e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2022; 14 (7); 181-198

Original Research Article

Analysis of Auditory and Verbal Outcome of Cochlear Implant in Pediatric Age Group and Various Factors affecting it: Our Experience

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Received: 20-05-2022 / Revised: 22-06-2022 / Accepted: 10-07-2022
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Conflict of interest: Nil

Abstract

Background: Cochlear Implantation is not just a surgical procedure but a well formulated program to transform hearing, speech, and language. Intensive auditory rehabilitation is particularly essential in cases with delayed intervention, and those with relatively poor intelligence and cognition. To assess the outcome of this surgery, the commonly used scoring systems include Categories of Auditory Performance (CAP) level, Speech Intelligibility Rating (SIR) score and Parents' Evaluation of Aural/Oral Performance of Children (P.E.A.C.H.) score.

Aim: To analyse the results of cochlear implant surgery in pediatric patients in terms of SIR test scores, CAP scale and PEACH score and also to analyze various factors affecting these outcome measures

Method: A retrospective analysis of the records of 120 pediatric patients diagnosed with bilateral severe to profound sensorineural hearing loss who underwent cochlear implant surgery at the otorhinolaryngology department of Indira Gandhi Institute of Medical Sciences between 2017 and 2022 was performed. The parameters used to assess outcome included SIR score, CAP scale and PEACH score. These parameters were evaluated at various stages of follow up, 3, 6, 9 months initially and annually thereafter. Various factors affecting these outcome variables were also evaluated and their correlation was studied. These include age at the time of implant, duration of deafness, gender, duration of AVT, PEACH score and mode of AVT.

Results: At 3 months the mean SIR score, CAP score and PEACH score were 1, 1.27 and 1.64 respectively; at 6 months these scores were 1.14, 1.57 and 1.71 respectively; at 9 months 1.5, 2.9 and 2.4 respectively; at 1 year 1.29, 2.96 and 2.46 respectively; at 2 years 1.25, 3.4 and 3.25 respectively; and beyond 3 years 1.79, 4.35 and 3.23 respectively. There is positive effect of Duration of AVT on SIR score and CAP score ($p=0.06$ and $p<0.001$ respectively) Effect of Age at implant on SIR and CAP score showed higher scores in 5-15 years of age group. ($p= 0.325$ $p= 0.165$ respectively). PEACH, SIR and CAP score show positive correlation ($p<0.001$). Out of total 120 patients 34 received offline AVT, 4 received online AVT and the remaining 82 patients attended AVT sessions both online and at the centre. When SIR and CAP scores were compared across the three groups there was positive correlation ($p=0.01$ and $p=0.007$ respectively).

Conclusion: We conclude from this study that the longer the duration of auditory and speech training the better is the outcome. To encourage this, facility of online AVT can be a valuable option. Also, parental satisfaction is another factor which favors patient compliance and enhances the outcome of cochlear implant surgery.

Introduction

Cochlear Implantation is not just a surgical procedure but a well formulated program to transform hearing, speech, and language. It not just benefits a handicapped individual but can reduce the disability burden of the society to a great degree. The cochlear implant is an electronic device surgically implanted, and the electrodes are placed in the cochlea of the inner ear which stimulates the cochlear nerve. The electrical stimulation of the auditory nerve helps in the perception of sound but in order to process this information and transform it into receptive and expressive language, extensive auditory and speech rehabilitation is crucial.

There are various factors influencing the result of cochlear implantation like the age at implant, duration of deafness, etiology, use of hearing aids before implantation, family support and commitment, optimized programming and amount and quality of re/habilitation before and after implant. Intensive auditory rehabilitation is particularly essential in cases with delayed intervention, and those with relatively poor intelligence and cognition. Each patient's need for rehabilitation is different based on the pre-operative auditory experience. For pre-lingually deaf patients, Auditory Verbal Therapy (AVT) are imperative for better communication abilities. When this procedure is performed under optimum circumstances with rigorous postoperative rehabilitation, the results are promising.

To assess the outcome of this surgery in terms of treating disability, there are various tools. The commonly used scoring systems include Categories of Auditory Performance (CAP) scores [1] and Speech Intelligibility Rating (SIR) by O'Donoghue *et al*. [2]. These assessments are performed by a professional at the centre, which is not the ideal setting for real world performance nor is the time constraint at the centre ideal to come to a conclusion. Hence, we have added another assessment tool in our study which is based on a questionnaire that measures parent satisfaction in terms of outcome and progress of their child. This is Parents' Evaluation of Aural/Oral Performance of Children (P.E.A.C.H.) score. [3]

Cochlear implant is a relatively new technology with not many centres having performed a large no. of this procedure for its significant outcome analysis. Our goal is to analyse the results of cochlear implant surgery in pediatric patients in terms of SIR test scores, CAP scale and PEACH score and also to analyze various factors affecting these outcome measures to add to the current knowledge of approach to the cochlear implant procedure.

CAP scale

Level 0	Unaware of environmental sounds
Level 1	Detects some environmental sounds
Level 2	Responds to some speech sounds
Level 3	Can identify some environmental sounds
Level 4	Understands some spoken words with additional performatives e.g. '*where is the duck that says quack quack*', '*give me the car brmm*'
Level 5	Understands common phrases e.g. *pick it up; it's bath time.*
Level 6	Understands some spoken words without performatives e.g. *give me the duck'/ 'go get the car'*
Level 7	Responds appropriately to simple questions e.g. *what is it?*
Level 8	Understands conversations with familiar speakers
Level 9	Understands conversations with unfamiliar speakers
Level 10	Follows recorded stories
Level 11	Uses the telephone with familiar speakers
Level 12	Uses the telephone with unfamiliar speakers

SIR Score

Category 1	Connected speech is unintelligible. Prerecognizable words in spoken language (primary mode of communication may be manual)
Category 2	Connected speech is unintelligible. Intelligible speech is developing in single words when context and lip-reading cues are available
Category 3	Connected speech is intelligible to a listener who concentrates and lip-reads within a known context
Category 4	Connected speech is intelligible to a listener who has little experience of a deaf person's speech
Category 5	Connected speech is intelligible to all listeners. The child is understood easily in everyday contexts

PEACH Score

	Question	Never 0%	Seldom 1 - 25%	Sometimes 26 - 50%	Often 51 - 75%	Always 75-100%
1.	How often has your child worn his/her hearing aids and/or cochlear implant?	0	1	2	3	4
2.	How often has your child complained or been upset by **loud** sounds?	4	3	2	1	0
3.	When you call, does your child respond to his/her name in a **quiet** situation?	0	1	2	3	4
4.	When asked, does your child follow simple instructions or do a simple task in a **quiet** situation?	0	1	2	3	4
5.	When you call does your child respond to his/her name in a **noisy** situation when he/she can't see your face? (examples of responses include looks up, turns, answers verbally)	0	1	2	3	4
6.	When asked, does your child follow simple instructions or do a simple task in a **noisy** situation?	0	1	2	3	4
7.	When you are in a **quiet** place reading with your child, how often does he/she pay close attention to what you are saying? OR if your child is listening to stories/songs on the TV or CD when there is no other background noise how often can he/she follow what is being said?	0	1	2	3	4
8.	How often does your child initiate/ participate in conversation in a **quiet** situation?	0	1	2	3	4
9.	How often does your child initiate/ participate in conversation in a **noisy** situation?	0	1	2	3	4
10.	How often does your child understand what you say in the car/bus/train?	0	1	2	3	4
11.	How often does your child recognise peoples' voices without seeing who was talking?	0	1	2	3	4
12.	How often does your child successfully use a phone?	0	1	2	3	4
13.	How often does your child respond to sounds other than voices?	0	1	2	3	4

Method:

Study design: Institutional retrospective clinical observational study.

Study population: 120 patients who have undergone cochlear implant surgery

Duration of Study: September 2017 to April 2022

Approval from the ethics committee of the institute was taken at the start of the study. Written informed consent was taken from all the participants guardians.

Inclusion Criteria:

- Twelve months-15 years of age
- History of Bilateral severe to profound sensorineural hearing loss
- Motivation and good family support.
- Patients who have started AVT

Exclusion Criteria:

- unilateral hearing loss

- age less than 1 year or more than 15 years
- poor motivation and family support
- Patients who have received implant but device switch-on and AVT is still awaited

A retrospective analysis of the records of 120 pediatric patients diagnosed with bilateral severe to profound sensorineural hearing loss who underwent cochlear implant surgery at the otorhinolaryngology department of Indira Gandhi Institute of Medical Sciences between 2017 and 2022 was performed. All these patients had prelingual deafness. They had regular follow ups and ongoing Auditory verbal therapy during the study period. The parameters used to assess outcome included SIR score, CAP scale and PEACH score. These parameters were evaluated at various stages of follow up, 3, 6, 9 months initially and annually thereafter. Various factors affecting these outcome variables were also evaluated and their correlation was studied. These include age at the time of implant, duration of deafness, gender, duration of AVT, PEACH score and mode of AVT.

Statistical Analysis:

SPSS statistics version 26 was used to analyze data. Descriptive statistics for SIR, CAP and PEACH score will be presented with mean, standard deviation, median, mode, minimum and maximum values, and range. The effect of various factors on SIR and CAP score will be cross tabulated and evaluated using Pearson Chi-Square test. The P value of <0.05 will be considered statistically significant.

Results:

In our study a total of 120 pediatric patients in the age group of 0-15 years have started auditory and verbal therapy after receiving cochlear implant. All these patients were evaluated for their auditory and speech progress at regular intervals of 3months until 1 year and annually thereafter. At 3 months the mean SIR score, CAP score and PEACH score were 1, 1.27 and 1.64 respectively; at 6 months these scores were 1.14, 1.57 and 1.71 respectively; at 9 months 1.5, 2.9 and 2.4 respectively; at 1 year 1.29, 2.96 and 2.46 respectively; at 2 years 1.25, 3.4 and 3.25 respectively; and beyond 3 years 1.79, 4.35 and 3.23 respectively. Other statistical measures of these scores are summarized in Table 1.

Table 1: SIR, CAP and PEACH score statistics

Duration of AVT		SIR	CAP scale	PEACH SCORE
3 months	N	11	11	11
	Mean	1.00	1.27	1.64
	Median	1.00	1.00	2.00
	Mode	1	1	2
	Std. Deviation	.000	.467	.505
	Range	0	1	1
	Minimum	1	1	1
	Maximum	1	2	2
6 months	N	7	7	7
	Mean	1.14	1.57	1.71
	Median	1.00	1.00	2.00
	Mode	1	1	2
	Std. Deviation	.378	1.397	.488
	Range	1	4	1
	Minimum	1	0	1
	Maximum	2	4	2

9 months	N	10	10	10
	Mean	1.50	2.90	2.40
	Median	1.00	2.00	2.00
	Mode	1	1	2
	Std. Deviation	1.269	3.348	.843
	Range	4	11	3
	Minimum	1	1	1
	Maximum	5	12	4
1 year	N	24	24	24
	Mean	1.29	2.96	2.46
	Median	1.00	2.00	2.00
	Mode	1	1	2
	Std. Deviation	.624	2.422	.977
	Range	2	8	3
	Minimum	1	1	1
	Maximum	3	9	4
2 years	N	20	20	20
	Mean	1.25	3.40	3.25
	Median	1.00	3.00	3.00
	Mode	1	3	3
	Std. Deviation	.639	1.729	.550
	Range	2	7	2
	Minimum	1	1	2
	Maximum	3	8	4
3+ years	N	48	48	48
	Mean	1.79	4.35	3.23
	Median	2.00	4.00	3.00
	Mode	1	4	3
	Std. Deviation	.988	2.264	.751
	Range	4	11	3
	Minimum	1	1	1
	Maximum	5	12	4

The effect of Duration of AVT on SIR score and CAP score is cross tabulated in Table 2 and 3 respectively. The Pearson Chi-Square test revealed p value of 0.06 for former and <0.001 for latter.

Table2: Effect of Duration of AVT on SIR

			Duration of AVT						Total
			3 months	6 months	9 months	1 year	2 years	3+ years	
SIR	1	Count	11	6	8	19	17	23	84
		% within Duration of AVT	100.0%	85.7%	80.0%	79.2%	85.0%	47.9%	70.0%
	2	Count	0	1	1	3	1	17	23
		% within Duration of AVT	0.0%	14.3%	10.0%	12.5%	5.0%	35.4%	19.2%
	3	Count	0	0	0	2	2	4	8
		% within Duration of	0.0%	0.0%	0.0%	8.3%	10.0%	8.3%	6.7%

		AVT							
	4	Count	0	0	0	0	0	3	3
		% within Duration of AVT	0.0%	0.0%	0.0%	0.0%	0.0%	6.3%	2.5%
	5	Count	0	0	1	0	0	1	2
		% within Duration of AVT	0.0%	0.0%	10.0%	0.0%	0.0%	2.1%	1.7%
Total		Count	11	7	10	24	20	48	120
		% within Duration of AVT	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	30.227[a]	20	.066
Likelihood Ratio	33.818	20	.027
Linear-by-Linear Association	9.138	1	.003
N of Valid Cases	120		

a. 24 cells (80.0%) have expected count less than 5. The minimum expected count is .12.

Symmetric Measures

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Interval by Interval	Pearson's R	.277	.072	3.133	.002[c]
Ordinal by Ordinal	Spearman Correlation	.365	.077	4.255	<.001[c]
Measure of Agreement	Kappa	.012	.013	.616	.538
N of Valid Cases		120			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

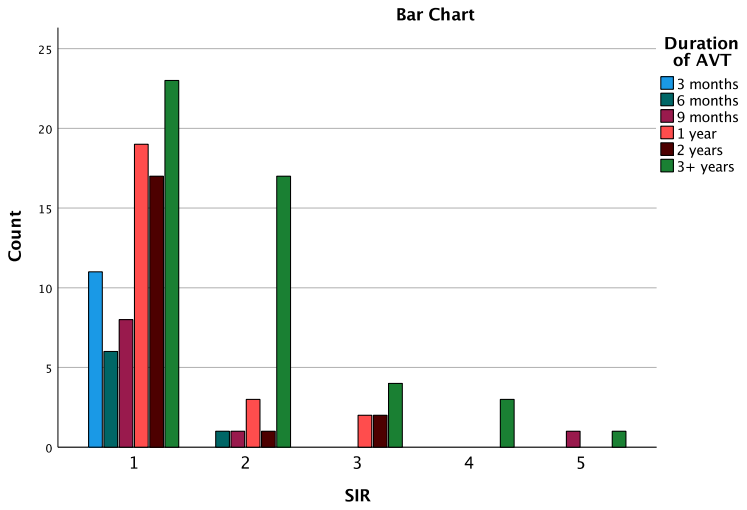


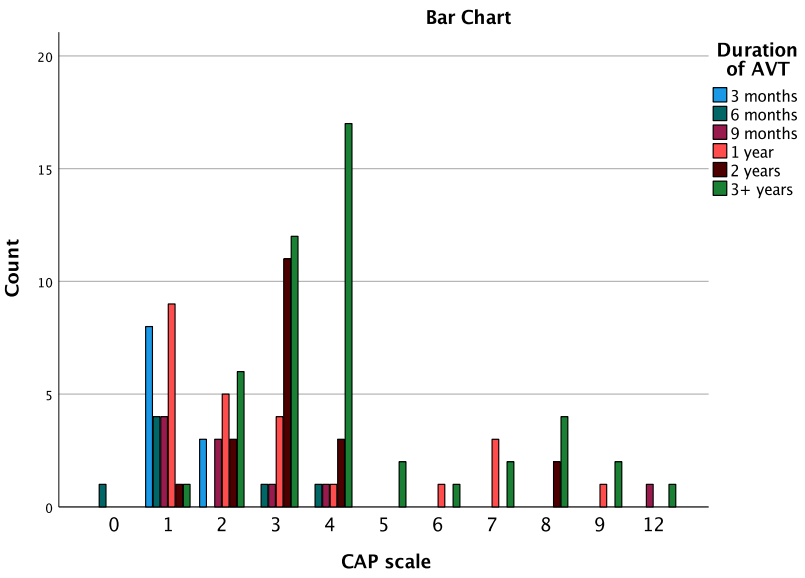
Table 3: Effect of Duration of AVT on CAP scale

			Duration of AVT						Total
			3 months	6 months	9 months	1 year	2 years	3+ years	
CAP scale	0	Count	0	1	0	0	0	0	1
		% within Duration of AVT	0.0%	14.3%	0.0%	0.0%	0.0%	0.0%	0.8%
	1	Count	8	4	4	9	1	1	27
		% within Duration of AVT	72.7%	57.1%	40.0%	37.5%	5.0%	2.1%	22.5%
	2	Count	3	0	3	5	3	6	20
		% within Duration of AVT	27.3%	0.0%	30.0%	20.8%	15.0%	12.5%	16.7%
	3	Count	0	1	1	4	11	12	29
		% within Duration of AVT	0.0%	14.3%	10.0%	16.7%	55.0%	25.0%	24.2%
	4	Count	0	1	1	1	3	17	23
		% within Duration of AVT	0.0%	14.3%	10.0%	4.2%	15.0%	35.4%	19.2%
	5	Count	0	0	0	0	0	2	2
		% within Duration of AVT	0.0%	0.0%	0.0%	0.0%	0.0%	4.2%	1.7%
	6	Count	0	0	0	1	0	1	2
		% within Duration of AVT	0.0%	0.0%	0.0%	4.2%	0.0%	2.1%	1.7%
	7	Count	0	0	0	3	0	2	5
		% within Duration of AVT	0.0%	0.0%	0.0%	12.5%	0.0%	4.2%	4.2%
	8	Count	0	0	0	0	2	4	6
		% within Duration of AVT	0.0%	0.0%	0.0%	0.0%	10.0%	8.3%	5.0%
	9	Count	0	0	0	1	0	2	3
		% within Duration of AVT	0.0%	0.0%	0.0%	4.2%	0.0%	4.2%	2.5%
	12	Count	0	0	1	0	0	1	2
		% within Duration of AVT	0.0%	0.0%	10.0%	0.0%	0.0%	2.1%	1.7%
Total		Count	11	7	10	24	20	48	120
		% within Duration of AVT	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	98.469[a]	50	<.001
Likelihood Ratio	96.641	50	<.001
Linear-by-Linear	21.141	1	<.001

Association			
N of Valid Cases	120		
a. 60 cells (90.9%) have expected count less than 5. The minimum expected count is .06.			

Symmetric Measures					
		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Interval by Interval	Pearson's R	.421	.072	5.049	<.001[c]
Ordinal by Ordinal	Spearman Correlation	.572	.068	7.572	<.001[c]
Measure of Agreement	Kappa	-.007	.027	-.265	.791
N of Valid Cases		120			
a. Not assuming the null hypothesis.					
b. Using the asymptotic standard error assuming the null hypothesis.					
c. Based on normal approximation.					



Effect of Age at implant on SIR and CAP score is cross tabulated in table 4 and 5 respectively.

Table 4: Effect of Age at implantation on SIR score

Crosstab

			Age group 0-5 years	Age group 5-15 years	Total
SIR	1	Count	60	24	84
		% within Age group	71.4%	66.7%	70.0%
	2	Count	18	5	23
		% within Age group	21.4%	13.9%	19.2%
	3	Count	4	4	8
		% within Age group	4.8%	11.1%	6.7%
	4	Count	1	2	3
		% within Age group	1.2%	5.6%	2.5%
	5	Count	1	1	2
		% within Age group	1.2%	2.8%	1.7%
Total		Count	84	36	120
		% within Age group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.654[a]	4	.325
Likelihood Ratio	4.331	4	.363
Linear-by-Linear Association	2.066	1	.151
N of Valid Cases	120		

a. 5 cells (50.0%) have expected count less than 5. The minimum expected count is .60.

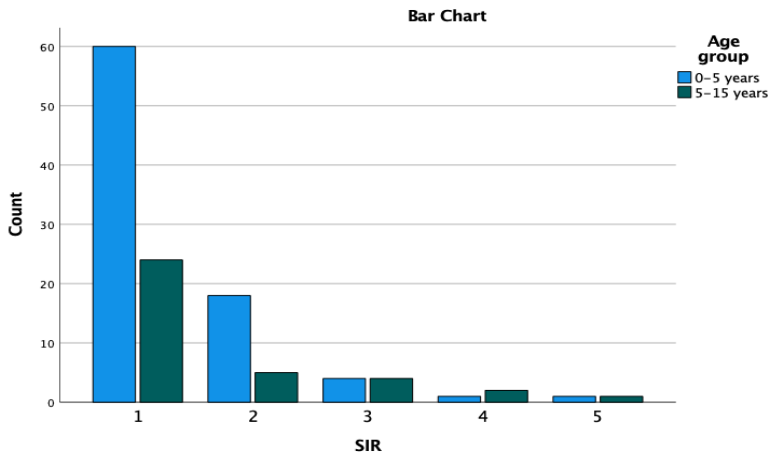


Table 5: Effect of Age at implantation on CAP scale

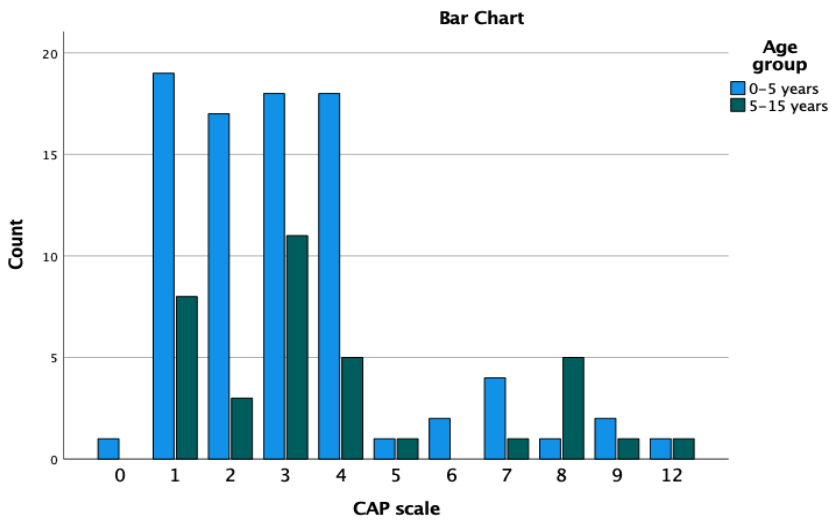
Crosstab

			Age group 0–5 years	Age group 5–15 years	Total
CAP scale	0	Count	1	0	1
		% within Age group	1.2%	0.0%	0.8%
	1	Count	19	8	27
		% within Age group	22.6%	22.2%	22.5%
	2	Count	17	3	20
		% within Age group	20.2%	8.3%	16.7%
	3	Count	18	11	29
		% within Age group	21.4%	30.6%	24.2%
	4	Count	18	5	23
		% within Age group	21.4%	13.9%	19.2%
	5	Count	1	1	2
		% within Age group	1.2%	2.8%	1.7%
	6	Count	2	0	2
		% within Age group	2.4%	0.0%	1.7%
	7	Count	4	1	5
		% within Age group	4.8%	2.8%	4.2%
	8	Count	1	5	6
		% within Age group	1.2%	13.9%	5.0%
	9	Count	2	1	3
		% within Age group	2.4%	2.8%	2.5%
	12	Count	1	1	2
		% within Age group	1.2%	2.8%	1.7%
Total		Count	84	36	120
		% within Age group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	14.189[a]	10	.165
Likelihood Ratio	14.528	10	.150
Linear-by-Linear Association	2.647	1	.104
N of Valid Cases	120		

a. 14 cells (63.6%) have expected count less than 5. The minimum expected count is .30.



Out of 120 patients 84 were in the age group 0-5 years and 36 were above 5 years of age. The higher SIR and CAP scores are seen in 5-15 years of age group. The Pearson chi-square test shows p value of 0.325 and 0.165 respectively.

On studying the gender distribution, out of total 120, 67 patients were male and 53

were female. Relation of gender with SIR and CAP score is summarized in Table 6 and 7 respectively. The p values are 0.072 and 0.051 respectively.

Table 6: Relation of gender with SIR score

Crosstab

			Gender		
			Male	Female	Total
SIR	1	Count	45	39	84
		% within Gender	67.2%	73.6%	70.0%
	2	Count	18	5	23
		% within Gender	26.9%	9.4%	19.2%
	3	Count	2	6	8
		% within Gender	3.0%	11.3%	6.7%
	4	Count	1	2	3
		% within Gender	1.5%	3.8%	2.5%
	5	Count	1	1	2
		% within Gender	1.5%	1.9%	1.7%
Total		Count	67	53	120
		% within Gender	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	8.593[a]	4	.072
Likelihood Ratio	9.024	4	.060
Linear-by-Linear Association	.235	1	.628
N of Valid Cases	120		

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .88.

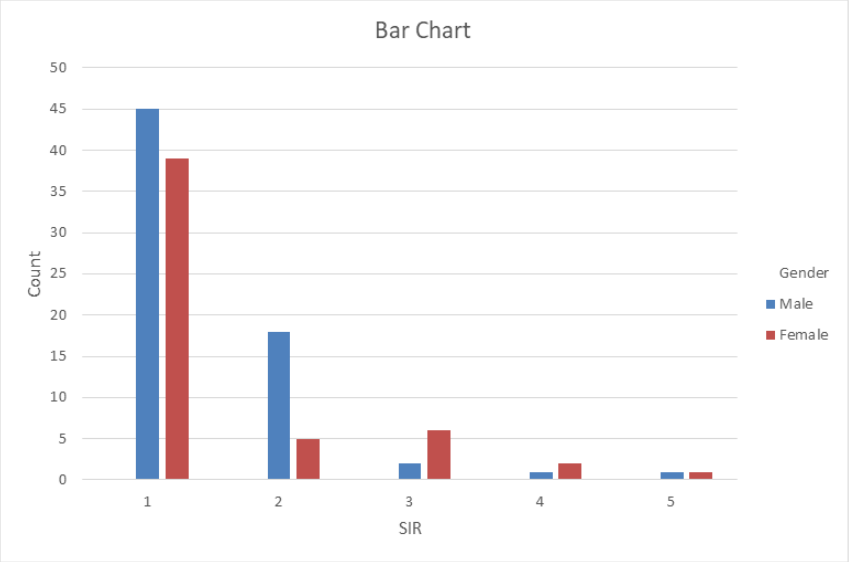


Table 7: Relation of gender with CAP scale

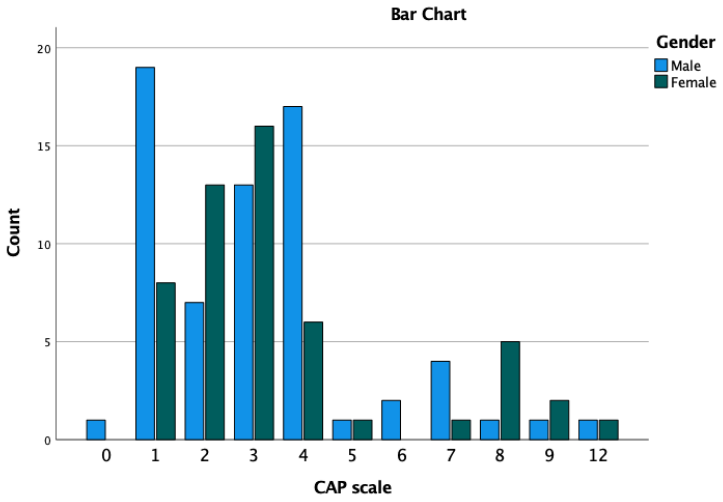
Crosstab

			Gender		Total
			Male	Female	
CAP scale	0	Count	1	0	1
		% within Gender	1.5%	0.0%	0.8%
	1	Count	19	8	27
		% within Gender	28.4%	15.1%	22.5%
	2	Count	7	13	20
		% within Gender	10.4%	24.5%	16.7%
	3	Count	13	16	29
		% within Gender	19.4%	30.2%	24.2%
	4	Count	17	6	23
		% within Gender	25.4%	11.3%	19.2%
	5	Count	1	1	2
		% within Gender	1.5%	1.9%	1.7%
	6	Count	2	0	2
		% within Gender	3.0%	0.0%	1.7%
	7	Count	4	1	5
		% within Gender	6.0%	1.9%	4.2%
	8	Count	1	5	6
		% within Gender	1.5%	9.4%	5.0%
	9	Count	1	2	3
		% within Gender	1.5%	3.8%	2.5%
	12	Count	1	1	2
		% within Gender	1.5%	1.9%	1.7%
Total		Count	67	53	120
		% within Gender	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	18.268[a]	10	.051
Likelihood Ratio	19.936	10	.030
Linear-by-Linear Association	.654	1	.419
N of Valid Cases	120		

a. 14 cells (63.6%) have expected count less than 5. The minimum expected count is .44.



On comparing the PEACH score with the SIR and CAP score (table 8 and 9 respectively), it was observed that there was positive correlation between these scoring systems with p value of <0.001 each.

Table 8: Correlation of PEACH and SIR score

PEACH SCORE * SIR Crosstabulation

Count

		SIR 1	2	3	4	5	Total
PEACH SCORE	0-25	12	0	0	0	0	12
	26-50	32	1	0	0	0	33
	51-75	33	12	0	0	0	45
	76-100	7	10	8	3	2	30
Total		84	23	8	3	2	120

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	64.622[a]	12	<.001
Likelihood Ratio	68.456	12	<.001
Linear-by-Linear Association	38.479	1	<.001
N of Valid Cases	120		

a. 13 cells (65.0%) have expected count less than 5. The minimum expected count is .20.

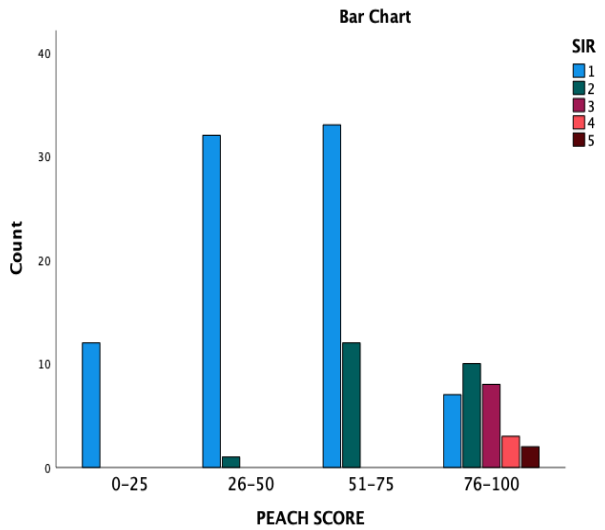


Table 9: Correlation of PEACH score with CAP scale

CAP scale * PEACH SCORE Crosstabulation

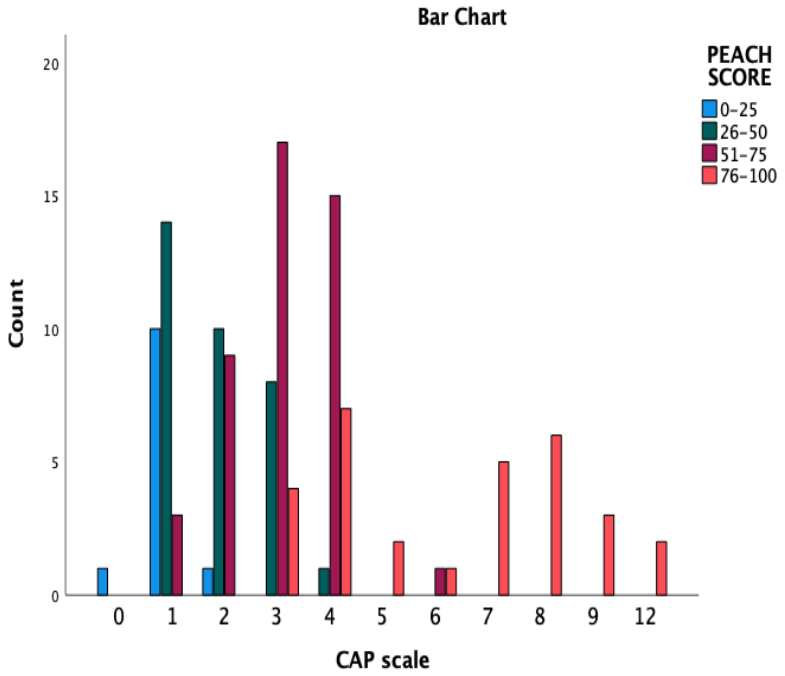
Count

		PEACH SCORE 0-25	26-50	51-75	76-100	Total
CAP scale	0	1	0	0	0	1
	1	10	14	3	0	27
	2	1	10	9	0	20
	3	0	8	17	4	29
	4	0	1	15	7	23
	5	0	0	0	2	2
	6	0	0	1	1	2
	7	0	0	0	5	5
	8	0	0	0	6	6
	9	0	0	0	3	3
	12	0	0	0	2	2
Total		12	33	45	30	120

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	130.712[a]	30	<.001
Likelihood Ratio	133.120	30	<.001
Linear-by-Linear Association	63.880	1	<.001
N of Valid Cases	120		

a. 32 cells (72.7%) have expected count less than 5. The minimum expected count is .10.



The effect of mode of AVT used, on SIR and CAP score was evaluated. Out of total 120 patients 34 received offline AVT, 4 received online AVT and the remaining 82 patients attended AVT sessions both online and at the centre. The correlation of SIR and CAP score with the mode of AVT is cross tabulated in table 10 and 11 respectively. The p value is 0.01 and 0.007 respectively for SIR and CAP score when mode of AVT was compared across the three groups.

Table 10: Effect of Mode of AVT on SIR score

Crosstab

			Mode of AVT			
			offline	online	both	Total
SIR	1	Count	33	3	48	84
		% within Mode of AVT	97.1%	75.0%	58.5%	70.0%
	2	Count	1	0	22	23
		% within Mode of AVT	2.9%	0.0%	26.8%	19.2%
	3	Count	0	1	7	8
		% within Mode of AVT	0.0%	25.0%	8.5%	6.7%
	4	Count	0	0	3	3
		% within Mode of AVT	0.0%	0.0%	3.7%	2.5%
	5	Count	0	0	2	2
		% within Mode of AVT	0.0%	0.0%	2.4%	1.7%
Total		Count	34	4	82	120
		% within Mode of AVT	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	20.089[a]	8	.010
Likelihood Ratio	25.777	8	.001
Linear-by-Linear Association	12.258	1	<.001
N of Valid Cases	120		

a. 10 cells (66.7%) have expected count less than 5. The minimum expected count is .07.

Table 11: Effect of Mode of AVT on CAP scale

Crosstab

			Mode of AVT			
			offline	online	both	Total
CAP scale	0	Count	1	0	0	1
		% within Mode of AVT	2.9%	0.0%	0.0%	0.8%
	1	Count	14	1	12	27
		% within Mode of AVT	41.2%	25.0%	14.6%	22.5%
	2	Count	11	1	8	20
		% within Mode of AVT	32.4%	25.0%	9.8%	16.7%
	3	Count	6	1	22	29
		% within Mode of AVT	17.6%	25.0%	26.8%	24.2%
	4	Count	1	0	22	23
		% within Mode of AVT	2.9%	0.0%	26.8%	19.2%
	5	Count	1	0	1	2
		% within Mode of AVT	2.9%	0.0%	1.2%	1.7%
	6	Count	0	0	2	2
		% within Mode of AVT	0.0%	0.0%	2.4%	1.7%
	7	Count	0	1	4	5
		% within Mode of AVT	0.0%	25.0%	4.9%	4.2%
	8	Count	0	0	6	6
		% within Mode of AVT	0.0%	0.0%	7.3%	5.0%
	9	Count	0	0	3	3
		% within Mode of AVT	0.0%	0.0%	3.7%	2.5%
	12	Count	0	0	2	2
		% within Mode of AVT	0.0%	0.0%	2.4%	1.7%
Total		Count	34	4	82	120
		% within Mode of AVT	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	38.594[a]	20	.007
Likelihood Ratio	43.365	20	.002
Linear-by-Linear Association	19.127	1	<.001
N of Valid Cases	120		

a. 25 cells (75.8%) have expected count less than 5. The minimum expected count is .03.

Discussion:

Cochlear implant surgery has gained tremendous momentum over last couple of decades ever since its indications expanded to unilateral deafness and deafness in adults. More and more centres are gaining expertise in this program. However, it is still widely performed for prelingually deaf pediatric patients. In our study all the pediatric patients were found to have prelingual deafness. To analyse the efficacy of cochlear implant surgery it is imperative to evaluate the rehabilitation

level of patient apart from surgical outcome in the form of complications, electrode insertion, NRT response. There will be no benefit to patient without providing intensive auditory verbal therapy in prelingual deafness. Several scoring systems are available to assess the response to AVT and plot progress of patients. The SIR and CAP scores are the commonly used tools. Peach score is another system which takes into account parental satisfaction of their child's performance.

In our study a total of 120 pediatric patients in the age group of 0-15 years have received auditory and verbal therapy after cochlear implant surgery. All these patients were evaluated for their auditory and speech progress at regular intervals of 3months until 1 year and annually thereafter. The SIR score, CAP score and PEACH score were evaluated at these intervals. The maximum CAP score was 9 and SIR 3 at 1 year. Our results were comparable with the study conducted by Rayamajhi, et al. who showed maximum CAP score 7 and SIR 5 at 1 year. [4]

The satisfaction of caregiver is also important when pediatric patients are concerned. This motivates them to be regular with AVT sessions for longer periods which in turn enhances the results. On correlating PEACH score with the SIR score and CAP level, it was observed that there was positive correlation between these scoring systems with p value of <0.001 each. Rayamajhi, et al. have also evaluated parental satisfaction using a different scoring system but the results were similar to our study. [4]

In the cross tabulation of the effect of duration of AVT on SIR score and CAP score it was observed that as the duration of AVT increases, the SIR and CAP scores improve.[5]. The Pearson Chi-Square test revealed p value of 0.06 for former and <0.001 for latter which suggests the association between duration of AVT and SIR to be statistically not very significant but the association between duration of AVT and CAP to be statistically significant. Thus, we also emphasize the value of regular and long term follow up in improving Cochlear implant outcome. At our center we provide online facility of AVT to avoid patient drop off. This is one of the reasons for 100% patient attendance at AVT sessions of all the cochlear implant procedures performed at our center till date. Another reason is strong counselling and stringent patient selection in terms of motivation and follow up post implant.

Our study also evaluated the effect of age at implantation on SIR and CAP score. The results were conflicting as it is a known fact now that early intervention is beneficial for cochlear implant outcome. A higher SIR and CAP score was seen in 5-15 years of age group compared to 0-5 years. However, The Pearson chi-square test showed p value of 0.325 and 0.165 respectively, suggesting that this difference in scores of the two age groups was statistically insignificant. [6] Intensive AVT and counselling in higher age group patients to obtain optimum results in view of odds can be thought as a reason for this conflicting result, but we do not have enough evidence to support this.

On studying the gender distribution, out of total 120, 67 patients were male and 53 were female. When we analysed the relation of gender with SIR and CAP score, we found that greater percentage of female patients had higher scores. The p values were 0.072 and 0.051 respectively.

At our centre the patients were given AVT in three forms: offline, online or both depending on patient comfort level and to improve compliance. Better scores were seen in the group with both modes of AVT compared to offline or online alone. This difference was found to be statistically significant. On intensive search of available literature we could not find any study evaluating this parameter to support our result.

Conclusion:

We conclude from this study that regular assessment of outcome of AVT by means of standard scores like CAP scale and SIR score is helpful in monitoring progress of patients and modifying therapy on individual basis. This study also revealed that the longer the duration of auditory and speech training the better is the outcome. Strict compliance and long term follow up is essential to gain speech and language post cochlear implant. To encourage this, facility of online AVT can be a valuable option. Also, parental satisfaction is another factor which favors patient compliance and enhances the outcome of cochlear implant surgery. However, we failed to establish any positive correlation between early age at implantation and higher scores. The factors responsible for better outcome in older pediatric patients is a subject for further analysis and beyond the scope of this study.

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