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**Original Research Article**

# Spatial hearing abilities among children with bimodal versus unilateral cochlear implant: parents report on spatial hearing questionnaire

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## ABSTRACT

**Background:** Spatial hearing questionnaire (SHQ) is a questionnaire developed and validated for evaluating the spatial hearing abilities for the tasks of localization of sound to complex task of speech perception in noise. SHQ is adapted in Dutch language, and in Persian language. The study aimed to compare the spatial hearing abilities of children using bimodal cochlear implant and unilateral cochlear implant using spatial hearing questionnaire a subjective assessment tool, SHQ.
**Methods:** The participants of the study included parents of 30 cochlear implant using children of age range 5-10 years, among 30 participants, 16 belonged to parents of children using unilateral cochlear implant and 14 were parents of children using bimodal cochlear implants. SHQ consisted of 24 questions distributed under 8 domains and the responses from the parents were collected over telephonic interview and statistically analyzed across domains.
**Results:** The results revealed that there was no significant difference observed between both the groups across all the 8 domains, except perception of children's voice, showed statistical difference between 2 groups. The baseline of spatial skills in children population using unilateral and bimodal cochlear implants was analysed.
**Conclusions:** Across the 8 domains of spatial hearing questionnaire there were no significant statistical difference found between unilateral and bimodal cochlear implanted groups.

**Keywords:** Cochlear implant, SHQ, Spatial hearing, Subjective evaluation of spatial skills

## INTRODUCTION

Spatial hearing refers to the ability of the auditory system to localize sound sources in space. Humans can localize sound along three dimensions: azimuth (left-right), elevation (up-down), and distance (near-ar). This ability is essential for situational awareness, communication, and navigation in our surroundings.The spatial hearing ability is ability of a listener to perceive sounds in complex sound environment.[1,2] It fosters hearing sounds in a three-dimensional space, localizing the source of the sound, and unmasking/decoding the sounds in background noise. It is determined by attention towards sound source, and whether it is near or far in the listening space.

Binaural hearing involves the processing of auditory information from both ears. Each ear receives a slightly different version of the sound wave arriving at different times and with different intensities due to factors like distance and angle of the sound source relative to the head. The brain integrates these binaural cues to extract spatial information and determine the direction of sound sources.

Disorders or impairments affecting binaural processing can result in difficulties with spatial perception and localization, which can impact communication, safety, and quality of life. One study found that interaural discrimination ability were degraded for patients with bilateral conductive hearing loss.[3] Byrne et al reported that conductive component of hearing loss causes significant disturbance in localization, predominantly in horizontal plane due to absence of low-frequency interaural time cues.[4] Ghahraman, et al reported that aging leads to structural and neuro chemical changes in the auditory system affecting different aspects of spatial hearing such as localization, precedence effect and speech perception in noise.[5]

Spatial hearing can be assessed using objective and subjective methods. Objective methods employ complex instrumentation such as different arrangements of speaker arrays for more accurate quantification of spatial hearing abilities in subjects.

LiSN-S or listening in spatialized noise-sentence test is to assess skills of auditory segregation in children aged between 6-10 years of age.[6] It is assumed that the listener uses pitch and spatial cues to segregate target sound from background noise.

Hearing in Noise test (HINT) (House ear institute) was to assess performance in the presence of background signal. A 10-sentence list would be presented to both ears under 4 test conditions i) sentences with no competing noise ii) sentences with competing noise of steady loudness 65dB(A) presented in front of the patient iii) sentences with competing noise presented to the left ear iv) sentences with competing noise presented to the right ear. The task for the subject is to listen to the sentence and repeat it. All words provided should be repeated correctly. When the signal-to-noise ratio is high, patient has difficulty in hearing. The results are analyzed if the response to speech vary in the location, it is concluded that problem arises due to lesion in brainstem.[7]

A§E sound localization test is an auditory speech sound evaluation consists of 2 parts Azimuth localization and ILD localization. Azimuth localization requires 5-7 loudspeakers and requires sound C software. In this stimulus is presented through multiple loudspeakers of sound. The stimuli consist of 1/3 octave narrow-band noise with 4KHz centre frequency, speech shaped noise, low pass filtered noise with cut off frequency, high pass filtered noise with cut off frequency (from a webpage; Audiqueen Helpdesk, n.d as quoted in Corbetto et al.[8,9]

Spatial speech in noise test (SSiN) test simultaneously evaluate localization and speech discrimination performance in competing multi-talker babble noise.[10] This uses speech signals appropriate for adults and children, and includes complex vowel, simple vowel, initial consonant and final consonant. In speech discrimination task, the listener needs to repeat 2 words within the group that is reference word and target word presented in succession and the localization task involves the subject is judge whether target word is presented to left or right from the reference word.[10]

Subjective methods involve self-rating scales, a less time-consuming procedure to quantify the spatial hearing subjects and can be employed in various environments unlike objective methods. There are various questionnaires available to assess hearing outcomes in hearing impairment population which majorly concentrates on benefit and satisfaction from hearing aids. Despite availability of many questionnaires on social, emotional and physical but very few studies throw lime light on perception of spatial perception of sound.[2]

Two commonly reported questionnaires in literature are, Speech spatial Questionnaire (SSQ) and Spatial hearing questionnaire (SHQ). The SSQ questionnaire is used to assess the speech, spatial and quality of hearing in individuals with hearing impairment. This questionnaire is designed in interview format between clinician and client. The SHQ is short questionnaire which is designed and validated for self-administration and is less time consuming. It is composed of 24 questions which explores on the spatial hearing ability using stimuli with different frequency content. It has 8 subscales includes male’s voices (items 1, 5, 9, 13, 17), female’s voice (items 2, 6, 10, 14, 18), children voice (items 3, 7, 11, 15, 19), music (items 4, 8, 12, 16, 20), sound localization (items 13-24), understanding of speech in quiet (items 1-4), understanding of speech in noise with target and noise sources (items 5-8), understanding of speech in noise with target and noise sources spatially separate (items 9-12).[2]

SHQ is a questionnaire developed and validated for checking the spatial hearing abilities which checks the lower level task of localization of sound to complex task of speech perception in noise .There has been adaptation of SHQ in Dutch language and in Persian language.[11-13] The SHQ was explored in normal ears and several profiles of cochlear implant adult recipients, but no studies have been reported so far among children. This is despite the fact that there are numerous subjective and objective methods of testing available for determining spatial hearing. Therefore, it is crucial to define norms and a baseline for different cochlear implant characteristics.

The aim of the study was to compare the spatial hearing abilities of children using unilateral cochlear implant and bimodal cochlear implant using spatial hearing questionnaire (SHQ).

## METHODS

A cross sectional observational study was conducted at

Dr. S R Chandrasekhar Institute of Speech and Hearing during 2022. The parents of children attending auditory verbal therapy or have attended therapy at the host institute for two years were the participants of the study. The sampling technique used was simple random sampling. Parents of 16 children using unilateral cochlear implant and 14 children using bimodal cochlear implant were included. Parents of unilateral/bimodal cochlear implanted children within age range of 5-10years with no other medical history other than hearing loss and attending therapy or have attended for period of at least 2 years were included. Parents who reported of any other health conditions excluding hearing loss among their children or attended therapy for less than 5months of a calendar year were excluded from participation. The ethical clearance was obtained from the institutional ethical committee.

The parents of children with cochlear implants were provided with the information about the study and explained the contents of the questionnaire. With the written consent of the participants, demographic information (including the type of the cochlear implant used) were collected from the prior to the administration of spatial hearing questionnaire (Appendix B & C). The mode of data collection was verbal telephonic conversation between the investigator and the parents. The participants responded for 24 questions in the SHQ (spatial hearing questionnaire) using rating scale (0-100), with 0 being very difficult and 100 being very easy. The ratings provided by the parents were entered for all the 8 domains in Microsoft excel along with demographic data for further analysis.

The ratings were analyzed using the SPSS (version 20.0). The Kolmorgorov-Smirnov test was used to assess the normality. For the comparison between the unilateral cochlear implantees and bimodal cochlear implantees, Independent t-test/Mann Whitney U test was used based on the normality of the data.

## RESULTS

The mean implant age was 39.1 months (SD:24.13) and mean therapy duration were 23.133 months (SD:17.77). The mean implant age of children in bimodal group was 37.43 months (SD:24.72) and children in unilateral implant group is 41 months (SD:25.94). Therapy duration for bimodal group was 21.5 months (SD:18.90) and in unilateral group was 21.25 months (SD:17.09). On observation the mean and standard deviation values of therapy duration and implant age suggests that both groups were comparable in their implant age and therapy duration (Table 1).

Perception of male's voices were evaluated in items 1, 5, 9, 13, 17; perception of female's voice were evaluated in items 2, 6, 10, 14, 18; perception of children voice were evaluated in items 3, 7, 11, 15, 19; music listening were evaluated in items 4, 8, 12, 16, 20; sound localization was evaluated in items 13-24; understanding of speech in quiet were evaluated in items 1, 2, 3, 4; understanding of speech in noise with target and noise sources were evaluated in items 5, 8, 6, 7; understanding of speech in noise with target and noise sources spatially separate were evaluated in items 9,10,11.

**Table 1: Demographic details of the participants.**

| Age (years) | Type of CI user | CI ear | Therapy duration (months) | Implant age (months) |
|---|---|---|---|---|
| **7** | Unilateral | R | 14 | 15 |
| **7.2** | Unilateral | R | 19 | 20 |
| **6** | Unilateral | R | 8 | 31 |
| **5.3** | Unilateral | R | 10 | 17 |
| **5** | Unilateral | R | 4 | 5 |
| **9** | Unilateral | R | 24 | 67 |
| **6.2** | Unilateral | R | 13 | 17 |
| **5.7** | Unilateral | R | 12 | 48 |
| **9.5** | Unilateral | R | 60 | 95 |
| **6** | Unilateral | R | 17 | 24 |
| **10** | Unilateral | R | 36 | 48 |
| **10** | Unilateral | R | 60 | 77 |
| **8** | Unilateral | L | 21 | 24 |
| **8.6** | Unilateral | R | 24 | 54 |
| **7** | Unilateral | R | 12 | 49 |
| **5** | Unilateral | L | 6 | 8 |
| **8** | Bimodal | R | 14 | 33 |
| **5.3** | Bimodal | R | 36 | 36 |
| **6** | Bimodal | R | 23 | 32 |
| **8** | Bimodal | R | 24 | 50 |
| **8** | Bimodal | R | 24 | 46 |
| **10** | Bimodal | R | 24 | 32 |
| **10** | Bimodal | R | 24 | 8 |
| **10** | Bimodal | L | 12 | 24 |
| **10** | Bimodal | R | 36 | 48 |
| **5.6** | Bimodal | R | 8 | 9 |
| **10** | Bimodal | R | 84 | 108 |
| **8** | Bimodal | R | 12 | 48 |
| **9.5** | Bimodal | R | 12 | 54 |
| **7.5** | Bimodal | R | 24 | 46 |

R-right; L-left ear

The Figure 1 represents the overall mean across domains. The highest mean value obtained for the domains, sound localization and perception in quiet (61.74 and 60.57) and lowest mean value was obtained for the domains, perception in noise with target and noise sources together and speech in noise with target and noise sources spatially separate (41.75 and 44.20).

### *Perception of male, female and children voice*

The mean values of unilateral and bimodal users for the domains perception of male voices, perception of female voices and perception children voices are given in Table 2.

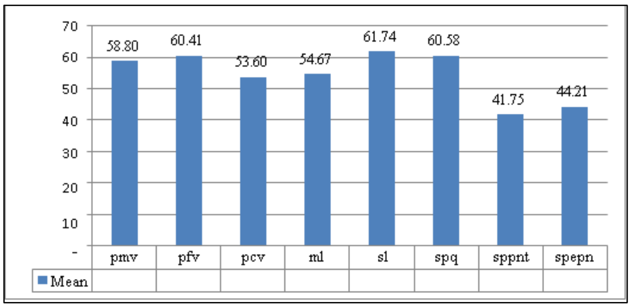


**Figure 1: The overall mean and SD values across domains.**

**pmv-Perception of male voice, pfv-perception of female voice, pcv-perception of children voice, ml-music listening, sl-sound localization, sp1-understanding of speech in quiet, spnnt-understanding of speech in noise with target and noise sources, spepn-understanding of speech in noise with target and noise sources spatially separate

*Perception of male voice*

The lowest mean values were observed when noise was behind (37.18±26.26). The highest mean values were found for front (64.43±30.40) and back (68.43±29.36) localization of male voices. In bimodal implanted children, the lowest mean values occurred for front localization with noise to the side (41.78±26.35), while the highest mean values were seen for localization from behind (83.21±15.64). Statistical tests did not reveal significant differences for any items in this domain.

*Perception of female voice*

The lowest mean values was for localization from the front with noise (37.81±28.282) and the highest mean values for localization from behind and front localization (67.81±29.94 and 62.56±31.11; respectively). Similarly, in bimodal implanted children, lowest mean values were observed for perception from the front with noise (45.71±27.44), while the highest mean values were seen for localization from behind (86.07±15.33). No statistically significant differences were found for any items in this domain.

*Perception of children's voice*

The lowest mean values was for perception with noise from behind (38.43±28.56) and highest mean values for localization from the front (57.18±31.77), as well as perception and localization from behind (56.56±29.19 and 56.25±26.92 respectively). In bimodal implanted children, lowest mean values were found for perception from the front with noise to the side (40.35±27.48), and highest mean values were seen for localization from behind (78.21±18.14). Statistical tests did not reveal significant differences in perception of children's voices, except for localization from behind, where a significant difference was found (t = -2.396, p = 0.023).

**Table 2: Mean values of unilateral and bimodal users for domain-male, female and children voices.**

| Category | Domain | Unilateral users (Mean+/-SD) | Bimodal users (Mean+/-SD) | Test statistic score | P value |
|---|---|---|---|---|---|
| Male | Man’s voice in quiet | 58.68±29.48 | 66.4±25.22 | -0.767 | 0.45 |
| | Man in front, noise behind | 37.18±26.265 | 51.0±24.82 | -1.482 | 0.15 |
| | Man in front, noise to side | 47.81±24.35 | 41.7±26.35 | 0.651 | 0.52 |
| | Location of man’s voice | 64.43±30.403 | 71.42±23.15 | -0.439 | 0.66 |
| | Location of man’s voice behind | 68.43±29.366 | 83.21±15.64 | -1.347 | 0.178 |
| Female | Woman’s voice in quiet | 61.25±28.431 | 68.92±23.71 | -0.796 | 0.432 |
| | Woman in front, noise behind | 37.81±28.282 | 51.78±25.16 | -1.421 | 0.166 |
| | Woman in front, noise to side | 49.68±25.130 | 45.71±27.44 | 0.414 | 0.682 |
| | Location of woman’s voice | 62.56±31.11 | 75.71±20.92 | -1.09 | 0.276 |
| | Location of woman’s voice behind | 67.81±29.94 | 86.07±15.33 | -1.93 | 0.054 |
| Children | Child’s voice in quiet | 56.2±26.92 | 55.35±28.24 | 0.089 | 0.93 |
| | Child in front, noise behind | 38.4±28.56 | 44.28±27.16 | -0.691 | 0.49 |
| | Child in front, noise to side | 42.5±25.36 | 40.35±27.48 | 0.222 | 0.826 |
| | Location of child’s voice | 57.1±31.77 | 69.28±25.70 | -0.794 | 0.427 |
| | Location of child’s voice, behind | 56.56±29.19 | 78.21±18.14 | -2.396 | 0.023 |

***Perception of music***

The mean values for unilateral implanted shown in table 3. It shows that mean values were lowest for perception of music with noise in front (35.62±18.87) and the highest mean values were seen for localisation of music from behind and localisation of music from front being; 64.37±29.82 and 60.93±28.23 respectively. Similar trend was observed in bimodal implanted children, it shows that mean values were lowest for question perception of music with noise in front(40.35±20.98), the highest mean values were seen for location of music placed behind (77.14±22.84). Statistical test did not show statistically significant difference for any of the 5 items listed under domain-perception of music listening.

**Table 3: Mean values of unilateral and bimodal users for domain-music listening.**

| Domain | Unilateral users (Mean±SD) | Bimodal users (Mean±SD) | Test statistic score | P value |
|---|---|---|---|---|
| **Music in quiet** | 57.81±26.954 | 61.07±27.04 | -0.33 | 0.744 |
| **Music and noise in front** | 35.6±18.874 | 40.35±20.98 | -0.65 | 0.521 |
| **Music in front, noise to side** | 42.18±22.28 | 42.85±24.62 | -0.23 | 0.818 |
| **Location of music** | 60.93±28.23 | 66.07±27.60 | -0.502 | 0.62 |
| **Location of music, behind** | 64.37±29.825 | 77.14±22.84 | -1.129 | 0.259 |

**Table 4: Mean values of unilateral and bimodal users for domain-sound localization.**

| Domain | Unilateral users | Bimodal users | Test statistic | P value |
|---|---|---|---|---|
| **Location of man's voice** | 64.43±30.40 | 71.42±23.15 | -0.439 | 0.66 |
| **Location of woman's voice** | 62.56±31.11 | 75.71±20.92 | -1.09 | 0.276 |
| **Location of child's voice** | 57.18±31.77 | 69.28±25.70 | -0.794 | 0.427 |
| **Location of music** | 60.93±28.23 | 66.07±27.60 | -0.502 | 0.62 |
| **Location of man's voice, behind** | 68.43±29.36 | 83.21±15.64 | -1.347 | 0.178 |
| **Location of woman's voice, behind** | 67.81±29.94 | 86.07±15.33 | -1.93 | 0.054 |
| **Location of child's voice, behind** | 56.56±29.19 | 78.21±18.14 | -2.396 | 0.023 |
| **Location of music, behind** | 64.37±29.82 | 77.14±22.84 | -1.129 | 0.259 |
| **Location of airplane** | 56.56±35.15 | 53.21±31.10 | 0.274 | 0.784 |
| **Direction of car** | 54.06±28.88 | 35.00±29.41 | 1.788 | 0.085 |
| **Movement of car** | 38.43±34.24 | 38.21±28.79 | 0.019 | 0.985 |
| **Distance of sound source** | 53.43±32.69 | 48.57±28.65 | -0.522 | 0.601 |

***Localization of sound***

The mean values of unilateral and bimodal users shown in Table 4. It shows that mean values were lowest for movement of car (38.43±34.24) and the highest mean values were seen for localization of man's voice, female's voice and music from behind; 68.43±29.36, 67.81±29.94, 64.37±29.82. Similarly for bimodal implanted children, it shows that mean values were lowest for direction of car (35.00±29.41) and the highest mean values were seen for localization of female's voice from behind (86.07±15.33). Statistical test did not show statistically significant difference for domain sound localization except for localization of children voice from behind.

***Speech perception in quiet, noise and in noise with target and noise sources spatially domain***

*Speech perception in quiet*

Table 5 shows that mean values were lowest for perception of children voice in quiet (56.25±26.92) and the highest mean values were seen for perception of women's voice in quiet (61.25±28.43). Similar trend was observed in bimodal implanted children, it shows that mean values were lowest for perception of children voice in quiet being (55.35±28.24) and the highest mean values were seen for perception of children voice in quiet (68.92±23.71). Statistical test did not show statistically significant difference for any of the 4 items listed under domain-speech perception in quiet.

*Speech perception in noise*

Mean values were lowest for perception of music with noise in front (35.62±18.87) and the highest mean values were seen for perception of children voice with noise from behind (38.43±28.56). Similar trend was observed in bimodal implanted children, it shows that mean values were lowest for perception of music with noise in front (40.35±20.98) and the highest mean values were seen for perception of women's voice with noise in behind (51.78±25.16). Statistical tests did not show statistically significant difference for any of the 4 items listed under domain-speech perception in noise with target domain

*Speech perception in noise with target and noise sources spatially domain*

The mean values shows that mean values were lowest for perception of music in front with noise in side (42.18±22.28) and the highest mean values were seen for perception of women's voice with noise in side (49.68±25.13). Similarly for bimodal implanted children, it shows that mean values were lowest for perception of children voice from front with noise in side (40.35±27.48) and the highest mean values were seen for perception of women's voice with noise inside (45.71±27.44). Statistical test did not show statistically significant difference for any of the 4 items listed under domain-speech perception in noise with target and noise sources spatially domain.

**Table 5: Mean values of unilateral and bimodal users for domain -speech perception in quiet, noise and in noise with target and noise sources spatially domain.**

| Domain | Unilateral users (Mean±SD) | Bimodal users (Mean±SD) | Test statistic | P value |
|---|---|---|---|---|
| **Man's voice in quiet** | 58.68±29.48 | 66.42±25.22 | -0.767 | 0.45 |
| **Woman's voice in quiet** | 61.2±28.43 | 68.92±23.71 | -0.796 | 0.432 |
| **Child's voice in quiet** | 56.2±26.92 | 55.3±28.24 | 0.089 | 0.93 |
| **Music in quiet** | 57.81±26.95 | 61.07±27.04 | -0.33 | 0.744 |
| **Man in front, noise behind** | 37.18±26.26 | 51.07±24.82 | -1.482 | 0.15 |
| **Woman in front, noise behind** | 37.81±28.28 | 51.78±25.16 | -1.421 | 0.166 |
| **Child in front, noise behind** | 38.43±28.56 | 44.28±27.16 | -0.691 | 0.49 |
| **Music and noise in front** | 35.62±18.87 | 40.35±20.98 | -0.65 | 0.521 |
| **Man in front, noise to side** | 47.81±24.35 | 41.78±26.35 | 0.651 | 0.52 |
| **Woman in front, noise to side** | 49.68±25.13 | 45.71±27.44 | 0.414 | 0.682 |
| **Child in front, noise to side** | 42.50±25.36 | 40.35±27.48 | 0.222 | 0.826 |
| **Music in front, noise to side** | 42.18±22.28 | 42.85±24.62 | -0.23 | 0.818 |

## DISCUSSION

The aim of our study is to compare the spatial hearing abilities of children who are implanted with bimodal and unilateral cochlear implants through a parental interview using spatial hearing questionnaire.[14]

In our study the overall scores of spatial hearing questionnaire revealed that there was no significant difference across domains between bimodal and unilateral cochlear implanted children. The study done by Perreau et al on population of various cochlear implant profiles including unilateral, bimodal, short electrode, bilateral cochlear implanted adults reported that significant difference was observed onSHQ, between bilateral implantee and unilateral implantee.[2] However, such significant difference was not seen between Bimodal and unilateral implantees on SHQ.

The reported scores on speech subscales i.e. speech in quiet, speech in noise with target and noise sources, speech in noise with target and noise source spatially separate showed that there was no significant difference observed between bimodal and unilateral implanted subjects which occurred in congruence with the our present study.

Across bilateral and unilateral cochlear implant users in SHQ, the highest means core was reported for the question no.18 which is available in the perception of female voice subscale and localization subscale for bimodal users (86.07±15.33) and for the question no.17 which is available in the perception of male voices and localization in unilateral users. The lowest mean scores across SHQ questionnaire was reported in question no.22 of localization subscale in (35.00±29.41) whereas the highest mean value was found to be in the subscale of speech in quiet with approximately 78% for unilateral implantees and around 82-84% for bimodal implantees and highest mean scores are reported for subscale of sound localization ranging around 35-38% for both unilateral implantees and bimodal implantees by Perreau et al. In the current study only the question no.19 from the perception of children voices had significant difference between groups p<0.05.

Music perception in study by Perreau et al also showed that there was no significant difference reported which also supports our study results.[2] This study implicated that users had fair experience in using both bimodal and unilateral devices, showed that no significant difference observed and adds supports our study.

In contrast, the study done by Erdem et al using SSQ questionnaire, which consists of 3 scales: speech, spatial and other qualities of hearing.[15] Speech scale comprised 14 questions, spatial scales comprises 17 questions and qualities scale comprises 18 questions. It compared the results between bilateral, bimodal and unilateral cochlear implants, revealed that bilateral cochlear implantees performed better than unilateral and bimodal cochlear implants. Among this, Bimodal users scored high than unilateral cochlear implanted subjects under all the 3 subscales of SSQ and overall SSQ. In the spatial domain the mean score for unilateral implanted users is 3.93 and 6.95 for bimodal users, it showed significant statistical difference whereas in our study the mean scores of unilateral and bimodal users were 52.91and 58.00, but no significant statistical difference found.

This study has some limitations. Unequal sample size between both groups of bimodal and unilateral cochlear implant users and subjective score had not been correlated with objective method of testing.

## CONCLUSION

The aim of the current study was to compare spatial hearing abilities among population of children between the age range of 5-10 years using spatial hearing questionnaire (SHQ) through telephonic interview. A total of 30 participants (parents of cochlear implanted children) were included in the study, among which 16 participants were parents of children using unilateral cochlear implant and 14 were parents of children using bimodal cochlear implant. The inclusion criteria consisted of parents of children with age range between 5-10 years and a child who had been attending AVT therapy or have attended AVT therapy for at least 2 calendar ears. The responses rated by parents of the cochlear implantees in a telephonic interview were recorded. Initially demographic data was collected followed by collecting responses for 24 questions of spatial hearing questionnaire (SHQ) under eight domains. The eight domains include perception of male's voices perception of female's voice, perception of children voice, music, sound localization, understanding of speech in quiet understanding of speech in noise with target and noise sources, understanding of speech in noise with target and noise sources spatially separately.

The question with the highest mean score for both unilateral and bilateral cochlear implant users in the SHQ was Q.18, localization of women voice from behind available under perception of female voice and localization subscales for bimodal users (86.07±15.33), also Q.17, localization of man's voice from behind which is available in the perception of male voices and localization for unilateral users. Q.22, direction car under localization subscale in (35.00±29.41) had the lowest mean scores across the SHQ questionnaire. Only Q.19, localization of child's voice from behind under domain perception of children voice showed significant difference between unilateral and bimodal groups ($p<0.05$). Across the 8 domains of spatial hearing questionnaire there were no significant statistical difference found between unilateral and bimodal cochlear implanted groups.

### *Recommendations*

Though in literature, subjective and objective approaches were reported, among them the spatial hearing questionnaire (SHQ) seem to be a quicker method than the speech, spatial, and hearing scale (SSQ) scale. The SHQ questionnaire is comprised of only 24 questions which solely focuses on spatial hearing abilities. These studies on spatial hearing using SHQ explored on normal hearing, various cochlear profiles among the population of adults and no studies reported on population of children using SHQ. The present study would act as a profile of spatial hearing abilities among children using bimodal and unilateral cochlear implant and established a baseline for the researchers. This study would be benchmark for enhancing future studies on spatial hearing among various test population in different age groups.

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