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# Facial nerve management in cochlear implant surgery

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Facial nerve injury and facial nerve stimulation are rare but important risks of cochlear implant surgery. Careful preoperative and intraoperative techniques can help minimize the possibility of facial nerve involvement in cochlear implantation. Meanwhile, judicious postoperative treatment can help minimize the impact of these disorders if either facial nerve injury or stimulation does occur.
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Cochlear implant surgery has proved itself to be a safe and effective option for the treatment of profound hearing loss, and its role continues to expand. Unfortunately, the surgery does involve risk. Two of the most important risks of cochlear implant surgery are facial nerve injury and facial nerve stimulation. Although rare in absolute terms, facial nerve involvement remains among the more common complications of cochlear implantation. The goal of this article is to explain the incidence and presumed etiology of each of these events, so that cochlear implant surgeons can reduce their risks. Should either facial nerve injury or facial nerve stimulation occur, this article will also address the treatment of these potentially serious complications.

## Facial nerve injury–Background

Facial nerve injury is a rare occurrence in cochlear implant surgery. Incidence rates have been estimated by Hoffman and Cohen[1] to be as low as 0.56% overall (0.55% in adults, 0.58% in children) in a 1995 survey of results from 4969 cochlear implants. Overall, the incidence of facial nerve injury may be slowly decreasing with time. Similar studies by Cohen et al[2] in 1988, and Cohen and Hoffman[3] in 1993 place the incidence of nerve injury at 1.74% and 0.73%, respectively. Other studies, such as the one by Fayad et al[4] in 2003, generally agree with these estimates, putting the reported incidence of seventh nerve paresis after cochlear implantation at 0.71%. Despite this absolute rarity of facial nerve injury, it remains the fourth most common complication of cochlear implantation, behind only flap complications, electrode migration, and facial nerve stimulation.[1]

Although the incidence of facial nerve injury is similar in both children and adults, 0.58% and 0.55%, respectively,[1] there are reasons to think that the nerve may be at increased risk in the pediatric cochlear implant population. Many pediatric patients with hearing difficulties severe enough to warrant implantation have congenital cochlear malformations. In this population, the incidence of aberrant facial nerve anatomy is 17%; if one looks only at patients with severe cochlear malformations, the occurrence of aberrant facial nerve anatomy increases to 27%.[5] Despite the increased risk of facial nerve injury in this population, cochlear implantation may still be performed safely among patients with cochlear malformation. Careful operative technique, preoperative imagine studies to assist nerve localization, and use of a facial nerve monitor all serve to protect the facial nerve in this setting.[5,6] One reason that surgery may remain safe among this at-risk population is that, on the whole, pediatric cochlear implants are generally performed by more experienced surgeons.[1]

When it does occur, facial nerve paresis may present in either an immediate or delayed fashion. Delayed onset may occur hours, days, or even weeks after the surgery itself. For instance, in the report by Fayad et al[4] of 5 cases of nerve paresis, all complications were delayed, with a range from 18 hours to 19 days postoperatively. In contrast, House and Luxford[7] show 8 cases of facial nerve injury after cochlear implant surgery and find that at least 4 cases presented immediately. When nerve injury presents immediately, it offers the opportunity for immediate intraoperative repair.

There are several proposed mechanisms through which the facial nerve might be injured in cochlear implantation. The most straightforward possible mechanism, and the one

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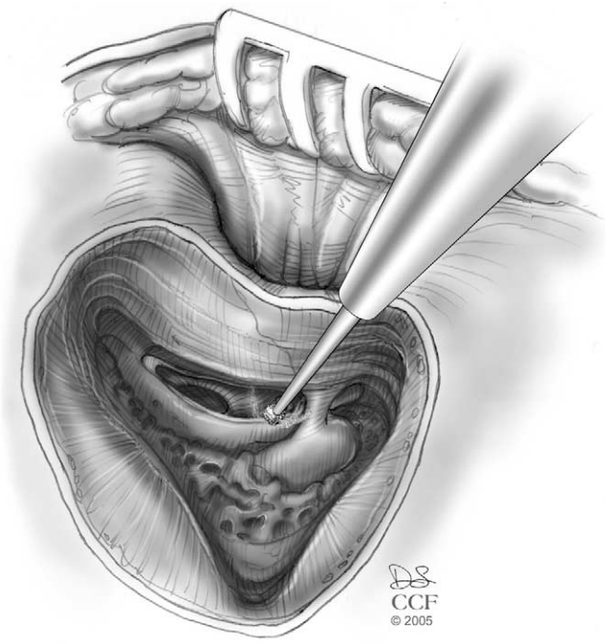


**Figure 1** Course of the facial nerve. Notice how it lays anterior/inferior to the lateral semicircular canal. The nerve does rise slightly laterally in the vertical segment.

most easily recognized intraoperatively, is when the nerve is injured directly by the drill bur. Such direct injury may occur in either the mastoid cavity itself or posteriorly to the facial recess, the anterior edge of the facial nerve. More subtle mechanisms of nerve damage include heat injury[4,7] and possible viral reactivation.[4] These mechanisms may lead to delayed nerve paresis through the progressive neural edema that follows injury. Heat injury is more likely if extensive drilling is required to open the round window niche, which happens in cases of cochlear ossification that may accompany meningitis. In these cases, drilling in the round window niche brings the drill shaft into the facial recess and allows heat to be transmitted to the nerve.[7]

If seventh nerve paresis does occur, it is important to understand that the natural history of facial nerve recovery is generally favorable, particularly for cases of delayed paresis. For instance, in the series by Fayad et al,[4] treatment of delayed paresis with steroids either with or without antiviral medication led to complete recovery in all cases. In more severe cases of nerve damage, recovery is not as complete. In the cases studied by House and Luxford[7] of direct nerve injury recognized intraoperatively, postoperative function reached III/VI on the House-Brackmann scale and was limited by the results attained by primary nerve reanastomosis.

## Facial nerve injury–Treatment

The primary goal in the treatment of facial nerve paresis in cochlear implant surgery is to avoid the complication. Knowledge of facial nerve anatomy, preoperative imaging studies, and intraoperative use of a facial nerve monitor can all help limit potential nerve damage (Figure 1). In cases of

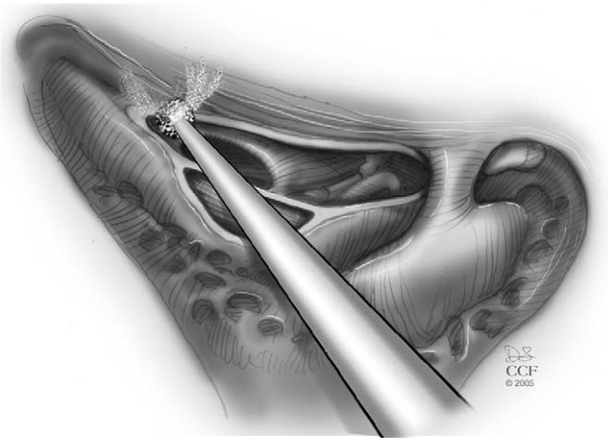


**Figure 2** Notice how the bur is held anteriorly, away from the facial nerve. However, this could result in an injury to cord tympani, thus altering taste. In addition, the shaft could cause a thermal injury to the facial nerve.

aberrant facial nerve anatomy, preoperative imaging and the use of a nerve monitor take on even higher importance. Surgical experience can also help limit complications, with more experienced surgeons having decreased incidence of facial nerve paresis.[8] Meanwhile, the operative technique for any surgeon should focus not only on avoiding direct injury to the nerve but also on limiting heat transfer to nerve, which may not even be seen during surgery. Toward this end, copious irrigation should always be used while drilling. Also, while drilling in the round window niche, the bur must be angled so that the drill shaft is held away from the floor of the facial recess (Figure 2).[7] With careful preoperative and intraoperative treatment, facial nerve paresis can be limited to the 0.56% to 0.71% incidence described previously.

In those cases in which nerve injury after cochlear implant surgery does occur, treatment principles follow the same principles as those for nerve injury in any other otologic surgery. If direct nerve injury is noted intraoperatively, the degree of nerve injury must be assessed. If the injury is thought severe enough to warrant repair, the edges of the nerve can be freshly transected and then repaired either with primary reanastomosis or cable graft (Figures

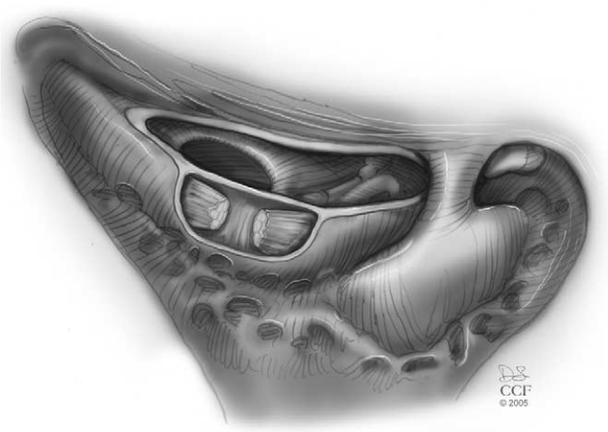


**Figure 3** Full thickness injury of the facial nerve.

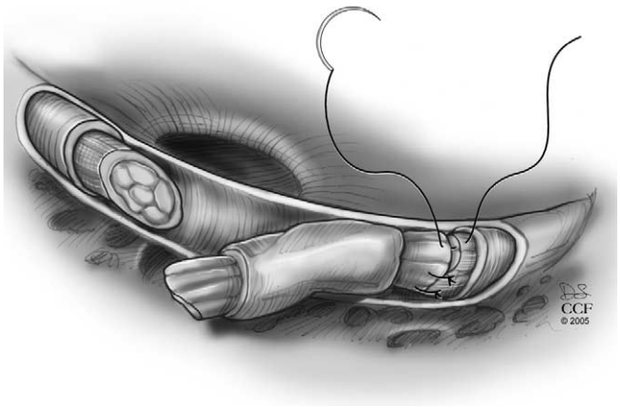


**Figure 4** Significant injury to the facial nerve with a cable graft being sown in. Note, one could also use fibrin glue or just lay the graft next to the facial nerve ends for the reanastomosis.

3-5). The cable graft for these short segments of loss would almost invariably come from the greater auricular found in the neck traversing the sternocleidomastoid muscle (Figure 6). In these cases, it is expected that postoperative function may include maintained tone and bulk of facial muscles, but without purposeful movement.

If nerve injury is noticed immediately postoperatively rather than intraoperatively, options include surgical exploration with decompression or repair versus observation and medical treatment. This decision depends on the surgeon's index of suspicion for direct nerve injury and the degree of facial nerve impairment. In severe cases (grade VI) in which direct injury is suspected, nerve exploration, decompression, and/or reanastomosis must be considered. However, if the nerve is known to be intact, then careful treatment may include the use of steroids and perhaps even antiviral medications. Similarly, in cases of delayed paresis, the nerve is presumed to be intact, and the role for surgical exploration/decompression is only considered if electroneuronography testing is worse than 95% degeneration. In these cases too, treatment consists of the use of steroids and perhaps antivirals, although there is no systematic evidence to support the role of antiviral medicines in this setting. Their use has been described in previous case studies.[4] In more mild cases of delayed paresis, complete recovery may be expected.

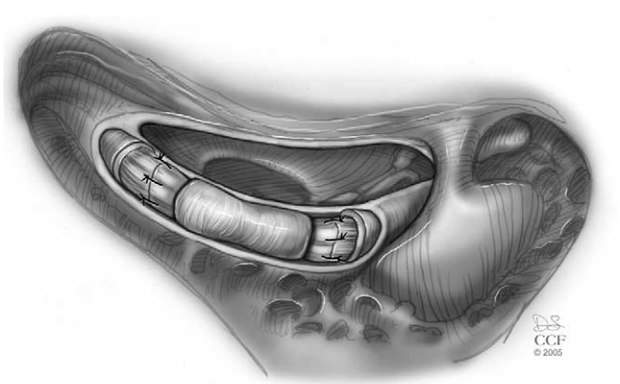


**Figure 5** Facial nerve graft sutured in. Notice the beveled edges.

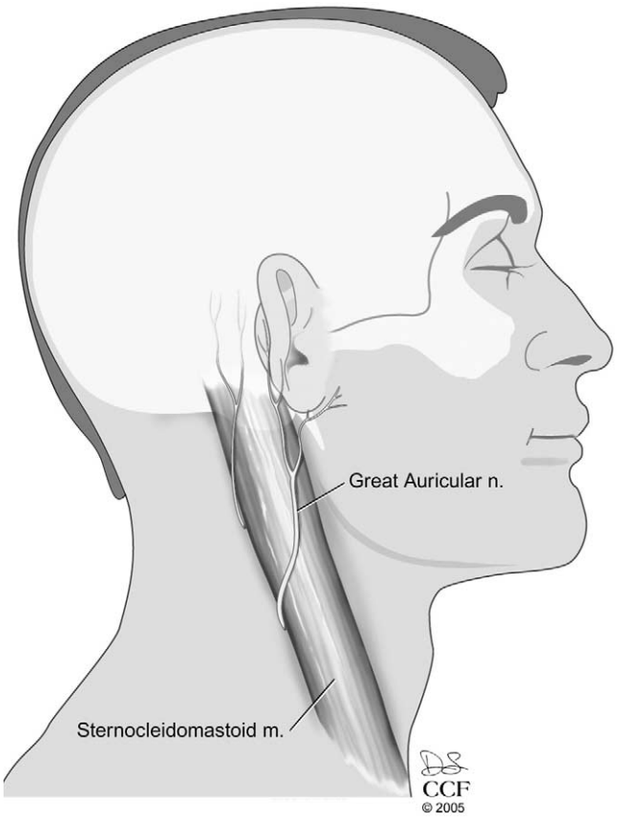


**Figure 6** Location of where the great auricular nerve lies. It can be found by making an incision on a line drawn from the angle of the mastoid to the mastoid tip, 1/3 of the way from the angle of the mandible.

## Facial nerve stimulation–Background

The reported incidence of facial nerve stimulation after cochlear implantation varies, although it is generally considered a more common complication of cochlear implant surgery than facial nerve paresis. In 1995, Hoffman and Cohen[1] estimated that 2.71% of adult and 0.94% of pediatric Nucleus 22 channel cochlear implant (Cochlear, Lane Cove, Australia) recipients had facial nerve stimulation after implantation. Other estimates place the incidence of this complication rate as high as 7% to 15%.[9-12] The differences between these estimated rates may have several explanations, with variability introduced not only by differences in implant design but also by differences in patient population. For instance, recent studies support the idea that patients with otosclerosis more susceptible to facial nerve stimulation have rates estimated to be as high as 50%[10] or even 78% to 100%.[13] In addition, the true incidence varies with the type of implant placed because certain design features may influence current spread within the electrode.[13]

Current spread within the electrode is important because direct spread of current from the electrode to the facial nerve is considered the most likely explanation for facial nerve stimulation after cochlear implantation. As current is generated within the electrode, it may conduct either to the cochlear nerve via the scala tympani (the preferred pathway of conduction) or spread along bony channels to other adjacent structures. One of these structures is the facial nerve, as the labyrinthine portion of the nerve crosses the

basal turn of the cochlea close to the scala tympani, and therefore close to the electrode array. Anatomic studies of temporal bones have found that the distance between the facial nerve and scala tympani at this location is only 0.33 ± 0.14 mm.[14] This anatomy places active electrodes 12-16 (electrodes 22-26 if 10 stiffening rings are included in the count) closest to the facial nerve; studies conclude that these are the electrodes most often implicated in facial nerve stimulation.[12,14] This theory of direct current spread has also been offered as an explanation of the increased incidence of facial nerve stimulation in patients with otosclerosis because spongiotic bone is thought to have decreased impedance to current spread than normal bone.[15]

## Facial nerve stimulation–Treatment

There are many different strategies for the treatment of facial nerve stimulation after cochlear implant surgery. The first strategy to be attempted is reprogramming of the device to minimize current activation through the involved electrodes. This technique is often all that is required, with some studies concluding that reprogramming is effective in 100% of cases.[11] Of course, the goal of reprogramming is to decrease or eliminate facial nerve stimulation, while preserving sound processing. If reprogramming cannot eliminate stimulation, or if it does so only with an unacceptable drop-off in sound quality, other medical and surgical therapies may offer some relief. In patients with otosclerosis, a study of 2 patients suggests that empiric treatment with fluoride might improve facial nerve stimulation and allow full use of the cochlear implant.[16] A similarly anecdotal report also supports the use of botulinum toxin injections into the facial musculature to prevent uncomfortable facial movements in patients who prove refractory-to-less invasive treatment.[17] If these techniques fail, surgical treatment can be considered. In the experience of the senior author (P.C.W.), repositioning of the muscle plug adjacent to the electrode at the level of the cochleostomy can change the position of the electrode array relative to the facial nerve and prevent facial nerve stimulation if the facial nerve is exposed in the facial recess. Alternatively, the electrode can be removed and the implant entirely replaced. This replacement could be performed with the goal of changing the type of electrode, which is used, or with the goal of replacing a mechanically faulty electrode with an implant of similar design.

## Conclusion

Facial nerve paresis and facial nerve stimulation are potentially serious complications of cochlear implant surgery. In the case of facial nerve paresis, knowledge of the possible etiologies of nerve damage can help prevent injury. If injury is delayed rather than immediate, full recovery is likely, even with conservative treatment. Facial nerve stimulation, although more common than facial nerve paresis, is more easily treated because reprogramming of the involved electrode leads to resolution of the problem in the majority of cases. For patients with refractory facial nerve stimulation, other techniques are available to allow full benefit from cochlear implantation.

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