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Assessment of binocular vision in kids with hearing loss

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Abstract
Background: Hearing is the ability to perceive sound. A person is said to have hearing loss when he/she is not able to hear as well as someone with a normal hearing threshold of 25 dB or better in both ears. Binocular function plays an important role as it helps to coordinate both eyes.
Methodology: A prospective study was conducted with 103 subjects. After taking permission authority and Hearing impairment school, consent was taken from participants. The comprehensive evaluation included demographic data, history of hearing impairment, refraction. Then binocular vision assessment (sensory, motor, accommodative, vergence tests) was done.
Results: 103 children with a mean age of 14.36±3.07years were included in the study. 54% had a severe hearing impairment and 46% of children had a profound hearing impairment. 9.7% refractive error among hearing- impaired children. Myopia is 4%. Hyperopia is 1% and Astigmatism is 5%. NSBVA was found around 49% among HI children. Convergence excesses 20.4%, Convergence insufficiency 3.9%, Divergence excess 1%, Divergence Insufficiency 3.9%. Accommodative insufficiency 5.8% and Accommodative excess 13.6%.
Conclusion: Non-strabismus binocular vision anomalies among profound and severe hearing-impaired subjects. So, it is important to consider binocular evaluation among hearing-impaired subjects.

Keywords: Hearing impairment, binocular vision, refractive error, NSBVA

Introduction

Hearing Ability

Hearing impairment is a significant health problem that majorly affects a person's quality of life [1-2]. The prevalence of hearing impairment has been reported from 1.4% in children aged 5-14 years to 9.8% in those who are 14 years old [3]. During embryonic development, the retina and cochlea develop from the same embryonic layer. Hence the occurrence of unlaudatory syndrome is more in hearing-impaired patients like retinitis pigmentosa, heterochromia iridium, and retinopathy along with the increased prevalence of refractive errors.

Eye screening is very important for the early detection of visual problems in deaf children because most of the knowledge is through a sense of sight and hearing, though some knowledge is obtained through tactile, olfactory, and kinesthetic senses. Hence early detection and diagnosis are the crucial aspects for social and professional adjustment of hearing-impaired patients [4, 5]. The study suggests that the possibility of ophthalmological abnormalities in hearing children ranges from 17% to 30% whereas in deaf children it ranges from 44% to 65% [4, 6-9]. Whereas previous studies also said that, the prevalence of visual disorder in the deaf population is up to 60% [10-13].

Therefore, vision is one of the important senses which has a significant role in communication in deaf people. Visual disorders with hearing impairment can negatively impact their life [10-14].

The studies have shown that refractive errors, stereopsis, amblyopia, strabismus, and reduced vision are among the most important visual disorders in the deaf [12, 14-16].

In a study done by Hadi *et al* [7], the prevalence of refractive error is high in deaf children along with that amblyopia and strabismus found in deaf children [17]. Another study was done by Richard Hollingsworth *et al*, [18] found refractive error, color vision defect, reduced stereopsis, and binocular vision anomalies in hearing impairment children [18].

Even the study done by Parikshit *et al*, [19] found refractive error, strabismus, and retinal pigmentary dystrophy in hearing-impaired children [19]. Another study was done by Bist J *et al*, [20] had been reported refractive error, strabismus, amblyopia, and convergence insufficiency in hearing-impaired children [20]. Binocular vision disorders are the second most common visual disorder in the pediatric population next to refractive error. Non-Strabismic Binocular Vision Anomalies mostly affect the binocularity, clarity, visual performance, and efficiency of the patient. The major part of the child's education involves learning through reading and using gadgets that involve both accommodative and vergence mechanisms and imbalance between sensory-motor function results in binocular anomalies [21, 22]. The previous studies done on hearing-impaired children showed a reduction in normative parameters of stereopsis, color vision, ocular motility, and cover tests. The current study has included all binocular vision tests like sensory, motor, accommodative, and vergence. Hence this study setup was planned to find out the prevalence of Non- Strabismic Binocular Vision Anomalies in children with hearing impairment.

Methodology

The prospective study started with taking permission from the respective hearing impairment school and fixed the date for evaluation after that every child was informed about the purpose and procedure of the study. The study was conducted among hearing-impaired children in Ramaya Institute for the deaf from December 2019 to 2020. Children were included in this study based on the inclusion and exclusion criteria of the study. Hearing-impaired students age ranges 8-20 years were included in the study. Lack of test co-operation, visual acuity less than 0.5 log MAR, and those who have not heard threshold value record were excluded from the study. Demographic data were recorded; participants' brief ocular history was taken that included a history of any ocular examination optical correction and ocular injuries. Hearing impairment history was also taken (acquired or congenital hearing loss, family history of hearing disorder, threshold of hearing impairment through medical record). The severity of hearing impairment was classified as slight (26-40 dB), moderate (41-60 d), severe (61-80 dB), profound (81 dB or >) [23]. The screening included vision and refraction [subjective and objective], Sensory evaluation, Motor evaluation, Accommodative test & Vergence test. The examination was performed in the schoolroom with proper illumination. The examination included Visual acuity with log MAR chart at 4 meters, near vision using Snellen near vision acuity chart at 40 cm. non-cycloplegic refraction was done followed by sensory tests like stereopsis, W4DT, color vision test using Ishihara color vision chart. Motor tests (Cover test, modified Torrington, AC/a ratio), accommodative tests (near the point of accommodation, monocular estimation method retinoscopy, accommodative facility, negative relative accommodation, and positive relative accommodation.) and vergence tests (near the point of convergence, negative fusional vergence, positive fusional vergence, and vergence facility) were performed.

Data were analyzed with SPSS. The data were analyzed using the statistical package SPSS software version 2.1. Independent t-test formula and chi-square were used as a part of statistical analysis.

Result

Among a total of 107 children screened, 4 were excluded. 103 subjects with a mean age of 14.36 ± 3.07years were included in the study. Among them, 40.77% were females, and 59.22% were males.

A total of 54% were found to have a severe hearing impairment (HI) and 46% had a profound hearing impairment. 46% of subjects with hearing impairment had a positive history of consanguinity. 90% of subjects had no refractive errors and 5% were Astigmatic, 4% Myopes, and 1% Hyperopic.

Severe and profound HI had a normal range of lag of accommodation where the *p*-value on comparison showed 0.59 and 0.53 for OD and OS respectively. The mean value of AC/A ratio in severe and profound HI was 2.16 and 2.00 which fell under the normal range.

Table 1: Comparison of NPA among children with severe and profound HI:

S. no	Test	Hearing impairment	Mean ± SD	*p*-value
1	NPA-OD	Severe	7.21±2.59	0.60
	NPA-OD	Profound	6.97±2.04	
2	NPA-OS	Severe	6.96±2.46	0.44
	NPA-OS	Profound	6.64±1.58	
3	NPA-OU	Severe	6.62±1.67	0.95
	NPA-OU	Profound	6.64±1.58	

Table 2: Comparison of MEM among children with severe and profound HI

S. no	Test	Hearing impairment	Mean ± SD	*p*-value
1	MEM-OD	Severe	0.58±0.58	0.59
	MEM-OD	Profound	0.51±0.73	
2	MEM-OS	Severe	0.61±0.59	0.53
	MEM-OS	Profound	0.53±0.77	

When compared between severe and profound HI, there was no statistically significant difference in NPA (table 1). The response of accommodation did not show a statistically significant difference when compared between severe and profound HI (Table 2).

Table 3: Comparison of NRA and PRA among children with severe and profound HI

S. no	Test	Hearing impairment	Mean ± SD	*p*-value
1	NRA	Severe	2.82±0.71	0.23
	NRA	Profound	3.00±0.76	
2	PRA	Severe	-2.83±0.31	0.20
	PRA	Profound	-2.87±0.36	

Table 4: Comparison of AF among children with severe and profound HI

S. no	Test	Hearing impairment	Mean (±)	*p*-value
1	AF-OD	Severe	14.08±3.69	0.37
	AF-OD	Profound	13.44±3.47	
2	AF-OS	Severe	13.89±3.40	0.29
	AF-OS	Profound	13.09±4.23	
3	AF-OU	Severe	14.94±3.62	0.55
	AF-OU	Profound	14.46±4.45	

NRA and PRA values did not show any statistically significant difference when the values were compared

between subjects with severe and profound HI (Table 3). Similarly, binocular and monocular AF also did not show any significant difference when compared between subjects with severe and profound HI (Table 4).

Table 5: Comparison between NPC among children with Severe and Profound hearing impairment

S. no	Test	Hearing impairment	Mean (±)	*p*-value
1	NPC-BREAK	Severe	4.87±1.13	0.94
	NPC-BREAK	Profound	4.88±1.08	
2	NPC-REC	Severe	6.72±1.69	0.37
	NPC-REC	Profound	7.02±1.69	

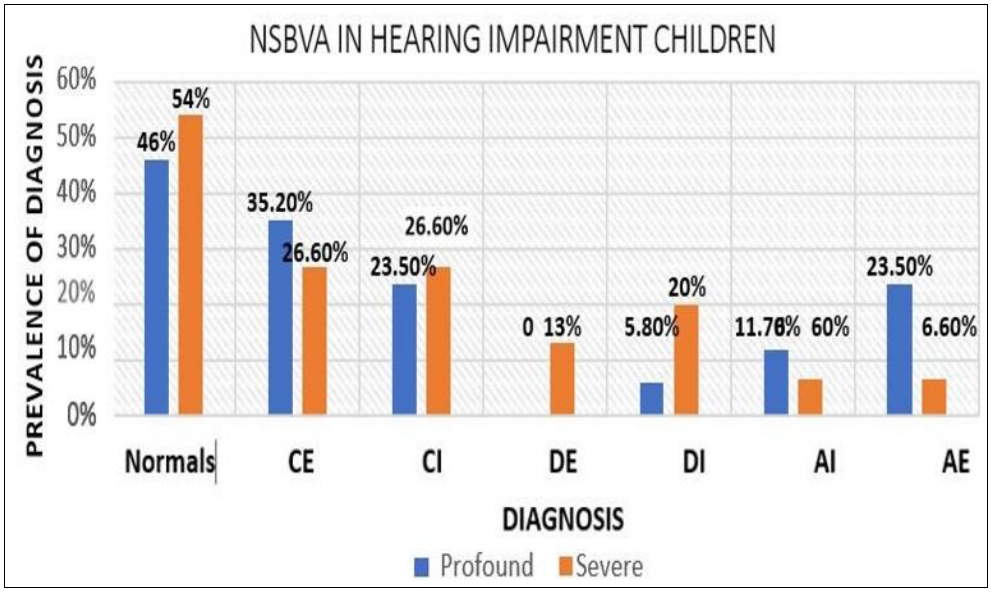
Table 6: NFV Distance and near among children with severe and profound HI

S. no	Test	Hearing impairment	Mean ± SD	*p*-value
1	NFV-BRK-D	Severe	10.55±3.99	0.20
	NFV-BRK-D	Profound	11.59±4.32	
2	NFV-REC-D	Severe	8.26±4.09	0.36
	NFV-REC-D	Profound	9.02±4.23	
3	NFV-BRK-N	Severe	12.96±4.88	0.26
	NFV-BRK-N	Profound	14.02±4.69	
4	NFV-REC-N	Severe	9.60±4.40	0.14
	NFV-REC-N	Profound	10.85±4.03	

Table 7: PFV for distance and near among children with severe and profound HI

S. no	Test	Hearing impairment	Mean ± SD	*p*-value
1	PFV-BRK-D	Severe	18.85±6.18	0.93
	PFV-BRK-D	Profound	18.97±6.15	
2	PFV-REC-D	Severe	15.51±5.16	0.99
	PFV-REC-D	Profound	15.51±5.59	
3	PFV-BRK-N	Severe	24.50±14.84	0.92
	PFV-BRK-N	Profound	16.67±5.59	
4	PFV-REC-N	Severe	17.52±6.23	0.72
	PFV-REC-N	Profound	16.62±5.23	

There was no statistically significant difference in NPC break and recovery, NFV break (distance and near), and PFV break (distance and near) values when compared between the children with severe and profound HI (Table 5-7).



Graph 1: Prevalence of NSBVA among children with severe and profound HI

The current study shows 30.7% have NSBVA (Non-Strabismic Binocular Vision Anomalies) among children with severe and profound hearing-impairment children which were found to be the same in comparison with young adults [24]. A total of 54.1% and 45.8% did not have NSBVA among the severe and profound groups. Convergence excess was found to be the most prevalent condition among children with both severe and profound HI with a prevalence rate of 26.6% and 35.2% respectively which was followed by convergence insufficiency. 26.6% and 23.5% of children from severe and profound HI groups were found to have convergence insufficiency. Accommodation insufficiency and excess were least prevalent among children with severe HI whereas divergence insufficiency

and excess were least prevalent among children with profound HI (graph 1).

Discussion

Hearing is important in human life. Hearing empowers us and helps us lead our everyday lives without any limitations. The study has shown that hearing impairment has an impact on vision. In a study done by SIRAJ ZAKZOUK in 2002, the prevalence of hereditary sensor neural hearing loss was 66.07% [23]. Hearing impairment can be congenital or hereditary. Congenital sensor neural hearing impairment may have User's Syndrome which is associated with retinitis pigmentosa.

Consanguinity

Consanguineous marriage is traditional which is practiced among, Asians, Africans, and Latin Americans. The siblings of consanguineous marriages have a significantly higher incidence of autosomal recessive diseases including hearing impairment. A current survey was done by TAREK S JAMAL *et al* in Saudi among 9540 children, 46% of a positive history of consanguinity, whereas even in the current study similarly there is 46% positive history of consanguineous marriage which shows a lack of awareness about consanguineous marriage [25]. The study can be conducted to create awareness about consanguineous marriage with systemic and ocular effect

Hearing Impairment

In the current study, we included severe and profound hearing-impaired children where severe hearing impairment is 54% and profound hearing impairment is 46%. A study by M. ARMITAGE *et al* on Visual impairment in severe and profound sensorineural deafness considered that severity of hearing loss is directly proportional to visual impairment [26].

Refractive Error

A study done by BAKSHEE *et al*, found that refractive error most common ocular problem in deaf [11]. The current study found the prevalence of refractive error is 9.7% which is supported by NIRANJAN *et al* [27] (7.2%). Although PARIKSHIT *et al* found an 18.53% of the high prevalence of refractive error among hearing- impaired children [19]. Also, most of the studies show Hyperopia is the most common refractive error among hearing-impaired children. A study done by HADI *et al*, SEBNEM *et al* found hyperopia is most common in the deaf [17, 28]. This is a contraindicating current study where astigmatism (5%) and myopia (4%) are seen in hearing- impaired children and hyperopia is only 1%. RAID M *et al*, Myopia is most common because of a lack of awareness of early ocular examination in children with hearing impairment [29].

Strabismus, Stereopsis and Color Vision

In a study done by J BIST P *et al* in 2010, out of 279 students, 15 subjects (5.37%) were found to have strabismus in the cover test [20]. A study done by SEBNEM *et al* in 2003, included 104 subjects (7-20) years, 42 children have an ophthalmic defect [28]. Out of which 18.2% have strabismus, 56 have normal stereopsis, 25% have reduced stereopsis and 6.8% have an absence of stereopsis. A study done by RICHARD *et al* found 32% of reduced stereopsis. Similarly, color vision deficiency was present in 6(5.8%) [18]. NIRANJAN k *et al* found strabismus 2% [27]. Whereas these results contradict the current study. As all Hearing-Impaired children in the current study are trichromatic with normal stereopsis, color vision & EOM. The previous study found strabismus among hearing-impaired children that could be the reason for stereopsis also affected among them whereas in the current study none of the children have strabismus so stereopsis is also normal and none of the subjects have amblyopia.

NSBVA

46.82%Severe Hearing-impaired children & 53.12% of profound hearing-impaired children have NSBVA. Convergence insufficiency and Convergence Excess and accommodative excess is common among severe and profound hearing impairment children. None of the research has considered only NSBVA although previous studies have shown strabismic binocular vision anomalies among hearing-impaired children. Only J BIST P *et al* found Convergence insufficiency in 2 subjects [20]. Whereas in the current study we found Convergence insufficiency among 4 subjects (3.9%). The current study indicates the more occurrence of convergence excess and accommodative excess in hearing-impaired children because school-going children are more involved in reading and even the children of today's era involve in using gadgets rather than playing outside so that accommodative and vergence demand is more in those children leading to a non-strabismic binocular vision disorder.

Binocular vision is very important in human life. Binocular Vision helps with depth perception, enabling the judgment of distance, widens the field of view, and removes the effect of the blind spot. The current study shows NSBVA among hearing-impaired children. Hence it is necessary to provide vision therapy to those children to improve their quality of life. Special attention should be given regarding awareness of NSBVA among hearing- impaired children. The study can be to understand NSBVA and its impact on quality of life among hearing- impaired children.

Conclusion

The current study found severe hearing impairment (54%) is more compared with profound hearing impairment (45.8%). 9.7% of hearing-impaired children have a refractive error. 30.7% of hearing-impaired children have Non-Strabismic Binocular Vision Disorder. NSBVA is found in children with profound hearing impairment (35.2% Convergence Excess, 23.5% convergence insufficiency) compared with children with severe hearing impairment. (26.6% Convergence excess, 26.6%convergence insufficiency and 23.5% accommodative access) So, it is important to consider binocular function in subjects with hearing impairment.

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