Original Article

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Effect of Consanguinity on the Audio Profile of Non Syndromic Sensorineural Hearing Impaired Children: A Cross-sectional Study

Ear, Nose and Throat Section

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ABSTRACT

Introduction: The incidence of bilateral sensorineural hearing loss is quite notable in live births worldwide. Among the aetiologies, the primary aetiology is thought to be genetic, followed by non heritable and unknown.

Aim: To study the effect of consanguinity on audiological profile in children presented with non syndromic sensorineural hearing loss.

Materials and Methods: This cross-sectional study was conducted in the Department of Ear, Nose and Throat, McGANN Teaching District Hospital (Shimoga Institute of Medical Sciences), Shivamogga, Karnataka, India, from January 2019 to December 2020, among 95 children with non syndromic sensorineural hearing loss. A Pure Tone Audiometry (PTA) test was done for each patient both air conduction and bone conduction thresholds were tested using different transducers. An audiogram was collected and the degree of hearing loss of each patient was analysed. Statistical tests were performed using Statistical Package for Social Sciences (SPSS) version 34.0, Kruskal-Wallis test, one-way Analysis of Variance (ANOVA) was used for comparing the difference in PTA followed by the Mann-Whitney U test.

Results: The mean age of the study population was 9.7 years; 39 subjects were female and 56 were male. The PTA among the study population showed asymmetric audiograms in 17 (17.9%) children. A majority 60 (63.1%) of the participants were born out of consanguineous marriage. Total 80 (84.2%) children had bilateral hearing loss, among which 58 (72.5%) were cases of bilateral profound. One-way ANOVA showed that there was an overall significant difference between the consanguinity and non consanguinity groups and post-hoc analysis with the Mann-Whitney U test revealed a significant difference between the different degrees of consanguineous marriage.

Conclusion: Consanguinity affects the audio profile (PTA) among the non syndromic hearing impaired children.

Keywords: Audiogram, Bilateral hearing loss, Pure tone audiometry

INTRODUCTION

Sensorineural hearing loss very common type of permanent loss of hearing becoming an important cause of disability in childhood. Studies from outside India have shown a 1-2 per thousand children had permanent hearing loss [1,2]. In a study done by Bhatia in urban Lucknow, six among 1332 children were found with perceptive deafness [3]. Hearing disability census in 2011 India showed that 2.4 per 1000 below the age of 10 years [4]. Share of the disabled population in Karnataka (India, 2018) showed that hearing, disability among males was 0.3%, and females were 0.4% [5].

Hearing disability suggests a loss in hearing greater than 35 decibels (dB) in the better hearing ear for children. Hearing loss may vary from severe to profound and may be presented in unilateral or bilateral forms. Although, there are several factors encountered with hearing loss, the most researched topic is the genetic factor as revealed by the consanguinity of the parents.

A gold standard for the assessment of deafness is Pure Tone Audiometry (PTA). Depending upon the range of hearing loss, the result is interpreted as mild, moderate, severe to profound [6]. Further, studies from the Arabian Gulf countries and eastern Mediterranean countries showed that a higher prevalence of consanguinity (54%), had a higher risk for diseases such as hearing loss [7,8]. Similarly, children born out of consanguinity have three times more likelihood of developing permanent deafness. The second-degree parents have three times the chances, and the third-degree has two times the chances of hearing disability [9]. Hence, the study aimed to find an association between the audiological profiles among different degrees of consanguinity in children presented with non syndromic sensorineural hearing loss.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Ear, Nose and Throat, McGANN Teaching District Hospital (Shimoga Institute of Medical Sciences), Shivamogga, Karnataka, India, from January 2019 to December 2020. Approval of the study was obtained from the Institutional Ethical Clearance (IEC) board (SIMS/IEC/214/2015-16). Screening for non syndromic congenital Sensorineural Hearing Loss (SNHL) for GJB2 mutations was conducted as a part of the study approved by the RGUHS and the audiological report was used for this paper. Children from Taranga School for Hearing Impaired (Shimoga and Bhadravathi taluk) and Mother Teresa Residential School for Hearing Impaired, (Bhadravathi taluk) were included in this study (after obtaining permission from the concerned authority and permission from the parent of/guardian), along with the subjects from the outpatient department of the study institute. Informed consent was obtained from each subject in the format approved by the IEC board.

Inclusion criteria: Screened of 95 unrelated subjects, within the age of 17 years of both gender were included in this study.

Exclusion criteria: Patients who had conductive hearing loss, syndromic hearing loss, had taken ototoxic drugs, history of otorrhea, head trauma, meningitis, Neonatal Intensive Care Unit (NICU) admissions, kernicterus, any other perinatal pathology, maternal complications during pregnancy, or history of maternal consumption of ototoxic drugs during pregnancy; or any other known causes of hearing loss were not included in this study.

Study Procedure

The audiological assessment was carried out in a special sound treated room by an audiologist using a diagnostic

audiometer (inner acoustic AD629). A PTA test was done using different transducers. Air conduction thresholds were tested using headphones (Sennheisers HD 300 supra-aural headphones) and bone conduction thresholds were tested using a bone vibrator (Radio ear B-71 w). Patients were instructed to press the patient response switch button whenever a sound was heard, they were expected to respond even to the mildest sound heard by them. The minimum level at which patients responded was taken as their threshold, a whole assessment was carried out using a standardised threshold estimation method. Patient responses were plotted on graphical representation on an audiogram, tested frequencies for air conduction were 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, and 8 kHz and bone conduction thresholds were tested at 250 Hz, 500 Hz,1 kHz, 2 kHz, and 4 kHz.

The PTA tests were conducted binaurally for each patient. Based on air conduction and bone conduction thresholds Air-Bone Gap (ABG) could be determined. ABG is the difference between air conduction and bone conduction thresholds, their gap is essential to determine the type of hearing loss.

The type of hearing loss could be conductive, sensorineural and mixed. In conductive hearing loss (air-bone gap would be greater than 10-15 dB). In the sensorineural hearing loss, the ABG would be within 5 dB and in mixed hearing loss both groups will dip below normal levels and the ABG would be more than 10-15 dB [10]. In the present study, patients with conductive and mixed types of hearing loss were ruled out. Patients with pure sensorineural type were selected. A pattern of audiograms was determined based on standard protocol and classifications. The degree of hearing loss was measured based on the mean average of a threshold at 500 Hz,1 kHz, 2 kHz and 4 kHz. Mean values were considered as pure tone audiometry thresholds and Goodman's classification was followed to finalise the degree of hearing loss of each patient [11].

The subjects were grouped as:

- Group I with first-degree consanguinity
- Group II with second-degree consanguinity
- Group III with third-degree consanguinity
- Group IV with no consanguinity

STATISTICAL ANALYSIS

The descriptive data was entered in excel and Statistical Package for Social Sciences (SPSS) version 34.0 was used for statistical evaluation. The test of normality for PTA values was evaluated using the Kolmogorov-Smirnov test of normality. The result of the Kolmogorov-Smirnov test statistic showed that the PTA values were not normally distributed between the groups, so Kruskal-Wallis one-way Analysis of Variance (ANOVA) test opted for comparison followed by the Mann-Whitney U test. A p-value <0.05 was considered significant.

RESULTS

The mean age of the study population was 9.7 years. There were 39 females and 56 males [Table/Fig-1]. Among the 95 subjects, 60 were born out of consanguineous marriage. Out of those 60 children nine had family history of deafness, while five in the non consanguineous group had a positive history. Overall, 82.1% of the subjects showed asymmetric type of audiogram [Table/Fig-2]. Bilateral type of hearing loss was highest among the group I (first-degree), followed by group III (third-degree) and group II (second-degree) [Table/Fig-3]. Among the children born out of consanguineous marriage (group IV), unilateral deafness was the least. Whereas the children born out of non consanguineous marriage, bilateral deafness was more than unilateral deafness as shown in [Table/Fig-3].

The comparison conducted to examine the difference in PTA according to the type of marriage involved is depicted in [Table/Fig-4,6]. It was observed that the median PTA values among the consanguineous groups were high when compared to the non-consanguineous group (group IV) in both the ear, as shown in [Table/Fig-4], and there was a statistically significant difference, as shown in [Table/Fig-5,6].

Group	Total		Female		Male	
	n	Mean age (year)	n	Mean age (year)	n	Mean age (year)
I	39	9.76	16	9.37	23	10.04
II	5	8	2	7	3	8.6
III	16	10.8	4	9.25	12	11.42
IV	35	10.25	17	10.14	18	10.33

[Table/Fig-1]: Gender distribution and mean age of the participants.

	Group I n (%)	Group II n (%)	Group III n (%)	Group IV n (%)	Total
Symmetric	35 (44.9)	5 (6.4)	15 (19.2)	23 (29.5)	78
Asymmetric	4 (23.5)	-	1 (6)	12 (70.5)	17

[Table/Fig-2]: Audiogram distribution among different consanguinity groups.

Hearing loss	Group I n (%)	Group II n (%)	Group III n (%)	Group IV n (%)
Bilateral (n=80)	37 (38.94)	5 (5.26)	16 (16.83)	22 (23.15)
Unilateral (n=15)	2 (2.10)	-	-	13 (13.68)

[Table/Fig-3]: Configuration of hearing loss.

Groups (n)	Left ear		Right ear	
	Median	IQR	Median	IQR
I (39)	100	22.5	100	27.5
II (5)	100	27.5	100	35.62
III (16)	100	1.875	100	0
IV (35)	65	68.75	72.5	66.25

[Table/Fig-4]: Descriptive statistics of PTA values.
IQR: Inter quartile range

Statistics	I vs IV	II vs IV	III vs IV	I vs II	I vs III	II vs III
U	476.5	66	120	93	184.5	23.5
Z	2.22	-0.8588	-3.2378	0.14792	-2.3535	1.32116
p-value	<0.05	0.39	<0.05	0.88	<0.05	0.19

[Table/Fig-5]: Comparison with respect to consanguinity and right ear PTA values (N=95).
U=Mann-Whitney U statistics, Z=Z Statistics

Statistics	I vs IV	II vs IV	III vs IV	I vs II	I vs III	II vs III
U	442	58.5	97	97.5	162	20.5
Z	2.598	-1.166	-3.705	0.018	-2.77	1.157
p-value	<0.05	0.24	<0.05	0.98	<0.05	0.12

[Table/Fig-6]: Comparison with respect to consanguinity and left ear PTA values (N=95).
U=Mann-Whitney U statistics, Z=Z Statistics

DISCUSSION

The primary purpose of the study was to find the distribution of hearing loss based on the audiogram and consanguinity among non syndromic sensorineural hearing loss children. It was found that consanguinity did affect the audio profile among the non syndromic hearing impaired children.

As studies have revealed that a major share of hearing loss in children is attributed to a hereditary cause and nearly 70% of them are non syndromic [12-17]. Further consanguineous marriage is known to be the cause of intensification of any hereditary diseases, and so is in the case of nodular sclerosis hodgkin lymphoma. Consanguineous marriage is one of the most types of marriage in southern India (the index study location) [18]. This tradition is also common among the Saudi and Pakistani communities [19,20].

Similar to the present study, Padma G et al., from Hyderabad had worked on subjects with profound sensorineural hearing loss, had reported 54.1% of consanguineous marriages [21]. Also a study conducted in rural Pakistan on paediatric hearing loss, reported that in the population with severe hearing loss, 70% were the outcome of consanguineous marriages [22]. Hence, high prevalence of consanguinity causes higher rates of deafness.

When the participants were divided according to the laterality of hearing loss, it was found that among the study population, bilateral hearing loss was seen in 61.05% subjects [Table/Fig-3]. A similar incident was reported from the Rehabilitation Deputy of the welfare organisation of Iran- the bilateral configuration of hearing loss was 62.9% among those born out of consanguineous marriage [23]. The high prevalence of bilateral hearing loss among the children born out of consanguineous marriage has to be explored. In several studies, on consanguinity in samples of varied ethnicity-Turkish, Iranian and Tunish-it was found that mutations in COL11A2 cause autosomal recessive non syndromic hearing loss. Further, hearing loss caused by this mutation was of profound type with prelingual hearing loss onset [24,25]. In a study by Sloan-Heggen CM et al., on the spectrum of autosomal recessive hereditary hearing loss in Iran, it was found that hearing loss was severe-to-profound in 85% of probands, moderate-to-severe in 14% and mild-to-moderate in 1% [25]. In a study done by Debnath TK et al., to find out the frequency of consanguinity and positive family history of hearing impairment among deaf children in a deaf school in Bangladesh, it was found that 90.0% of children with deafness showed bilateral profound hearing loss and 20.0% had bilateral severe hearing loss. Overall, 82% were with bilateral sensorineural and 18% were bilateral mixed type deafness [26]. These results are similar to the present study findings.

Not many studies have been published on the incidence of bilateral hearing loss based on the consanguinity of marriage. In a study by Jamal TS et al., in a Saudi population, it was revealed that the level of hearing impairment was higher in siblings whose parents had consanguineous marriages [27]. In the present study, there was a significant difference in the scores for consanguineous and non consanguineous instances. It was observed that the median values of PTA were higher in the consanguineous group than in the non consanguineous group. Observational studies have ascertained that consanguinity is a factor in the occurrence of hearing loss. The lower the degree of consanguinity higher is the susceptibility to hearing loss [9]. In this study, it was seen that the difference in PTA with respect to the type of marriage existed between the degree and non consanguineous type of marriage. This shows that the selected population did account for the effect of PTA with the degree of consanguinity, which implies that the cause of hearing loss remains determined with the PTA testing.

Limitation(s)

This was a cross-sectional study. The sample size among the second degree of consanguineous marriage was less. Hence, the approximation to the form of the normal distribution becomes less robust at sample sizes smaller than 10, so no significant difference was formed when the results of other groups were compared with this group. So, it is strongly recommended to conduct a study of this nature on a bigger groups with substantially larger subgroups.

CONCLUSION(S)

It was observed that the hearing ability of the subjects was more of a bilaterally symmetrical type of deafness and was prevalent both among the consanguineous and non consanguineous study population. But in consanguineous marriage, the degree of hearing loss was more, as estimated by PTA. Continued awareness in the community regarding the high prevalence of hearing loss in children born to consanguineous parents may avoid the consanguineous marriage itself. In the event of already existing children with hearing disability to the consanguineous parents, early diagnosis of hearing loss by audiological evaluation in such children would be beneficial for their proper rehabilitation and this will make them normalise with other people in the society.

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