ORIGINAL ARTICLE

Cochlear Implantation and Intraoperative Neurophysiological Monitoring of the Facial Nerve

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ABSTRACT

Cochlear implants (CI) provide significant benefits to patients. Given these benefits and the increasing number of CI surgeries, great care should be taken to prevent facial nerve injury. Intraoperative neurophysiological monitoring (IONM) of the facial nerve during CI surgery can greatly benefit the surgeon when combined with a thorough history and physical and appropriate pre-operative imaging. In this case, we review the pre-operative and intraoperative considerations of CI surgery and the implications of using IONM for facial nerve monitoring.

Preoperative considerations include appropriate workup, including a thorough history and physical examination with special care for audiometric history, evaluation, and preoperative imaging. Intraoperatively, special consideration should be given to IONM of the facial nerve while drilling over the facial recess. Care should be taken about specific anatomical considerations based on preoperative imaging.

IONM of the facial nerve during CI surgery can significantly help the surgeon. While rates of facial nerve injury are low in incidence during CI surgery, IONM can be especially useful in cases of variant anatomy, younger patients, congenital malformations, or revision surgeries. It is a cheap and cost-effective way to safeguard the facial nerve and should be considered during all CI surgeries.

Cochlear implantation can have tremendous benefits for patients, but the potential risks of facial nerve injury can be devastating. IONM of the facial nerve during CI surgery can help prevent such injury and do so in a cost-effective and time-efficient manner.

INTRODUCTION

Cochlear implants (CI) benefit patients significantly, including improved word-recognition scores, post-implantation speech perception testing, and quality of life [1]. With these significant benefits and increased numbers of patients receiving CI, it is vital that experienced surgeons carefully perform CI surgeries to minimize the potential risks. One of the most dreaded risks of cochlear implantation is facial nerve injury and paralysis. While the incidence has been reported to be less than 1.2% [2], the impact of facial paralysis can be devastating to patients. While surgeon experience plays a crucial role in preventing facial nerve injury, intraoperative neurophysiological monitoring (IONM) of the facial nerve can serve as an additional guide for the surgeon in avoiding injury to the facial nerve during cochlear implantation.

In Otolaryngologic surgeries, IONM helps monitor all cranial nerves' structural and functional integrity. Intraoperative nerve monitoring during cochlear implantation isn't standard practice during otologic surgery. It is a cost-effective and valuable tool in identifying the facial nerve, specifically when it may be at risk during otologic surgery [3]. IONM of the facial nerve is conducted through electromyography (EMG), which monitors muscles innervated by the facial nerve, such as orbicularis oculi and orbicularis oris – trauma to the nerve or near the nerve evokes detectable motor-unit potentials that are detected by a monitor [4]. In this surgical report, we review the pre-operative and intraoperative considerations for patients undergoing cochlear implantation (Figure 1) and discuss the benefits and implications of using IONM for the facial nerve during these critical surgeries.

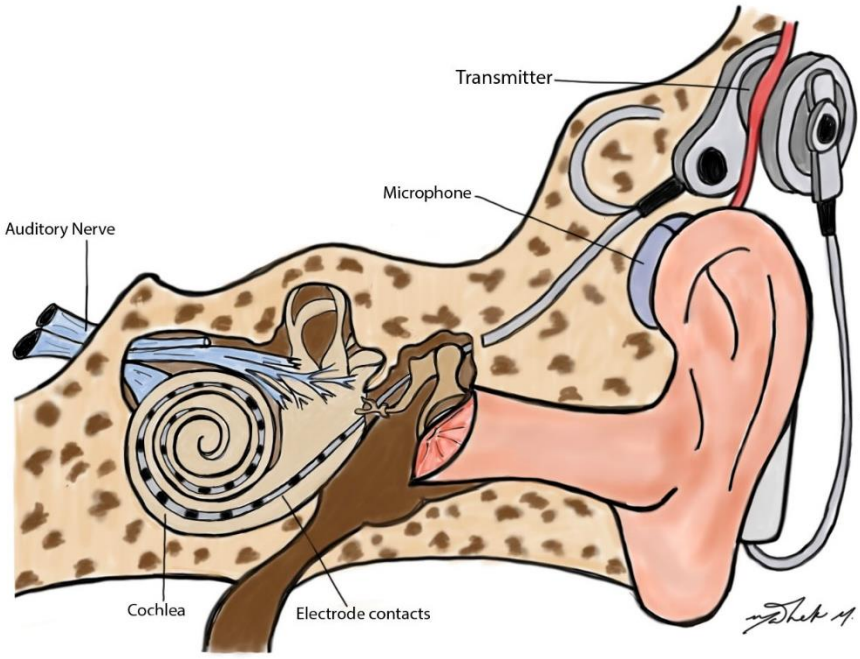

Figure 1. A cochlear implant with the relevant surrounding anatomy and placement (illustration by Mahek Mumtaz).

CASE WALKTHROUGH

Pre-Operative Considerations

In general, indications for cochlear implantation differ for adults (over 18 years of age) and children. Some major indications of cochlear implantation in adults include bilateral severe sensorineural hearing loss, post-lingual onset of deafness, or little to no helpful benefit with appropriately fit hearing aids and consistent use. There are further sub-criteria that regard the specific performance of the patient in open-set sentence recognition testing, which can differ based on the FDA guidelines and the criteria provided by medical insurance. Private insurance criteria can differ from Medicare criteria and allow for further variations. In children, similar indications exist, though with more specific guidelines for those aged 1-2 years old and those from 2-18 years old.

Absolute contraindications to cochlear implantation include cochlear nerve aplasia and cochlear agenesis. Other relative contraindications include intracochlear ossification or fibrosis, congenital malformations, and chronic otitis media that is active. The cochlear nerve must be present for CI to be a success. Radiological imaging is particularly important, specifically in pre-lingual deaf children. Inner ear malformations and abnormal facial nerve anatomy may result in different implantation techniques and thus place the facial nerve at greater risk.

A complete and thorough history should be completed pre-operatively, which should also inquire about past bouts of meningitis or post-traumatic sensorineural hearing loss, as well as any history of prior ear surgeries or infections. A thorough physical examination should be performed with increased focus on any craniofacial abnormalities that may lead to differences in facial nerve anatomy. Facial nerve function should also be documented pre-operatively. A complete audiometric evaluation should include speech perception testing, an audiogram, and a prior hearing-aid trial. Radiological studies are also necessary, with high-resolution CT without contrast being the imaging for adults and T2 MRI being the scan of choice for children [5]. Patients must be immunized against *S. pneumonia* before implantation.

Intraoperative Considerations

Anesthetic considerations include appropriate patient positioning, with the patient usually turning 180 degrees. Anesthetic agents that do not cause paralysis should be used after induction and intubation. Electromyography (EMG) is used to monitor the functional integrity of the nerve supplying a muscle. The five branches of the facial nerve, temporal, zygomatic, buccal, marginal mandibular, and cervical, are monitored by the EMG of the frontalis, orbicularis oculi, buccinator, orbicularis oris, mentalis, and platysma muscles, respectively. Subdermal needle electrodes are placed in these muscles. Two types of EMG, spontaneous (s-EMG) and triggered (t-EMG) are used. A t-EMG (t-EMG) is done by stimulating a

nerve and monitoring its response to the corresponding muscles. In s-EMG, subdermal needles are placed in muscles corresponding to nerves at risk and are then monitored passively without any nerve root stimulation (Figure 2).

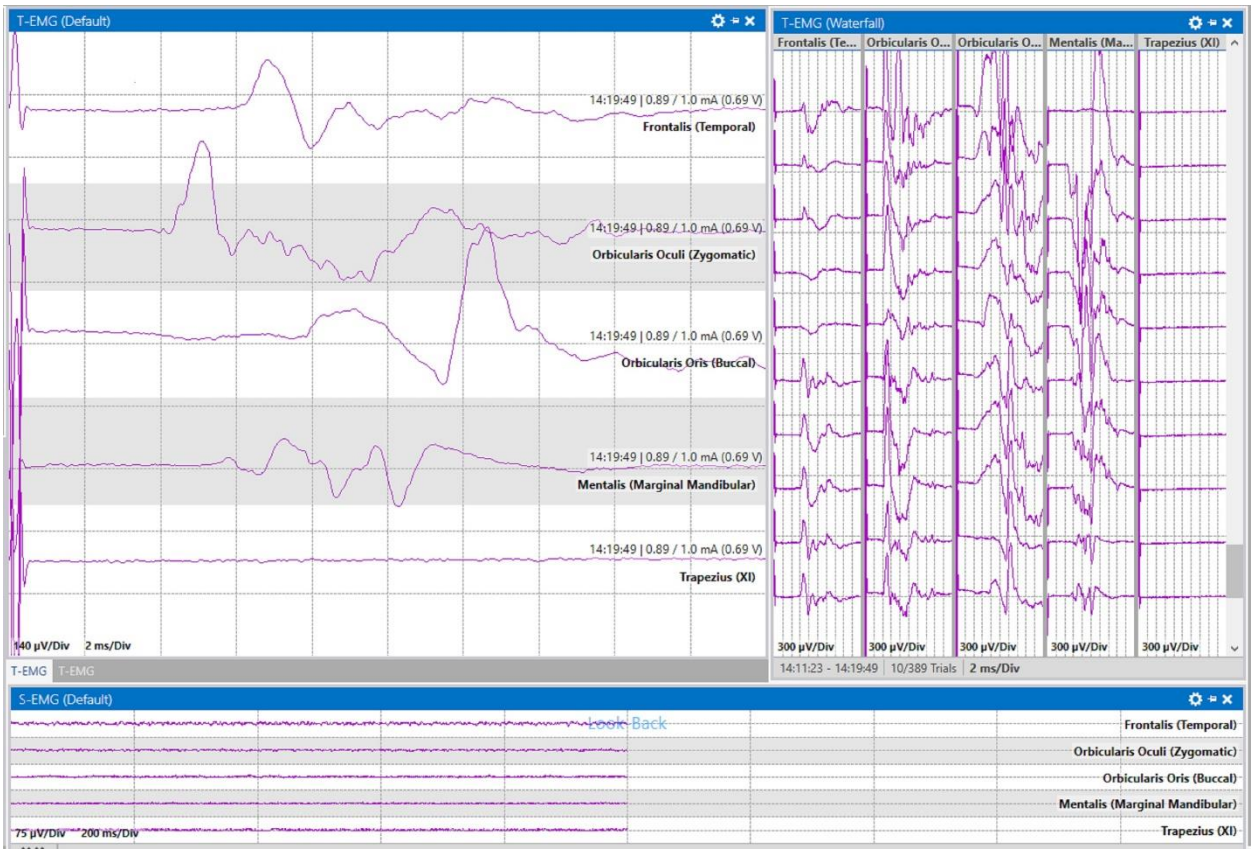

Figure 2: Facial nerve (CN VII) EMG responses. (Left) Triggered EMG (t-EMG) responses with a monopolar hand-held probe at 1.0 mA. (Right) Stack view of t-EMG responses from facial muscles with trapezius muscle as a control. (Bottom) Spontaneous EMG (s-EMG) responses from the muscles of the facial expression.

The procedure begins with a post-auricular incision, usually C-shaped, down to the level of the deep temporalis facia. This incision should be placed approximately 4 mm behind the post-auricular crease. If the patient already has a cochlear implant on the contralateral side or is undergoing bilateral cochlear implantation, monopolar electrocautery is contraindicated. A Palva flap comprising periosteum, muscle, and temporalis fascia will cover the CI processor. Once this is done, a limited mastoidectomy is done while opening the facial recess to provide exposure to the round window. In this stage, one should take great care in not sacrificing the chorda tympani nerve. The round window should be exposed with the stapes visualized. The well should then be drilled for each device as recommended, with particular consideration to ensure the device does not migrate.

Attention is then turned to performing the cochleostomy, which should be performed using a 1 mm diamond burr under high magnification. It should be placed inferior and anterior to the round window. The size should be decided based on the manufacturer of the device itself. The device should then be introduced and placed into the well drilled out prior and secured as needed, with sutures or screws being appropriate if necessary. The electrode array can then be inserted into the scala tympani into the cochleostomy made previously with full insertion of all electrodes. Insertion should be performed slowly and carefully. The excess electrode can be curled into the defect area, while the cochleostomy around the device can be plugged using a piece of temporalis muscle or fascia. The Palva flap created previously can then be closed, with the complete coverage of the electrode and device. The wound is closed with a mastoid dressing applied. Patients can be discharged post-operatively within the same day or two with postoperative antibiotics. The cochlear implant is typically activated about a month postoperatively.

DISCUSSION

While the risk for facial nerve injury during cochlear implantation surgery is low, great care should be taken pre-operatively and intraoperatively to prevent this devastating complication. Pre-operatively, a thorough history, physical examination, and proper radiologic imaging are vital [6]. Congenital malformations or anatomical variants that may present themselves in such instances can help the surgeon navigate them accordingly, especially with the help of IONM in these variant cases. IONM can also be of great use in revision cases of cochlear implantation, where prior scarring and fibrosis can distort anatomy and make identifying the facial nerve more difficult. Intraoperatively, IONM of the facial nerve serves as an additional safeguard for the surgeon in combination with pre-operative imaging, surgeon experience, and patient history.

Multiple studies have looked at the impact of IONM on the facial nerve during cochlear implant surgery. Hsieh et al. found that while there wasn't a strong relationship between the use of IONM and delayed facial nerve palsy, IONM is still of great value in the early identification of dehiscent facial nerves and maintaining their integrity [2]. Additionally, IONM of the facial nerve is an economical safeguard and has also been shown to be a helpful training tool for surgeons in training [7]. Fayad et al. found no relationship between using IONM and delayed facial nerve palsy [8]. At the same time, Thom et al. observed a 4.5-fold increased risk of delayed postoperative facial nerve palsy in cases where IONM was not used in cochlear implant surgery[9]. These conflicting results still lend themselves to the fact that IONM is a valuable tool in identifying the facial nerve during cochlear implant surgery and should be used whenever possible. Hsieh et al. also showed that facial nerve sheaths that were unexpectedly dissected sounded an alarm through the IONM [2], further strengthening the case for the use of IONM during cochlear implant surgery for the preservation of the facial nerve and early detection of possible injury.

The most common mechanism of injury to the facial nerve that has been postulated is the heat of the diamond bur shaft rotating over the facial nerve [6]. IONM of the facial nerve in CI surgery can be an incredibly useful tool in preventing such injury for the new and experienced surgeon in facing all the possible variations of facial nerve anatomy that may present during the case. IONM should be used with a thorough patient history, appropriate pre-operative imaging, a thorough physical examination, audiological workup, and appropriate surgeon experience.

CONCLUSION

IONM of the facial nerve during cochlear implant surgery is a cost-effective and valuable tool in the early identification of the facial nerve in preventing further injury. While studies have not delineated the exact correlation between using IONM in cochlear implantation and facial nerve injury, it has been proven useful in preventing facial nerve injury when used with appropriate pre-operative imaging. This is especially true in patients with variant anatomy, congenital malformations, or revisional surgery.

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