The Pattern of Outcome in minimally invasive (Veria) Technique of cochlear implant surgery: A Retrospective Study

[1]Dr Gautam Kumar, [2]Dr Sunil Ramnani, [3]Dr Durgesh Gajendra, [4]Dr Hansa Banjara

Junior resident, Professor & Hod, Associate Professor, Professor & Hod
[1,4]Department of ENT, pt jnmmc, Raipur
[2,3]Department of ENT,late baliram kashyap memorial medical College, jagdalpur, CG

Abstract

Background: Mastoidectomy and posterior tympanotomy are the classical surgical techniques for cochlear implantation (CI). These classical techniques often accompany extensive bone work, destruction of the mastoid air cell system, and facial nerve injury. Various modification in CI surgery has been done. Veria technique can minimize these complications.

Aims and objectives: To evaluate the outcome pattern in the minimally invasive Veria technique of CI surgery and major and minor intra and post-operative complications.

Materials and Methods: One hundred and ninety-four patients undergoing Veria technique for CI were studied in a facility-based, retrospective observational study in the Department of Otorhinolaryngology in a tertiary care center of Raipur Chhattisgarh from January 2009 to December 2020. Sex, implantation side, type of implantation, duration of profound hearing loss, type of CI, antenatal/natal/post-natal history, developmental history, and immunization history was recorded. The follow-up time was at least six months of post-op. Duration and etiology of deafness, communication mode, age at implantation, duration of implant usage, and pre-usage of hearing aids were the outcome variable measured.

Results: The majority were 3.1-5 years (39.17%) old and were males (52.06%). Out of 194 Patients, 2.06% had EV bleeding, 1.03% had Perilymph gusher, 0.51% had chorda tympani and canal wall injury, and 1.03% had difficulty while electrode insertion. Only 1 (0.51%) patient had TM Injury as an intra-operative complication. The most common major post-operative complication was FN paralysis/ paresis and ASOM in 1.03%, 1.03% had wound dehiscence in the early period, 1.03% showed device extrusion, only 1 (0.51%) showed electrode migration in the late period. Minor post-operative complications included wound infection in 1.03%, 1.02% had FN paresis due to thermal injury, and one patient developed seroma in the late period. Five patients had explantation due to hard device failure.

Conclusion: Veria technique is a well-known and accepted surgical procedure with fewer minor complications. It is also less time-consuming with equal efficacy and results as the classical technique.

Keywords: post-operative complications, minimally invasive surgery, Veria technique, Retrospective Study

Introduction

The most common sensory deficit in children is hearing loss, with its incidence being 1–3 in 1000 live birth per year. (Allen SB 2022) Half of these children will have severe to profound hearing loss. (Afshar PJ 2022)

Hearing rehabilitation with cochlear implants (CI) is well-established. It is indicated as younger age at implantation, bilateral implantations, single-sided deafness, hearing preserving techniques, electroacoustic devices, and severe and profound sensorineural hearing loss (SHL). (Das S 2005, Tait M 2007)

There are various surgical techniques for CI, the classical one being mastoidectomy and posterior tympanotomy, introduced in 1979. (Jappel A 2004) To minimize various disadvantages and surgical complications involved in standard procedure, various modifications in CI surgery have been taken, including introducing the Veria technique. (Mostafa BE 2014)

A supramental approach for CI was started by Kronenberg et al. in 2000, where electrodes were inserted without mastoidectomy and posterior tympanotomy. (Kronenberg J 2002) Veria technique has also seen various modifications. The Veria technique or the transcanal approach is unique because it provides a wide visibility/accessibility for performing the electrode insertion into the cochlea with minimal or no removal of the healthy mastoid bone, keeping the mastoid air cell system intact. (Singhal P 2020)

Usually, the most commonly used technique is posterior tympanotomy, but it has its limitations and complications. (Singhal P 2020)

The minimally invasive Veria technique has overcome these limitations and complications. (Singhal P 2020)

This retrospective study aims to know the outcome pattern in the minimally invasive (Veria technique) technique of CI surgery and evaluate the major and minor challenges and complications during surgery and the post-operative period. The study will provide information regarding risks posed to implant recipients and suggests approaches improve surveillance of complications and their management to increase the outcome of surgery.

Materials and Methods

A facility-based, cohort retrospective observational study was performed on 194 patients operated by Veria technique at the Department of Otorhinolaryngology, Dr. B.R.A.M. Hospital and Pt. J.N.M. Medical College, Raipur, Chhattisgarh from January 2009 to December 2020.

All the patients/ attendees signed the written informed consent before the surgery (as the patient were minor). Institutional research committee approval was obtained from MS (Dr. BRAMH.) Raipur. The follow-up time was at least six months of post-op.

The patient whose data was not available had neurological deficits (cerebral palsy, MR, and Down's syndrome) and behavioral problems (such as autism) were excluded.
The relevant data were retrieved from fully completed clinical records. Information regarding the performance level of the implanters from health care professionals like ENT surgeons audiologists was obtained from the medical record department.
Details on sex, implantation side. (right and left), type of implantation (unilateral, bilateral), duration of profound hearing loss, type of CI (AB, cochlear, med-el), antenatal/natal/post-natal history, developmental history, and immunization history was recorded.
The outcome variable measured were duration and etiology of deafness, communication mode, age at implantation, duration of implant usage, and pre-usage of hearing aids (HA).

Statistical analysis

All the data analyses were performed using IBM SPSS ver. 20 software. Frequency distribution and cross-tabulation were performed to prepare the tables. Descriptive analysis was performed for obtaining baseline characteristics of the study cohort. Data were expressed as numbers and percentages.

Results

The majority had an age between 3.1-5 years (39.17%) followed by 1-3 years (29.89%), 5.1-7 years (23.19%), 11 (5.67%) patients had an age between 7.1-10 years, and only 4 (2.06%) patients had aged more than 10 years. The majority were males (52.06%) than females (47.94%).
Out of 194 patients, 179 (92.35%) patients used HA for 0-3 months, 14 (7.14%) for 4-10 months and 1 (0.51%) patient it for >10 months.
The majority [190 (97.94%)] had congenital etiology, and 4 (2.06%) had acquired etiology. None of the patients had a history of syndromic sensorineural hearing loss (SNHL) and TORCH infection in congenital etiology. In acquired etiology, 4 patients had a history of meningitis, 5 had physiological jaundice, 1 had typhoid during the perinatal and post-natal period.
Out of 194 patients, 186 (95.87%), 7 (3.61%), and 1 (0.51%) underwent right, left, and bilateral CI surgery, respectively. Most of the patients underwent right side CI (cerebral lateralization of language processing, the dominant left hemisphere is seen in 95-98% of right-handed and 70-80% of left-handed).
Out of 194, 190 (97.94%) and 4 (2.06%) patients were pre-and post-lingual deafness who underwent CI surgery. The majority of patients [172 (88.66%)] had normal and intact tympanic membrane (TM), 4 (2.06%) had retracted TM, 18 (9.28%) had intact and dull TM.
All patients were investigated for brainstem evoked response audiometry and otoacoustic emissions; of that, 134 (69.07%) had inconsistent reports, 60 (30.93%) had profound bilateral SNHL, and 18 (9.28%) had investigated for tympanometry.
Out of 194 patients who had undergone CI surgery, 5 patients had sclerosed pneumatization of mastoid, 5 (2.58%) had right side otomastoiditis, 2 (1.03%) had right labyrinthitis ossificans (Balkany Grading System) Grade I, and 5 (2.58%) had right rotated cochlear anatomy on HRCT finding of the temporal bone. The right labyrinthitis ossificans and right rotated cochlear anatomy patients underwent left-sided CI surgery. Two (1.03%) patients had dilated vestibular aqueduct in magnetic resonance imaging of the temporal bone.

Table 1: Major and Minor Intraoperative Complications

Minor	N (%)	Major	N (%)
Chorda Tympani Injury	1 (0.51)	FN Injury	0 (0)
Canal wall Injury	1 (0.51)	TM Injury	1 (0.51)
Perilymph Gusher	2 (1.03)	Electrode Breakage	0 (0)
Emissary vein Bleed	4 (2.06)	Difficulty during Electrode Insertion	2 (1.03)
Ossicular Injury	0 (0)	Difficulty during cochleostomy	0 (0)
Oedematous Mucosa	0 (0)	Intra- op NRT (Not- Measurable)	2 (1.03)

Data are expressed as no of patients (percentage).

Table 2: Major Post- Operative Complications based on time of occurrence

Early complications	N (%)	Late complications	N (%)
FN Paralysis/ Paresis	2 (1.03)	Device Failure	3 (1.55)
ASOM	2 (1.03)	Electrode Migration	1 (0.51)
CSOM	0 (0)	Magnet Migration	0 (0)
Wound Dehiscence	2 (1.03)	Flap Necrosis	0 (0)
Altered Taste Sensation	0 (0)	Cholesteatoma Formation	0 (0)
Meningitis	0 (0)	Device Extrusion	2 (1.03)

Table 3: Minor Post- Operative Complications based on time of occurrence

Early complications	N (%)	Late complications	N (%)
Hematoma	0 (0)	Recurrent AOM	0 (0)
Wound Infection	2 (1.03)	SOM	0 (0)
Tinnitus	0 (0)	Thermal Injury to FN	2 (1.03)
Vertigo	0 (0)	Balance Disorder	0 (0)
		Seroma	1 (0.51)

Five patients had explantation due to hard device failure. Out of 5 patients, 3 underwent reimplantation, and 2 did not undergo reimplantation due to technical and financial issues.

Discussion

Cochlear implants are electronic devices that stimulate the inner ear and act as a functional replacement for the inner ear. The most typical indication of CI is bilateral severe to profound SHL. The standard surgical procedure for CI is a transmastoid procedure with posterior tympanotomy. (Lenarz T 2018)

The standard procedure is lengthy due to the drilling of the large cavity and the need to locate the structures that can get damaged while drilling. (Brett B 2012) There are several complications related to this procedure, such as facial nerve injury, injury to chorda tympani nerve, injury to various structures while drilling like sigmoid sinus, dura, and ossicular chain. (Mostafa BE 2014) The pneumatization of mastoid bone is important in CI as drilling becomes difficult in sclerotic mastoids compared to good porous mastoids. (Jain R 2019) The position of the cochlea also varies with facial nerve and oval window, which makes CI difficult through the classical approach.

Proper pre-operative assessment with HRCT temporal bone cochlear cuts, 3D MRI membranous labyrinth, and brain screening is essential for identifying anatomical variations, anatomy of the facial nerve, anomalies of the cochlea, presence/absence of cochlear nerve. The present study evaluated all patients with imaging HRCT temporal bone, MRI brain and membranous labyrinth, syndromic workup, and opinion from pediatrician and psychiatrist were also obtained. Before surgery, all of our cases were immunized with the pneumococcal polysaccharide and meningococcal vaccine. The present study did not find any incidence of post-operative meningitis. Most of the patients had undergone the right CI in the present study.

Many surgical modifications have been proposed to reduce the complications and overcome most of the drawbacks seen in CI with mastoidectomy and posterior tympanotomy approach. In 2000, Kronenberg et al. proposed a supramental approach for cochlear implantation, where cochlear implantation was done without mastoidectomy and posterior tympanotomy. (Kronenberg J 2002)

Later, Kiratzidis designed an alternative approach to the classical technique for CI and named it after the Veria city. (Kiratzidis T 2002) It is a non- mastoidectomy procedure where the endaural route is used for transcanal cochleostomy. Electrodes of the CI are passed through the tunnel, drilled parallel to the posterior canal wall through facial recess, which opens into the middle ear. It gives access to the cochlea without endangering the facial nerve and maintaining natural mastoid air cell systems. The tunnel is drilled with a specially designed device known as the Veria perforator. In Veria technique, endaural approach to the middle ear with an elevation of tympanomeatal flap, straightening the posterosuperior bony canal wall, drilling the transcanal wall direct tunnel with alignment to the cochleostomy, superiorly bases musculoperiosteal flap is elevated, creating a bed and fixing the device. Overall, the major advantage of Veria technique is the versatility to handle all possible types of cochlear rotations, cochlear malformations, non-pneumatised temporal bone, and jugular bulb variations with ease due to the transcanal direct approach to the cochlea. The electrode is well covered with a thin shell of bone which is no less than 0.6 mm, and none of the cases had electrode extrusion. Caversaccio et al. have demonstrated the feasibility of robotic middle ear keyhole access through the same route which the modified Veria technique uses. (Caversaccio M 2019)

We are routinely following the Veria technique of CI surgery; this is associated with fewer problems like injury to the facial nerve, chordaetympani nerve, tympanic membrane, and dura. No difficulty in round window identification. None of our cases had permanent facial nerve palsy; 2 patients had a thermal injury to the facial nerve, which was recovered within 3-4 weeks of the post-operative period with intravenous steroids physiotherapy. None of our cases had partial/ complete nerve transactions. Long-term results are satisfactory without disfigurement. Ajalloueyan et al. in Iran showed a report of surgical complications in 262 pediatric cochlear with a higher incidence of surgical complications than our series. (Ajallouyean M 2011) Hoffmann and Cohen reported that CI by Veria technique results showed 15 cases of temporary facial palsy, a slightly higher incidence than our study. The author also reported 18 cases of facial nerve injuries. They have not mentioned whether the paralysis is permanent or temporary. (Hoffman RA 1995)

In another study by Venial et al., reliability and complications of 500 consecutive cochlear implantations were observed; 1 case of transient facial palsy was reported as Brackmann grade 4. However, full recovery was noted within 15 days with steroid therapy. (Venail F 2008) In the present series, a lesser incidence of facial nerve injury and temporary palsy was reported than in previous studies.

The present study reported chordae tympani injury in 1 patient during drilling of transcanal tunnel with no significant post-operative taste disturbances because most of the patients were young children, and taste sensation also carried out by other nerve compensate this injury. One patient had canal wall injury with no evidence of post-operative cholesteatoma formation on 6 months follow-up. All patients had healed neo tympanum in 6 months follow-up period. Not much data regarding posterior canal wall injury and grafting in the literature is reported.

Perilymph gusher seen in 2 cases while attempting insertion of electrodes, which is reduced by itself in about 10 minutes by supportive measure (head-end elevation and hyperventilation by anesthetist). We encountered 2 MRI findings of the enlarged vestibular aqueduct. Gheorghe et al. reported 2 cases of CSF gusher in the anomalous cochlea. (Gheorghe DC 2015) Daneshi et al. studied 4400 pediatric cochlear implantations and reported 17 cases of intra-operative CSF leakage, mostly with inner ear anomalies. However, this is not a significant concern and usually stops with hyperventilation. (Daneshi A 2015) Heman-Ackah et al. reported CSF fistula and secondary meningitis in 1% of pediatric patients after CI. (Heman-Ackah S. E 2010) CSF fistulas can be prevented by packing cochleostomy around the electrode.

Emissary vein bleeding was seen in 4 cases during drilling for receiver-stimulator well creation in the present study. In 1 case, bleeding subsides with cautery; in 3 cases, bleeding subsides with bone wax. None of our patients had an injury to major vessels like carotid injury, sigmoid sinus, injury to the jugular bulb. Literature does not provide much information about the emissary's vein bleeding.

Two patients had difficulty in electrode insertion. Forceful insertion was avoided in these 2 cases to assure atraumatic electrode insertion. We are routinely following the atraumatic method for electrode insertion. Mecca et al. reported that to reduce the complication of CI surgery, the position of electrodes should be along the perimodiolar and closer to spiral ganglion cells for target stimulation; deeper insertion is needed for low-frequency perception. (Mecca MA 2003) Gheoghe et al. reported that cochlea that

prevents full electrode array insertion could be challenging; using a short array, partial insertion, and voluntary inactivation of some electrodes post-operatively gives good results. (Gheorghe DC 2015)

Wound infection was reported in 2 cases that led to the development of wound dehiscence. Wound infection has to be avoided by proper pre-operative sterile methods like sterile microscope cover, adequate cleaning and painting of ear, sterile drapes, covering other body areas properly to prevent surgical site contamination. Ethilon suture material may cause wound dehiscence following primary infection- ethilon suture has to be removed at 10th post-operative day to prevent wound infection.

Explantation is done in 5 cases of our study because fall injury leads to hard device failure. Comparable results were reported by Venial et al. where explantation was performed due to hard device failure and soft device infection trauma. (Venail F 2008) Tambyraja et al. proposed a new database for malfunctioning devices. Categorization and rationalization of device-related and patient-related factors were highlighted in their study. (Tambyraja RR 2005)

One of our patients had seroma reported after 3 months. Aspiration shows serous material, subsided with aspiration and conservative methods like tight compressive mastoid dressing, local wound care, and systemic antibiotics.

Sheng- dean et al. studied mastoid pressure dressing for CI in 92 patients and reported no significant benefits for the use of mastoid pressure dressing following CI. There was an increased incidence of periorbital edema forehead skin necrosis from restricted lymphatic and venous drainage as a complication of pressure dressing. (Sheng-Dean L 2009)

We encountered post-operative otitis media in 2 of our patients, all 2 patients were effectively managed with intravenous antibiotics, and none needed revision surgery. Venail et al. reported a slightly higher incidence of post-operative otitis media, device failure, and magnet displacement in children than adults; in their series, 5 post-operative otitis media cases were managed conservatively with systemic oral antibiotics. (Venail F 2008)

Revision surgery is done in 3 of our patients. Due to Trauma (hard device failure), all these patients underwent reimplantation on the same side. Venail et al., in their series of 500 consecutive CI, showed 30 cases of device failure, of which 13 cases were of electronic failure. Some patients had a history of retro auricular pain as a primary manifestation of device failure. (Venail F 2008) Reimplantation is the only acceptable treatment option in these cases.

Post-operative radiological confirmation of implant position with x-ray Mastoid (stenver view) was obtained for all patients. For up to 2 years, most patients were followed with audio-verbal therapy and proper mapping post-operatively. Speech responses were assessed in all patients and compared in patients with challenged and without challenges by an audiological team and ENT surgeons.

Conclusion

Cochlear implant surgery is a reliable and well-accepted procedure to cope with severe to profound sensory-neural hearing loss, especially in the pediatric age group. This helps the children attain near-normal language and speech milestones if done earliest. Hence allowing them to lead an everyday life. The Veria technique for CI is a non -mastoidectomy technique using the endaural approach for cochleostomy and the transcanal wall approach for the electrode. It is an effective tool to improve surgical results in cochlear implantations. The classical technique's complications related to cochlear implant surgeries are not lethal or dangerous, but these complications are reduced significantly with the Veria technique. They are mainly minor intraoperative surgery-related, flap-related problems, or infections. This can be easily tackled by being more skilled and cautious during surgery, and conservative management can treat minor complications. Veria technique is a well-known and accepted surgical procedure with fewer minor complications. It is also less time-consuming with equal efficacy and results as the classical technique.

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