PREVALENCE AND AUDIOLOGICAL CHARACTERISTICS OF SINGLE SIDED DEAFNESS IN INDIVIDUALS WITH SENSORINEURAL HEARING LOSS REPORTED TO AIISH 2015-2018

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April, 2018

CERTIFICATE

This is to certify that this dissertation entitled **'Prevalence and Audiological Characteristics of Single Sided Deafness in Individuals with Sensorineural Hearing Loss reported to AIISH 2015-2018'** is a bonafide work submitted in part fulfilment for degree of Master of Science (Audiology) of the student Registration Number: 16AUD036. This has been carried out under the guidance of faculty of the institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru

April, 2018

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DECLARATION

This is to certify that this dissertation entitled **'Prevalence and Audiological Characteristics of Single Sided Deafness in Individuals with Sensorineural Hearing Loss reported to AIISH 2015-2018'** is the result of my own study under the guidance of Dr. Hemanth N, Reader in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru **Registration No: 16AUD036**

April, 2018

Dedicating this work to my late brother Pruthvi raj Chowhan P J

My Father S M Puttamadaiah

My Mother Jayagowri

And to all the Humankind

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Abstract

Single sided deafness (SSD) is defined as unaidable hearing in one ear and normal hearing sensitivity in other ear. They often complain of difficulty to localize and understand speech in noise. Till date there is no prevalence study of SSD in India. Thus, a retrospective study was conducted on prevalence of SSD on audiological characteristics. A total of 11,534 cases having sensorineural hearing loss reported to Audiology department at All India Institute of Speech and Hearing from January 2014 to December 2017. Out of these, 225 cases were diagnosed as having SSD in a total of 11,534 SNHL cases. It accounts approximately two cases of SSD being diagnosed in a cohort of 100 SNHL cases. In addition, males are affected more than female. Right ears had more prevalence of SSD than left ear. The major complaints reported in them were tinnitus and vertigo. The medical history majorly observed in them was having the history of trauma followed by headache, vomiting and other problems like blurring of vision and imbalance. The study also showed that the type 'A' tympanogram with contralateral reflex present in the ear having SSD. No measurable speech scores on masking the non-test ear. OAEs and ABR-SOL were absent in the affected ear. Only 54 individuals (0.25%) out of 225 diagnosed cases of SSD underwent Hearing Aid Trail (HAT). In 46 individuals a measurable mean score on questions and SIS were 4.17 and 17.28, respectively. In remaining eight cases who had no measurable speech scores but aided thresholds were with in speech spectrum. The study shows that the prevalence of individuals with SSD who preferred to undergo for HAT is low due to another ear had have normal hearing sensitivity.

CHAPTER 1

INTRODUCTION

Prevalence is a frequently used epidemiological measure of how commonly a disease or condition occurs in a population. Prevalence measures how much disease is there in a given population at a particular period of time. In the present study a prevalence on single sided deafness and its audiological characteristics were documented. Single sided deafness (SSD) is defined as unaidable hearing in one ear and normal hearing in the opposite ear. The onset of SSD may occur congenitally or suddenly (Clark, 1981; Goodman, 1965). The probable aetiologies related to SSD are ototoxicity, meniere's disease, trauma, inner ear infection, otosclerosis, schawnnoma, circulatory/ metabolic diseases, genetic and other factors (Schreiber, Agrup, Haskard, & Luxon, 2010). Single sided deafness is usually unnoticed by themselves, especially when they are at young age. In addition, informants or school teachers may fail to detect SSD may be due to the reason that the unaffected ear is almost near normal hearing sensitivity. Thus, there is always a discrepancy between the age of onset and age at which they are diagnosed to have SSD. They seek intervention from audiologist until they really face problem in locating the sound source and or unable to understand the speech especially a noise coming from the side of better ear.

Epidemiological study conducted at other countries on prevalence of SSD was documented by considering a few variables. (Berg & Pallasch, 1981)have reported greater prevalence of single sided deafness occurs in adolescents or older adults i.e., 30 to 60 years of age. In yet another study by Oyler, Oyler, & Matkin, (1988) who examined the prevalence of SSD in a large 54000 students. The prevalence of it was 2 per 1000 approximately. In addition, male children affected more than female children. Further, they noticed SSD was commonly seen in right ear than left ear. In

the same line of retrospective research (Everberg, 1960) reported a greater prevalence of UHL among males (62.8%) than females (37.7%) and they have also noticed a greater percentage of left hearing impairment than right ear. In considering gender the prevalence of SSD on both studies indicated males are affected more than females. However, prevalence of SSD in considering the ear is contradictive. Tieri, Masi, Ducci, and Marsella, (1988) studied prevalence of SSD in children and they documented 280 cases of unilateral sensory neural hearing loss from 1979 to 1986. It was noted that approximately 62% male and 37% female were affected from SSD. Further, impact of single sided deafness was studied by Bovo, Martini, Agnoletto, & Beghi, (1988) who administered a questionnaire to 115 unilaterally hearing impaired individuals who were diagnosed as impaired during the first 12 years of their life. A total of 55 males and 60 females were included in the study, with 62 who have had hearing loss in the left and 53 had loss in the right ear. About 70% of the children were diagnosed as SSD over 6 years of age. They reported difficulties in speech recognition, localization, feelings of embarrassment and passivity. In addition, a 22 % of them have failed at least in one grade, 12 % were receiving special services in the area of learning disability, and 27% described embarrassment and a sense of inferiority. Bergenius (1985) who reported vestibular impairment of 12.9 % of their 1635 reviewed cases of SSD caused by sudden onset of sensorineural hearing.

The prevalence have had documented in many nations across globe. However, India has a very small amount of information about the SSD prevalence. A survey was conducted by Konadath, Chatni, Lakshmi, & Saini, (2017) to find out the prevalence of communication disorders in a group of islands in India. They used high risk register during survey to find the prevalence of communication disorders. Based on their study, hearing loss was identified in 106 individuals from the total population

of 22,558. Among 106 individuals with hearing loss 13 individuals had unilateral hearing loss. The prevalence of SSD was 0.05 % in all age groups. However, they did not provide any information about the risk factors accompanying the SSD. Moreover information of prevalence on variables such as onset of SSD, medical problem, associated problem, audiological characteristics and rehabilitative options are missing in the previous study. To document these variables under one study the present project is taken up. The prevalence of SSD is of such significance that audiologists and otologists are seeing such patients on a regular basis and plan rehabilitation program to help maximize the residual hearing of the affected ear. In addition it also helps to develop assessment protocols, appropriate infrastructure, and rehabilitation strategies for SSD. Further, risk factors accompanying SSD provides an information regarding proper prevention campaigns.

1.1Need for the study:

Prevalence varies within and across country which may differs because of the different population and regions. The purpose of this investigation is to provide the first ever prevalence statistics for SSD in India to determine the risk factors and probable associated variables so that prevention programs may be implemented effectively and efficiently. In addition, AIISH is an institute specialized to offer service for communication disorder. Wide Spectrum and unique cases of hearing impaired registers at AIISH. In the previous reporting year (2016-17) an approximately 16 409 cases of hearing impaired registered at AIISH, Mysuru. This immense case load seen nowhere in India to conduct prevalence study. Thus, prevalence of SSD will be studying in considering wide spectrum of variable who have reported to AIISH between January 2014 and December 2017.

1.2. Aim of the study:

To estimate the prevalence of individuals with single sided deafness who reports to AIISH between January 2014-15 and December 2016-2017.

1.3. Objectives of the study:

1. To determine the total number of the SSD cases reported at AIISH between January 2014 and December 2017
2. To estimate distribution of SSD across age, gender, common complaints, associated problem, medical history, audiological characteristics and findings of rehabilitation.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Definition of SSD and common complains

Single sided deafness is defined as unaidable hearing in one ear and normal hearing in the opposite ear. The onset of SSD may occur suddenly (Clark, 1981; Goodman, 1965). The probable aetiologies related to SSD are ototoxicity, meniere's disease, trauma, inner ear infection, otosclerosis, schawnnoma, circulatory/ metabolic diseases, genetic and other factors (Schreiber et al., 2010).

Individuals with single sided deafness have difficulties in speech recognition, localization, and feelings of embarrassment, passivity, communication breakdown, social isolation and avoidance. If SSD occur congenitally, about 22 % of them have failed at least in one grade, 12 % received special services in the area of learning disability, and 27% described embarrassment and a sense of inferiority. In addition, vestibular impairment is common in individuals with SSD. It is in inconsonance with retrospective study conducted by Bergenius, 1985 who reported 12.9 % of their 1635 reviewed cases with sudden sensorineural hearing had vestibular problem.

2.2 Histopathology of single sided deafness

The pathology of single sided deafness is generally found in inner ear or the auditory nerve connected to it. Everberg, (1960) has reported the causes for unilateral deafness, where he had considered the patients having severe to profound hearing loss in one ear and normal hearing in the other , in which he stated Meningitis (52.3%), Mumps (23.8%), Labyrinthitis (otogenic) (9.5%), Scarlet fever (4.8%), Injury (4.8%), Sudden idiopathic deafness (4.8%) to be the causes for the hearing loss. In yet another study by Vartiainen and Karjalainen (1998) who estimated cause of SSD as genetic in 2%, congenital non-genetic in 12%, delayed-onset non-genetic in 35% and remained

unknown in 51%. Serological tests and viral cultures of the blood and stools on sixty-six patients with sudden severe unilateral hearing loss were evaluated in order to find out the probable cause factor (Van Dishoeck & Bierman, 1957). They found mumps in early childhood could be the common cause for SSD. Beal, Hemenway, and Lindsay (1967) reported the pathological findings in temporal bone of a patient who experienced sudden profound unilateral hearing loss. They examined the inner ear found severe distortion and degeneration of the organ of Corti and stria vascularis with atrophy and encapsulation of the tectorial membrane and also reported the possible collapse of cochlear duct. They also found the collapsed saccule which appeared similar to the findings usually observed in viral disease of the endolymphatic system. Histopathological examination was conducted by Schuknecht, Kimura, and Naufal (1973) who recruited eight cases with sudden deafness in which they found 2 cases having profound loss unilaterally. When they examined histology on one case who had profound loss in right ear, they found severe atrophy of the organ of corti, which consisted of flattening cell mass, severe loss of hair cells, collapse of pillars and distortion of Hensen's and Deiter's cells. The limbus was atrophied in the basal turn. Reissner's membrane was collapsed onto remnants of the organ of corti in the basal turn and was in the normal position elsewhere. In addition, mild atrophy of the stria vascularis in the apical region was found. The vestibular nerves and sensory structures appeared normal. They stated, the profound hearing loss is adequately accounted by the severe atrophic changes in the organ of corti. For another case who had profoundly deaf in the left ear showed missing of organ of corti or flattened to a small epithelial mound in the basal 13 mm of the cochlea. From the 13 mm area to the apex, the supporting cells were present but about 50% of the external hair cells were missing. There was a diffuse atrophic change in the stria

vascularis with about 90% missing in the basal 4 mm, 50% from 4 to 21 mm, and 80% from 21 mm to the apex. The tectorial membrane appeared normal throughout and Reissner's membrane was in the normal position. The vestibular sense organs and nerve appeared normal. The pathological cause of sudden deafness in the left ear was stated as because of the atrophic changes in the cochlea which principally involved the organ of corti and stria vascularis.

2.3 Prevalence

Epidemiological study conducted at other countries on prevalence of SSD which was documented by considering a few variables. Berg and Pallasch, (1981) have reported greater prevalence of single sided deafness occurs in adolescents or older adults i.e., 30 to 60 years of age. In yet another study by Oyler, Oyler, and Matkin (1988) who examined the prevalence of SSD in a large 54000 students. The prevalence of it was 2 per 1000 approximately. In addition, male children were more affected than female children. Further, they noticed SSD was commonly seen in right ear than left ear. In the similar line of retrospective research on SSD, Everberg (1960) reported a greater prevalence of UHL among males (62.8%) than females (37.7%) and they have also noticed a greater percentage of left hearing impairment than right ear. In considering gender, the prevalence of SSD on both studies indicated males are affected more than females. However, prevalence of SSD in considering the ear is equivocal. Tieri, Masi, Ducci, and Marsella (1988) studied prevalence of SSD in children and they documented 280 cases of unilateral sensory neural hearing loss from 1979 to 1986. It was noted that approximately 62% male and 37% female were affected from SSD.

Van Dishoeck and Bierman(1957) had conducted study on 100 patients having sudden deafness where they have noted 83 patients as having unilateral

sudden deafness in which they found a total of 41 patients having >80 dB hearing loss. It infers, on an average 49% of the sudden unilateral deafness cases had hearing loss > 80 dB HL. A retrospective study was carried out among the children born between 1972 and 1986 by Vartiainen and Karjalainen(1998) who studied the prevalence and aetiology of unilateral sensorineural hearing impairment in a Finnish childhood population . They found 35% of the children having profound loss among 84 children with unilateral sensorineural hearing impairment. In Universal newborn hearing screening conducted in eight hospitals across New York State by Dalzell et al. (2000) found the prevalence of hearing loss 2.0 /1000, out of 43351 children 85 were having hearing loss , 36 (0.8%) were found to have unilateral hearing loss in which they reported 53% of children to have severe to profound hearing loss. Colletti, Fiorino, Carner, and Rizzi (1988) conducted hearing evaluation on 31235 patients between 1970 and 1987. They found 11 % of the them had unilateral profound hearing loss which turns out to be 1583 in number, in which 62 (4.3%) of them who had greater than equal to 13 years of age and 9 (5.8%) patients who were less than 13 years.

2.4 Audiological findings

Audiological findings reported on single sided deafness were reviewed in this section. Berg and Pallasch (1981) studied audiological characteristics on a patient of 13-year-old male who experienced a sudden deafness and tinnitus in his right ear comorbid with vertigo and nausea after he had a strong cold infection. The ENT inspection was normal except for large fissured tonsils. The audiogram showed normal hearing on the left and 80- to l00 dB hearing loss on the right ear. The vestibular examination yielded a direction-fixed spontaneous nystagmus beating to the left, a positioning nystagmus and no reaction to caloric stimuli to the right ear.

Jensen, Johansen, and Børre (1989) studied the auditory performance with respect to right/ left ear differences in children with unilateral sensorineural hearing. A word discrimination scores at the MCL was performed. The auditory performance expressed by word discrimination scores for the PB lists confirms the well-known superiority of binaural v/s monaural hearing and also confirms the observation made by Bess, Tharpe, and Gibler, (1986) that the unilaterally hearing impaired perform more poorly compared with normal listeners even in quiet conditions when the signals comes from the impaired side. Shetty (2017) studied on a case to give a battery of tests for fitting hearing aid to single sided deafness client. Their client had following audiological characteristics. The conventional pure-tone audiometry for the client aged 15 years revealed a profound hearing loss in the right ear (92.5 dB HL) and normal hearing sensitivity in the left ear (15 dB HL). Speech audiometry was completed in each ear. The SRT was 10 dB and 100% speech identification score (SIS) on the left ear. Whereas on the right ear no measurable SRT and SIS upon masking noise delivered to the left ear to avoid its participation. Tympanometric evaluation revealed 'A'type on both ears, which indicated normal middle ear status. Left ear ipsilateral and right ear contralateral reflexes were present from 500 Hz to 4 kHz (in octaves). Whereas, right ear ipsilateral and left ear contralateral reflexes were present at each frequency from 500 Hz to 4 kHz (in octaves). Otoacoustic emissions (OAE) testing documented the presence of transient OAE in left ear and absence of transient and distortion product OAEs in right ear. Auditory brain stem response was administered to assess space occupying lesion. It was found that the peak latency of V was less than 0.8 ms between two repetition rates of 11.1 and 90.1 s in the left ear. However, in the right ear there was no identifiable wave V peaks.

2.5 Risk factors

Risk factors associated with single sided deafness have been reported in this section. Yelverton et al., (2013) analysed the risk factors associated with unilateral hearing loss in children who initially passed newborn hearing screening but who were then found to have UHL at their follow-up exam, the most common risk factor was neonatal indicators (54.2%). Neonatal indicators were the most commonly identified risk factor for hearing loss overall in this cohort. This was followed by craniofacial anomalies (16.7%), family history of hearing loss (14.6%), and stigmata of hearing loss associated syndrome (10.4%). The risk factor with the highest rate of association with unilateral hearing loss discovered after passing the initial hearing screen was craniofacial anomalies with 6.11% (8/131) demonstration hearing loss. After craniofacial anomalies, the risk of subsequently developing confirmed hearing loss was more likely with patients with stigmata of hearing loss syndromes (2.73%), postnatal infection (1.69%), head trauma (1.64%), family history of hearing loss (0.28%), and neonatal indicators (0.22%). Fitzpatrick, Al-Essa, Whittingham, and Fitzpatrick, (2017) studied the characteristics of children with unilateral hearing loss. The study included all children identified with UHL in one region of Canada over a 13-year period (2003–2015) after implementation of universal newborn hearing screening. About 40% are at risk for deterioration in hearing either in the impaired ear and/or in the normal hearing ear. And the risk indicators observed were neonatal intensive care unit 12 (11.1%), in-utero infection 1 (0.9%), craniofacial anomalies 23 (21.3%), family history 8 (7.4%), postnatal infections 5 (4.6%), syndrome 5 (4.6%), No reported risk indicators 54 (50.0%). In yet another study Yelverton et al.(2013) studied the risk factors associated with unilateral hearing loss in children .The study population comprised of 371 children with confirmed UHL were selected . Of the 371

children, 362 (97.5%) were identified through a failed universal newborn hearing screening program. Of these 362 children, 252 (69.6%) had no JCIH risk factors and 110 (30.3%) had 1 or more risk factor reported. Nine children (2.5%) with 1 or more risk factors passed the universal newborn hearing screen but had later-onset of UHL. Craniofacial anomaly was the most commonly reported JCIH risk factor in 48 children (43.6%). A family history of permanent childhood hearing loss was present in 24 children (21.8%). Twenty children (18.2%) had stigmata associated with a syndrome including hearing loss. Of the 110 children with UHL and a JCIH risk factor, additional Co-occurring Birth Defects were identified in 83 (75.5%). An ear specific anomaly was most prevalent in 37 infants (44.6%), followed by cardiovascular anomalies in 34 infants (41.0%).

2.6 Complications

Single sided deafness can lead to various complications if not treated. Lieu (2004) studied speech-language and educational consequences of unilateral hearing loss in children. Author reported problems in school included a 22% to 35% rate of repeating at least one grade, and 12% to 41% receiving additional educational assistance and increased perceived behavioural issues in the classroom. Speech and language delays may occur in some children with UHL, but it is unclear if children "catch up" as they grow older. Subramaniam, Eikelboom, Eager, and Atlas(2005) studied the effect of unilateral profound hearing loss on quality of life after cerebellopontine angle surgery. Quality of life of 51 postoperative patients was assessed by using the Glasgow Benefit Inventory (GBI). Thirty patients with unilateral profound hearing loss who had undergone the translabyrinthine approach completed a subsequent quality-of-life questionnaire on speech discrimination and sound localization. Ninety-four percent of respondents to the 2nd survey reported

difficulties with speech discrimination, and 97%, with sound localization. They concluded unilateral profound hearing loss may have a significant problem in speech comprehension especially in noisy condition. Bess et al.(1986) studied a group of 60 children aged 6 to 13 years with normal intelligence and unilateral SNHL of greater in the speech frequencies which had been present for at least 3 years. They found that 35 % of the study population had failed at least one grade, most frequently first grade and additional 13.3 % required resource assistance at school. Many children with unilateral SNHL were reported to exhibit behavioural problems in classroom. Children with early onset of severe to profound unilateral losses involving right ear are most likely attributable to perinatal or post-natal complications. A few children with USNHL performed more poorly than controls with normal auditory acuity even if the primary test signal was presented to the impaired child's good ear. Culbertson and Gilbert (1986) studied the cognitive, academic, and social development of the children with unilateral sensorineural hearing loss on a group of 25 monaurally hearing-impaired compared with 25 non hearing impaired children. Results indicated no significant differences between the two groups on cognitive or self-concept measures. However, the unilateral group had significantly lower scores on academic tests of word recognition, spelling, and language. The unilateral group was more likely to have repeated a grade, needed special education resource help, or additional tutoring in school. Within the unilateral group, children with severe-to-profound hearing loss had significantly lower WISC-R full scale as compared to the group with mild-to-moderate hearing loss. The results of this study suggest that monaural deafness, especially when severe to profound hearing loss may be associated with cognitive and academic deficits, as well as secondary behavioural adjustment problems. Bovo, Martini, Agnoletto, and Beghi (1988) studied the effect of auditory

and academic performance of children with unilateral hearing loss. Their results demonstrated that unilateral deafness represents a far from negligible handicap concerning the child's learning and relationship with classmates and teachers, especially during compulsory school life.

2.7. Management

Audiologic rehabilitation of individuals with profound unilateral sensorineural hearing loss (USNHL) has traditionally been limited to the use of air-conduction contralateral routing of sound (CROS) hearing aids. Treatment for these individuals has expanded with new applications of the bone-anchored hearing aid (BAHA), transcranial hearing aid (t-CROS), and the cochlear implant. Shetty (2017) studied on a case to give a battery of tests for fitting hearing aid to single sided deafness client. It was observed that a hearing aid programmed to unmasked thresholds resulted in no intolerance to amplified speech and eliminated a sensation of vibration. Then, the binaural advantage was assessed using localization and speech in noise tests and the programmed using unmasked threshold was found to be beneficial in the aided condition compared to the unaided condition. The aided benefit in each hearing aid was best when occluding the better ear with an otoblock than masking the better ear with a noise to avoid its participation. It is concluded that programming the hearing aid using unmasked threshold of poor ear is reasonably best in fitting aid such that amplified speech overcomes the skull attenuation and also avoid an experience of vibration. Christensen, Richter, and Dornhoffer (2010) evaluated the use of bone-anchored hearing aids (BAHA) in children with single-sided deafness. Pre implant mean HINT scores at speech-noise ratios of 0, 5 and 10 dB were 42%, 76%, and 95%, respectively. Post implant mean HINT scores improved to mean speech-noise ratios of 82%, 97%, and 99% at 0, 5, and 10 dB, respectively. They concluded a bone-

anchored hearing aid is a treatment option that can achieve noticeable improvements in hearing especially in noisy condition. Giardina, Formeister, and Adunka (2014) studied the efficacy of cochlear Implants in single-sided deafness while hearing aids and similar amplifiers are reasonable strategies for initially attempted to correct hearing loss with minimal risk to the patient, CI is the definitive treatment for replacing a non-functioning cochlea and providing binaural hearing benefits. Squelch and summation aid in increasing the signal-to-noise ratio of incoming sounds and interaural comparisons assist in localization after the head shadow effect is eliminated. Because the treatment progression from hearing aids to CI is a large decision for both patients and providers, it is important to evaluate the most recent information regarding who will benefit most. The anticipated benefit of implantation, namely speech in noise, localization, and a decreased effort to hear, should be weighed on an individualized level against the potential risks. For children, the argument to implant is compelling. For adults, the duration of unilateral deafness may not be as strong a contributor to outcomes as duration of bilateral deafness, so the decision to implant may not require quick judgment. Bishop and Eby (2010) reviewed the literature that addresses the various treatment options for the client having unilateral profound hearing loss. They suggested BAHA provides greater relief of hearing handicap associated with USNHL than CROS hearing aids; however, both have been found to provide limited patient satisfaction and seemingly fall short of restoring true sound localization. Adequate trials have not been performed comparing BAHA with the best CROS hearing aid technology. Transcranial hearing aids and cochlear implants are experimental methods to treat USNHL and hold promise. Hansen, Gantz, and Dunn (2013) compared pre and postoperative performance in patients undergoing cochlear implantation (CI) for unilateral severe-to-profound

sensorineural hearing loss (single-sided deafness, SSD) including those with Ménière's disease. CNC word and AzBio sentence scores showed improvement in the implanted ear. Sound localization appeared to improve in an experience dependent fashion in some patients. Most patients reported diminished tinnitus following cochlear implantation. All patients underwent labyrinthectomy experienced resolution of vertigo attacks. They concluded CI restores auditory function to the deafened ear. Additionally, the binaural input appears to improve sound localization for most patients.

CHAPTER 3

METHOD

A retrospective research design was carried out to study the prevalence of single sided deafness (SSD). A complete audiological findings from those cases diagnosed to have had single sided deafness reported to AIISH between January 2014 and December 2017 were considered for profiling. Client Database Management Software (CDMA) and excel based application register were used to retrieve the OPD numbers of SSD.

In the research module of CDMA, the following search keys such as a) right ear normal hearing -left ear profound loss and b) right ear profound loss - left ear normal hearing were used to retrieve the OPD numbers of SSD within period between 2015 and 2017. In addition, the OPD numbers of SSD of the year 2014 was selected from excel based application register.

From the clinical service registration counter the case files of clients who have had reported of SSD (2014 to 2017) were retrieved. A case history, medical history, associated problem, complete audiological evaluation and hearing aid trials were noted down manually from each case file of confirmed SSD.

In case history, demographic details such as age, gender, duration of occurrence, ear specific complaints, possible cause for SSD, associated problems were considered.

Audiological evaluation- A calibrated diagnostic audiometry used to track the threshold. Air conduction thresholds at octave frequencies from 250 Hz to 8000 kHz and bone conduction threshold at octave frequencies from 250 Hz to 4 kHz determined using the modified Hughson and Westlake procedure was documented. In addition, a live voice presented to assess the speech identification scores from each

ear was noted down. A tympanogram utilized to determine the middle ear status and reflexometry in each ear were tabulated. Cochlear status and auditory neural integrity assessed using otoacoustic emission (OAE) and auditory brainstem Response (ABR), respectively were noted down. The interpretation of the results of the above tests and the provisional diagnosis based on results made by qualified audiologists was noted down.

Results on rehabilitative device or management advice/recommendation provided by Otolaryngologist (medical line of treatment), or Audiologist (audiological management) were recorded for the analysis of data.

CHAPTER 4

Results

The study was conducted with the aim of determining the prevalence and audiological findings in the individuals with single sided deafness who reported to All India Institute of speech and hearing (AIISH) Mysuru between January 2014 and December 2017. The collected data was tabulated and reported. The results of the study are discussed below.

4.1 Prevalence of single sided deafness

The review of Client Database Management Software (CDMA) and excel based application register revealed a total of 11,534 individuals as having sensorineural hearing loss. Of these 11,534, it was found that a total of 225 individuals as having single sided deafness. The demographic details and audiological findings of these 225 cases are documented. When the total number of sensorineural cases was seen in individual years, it was 5,801 in 2014-2015, 3,067 in 2015- 2016 and 2,666 in 2016-2017. In addition, the number of single sided deafness among SNHL was 57 in 2015, 91 in 2016 and 77 in 2666. Among 11534 SNHL cases a total of 225 cases of SSD were noted in the reported year 2014-2017. Hence the overall prevalence of all the three years accounted to 1.95 % and for individual years it is 0.98% in 2015, 2.96% in 2016, and 2.88% in 2017 (Figure-4.1).

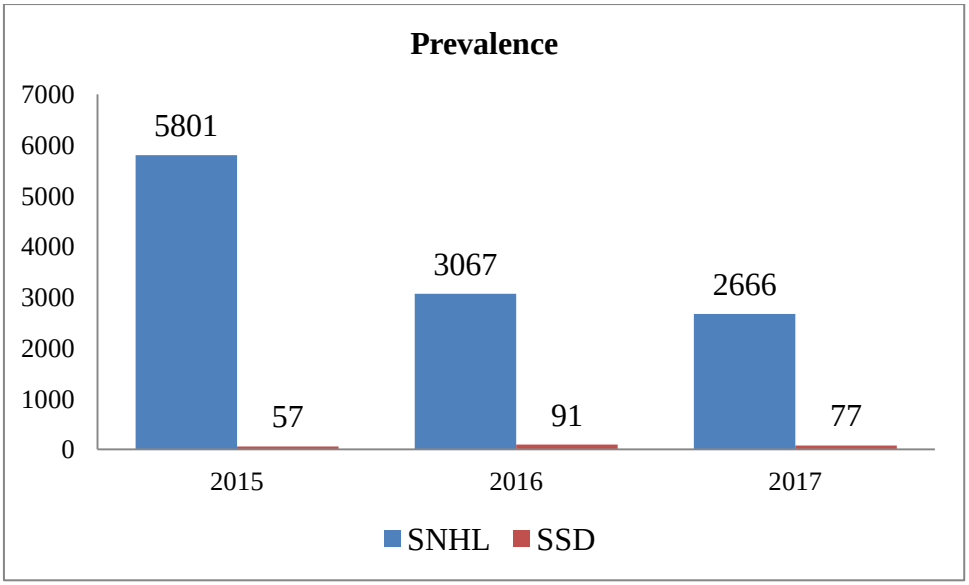

Figure-4.1. Number of SSD cases observed in SNHL in each year

4.2 Single sided deafness in different age groups

The age wise analysis of single sided deafness revealed that, among 225 individuals with single sided deafness, 32 (14.22%) were children, 39 (17.33%) were adolescents, 135(60%) were adults, 19 (8.44%) were geriatrics. That is, in a decreasing order of percentage, it was more in adults, followed by adolescents, children and geriatrics (Table-4.1 and Figure-4.2).

Table-4.1. Number of individuals with SSD across age range.

Age range	Number of individuals with SSD
0-12	32
13-18	39
19-59	135
>60	19

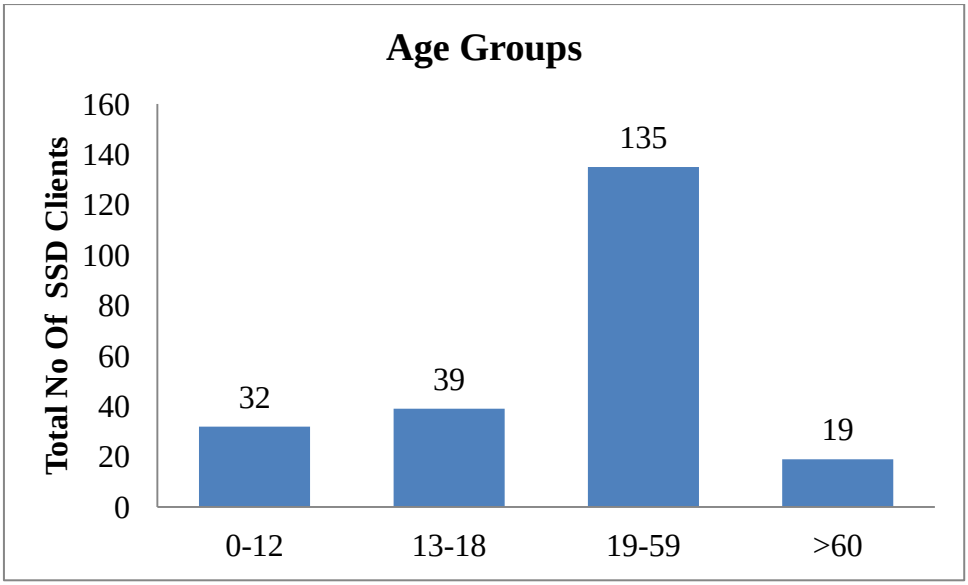

Figure-4.2. Number of SSD cases observed across age groups.

4.3 Gender wise analysis of Single sided deafness.

The assessment of prevalence of single side deafness with respect to gender revealed that, among 225 individuals with single sided deafness, 136 (60.44%) were males and 89 (39.55%) were females (Table-4.2 and Figure-4.3).

Table-4.2. Number of SSD individuals across gender

Gender	Number of individuals with SSD
Male	136
Female	89
Total	225

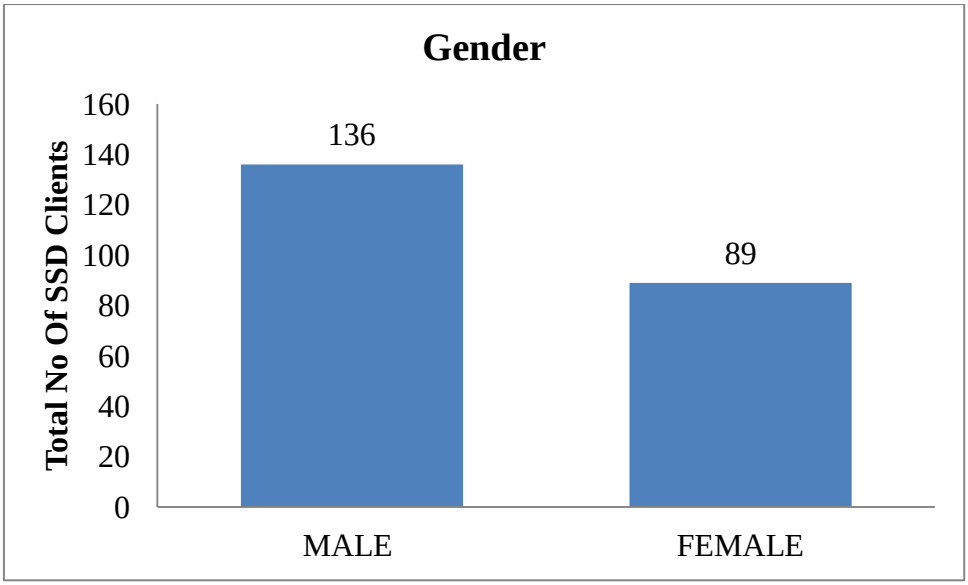

Figure -4.3. Number of individuals with SSD across gender.

4.4 Analysis with respect to the complaints reported.

With respect to complaints other than hearing loss is documented in this section. From Table- 4.3 and Figure 4.4 it was observed that about 44 cases (19.55%) reported as having ear pain, 20 (8.88%) as having itching, 39(17.33%) as having blood discharge, 61(27.11%) as having tinnitus, 35(15.55%) as having blocking sensation, 1(0.44%) as having congenital malformation, 4(1.77%) as having foreign body.

Table-4.3. Number of individuals with SSD with respect to the complaints reported.

Complaints	Number of individuals with SSD
Reduced hearing	225
Ear pain	44
Itching	20
Blood discharge	39
Tinnitus	61
Blocking	35
Congenital malformations (CM)	1
Foreign body	4

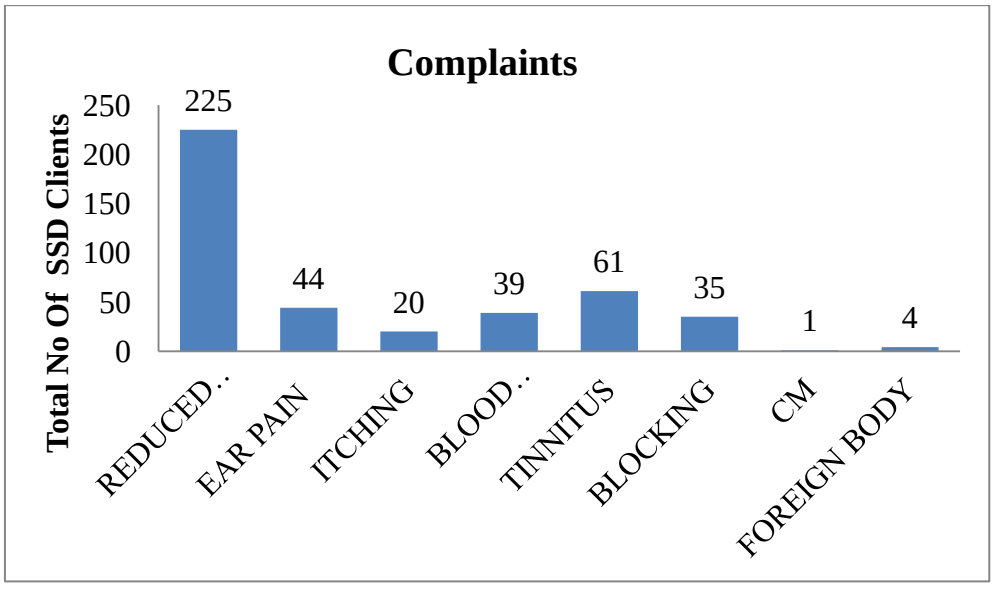

Figure -4.4. Number of SSD cases reported different complaints.

4.5 Analysis of Duration of occurrence of single sided deafness.

The analysis of single sided deafness with respect to the duration of occurrence revealed that, among 225 individuals with single sided deafness, 32

(14.22%) was congenital. In acquired cases, the duration of SSD were reported in which 10 cases (4.44%) in <1week, 16(7.11%) cases in 1 to 4 weeks, 35(15.55%) cases in1 to 6months, 27(12%) cases in 1 to 6months, 51(22.66%) cases in 1 to 5 years and 44(19.55%) cases in >5years (Table- 4.4 and Figure 4.5).

Table-4.4. Duration of occurrence of hearing loss among individuals with SSD.

Duration of occurrence	Number of individuals with SSD
Congenital	32
<1week	10
1 to 4 weeks	16
1 month to 6 months	35
6months to 1 year	27
1year to 5 years	51
>5years	44

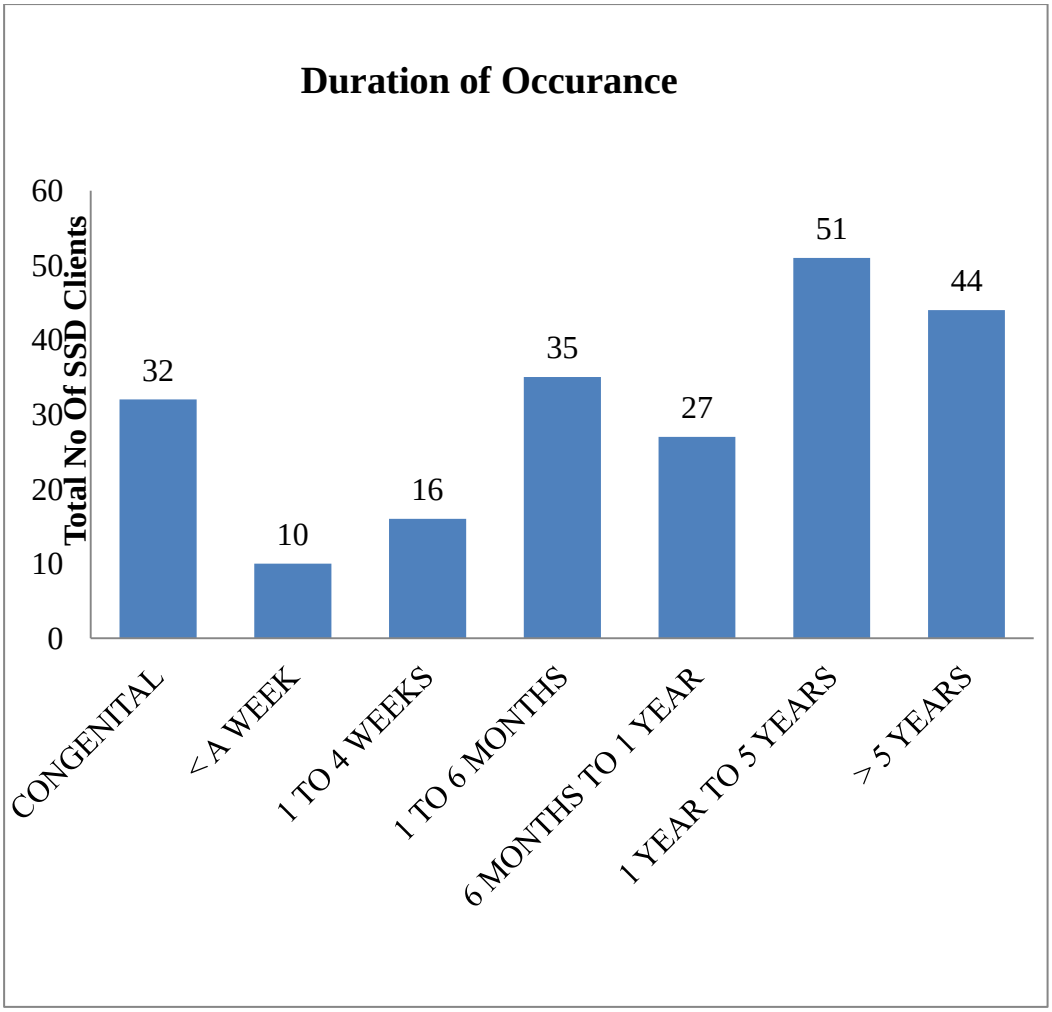

Figure-4.5. Duration of occurrence of hearing loss in individuals with SSD

4.6 Analysis based on Medical history

The data was analysed in terms of various medical history present in individuals with single sided deafness. From Table- 4.5 and Figure 4.6 it was observed that the different medical history were noted in the cases with single sided deafness were hypertension 17 , diabetes 9 , post surgery 7, post trauma 22, mumps 5, facial palsy 2, high fever 2, chicken pox 1, thyroid problem 4, cerebellopontine angel tumor (CPA) 2, meningitis 1, jaundice 1, human immuno deficiency virus (HIV)1, vestibular schwannoma 1, seizures 1.

Table 4.5: Number of individuals with SSD exhibiting various medical History.

Medical history	Number of individuals with SSD
Hypertension	17
Diabetes	9
Post surgery	7
Post trauma	22
Mumps	5
Facial palsy	2
High fever	2
Chicken pox	1
Thyroid problem	4
CPA Tumour	2
Meningitis	1
Jaundice	1
HIV	1
Vestibular Schwannoma	1
Seizures	1

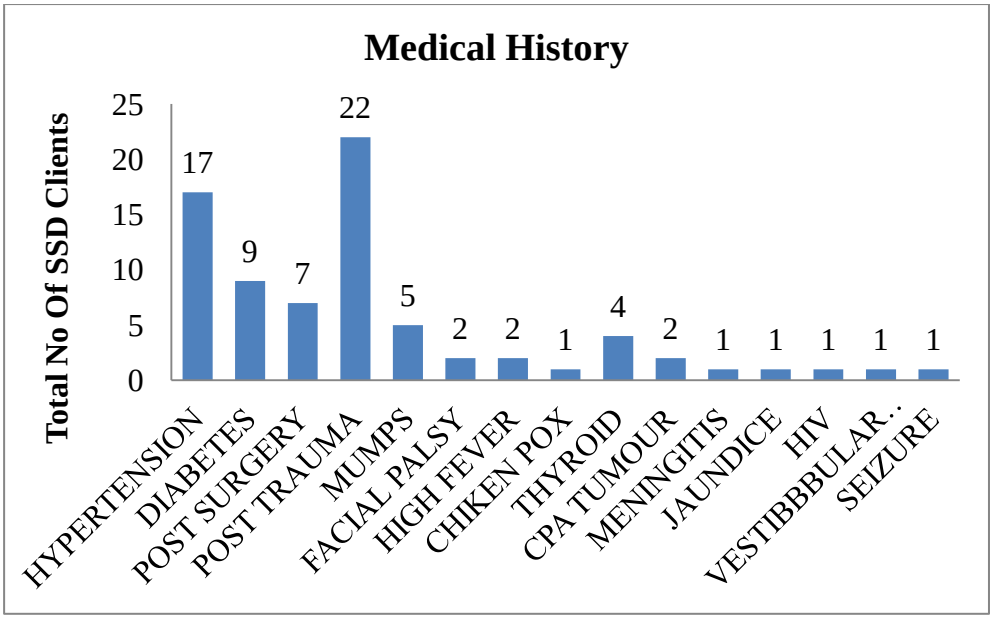

Figure-4.6. Numerical number on medical history in individuals with SSD.

4.7 Analysis based on other associated problems.

The data was analyzed for associated complaints namely, imbalance, headache vertigo/giddiness, vomiting, blurring of vision, difficulty in understanding speech. Out of 225 individuals who had single sided deafness, 89 (39.55%) clients had associated problems and the results revealed that prevalence of vertigo 21.33% was more followed by headache 10.6% (Table- 4.6 and Figure 4.7).

Table-4.6. Number of individuals with SSD exhibiting various associated problems.

Associated problems	Number of individuals with SSD
Imbalance	2
Headache	24
Vertigo/Giddiness	48
Vomiting	8
Blurring of Vision	5
Difficulty in understanding Speech	2

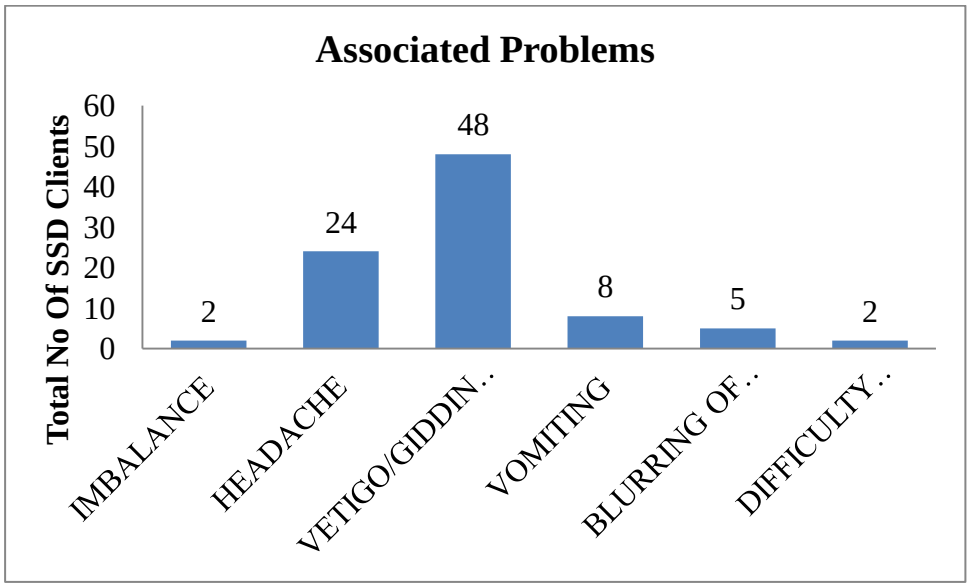

Figure-4.7. Numerical value on associated problems in individuals with SSD.

4.8 Audiological characteristics in SSD.

In the total of 225 cases having single sided deafness, the analysis showed that right ear as having more prevalence that is 58.66% than left ear which had 41.33% (Table- 4.7 and Figure 4.8).

Table-4.7. Number of individuals with SSD exhibiting hearing loss with respect to each ear.

Ears	Number of individuals with SSD
Right	132
Left	93
Total	225

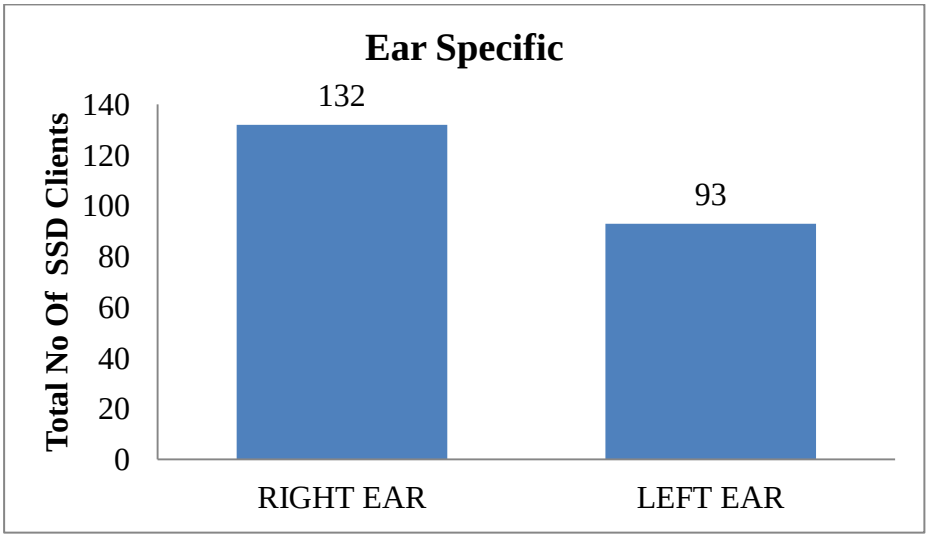

Figure-4.8. Numerical value respect to each ear in individuals with SSD.

The tympanometric findings of 225 ears were documented. The type of tympanogram was categorised as type A, As, Ad, B, C and Cs. it was noted that maximum number of individuals with single sided deafness had Type A tympanogram in both the ears as shown in the Table-4.8 and Figure-4.9.

Table -4.8. Number of individuals with SSD having different type of tympanogram .

Tympanogram type	Right	Tympanogram type	Left
A	129	A	134
As	50	As	44
Ad	22	Ad	21
B	15	B	20
C	4	C	4
Cs	5	Cs	2
Total	225		225

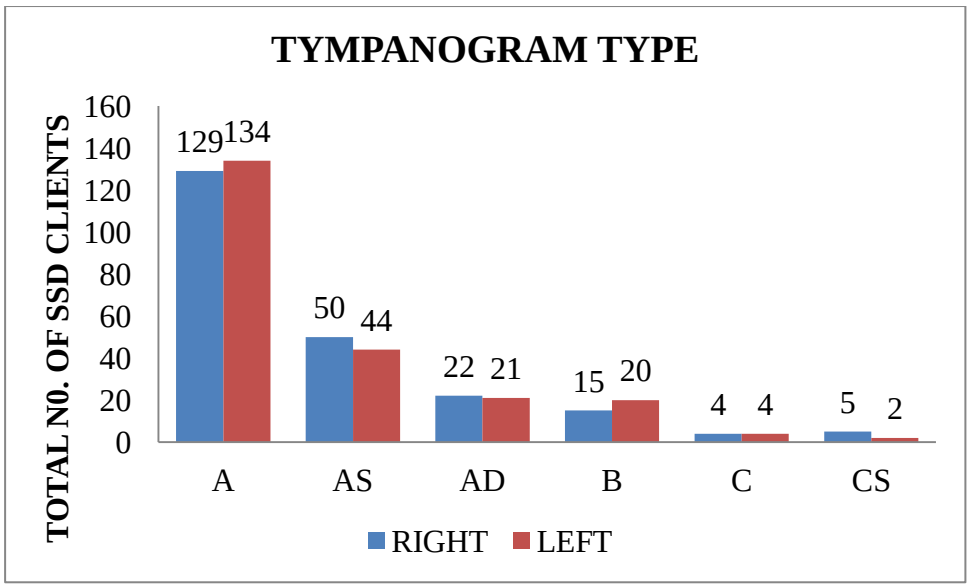

Figure-4.9. Type of tympanograms observed across individuals with SSD.

In the normal ear of SSD the speech recognition threshold was noticed at 15 – 20 dB and 100 % speech recognition score. When tested with ear with SSD, the measureable SIS 20- 34 % was observed in masking the better ear. In addition, contralateral reflex was observed within the range of 90- 100 dB in the ear having SSD. Further, OAE was absent and ABR for site of lesion results were absent in the ear having SSD.

4.10 Analysis of the number of individuals who preferred to go for hearing aid trail.

Out of 225 individuals who were identified as having single sided deafness, the number of individuals who preferred to go for hearing aid trail (HAT) are minimal, which is reported individually for each year (Table-4.9). HAT was performed in 24 %, 27 % and 19 % in 2015-16, 2015-17 and 2017-18, respectively.

Table-4.9. Number of individuals who underwent HAT among the total number of individuals with SSD

Year	No of individuals with SSD	No of individuals underwent HAT
2014-15	57	14
2015-16	91	25
2016-17	77	15
Total	225	54

Those individuals who had undergone HAT were administered with questions and speech recognition test. Five unrelated questions were asked. Client was instructed to repeat the standardized PB word list (which is out of 25). In the total of 54 individuals (0.25%) who underwent Hearing Aid Trail (HAT). The speech tests were administered to only 46 individuals using otoblock method. The mean scores for questions from 46 individuals were 4.17 and 17.28 in SIS. The other eight SSD cases were not benefitted with hearing aids because of no measurable speech scores on questions and recognition of speech. Thus, aided audiogram was administered on them. It was found aided threshold was within speech spectrum. These patients were informed that hearing aid only be useful for awareness.

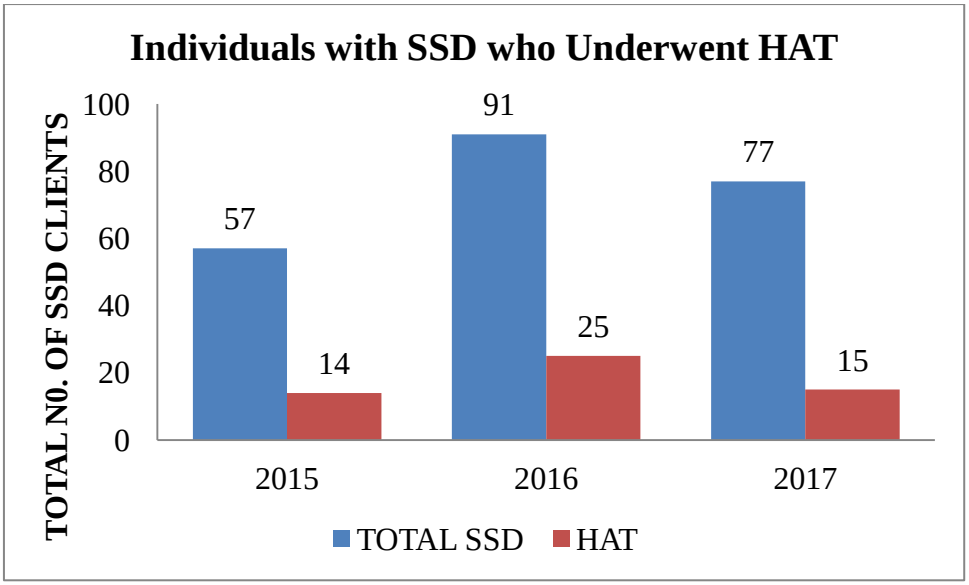

Figure-4.10. Number of individuals preferred to go for HAT among the total number of individuals with SSD across years.

CHAPTER 5

Discussion

The prevalence of single sided deafness reported to AIISH from January 2014 to December 2017 was 1.95%. An approximately two individuals suffers from single sided deafness in 100 SNHL cases. The result of the study is in consonance with the research of Oyler, Oyler, and Matkin (1988) who reported the prevalence of SSD is two per 1000 hearing impaired individuals. Single sided deafness across age showed that the prevalence was more in adults followed by adolescents, children and geriatrics. This is in consensus with Berg and Pallasch, (1981) who reported greater prevalence of single sided deafness occurs in adolescents or older adults i.e., 30 to 60 years of age. One possible reason for having found greater prevalence in the age range of 19-59 years could be broader age range. In this age range especially 20-35 years clients seek hearing disability certificate to apply for job under hearing impaired quota. More likely this age group would face problem in communication as clients actively involves in conservation with many people. The prevalence of SSD was more in male than female. Similar result was found in research report of Tieri, Masi, Ducci, and Marsella (1988) who reported 62% male and 37% female were affected from SSD. Probably it may be a social stigma of ignorance if female have problem and more concern shown if male has a problem. Most patients with SSD compliant of giddiness and tinnitus. In the present study showed similar result and possible reason could be space occupying lesion. Though the duration of SSD is anecdotal most commonly it may occur congenitally or acquired. If SSD occur at advanced age then it may be sudden or gradual in nature. If SSD is sudden it could be vascular and they come to clinic immediately. If the nature is gradual they tend to ignore because the other ear is normal or it may go unnoticed for initial days of occurrence.

Analysis in terms of various medical history for each individual who had single sided deafness revealed hypertension in 17 cases, diabetes in 9, post surgery in 7, post trauma in 22, mumps in 5, facial palsy in 2, high fever in 2, chicken pox in 1, thyroid problem in 4, cerebellopontine angel tumor (CPA) in 2, meningitis in 1, jaundice in 1, human immune deficiency virus (HIV) in 1, vestibular schwannoma in 1, seizures in 1 case. Here it was noted that the percentage of prevalence of cases that had post trauma (28.94%) in their medical history was more than others in medical history. Out of 225 individuals with SSD, 89 (39.55%) clients had associated problems. The results revealed that prevalence of vertigo 21.33% was more followed by headache 10.6%. The possible reason for vertigo and hearing loss could be space occupying lesion.

In the total of 225 cases having single sided deafness, the analysis showed that right ear as having more prevalence of 58.66% than left ear which had 41.33%. The result of the present study is in consonance with the research findings of Everberg (1960) and Oyler, Oyler, and Matkin (1988) who have reported prevalence of ear having profound loss is found more in right ear as compared to that left ear. However, the reason for being more prevalent in right is unknown. The tympanometry finding was found type 'A' tympanogram in both the ears. This is because the single sided deafness involves the pathology of inner ear and not in the middle ear. The A type of tympanogram shows the intact middle ear. The SIS and SRT scores had measurable score due to the participation of non-test ear. After masking in the non-test ear, SRT and SIS score had no measurable score. In addition, ipsi-lateral reflex was absent in all clients with SSD due to profound loss. However, contralateral reflex was present; this is because the other ear had normal hearing sensitivity which stimulates contralateral stapedius muscle which in turns pulls the bone of middle ear stapes and

vibrates tympanic membrane. The OAEs are absent in ear having profound loss due to outer hair cells damage. Further, site of lesion in ABR revealed absent response due to profound hearing loss. To diagnose SSD, a sound both room, case history diagnostic audiometer and immitance meter are the bare minimum infrastructure required.

Out of 225 individuals who were identified as having single sided deafness, it was found that only total of 54 individuals (0.25%) underwent Hearing Aid Trail (HAT), though individuals with SSD was counselled to undergo HAT trial. The client showed reluctance because other ear was normal hearing sensitivity. For those who underwent hearing aid trail in otoblcok method the mean scores observed for questions and SIS were 4.17 and 17.28 respectively on 46 clients. This suggests the site of lesion could be inner hair cells of cochlear. However, eight clients with SSD showed no measurable speech scores on questions and recognition of speech. Thus aided threshold was obtained in them and result showed that each frequency is within speech spectrum. It indicates that amplified speech have transcranially reached the better ear when its participation is avoided with otoblock method. Only those patients who were actively participated communication voluntarily asked us treatment options other than hearing aid. It was advised for cochlear implantation in individuals with SSD. Due to cost factor and hearing status in other ear have had normal hearing sensitivity refused option of cochlear implantation, bone anchored hearing aid.

Clinical Implication

- This study is the first ever prevalence study for SSD in India provided information regarding the different audiological findings seen in individuals with SSD.
- The study results help to initiate secondary and tertiary preventive campaign of SSD

- Minimum infrastructure required to diagnose SSD documented from the findings of the study.
- It also helps in counsel to procure a management device in SSD patients who were reviewed.

CHAPTER 6

Summary and conclusion

Single sided deafness (SSD) is defined as unaidable hearing in one ear and normal hearing sensitivity in other ear. A retrospective study was conducted on prevalence of audiological characteristics in individuals with SSD. A total of 11,534 cases having sensorineural hearing loss reported to Audiology department at All India Institute of Speech and Hearing from January 2014 to December 2017. Out of these, 225 cases were diagnosed as having SSD in a total of 11,534 SNHL cases. It accounts approximately two cases of SSD being diagnosed in a cohort of 100 SNHL cases.

The salient features of the present study were

- SSD was found to be more prevalent in adults followed by adolescents, children and geriatrics.
- Prevalence of SSD was more in males than females. In addition, SSD was observed more in right ear than left ear.
- The prevalence of complaints associated with SSD after reduced hearing sensitivity was more for tinnitus (27.11%) followed by ear pain (19.55%), blood discharge (17.33%), blocking sensation (15.55%), itching (8.88%), foreign body(1.77%) and then congenital malformations(1.77%).
- The duration of occurrence of SSD was acquired rather congenital. In addition, nature of SSD was gradual than sudden.
- Most often the medical history reported was post trauma followed by hypertension, diabetes and post-surgery.

- The associated problem reported majorly was vertigo followed by headache, vomiting and other problems like blurring of vision difficulty in understanding speech and imbalance.
- Audiological findings in SSD revealed type ‘A’ tympanogram with contralateral reflex present in the ear having SSD. No measurable speech scores on masking the non-test ear. OAEs and ABR-SOL were absent in the affected ear.
- Only 54 individuals (0.25%) out of 225 diagnosed cases of SSD underwent Hearing Aid Trail (HAT). In 46 individuals a measurable mean score on questions and SIS were 4.17 and 17.28, respectively. In remaining eight cases that had no measurable speech scores but aided thresholds were within speech spectrum.

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