 (12.84)	25 (5.63)
71-80	210	3 (1.43)	46 (21.90)	78 (37.14)	52 (24.76)	23 (10.95)	8 (3.81)
81-90	84	2 (2.38)	10 (11.90)	37 (44.05)	26 (30.95)	6 (7.14)	3 (3.57)
Above 90	1	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)
Total	1420	309 (21.76)	302 (21.27)	391 (27.54)	223 (15.70)	139 (9.79)	56 (3.94)

Table 5: Age distribution with degree of hearing loss in the left ear.

Age in years	No	Normal (%)	Mild (%)	Moderate (%)	Moderately severe (%)	Severe (%)	Profound (%)
Upto 10	24	15 (62.50)	2 (8.33)	3 (12.50)	3 (12.50)	1 (4.17)	0 (0.00)
11-20	22	9 (40.91)	2 (9.09)	5 (22.73)	4 (18.18)	1 (4.55)	1 (4.55)
21-30	131	72 (54.96)	18 (13.74)	8 (6.11)	12 (9.16)	8 (6.11)	13 (9.92)
31-40	100	55 (55.00)	20 (20.00)	17 (17.00)	5 (5.00)	1 (1.00)	2 (2.00)
41-50	120	50 (41.67)	34 (28.33)	14 (11.67)	13 (10.83)	4 (3.33)	5 (4.17)
51-60	284	63 (22.18)	75 (26.41)	67 (23.59)	42 (14.79)	30 (10.56)	7 (2.46)
61-70	444	35 (7.88)	109 (24.55)	130 (29.28)	86 (19.37)	65 (14.64)	19 (4.28)
71-80	210	4 (1.90)	48 (22.86)	68 (32.38)	53 (25.24)	30 (14.29)	7 (3.33)
81-90	84	0 (0.00)	7 (8.33)	44 (52.38)	18 (21.43)	13 (15.48)	2 (2.38)
Above 90	1	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)
Total	1420	303 (21.34)	315 (22.18)	357 (25.14)	236 (16.62)	153 (10.77)	56 (3.94)

Table 6: Sex distribution with type of hearing loss in right and left ears.

Sex (number)	Normal right (%)	Sensorine-ural right (%)	Conductive right (%)	Mixed right (%)	Normal left (%)	Sensorin-eural left (%)	Conduc-tive left (%)	Mixed left (%)
Males (905)	194 (21.44)	419 (46.30)	8 (0.88)	284 (31.38)	189 (20.88)	446 (49.28)	5 (0.55)	265 (29.28)
Females (515)	115 (22.33)	203 (39.42)	11 (2.14)	186 (36.12)	114 (22.14)	197 (38.25)	14 (2.72)	190 (36.89)
Total (1420)	309 (21.76)	622 (43.80)	19 (1.34)	470 (33.10)	303 (21.34)	643 (45.28)	19 (1.34)	455 (32.04)

Table 7: Sex distribution with degree of hearing loss in right ear.

Sex	No	Normal (%)	Mild (%)	Moderate (%)	Moderately severe (%)	Severe (%)	Profound (%)
Males	905	194 (21.44)	181 (20.00)	257 (28.40)	150 (16.57)	83 (9.17)	40 (4.42)
Females	515	115 (22.33)	121 (23.50)	134 (26.02)	73 (14.17)	56 (10.87)	16 (3.11)
Total	1420	309 (21.76)	302 (21.27)	391 (27.54)	223 (15.70)	139 (9.79)	56 (3.94)

Table 8: Sex distribution with degree of hearing loss in left ear.

Sex	No	Normal (%)	Mild (%)	Moderate (%)	Moderately severe (%)	Severe (%)	Profound (%)
Males	905	189 (20.88)	187 (20.66)	253 (27.96)	158 (17.46)	82 (9.06)	36 (3.98)
Females	515	114 (22.14)	128 (24.85)	104 (20.19)	78 (15.15)	71 (13.79)	20 (3.88)
Total	1420	303 (21.34)	315 (22.18)	357 (25.14)	236 (16.62)	153 (10.77)	56 (3.94)

Table 9 Presbycusis and age distribution.

Age	No. of patients	No. with presbycusis	Percentage
60-70	484	319	65.91
71-80	210	165	78.57
>80	85	66	77.65
Total 60 years and above	779	550	70.60

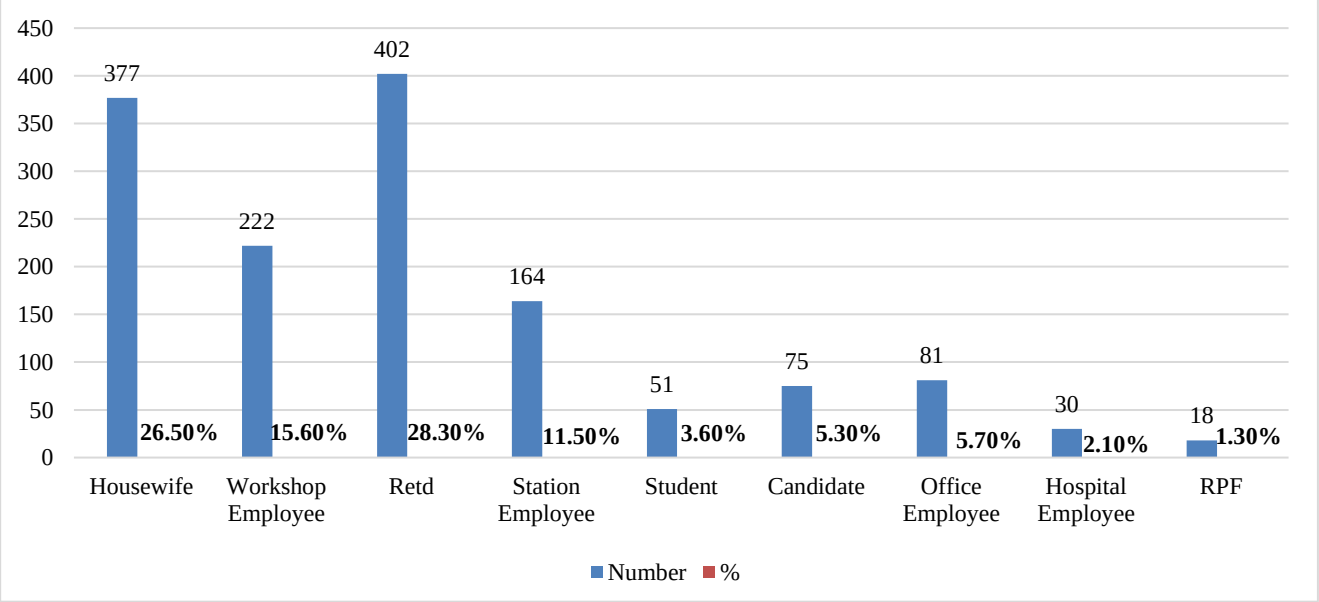

Figure 1: Job profile of 1420 patients.

DISCUSSION

In our study males contributed to 63.73% and females formed 36.27% of the patients. In the study by Balasubramaniam et al, the male-female ratio was 64% and 34% and the study by Kanhjikar et al had a male-female ratio of 66.9% and 33.1% which are almost similar to our study.[19,20] Studies by Ravi et al had a male-female ratio of 56.87% and 43.13%.[21] In a study by Hoffman et al regarding the prevalence of hearing loss in adults in the United States, it was found that men are almost twice as likely as women to have hearing loss among adults aged 20-69.[22] In the Indian railways, there are only 100,000 female employees in the total workforce of 1.3 million, i.e. only 7.71%. This ratio at the management level is 11.30% (2063 female officers in total of 18263 officers).[23] The reason for a higher male percentage in this study may be because in general, more male patients attend the OPD or due to mandatory regular health check-ups of employees.

In the current study, the ages ranged from 5 to 91 years though the maximum patients were in the age group of 61 to 70 years (31.2%) followed by 51 to 60 years (20%). According to the American study conducted by Hoffman et al, age is the strongest predictor of hearing loss among adults aged 20-69, with the greatest amount of hearing loss in the 60 to 69 age group.[22] Even in the study by Guleria et al in Shimla, the maximum number of patients with hearing loss were in the above 60 age group.[24] The age group of 61 to 70 years has a large number of persons in the present study because many retired railway employees attend the railway hospitals even after retirement because of the excellent comprehensive health care provided by the railways to all retired railway employees.

In our study, SNHL was the commonest finding followed by MHL, which is similar to the findings in many studies by Katiyar et al, Ravi et al, and Kanjikar et al.[20,21,25] CHL was the least common finding in our study as well as all the studies mentioned above. MHL was more common than SNHL in less than 50 years of age, this may be due to conditions like ASOM, OME, CSOM, Tympanic membrane perforation, Eustachian catarrh and adenoid hypertrophy in addition to the sensorineural component.

The majority of the patients who attended our ENT OPD and reported for PTA in our study were having moderate hearing loss, 27.6% (392) on the right side and 25.1% (357) on the left side. In our study, the incidence of Moderate hearing loss was followed by mild hearing loss 21.3% (302) on the right and 22.2% (315) on the left side. This finding is similar to the finding of Ravi et al in his study where the incidence of moderate hearing loss was the most common.[21] While in the study by Balasubramaniam et al the incidence of mild hearing loss was the commonest (29%) followed by moderate hearing loss (26%).[19] Normal hearing was found in 309 patients (21.8%) in the right ear and in 303 patients (21.3%) in the left side. In the study by Katiyar et al, 14.4% had normal hearing on the right side and 10.1% had normal hearing on the left side.[25] In all the studies including the present study, the incidence of severe and profound hearing loss was the least common.

A study by McBride, has showed that the notch for NIHL has long been recognized as a clinical sign of exposure to noise, and although the classic association is between continuous exposure to noise and a notch at 4 kHz, notches have been also been observed at 6 kHz in people exposed to impulse noise and at 3 kHz with low-frequency noise. The notch broadens with increasing exposure, and may eventually become indistinguishable from the changes of aging (presbycusis), where the hearing shows a gradual deterioration at the high frequencies. Although 4 kHz is the classic frequency affected, the notch may be noted elsewhere. The frequency range of the noise influences where the cochlear damage occurs.[26] In the present study the incidence of NIHL, with a notch at 4000 Hz, is 4.65% and 5.56% in the right and left ears respectively. This may be because we had a cross-section of employees who had a lifelong exposure to low-frequency and high-frequency sounds from machinery during the course of their jobs in the Indian railways.

A study conducted by Wegner et al concluded by saying that there is insufficient high-quality evidence regarding the diagnostic value of the Carhart notch, it seems it is a useful hint for the presence of otosclerosis, but it cannot be used to confirm a diagnosis of otosclerosis.[27] Study conducted by Yasan, showed that otitis media with effusion, tympanosclerosis and congenital malformations should be considered in the differential diagnosis of a patient with a Carhart notch seen on pure tone audiometry.[28] In the present study the incidence of Carhart notch is seen in 3.52% and 2.96% in right and left ear respectively and 1.34% bilaterally.

Presbycusis refers to bilateral age-related hearing loss. In literal terms, presbycusis means "old hearing" or "elder hearing".[29] It becomes noticeable around age 60 and progresses slowly; however, there is evidence that certain stressors can speed the rate of deterioration. The diagnosis can be confirmed with audiometry.[30] Presbycusis is a very common type of hearing loss, often having profound effects on the quality of life in old age. Since the number of elderly persons is increasing, the incidence of presbycusis is also expected to increase in the future. Presbycusis is caused by cochlear degeneration, most pronounced in the basal cochlear coil. The most common audiometric configuration is a gently sloping audiogram, above all affecting the high frequencies. Efforts to improve auditory communication in old age are important and can be expected to result in improved quality of life for elderly persons and in more efficient use of public resources.[31] Presbycusis is the most common cause of hearing loss worldwide and is estimated to affect approximately two-thirds of Americans aged 70 or older.[32] Hearing loss affects approximately one-third of adults over 60 years.[33] The present study shows a steady increase in the incidence of presbycusis with age. While in the 7th decade the

incidence was 65.91% it increased to 78.57% in the 8th decade and it was almost similar in the above 80 years age group (77.65%).

CONCLUSION

PTA is an important investigation to document the type and severity of hearing loss. Hearing loss is found even during the productive years and the incidence increases progressively with age. The audiometry report is the basis for deciding the treatment and rehabilitation using hearing aids. Early detection of hearing loss and early intervention helps individuals to reintegrate into society and also help to delay the onset of dementia.

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