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Preoperative Radiological Assessment of Temporal Bone In Patients Undergoing Cochlear Implants And Correlate With Intraoperative Findings – Review of Efficacy of Radiology

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Abstract
Background: *Congenital hearing loss accounts for 1 in 1000 live births in India. For sensorineural hearing loss, Cochlear implantation is the choice of treatment. Preoperative imaging helps in various aspects of planning and surgery.*
Objective*To correlate preoperative imaging with intraoperative findings To study the efficacy of radiology with respect to cochlear implantation.*
Method: *Children in the age group of 1 to 6 years with sensorineural hearing loss, who came to the Department of ENT, Rajiv Gandhi Government General Hospital, Chennai, were included in the study. Preoperative radiological evaluation was compared with the intraoperative findings.*
Results: *The combination of preoperative HRCT and MRI gave more accurate detail regarding any abnormalities.*
Keyword: *Cochlear Implant, Imaging, Preoperative, intraoperative*

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I. Introduction

Congenital sensorineural hearing loss is one of the most common birth defects with the incidence of 1 : 1000 live births in India. Cochlear implantation is the method of choice in children with severe to profound sensorineural hearing loss. Imaging is required to properly evaluate these cases for any anatomical anomalies, especially in the prelingualdeaf children. Both high resolution computerized tomography and magnetic resonance imaging prove to be important diagnostic modalities in patients to undergo cochlear implant. Both have their own advantages and disadvantages. The high resolution computerized tomography can detect anatomical malformations of the bony inner ear, while the magnetic resonance imaging provides details about the membranous labyrinth and the status of the vestibulocochlear nerve. Bony inner ear malformations are fairly uncommon, accounting for 20% of sensorineural hearing loss, while anomalies of the membranous labyrinth account for approximately 80% of the cases. There has been a debate to which modality serves a better purpose in evaluating patients undergoing cochlear implantation. Accurate preoperative imaging is required for candidate selection, identification of suitable ear for cochlear implantation and selection of appropriate divide. Proper surgical planning must involve careful review of sectional images, to anticipate potential complication and their management.

II. Aims And Objectives

1. To study the facial nerve course, status of ossicles, position of jugular bulb, cochlear turns and vestibule, cochlear nerve by radiology and correlate with intra-operative findings.
2. To study the efficacy of radiological evaluation (HRCT temporal bone and MRI brain and cochlear nerve)

III. Materials

1. Study Place : Rajiv Gandhi Government General Hospital, Chennai – 600003
2. Collaborating Department : Upgraded Institute Of Otorhinolaryngology
3. Study Design : Prospective And Retrospective Study
4. Study Period : August 2013 To November 2014
5. Ethics Committee Clearance : Obtained

3.1 Inclusion Criteria
1. Age 1-6 years (pre-lingual child)
2. Severe to Profound SNHL
3. Facial nerve course
4. Status of ossicles
5. Jugular bulb position
6. Inner ear (cochlea).

3.2Exclusion Criteria
1. Below 1 year
2. Absent cochlear nerve
3. Post-lingual patient

3.3Investigations
1. Routine blood investigations
2. Pure tone audiometry
3. Impedance audiometry
4. Behavioural observational audiometry (BOA)
5. Otoacoustic emissions (OAES)
6. Brainstem evoked response audiometry (BERA)
7. HRCT Temporal Bone and cochlea
8. MRI of brain including cochlear nerve
9. TORCH test
10. Echocardiogram

3.4Clinical Benefit To The Community
1. To Restore Hearing
2. Lesser Morbidity
3. Lesser Post-Operative Complications
4. Early Speech Development
5. To Bring Back Normal Social Well-Being Of The Child
6. CONFLICT OF INTEREST : Nil
7. FINANCIAL SUPPORT : Nil

IV. Methodology

The study was conducted in the tertiary care Rajiv Gandhi Government General Hospital and Madras Medical College in the Department of Upgraded Institute of Otorhinolaryngology. Prelingual children (1-6 years) with severe to profound sensorineural hearing loss coming to Upgraded Institute of Otorhinolaryngology, Rajiv Gandhi Government General Hospital who satisfy the inclusion criteria are studied.

Imaging Protocol

All HRCT investigations were performed in the axial orientation using multi-slice light speed with slice thickness of 1mm and ultrahigh algorithm. These are documented in a bone window. Coronal and sagittal reconstruction is performed volume rendered images. All images were evaluated as advantage windows work stations. MRI was performed using 3 tesla MRI scanner using an 8 channel head coil and the space sequence (heavily T2 weighted). Images are viewed on a Siemens work station in multiple planes.

4.1Jackler's Classification Of Congenital Malformations Of The Inner Ear
Absent or malformed cochlea
1. Complete labyrinthine aplasia
2. Cochlear aplasia
3. Cochlear hypoplasia
4. Incomplete partition
5. Common cavity

Normal Cochlea
1. Vestibule – lateral semicircular canal dysplasia
2. Enlarged vestibular aqueduct

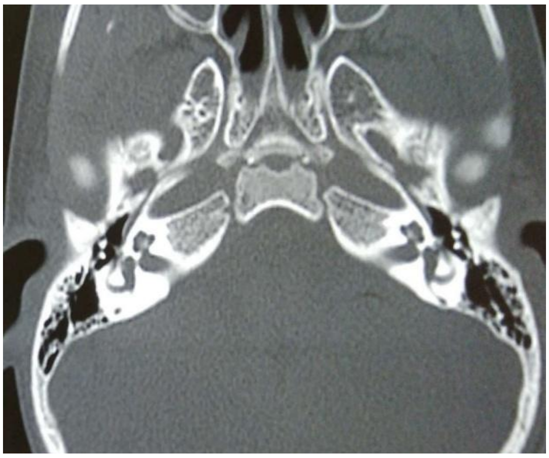
A very narrow internal auditory canal of a diameter 2 to 2.5mm or less on either conventional tomography or CT has been reported in association with a normal inner ear as well as a variety of inner ear malformations. A CT scan demonstrating an internal auditory canal of less than 2 to 2.5mm is considered by many investigators to be an absolute contraindication to cochlear implantation. It has been detailed by both CT and MRI imaging, and holds the clinical implications that there is an obvious large communication between CSF-containing internal auditory canal and the cochlea. This situation also presents the concern that a multichannel electrode array may be introduced into the internal canal at the time of implantation.

4.2Jugular Bulb

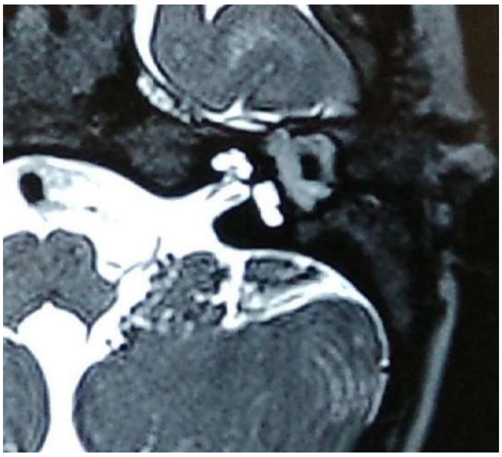
Aberrant middle ear vascular anatomy may complicate mastoidectomy and facial recess approach to the cochleostomy. An extreme anterior displacement of the sigmoid sinus against the posterior canal wall reported in 1.6%. A high riding jugular bulb present on 6% of the population. A high riding jugular bulb may overlie the round window niche or promontory.

4.3Facial Nerve

Preoperative HRCT is especially useful in identifying the position of the aberrant facial nerve associated with cochlear malformations. The course of the facial nerve is quite unusual and increases risk during cochlear implantation. The careful preoperative review of the position of the facial nerve is warranted for safe and successful implantation. The dehiscence of the infratympanic portion without cochlear malformation may be encountered in the approach to the cochleostomysite. The mastoid air cell system and tympanic cavity also included in the analysis of preoperative HRCT. The degree of mastoid pneumatisation is useful information in operating in youngchildren. The fully pneumatised mastoid accounts for 79.5%, the diplopic being 17.5% and sclerotic being 3%. Though considered fully developed at birth, the depth of the facial recess as well as its degree of pneumatisation may be anticipated.



Picture showing Normal HRCT Temporal Bone with normal Cochlea



Normal MRI showing Cochlea and cochlear nerve

V. Review Of Literature Cochlear Implant

5.1History

Auditory nerve stimulation is required for cochlear implantation. It requires surgical expertise in facial recess approach and considerable post-operative speech therapy. Electrical stimulation of the auditory system was first done by an Italian physicist, Alessandro Volta in 1790. By placing the ends of metal rods in his ears connected to an electrical supply, he discovered that the initial “boom in the head” was followed by an electrical sound similar to “a thick boiling soup” - what we know now to be electronic static.In the early 19^{th} century, the Frenchman Duchenne used current to stimulate hearing. He observed that it was described “as a sound similar to an insect trapped between a glass pane and a curtain.”Wever& Bray, (1930) discovered that an electrical response recorded in the auditory nerve of a cat was similar to the amplitude and frequency to the sound that stimulated it. Gersuni&Volokhov,(1936) are credited for observing the effects of an alternating electrical stimulus on hearing.

1. Steven & Jones, (1939) observed that various mechanisms were involved in the perception of sound. Direct stimulation of the auditory nerve was performed by Lundberg in 1950 on a human and resulted in the patient hearing noise.

2. Andre Djourno and Charles Eyries directly stimulated exposed acoustic nerves and found response in humans.
3. In 1961, William House developed a device to stimulate auditor function. Together with Jack Urban, an engineer, he developed an implant device with a single electrode.
4. William F House – Father of Neurotology and first person to perform cochlear implantation.
5. Doyle et al.,(1964), designed a four-electrode implant.
6. Simons, (1966) went on to perform a more extensive study by placement of electrodes throughout the vestibule, promontory areas andmodiolar section of the auditory nerve. This allows for stimulation of auditory fibres representing different frequencies.
7. House, (1976) and Michelson, (1971) developed a scala tympani insertion of electrode and refined the procedure. The first commercially available cochlear implant in the US was the house 3M.
8. Professor Graeme Clark and colleagues developed a multi-channel cochlear implant, which enhanced the speech recognition in adult patients. Rod Saunders was the first person to receive the multi-channel cochlear implant in 1978.

5.2Similar Studies

Jae Jin Song et al., Seoul – July 2012His study included 972 cases from 1988 to 2009. Out of 972 cases only seven had preoperative cochlear malformations and aberrant facial nerve course. Out of these seven cases, 4 had an anteriorly placed vertical segment of facial nerve, 2 had bifurcated facial nerve and one had inferiorly placed horizontal segment. These findings correlate with intraoperative findings. Lima junior L R et al – Brazil, May 2008His study included 100 patients. 67 patients underwent CT and MRI, 33 patients underwent CT only. In HRCT of 33 patients, 23 patients had radiologically similar findings to intraoperative findings. MRI and HRCT of 67 patients, 54 had radiologically similar finding to intraoperative findings.

CT only

a. Accuracy – 69.69%
b. Sensitivity – 36.36%
c. Specificity – 86.36%
d. Positive Predictive value – 57.14%
e. Negative Predictive Valour – 73.07%

CT and MRI

a. Accuracy – 80.59%
b. Sensitivity – 38.46%
c. Specificity – 90.74%
d. Positive Predictive value – 50.00%
e. Negative Predictive Valour – 85.96%

VI. Surgical Approaches

6.1Mastoidectomy With Posterior Tymponotomy Approach

In 1961, Dr House introduced the mastoidectomy with posterior tympanotomy approach (MPTA) for cochlear implantation. As the name implies, a mastoidectomy is performed followed by a posterior tympanotomy, which opens the facial recess exposing the round window. Several techniques have been developed and explored to try to minimize the extent of surgery needed to place the implant and the risk to the facial nerve and chorda tympani.

6.2 Suprameatal Route

Kronenberg and colleagues developed a technique that avoids a mastoidectomy altogether and introduces the electrode into the middle ear via a suprameatal route. The suprameatal approach is based on a retroauriculartympanotomy approach to the middle ear in which the facial nerve is protected by the body of the incus.

Drawbacks To The Suprameatal Approaches Are

1. The electrode is stretched during insertion into the cochleostomy.
2. Low-lying dura is a relative contraindication
3. A round window insertion and inferior cochleostomy is difficult.
4. The revision surgery rate is much higher with this technique.

6.3 Endaural Approach

This endaural approach, also known as the Veria operation, requires a special perforator for drilling a direct tunnel and a safety electrode forceps for inserting the electrode.

6.4 Minimial Access Incision Techniques

A percutaneous cochlear implant technique that involves a single, image-guided drill passed from the mastoid cortex through the facial recess to access the cochlea has been developed. Access to correct cochleostomy or round window insertion may also be limited and the 3-D approach to scala tympani insertion is limited.

6.5 Securing The Cochlear Implant

Balkanu and colleagues described the temporalis pocket technique obviating drilling a well or fixation of any type. The theory behind this technique is based on the anatomic limitations of the temporalis pocket, which is bounded "anteriorly by dense condensations of pericranium anteriorly at the temporal-parietal suture, posteroinferiorly at the lambdoid suture, and anteroinferiorly by the bony ridge of the squamous suture." It is widely used technique for securing the implant.

6.6 Other Techniques Include

1. Drilling two 4-mm titanium screws on either side of the well and connecting them with a 3-0 nylon suture.
2. Applying polypropylene mesh over the R/S and securing the mesh with titanium screws.
3. Cementing the R/S with ionomeric bone cement.
4. Securing the proximal portion of the electrode by placing it in a drilled-out groove connecting the well and mastoid, thus eliminating the need for fixation of any type,
5. Sewing the periosteum together over the implant.

VII. Insertion Technique

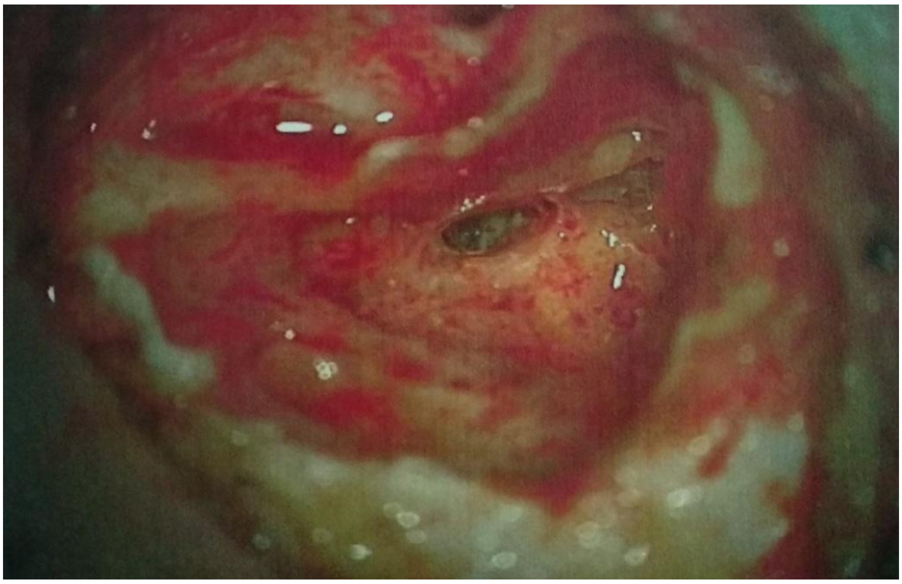
7.1 Cochleostomy Technique

1. The traditional way to drill the cochleostomy is through the promontory anterior and inferior to the round window membrane using a 1-mm to 1.5-mm diamond burr.
2. The round window membrane is usually 1-mm to 1.5mm inferior to the stapes tendon.
3. If necessary, the round window niceh is removed to identify the round window.
4. Meticulous drilling with a 1-mm diamond burr is then used and continued until the "blue" lining of the endosteum because this may expose the inner ear to significant acoustic trauma, up to 130dB
5. The endosteum is at the same level and is continuous with the round window membrane.
6. The size of the cochleostomy is determined by the size of the electrode array, which ranged from 1.0mm to 1.4mm.
7. Once the endosteum is exposed, great care is taken to prevent bone dust or blood from entering into the cochleostomy. Some centres encourage the use if hyaluronic acid or dilute surgical-grade glycerine at this point to prevent entrance of blood and bone dust.
8. These substances have a buoyant density greater than bone dust and blood, thus preventing ingress to the scala tympani.
9. At this point, a straight pick is used to open the endosteum and the electrode is inserted.
10. Suction is prohibited at this stage to avoid loss of perilymphatic fluid. Systemic and/or topical intratympanic steroids may be used in hearing preservation cases.

7.2Round Window Technique

The round window approach preserves the residual low frequency hearing and electroacoustic stimulation in children. In addition to avoiding the potential trauma that the inner ear experiences from 130dB produced from drilling the traditional cochleostomy, the round window approach may reduce postoperative vertigo.

Picture showing Cochleostomy Opening


Picture showing Round Window via Facial Recess Approach

7.3 Intraoperative Monitoring Of Cochlear Nerve

Intraoperative monitoring and the integrity of the cochlear nerve were measured by using telemetry. The following responses are monitored

1. Impedance telemetry
2. Integrity testing
3. Electrical stapedial reflex response
4. Electrical auditory brainstem response
5. Neural response telemetry (ECAP)

Normal intraoperative findings provided immediate assurance to the implant team and parents of young children that the implant was fully functioning and that electrical stimulation was activating the auditory pathways.

VIII. Statistics

8.1 Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Age Valid N (list wise)	30 30	2	6	4.6	1.303

8.2 Frequencies

Frequency TableGroup

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cochleostomy	18	60.0	60.0	60.0
	Round Window	12	40.0	40.0	100.0
	Total	30	100.0	100.0	

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	3	10.0	10.0	10.0
	3	4	13.3	13.3	23.3
	4	3	10.0	10.0	33.3
	5	12	40.0	40.0	73.3
	6	8	26.7	26.7	100.0
	Total	30	100.0	100.0	

Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	15	50.0	50.0	50.0
	Female	15	50.0	50.0	100.0
	Total	30	100.0	100.0	

Facial Nerve – Preop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	30	100.0	100.0	100.0

Ossicles – Preop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	30	100.0	100.0	100.0

Cochlear Turn's – Preop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	29	96.7	96.7	96.7
	Abnormal	1	3.3	3.3	100.0
Total		30	100.0	100.0	

Cochlear Nerve- Preop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	30	100.0	100.0	100.0

Facial Nerve – Intraop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	29	96.7	96.7	96.7
	Abnormal	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

Ossicles – Intraop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	30	100.0	100.0	100.0

Jugular bulb – Intraop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	29	96.7	96.7	96.7
	Abnormal	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

Cochlear Turn's – Intraop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	29	96.7	96.7	96.7
	Abnormal	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

Cochlear Nerve -Intraop

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Normal	30	100.0	100.0	100.0

8.3 Crosstabulation

Warnings

No measures of association are computed for the cross tabulation of Facial Nerve – Preop* Facial Nerve – Intraop. At least one variable in each 2-way table upon which measures of association are computed is a constant.

Facial Nerve – Preop * Facial Nerve – Intraop

	Facial Nerve - Intraop		Total
	Normal	Abnormal	
Facial Nerve – Preop Normal Count % of total	29 96.7	1 3.3%	30 100.0%
Total Count % of total	29 96.7	1 3.3%	30 100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square McNemar-Bower Test N of Valid Cases	.[a] . 30	.	.[b]

a.No statistics are computed because Facial Nerve – Preop is a constant
b. Computed only for a PxP table, where P must be greater than 1.

Warnings

No measures of association are computed for the cross tabulation of Ossicles – Preop* Ossicles – Intraop. At least one variable in each 2-way table upon which measures of association are computed is a constant.

Ossicles – Preop * Ossicles – Intraop

	Ossicles - Intraop	Total
	Normal	
Ossicles – Preop Normal Count % of total	30 100.0	30 100.0%
Total Count % of total	30 100.0	30 100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square McNemar-Bower Test N of Valid Cases	.[a] . 30	.	.[b]

A. No Statistics Are Computed Because Ossicles – Preop And Ossicles – Intraop Are Constants
B. Computed Only For A Pxp Table, Where P Must Be Greater Than 1.

Jugular Bulb – Preop *Jugular Bulb – IntraopCross tabulation

			Jugular Bulb - Intraop		Total
			Normal	Abnormal	
Jugular Bulb – Preop	Normal	Count % of total	29 96.7	0 0.0%	29 96.7%
	Abnormal	Count % of total	0 0.0%	1 3.3%	1 3.3%
Total % of total		Count	29 96.7	1 3.3%	30 100.0%

Chi-Square Tests

	Value	df	Asym. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	30.000[b]	1	.000		
Continuity Correction [a]	6.992	1	.008		
Likelihood Ratio	8.769	1	.003		
Fischer's Exact Test				.003	
Linear-by-Linear Association	29.000	1	.000		.003
McNemar Test				1.000[c]	
N of Valid Cases	30				

a. Computed only for a 2x2 table
b. 3 cells (75.0%) have expected count less than 5. The minimum expected count is 03.
c. Binomial distribution used.

Cochlear Turn's – Preop*Cochlear Turn's – IntraopCross tabulation

			Cochlear Turn's - Intraop		Total
			Normal	Abnormal	
Cochlear Turn's – Preop	Normal	Count	29	0	29
		% of total	96.7	0.0%	96.7%
	Abnormal	Count	0	1	1
		% of total	0.0%	3.3%	3.3%
Total		Count	29	1	30
		% of total	96.7	3.3%	100.0%

Warnings

No measures of association are computed for the cross tabulation of Cochlear Nerve – Preop* Cochlear Nerve – Intraop. At least one variable in each 2-way table upon which measures of association are computed is a constant.

Cochlear Nerve – Preop* Cochlear Nerve – IntraopCross tabulation

	Cochlear Nerve - Intraop	Total
	Normal	
Cochlear Nerve – Preop Normal Count	30	30
% of total	100.0	100.0%
Total Count	30	30
% of total	100.0	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.[a]		
McNemar-Bower Test	.	.	.[b]
N of Valid Cases	30		

a. No statistics are computed because Cochlear Nerve – Preop and Cochlear Nerve – Intraop are constants
b. Computed only for a PxP table, where P must be greater than 1.

Sex*Group

			Group		Total
			Cochleostomy	Round Window	
Sex	Normal	Count	7	8	15
		% with Group	38.9%	66.7%	50.0%
	Abnormal	Count	11	4	15
		% with group	61.1%	33.3%	50.0%
Total		Count	18	12	30
% with group			100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asym. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.222[b]	1	.136		
Continuity Correction [a]	1.250	1	.264		
Likelihood Ratio	2.256	1	.133		
Fischer's Exact Test				.264	.132
Linear-by-Linear Association	2.148	1	.143		
N of Valid Cases	30				

a. Computed only for a 2x2 table
b. 0 cells (0%) have expected count less than 5. The minimum expected count is 6.00.

Facial Nerve – Preop* Group

			Group		Total
			Cochleostomy	Round Window	
Facial Nerve – Preop	Normal	Count % of total	18 100.0%	12 100.0%	30 100.0%
Total		Count % of total	18 100.0%	12 100.0%	30 100.0%

Chi-Square Tests

	Value
Pearson Chi-Square	.[a]
N of Valid Cases	30

Ossicles– Preop* Group

			Group		Total
			Cochleostomy	Round Window	
Ossicles – Preop	Normal	Count % of total	18 100.0%	12 100.0%	30 100.0%
Total		Count % of total	18 100.0%	12 100.0%	30 100.0%

Chi-Square Tests

	Value
Pearson Chi-Square	.[a]
N of Valid Cases	30

a. No statistics are computed because Ossicles – Preop is a constant

Jugular Bulb Preop*Group

			Group		Total
			Cochleostomy	Round Window	
Jugular Bulb Preop	Normal	Count % with Group	17 94.4%	12 100.0%	29 96.7%
	Abnormal	Count % with group	1 5.6%	0 .0%	1 3.3%
Total % with group		Count	18 100.0%	12 100.0%	30 100.0%

Chi-Square Tests

	Value	df	Asym. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.690[b]	1	.406		
Continuity Correction [a]	0.000	1	1.000		
Likelihood Ratio	1.045	1	.307		
Fischer's Exact Test				1.000	.600
Linear-by-Linear Association	.667	1	.414		
N of Valid Cases	30				

a. Computed only for a 2x2 table
b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.

Cochlear Turn's Preop * Group

			Group		Total
			Cochleostomy	Round Window	
Cochlear Turns Preop	Normal	Count % with Group	17 94.4%	12 100.0%	29 96.7%
	Abnormal	Count % with group	1 5.6%	0 .0%	1 3.3%
Total % with group		Count	18 100.0%	12 100.0%	30 100.0%

Chi-Square Tests

	Value	df	Asym. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.690[b]	1	.406		
Continuity Correction [a]	0.000	1	1.000		
Likelihood Ratio	1.045	1	.307		
Fischer's Exact Test				1.000	.600
Linear-by-Linear Association	.667	1	.414		
N of Valid Cases	30				

a. Computed only for a 2x2 table
b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.

Cochlear Nerve– Preop * Group

	Group		Total
	Cochleostomy	Round Window	
Cochlear Nerve – Preop Normal Count % of total	18 100.0%	12 100.0%	30 100.0%
Total Count % of total	18 100.0%	12 100.0%	30 100.0%

Chi-Square Tests

	Value
Pearson Chi-Square	.[a]
N of Valid Cases	30

a. No statistics are computed because Cochlear Nerve – Preop is a constant

Facial Nerve – Intraop * Group

			Group		Total
			Cochleostomy	Round Window	
Facial Nerve Intraop	Normal	Count % with Group	17 94.4%	12 100.0%	29 96.7%
	Abnormal	Count % with group	1 5.6%	0 .0%	1 3.3%
Total % with group		Count	18 100.0%	12 100.0%	30 100.0%

Chi-Square Tests

	Value	df	Asym. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.690[b]	1	.406		
Continuity Correction [a]	0.000	1	1.000		
Likelihood Ratio	1.045	1	.307		
Fischer's Exact Test				1.000	.600
Linear-by-Linear Association	.667	1	.414		
N of Valid Cases	30				

a. Computed only for a 2x2 table
b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.

Ossicles – Intraop * Group

			Group		Total
			Cochleostomy	Round Window	
Ossicles – Intraop	Normal	Count % of total	18 100.0%	12 100.0%	30 100.0%
Total		Count % of total	18 100.0%	12 100.0%	30 100.0%

Chi-Square Tests

	Value
Pearson Chi-Square N of Valid Cases	.[a] 30

a. No statistics are computed because Ossicles – Intraop is a constant

Jugular Bulb – Intraop * Group

			Group		Total
			Cochleostomy	Round Window	
Jugular Bulb Intraop	Normal	Count % with Group	17 94.4%	12 100.0%	29 96.7%
	Abnormal	Count % with group	1 5.6%	0 .0%	1 3.3%
Total % with group		Count	18 100.0%	12 100.0%	30 100.0%

Chi-Square Tests

	Value	df	Asym. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.690[b]	1	.406		
Continuity Correction [a]	0.000	1	1.000		
Likelihood Ratio	1.045	1	.307		
Fischer's Exact Test				1.000	.600
Linear-by-Linear Association	.667	1	.414		
N of Valid Cases	30				

a. Computed only for a 2x2 table
b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.

Cochlear Turns – Intraop * Group

			Group		Total
			Cochleostomy	Round Window	
Cochlear Turns Intraop	Normal	Count % with Group	17 94.4%	12 100.0%	29 96.7%
	Abnormal	Count % with group	1 5.6%	0 .0%	1 3.3%
Total % with group		Count	18 100.0%	12 100.0%	30 100.0%

Chi-Square Tests

	Value	df	Asym. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.690[b]	1	.406		
Continuity Correction [a]	0.000	1	1.000		
Likelihood Ratio	1.045	1	.307		
Fischer's Exact Test				1.000	.600
Linear-by-Linear Association	.667	1	.414		
N of Valid Cases	30				

a. Computed only for a 2x2 table
b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.

Cochlear Nerve – Intraop * Group

	Group		Total
	Cochleostomy	Round Window	
Cochlear Nerve–Intraop Normal Count % of total	18 100.0%	12 100.0%	30 100.0%
Total Count % of total	18 100.0%	12 100.0%	30 100.0%

Chi-Square Tests

	Value
Pearson Chi-Square	.[a]
N of Valid Cases	30

a. No statistics are computed because Cochlear Nerve – Intraop is a constant

IX. Interpretation Of Results

A total of 30 patients were selected for our study. All patients had congenital sensorineural hearing loss between the ages of one to six years underwent cochlear implantation. The study group consists of 15 male and 15 female patients. Out of 30 patients, 1 patient had rotated cochlea, enlarged vestibular aqueduct and high jugular bulb in preoperative radiological study. All the 30 patients the facial nerve course, ossicular status and cochlear nerve are anatomically normal in radiological studies.Out of 30 patients, 12 patients underwent round window insertion of electrodes. 18 patients underwent traditional cochleostomy with electrode insertion. 7 males and 11 females underwent cochleostomy technique.8 males and 4 females underwent round window technique.

Out of 30 patients, 29 patients cochlear implantation was done through facial recess approach. 1 patient underwent canal wall down approach with blind sac closure.Facial nerve course in all the 30 patients was radiologically normal but intraoperatively we found anteriorly displaced facial nerve in one patient.In our study, except facial nerve, all other findings in preoperative radiological findings correlate with intraoperative findings.

X. Discussion

In our study, two imaging modalities, HRCT temporal bone and MRI brain with cochlea are performed. This study shows HRCT scan can outline border of malformed labyrinth, ossicles, jugular bulb and facial nerve course, MRI provides additional information in the preoperative work up of patients with congenital sensorineural hearing loss. The detailed imaging of the internal cochlea and the malformed cochlea are needed for proper insertion of the electrode array of the cochlear implantation. This can be visualised with MRI scan in T2 weighted images. The diameter of the internal auditory cortex of brain is clearly visualized in MRI scan.The importance of HRT scan to study the temporal bone, the surgeon can decide on the direction of electrode array to minimize the risk of misplacement and assessing the malformation preoperatively and minimizing the trauma to vital structures. Implantation of the cochlear implant requires the knowledge about the anatomical structures and its variants in the temporal bone.The most important finding of our study, MRI scan allows full appreciation of the anatomy of the cochlear nerve within the IAC of children with congenital sensorineural hearing loss. A contraindication for cochlear implantation is a missing or ill-defined cochlear nerve as this nerve is necessary to conduct the cochlear implant impulses.Evoked potential may be used to study the function and condition of the nerve in a clinical setting. A positive brain stem evoked potential confirms a functional nerve but a negative test does not differentiate from a damaged, undeveloped nerve or normal nerve.Our study shows that imaging studies in congenital sensorineural hearing loss patients should not only focus just on the cochlear nerve or cochlea. One of our patients demonstrated multiple anomalies.In patients with cochleo-vestibular malformations should always anticipate aberrant course or shape of the facial nerve.Preoperative radiological imaging of temporal bone and brain help in determining the side of cochlear implantation and surgical approaches for cochlear implantation.

XI. Conclusion

Preoperative imaging before cochlear implantation surgery is important evaluation but should be done with ideal standards. This helps in selecting patients for cochlear implant surgery and also for preparing surgeons to anticipate complications and the best approach to avoid them. Full electrode insertion was possible in all patients with radiological absence of preoperative complication. Our study demonstrated that preoperative HRCT and MRI together is more accurate in detecting cochlear malformations, ossicles, jugular bulb and cochlear nerve.

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S.No.	Name	Age	Sex	Preoperative Findings in Radiology (HRCT & MRI)					IT	Intra-Operative Findings				
				FN	OSSI	JB	CT	CN		FN	OSSI	JB	CT	CN
1	Kavitha	3	F	N	N	N	N	N	RW	S	S	S	S	S
2	Ashwanth	4	M	N	N	N	N	N	RW	S	S	S	S	S
3	Mukunthan	3	M	N	N	N	N	N	RW	S	S	S	S	S
4	Madesh	2	M	N	N	N	N	N	C	S	S	S	S	S
5	Hemalatha	6	F	N	N	N	N	N	RW	S	S	S	S	S
6	Vishnu	5	M	N	N	N	N	N	RW	S	S	S	S	S
7	Pugal	2	M	N	N	N	N	N	RW	S	S	S	S	S
8	Kalpana	3	F	N	N	N	N	N	C	S	S	S	S	S
9	Saravanan	5	M	N	N	N	N	N	RW	S	S	S	S	S
10	Abinesh	5	M	N	N	N	N	N	RW	S	S	S	S	S
11	Jeebika	5	F	N	N	N	N	N	C	S	S	S	S	S
12	Vikram	4	M	N	N	Ab	Ab	N	C	Ab	B	S	S	B
13	Asma Parveen	5	F	N	N	N	N	N	C	S	S	S	S	S
14	Hasanidos	5	M	N	N	N	N	N	C	S	S	S	S	S
15	Ayisha Banu	5	F	N	N	N	N	N	C	S	S	S	S	S
16	Hasina	5	F	N	N	N	N	N	C	S	S	S	S	S
17	Praveena	2	F	N	N	N	N	N	C	S	S	S	S	S
18	Mugammed Salem	4	M	N	N	N	N	N	RW	S	S	S	S	S
19	Dinesh	6	M	N	N	N	N	N	C	S	S	S	S	S
20	Ponmozhi	5	F	N	N	N	N	N	RW	S	S	S	S	S
21	Rachel	5	F	N	N	N	N	N	C	S	S	S	S	S
22	Sanjay	6	M	N	N	N	N	N	C	S	S	S	S	S
23	Sivasakthi	6	F	N	N	N	N	N	C	S	S	S	S	S
24	Namira Banu	5	F	N	N	N	N	N	C	S	S	S	S	S
25	Sundarsan	6	M	N	N	N	N	N	C	S	S	S	S	S
26	Sanjay	3	M	N	N	N	N	N	C	S	S	S	S	S
27	Vijay Shri	6	F	N	N	N	N	N	RW	S	S	S	S	S
28	Kabilan	6	M	N	N	N	N	N	RW	S	S	S	S	S
29	Abirami	6	F	N	N	N	N	N	C	S	S	S	S	S
30	Jayasurya Kala	5	F	N	N	N	N	N	C	S	S	S	S	S

FN	Facial Nerve	Ossi	Ossicles	JB	Jugular Bulb	N	Normal
CN	Cochlear Nerve	IT	Insertion Technique	C	Cochleostomy	Ab	Abnormal
CT	Cochlear Turns	S	Same	RW	Round Window		

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