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REVIEW ARTICLE

Vestibular Implant: Are We Ready for It?

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ABSTRACT

The present article aims to provide an overview of the research and development in the field of vestibular implants for patients suffering from bilateral vestibulopathy. There is a strong justification for surgical intervention in such patients because of a negative impact and disability of disease on the life of the patients. A few animal and human studies have been undertaken, and the available data from both animal and human studies are encouraging. It is evident that there is a technical feasibility for the use of vestibular implants. Although normal vestibular function is not expected, significant, physical improvement is expected in these patients.

Keywords: Oscillopsia, Vestibular implants, Vestibulopathy.

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INTRODUCTION

The primary goal of cochlear implant, which was introduced about three decades ago, was to afford serviceable hearing to profoundly deaf patients. It was contemplated that they would perceive basic speech and environmental sounds, but the scenario has changed over a period of time. People with implants are doing reasonably well and they are very near normally hearing people.

Another device in its early phase of development is in the offing, viz. a vestibular implant for patients with fluctuating vestibular function. Abnormal hyperfunction can be suppressed, but those with fluctuating vestibular function cannot be helped. Oscillopsia, though uncommon, is highly debilitating. Vestibular implant is being developed to help such disabled patients.

Patients with bilateral vestibulopathies have varying degrees of disability. Treatment option for these patients is to teach them to adapt and cope with their disability. A vestibular implant that uses electrical stimulation of vestibular neurons is in the developmental stage as one treatment option for these patients. The implant is supposed to replace absent or severely reduced semicircular canal function.

REVIEW OF LITERATURE

Short-term electrical stimulation of the vestibular periphery has a long history. In the early 19th century, Purkynje (1820, quoted by Merfeld and Lewis[1]) used low-frequency electrical stimulation between the left and right ears to induce vertigo. Later studies by Mach[2] reported nystagmus, illusory motion of visual object and illusions of self-tilt by electrical stimulation of the vestibular periphery.

Suzuki, Cohen, et al[3,4] implanted electrodes for short duration electrical stimulation of the vestibular periphery. They used voltage pulses to limit current spread and observed that individual ampullary nerve branches could be stimulated, and that the eye responses to such stimuli were like natural responses.

Study of long-term stimulation of vestibular periphery was undertaken as nothing was known about the behavior of nervous system to chronic stimulation of the vestibular periphery. Vestibular periphery of animals was chronically stimulated for 24 hours/day for 7 days a week for many months.[5-7] Initially, a brisk nystagmus was induced when pulsatile current pulses were turned on.

It was seen that animals acclimated to this baseline stimulation, and the time required for acclimation became less and less with repeated exposures to stimulation.

Recently, the first human study by Wall et al[8] has been published that utilized electrical stimulation provided by electrodes inserted into the vestibular periphery for focal vestibular stimulation using short-term current pulses intraoperatively.[8] The study demonstrated an electrically evoked response in humans as was seen previously in animal models.

Guyot et al[9] chronically implanted electrodes near the left posterior ampullary nerve of a deaf patient as part of a cochlear implant surgery. Electrical stimulation was provided intermittently for varying periods of time. When the baseline pulsatile current pulses were turned on, a nystagmus was evoked. This nystagmus dissipated over a period of about 30 minutes. When the stimulus was turned off after 27 minutes of constant stimulation, a nystagmus in the opposite direction was initiated, which indicates adaptation. When the stimulus was alternately turned on and off, the duration of the nystagmus response

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decreased. This is the first study of human plasticity to electrical stimulation provided by electrodes chronically implanted near vestibular neurons.[10]

A study by Guinand et al[11] assessed the quality of life for patients diagnosed with bilateral vestibulopathy. It was observed that bilateral vestibulopathy affects the quality of life by negatively affecting physical and social function and that there is a clear need for a therapeutic solution for patients of bilateral vestibulopathy, such as a vestibular implant.

Surgery for Vestibular Implant

Vestibular implant surgery is in the initial stage of development. Two surgical approaches have been described for inserting electrodes for vestibular stimulation: Extralabyrinthine and intralabyrinthine and also its combined approach.

A comparison of the two surgical approaches used to insert electrodes to stimulate canal ampullary nerve branches has been reviewed. The intralabyrinthine approach utilizing the osseous canal lumen to guide the electrode to the ampullae was originally pioneered by Suzuki and Cohen.[3] The other approach is extralabyrinthine and has been utilized for human studies performed by the Geneva group.[9,10] The extralabyrinthine approach has two components using transmeatal approach. The posterior ampullary nerve is reached via a transmeatal approach after drilling the floor of the round window niche. The other two ampullary nerve branches are reached transmeatally after the removal of the head of the malleus and incus.

Drawbacks to the extralabyrinthine approach are that the ampullary nerves may sometimes be difficult to reach. There is risk of both sensorineural and conductive hearing loss following reconstruction of the ossicular chain. These can be facial nerve damage. The main advantage is that the electrodes can be located near the desired neurons and stimulation might be possible even if the peripheral dendrites have been destroyed up to Scarpa's ganglion following peripheral damage.

Complications associated with the intralabyrinthine approach include perilymph leaks following canal fenestration, possible sensorineural hearing loss, and difficulty in stimulating neurons if they have died back to Scarp's ganglion, but the facial nerve is less likely to be damaged and the middle ear is preserved in this procedure.

Combination of both approaches has been successfully used for stimulating ampullary neurones selectively. Both approaches are surgically compatible. Individual ampullary nerves can be stimulated by any of the approaches in the same patient.

Two recent vestibular implant studies by Dai et al[12] and Bierer et al[13] have evaluated the effects of a vestibular implant on hearing in rhesus monkeys. The studies suggest that electrode implantation in all three canals is not likely to result in considerable hearing loss. Once there is development and refinement in the vestibular implant technology, the risk to hearing will roughly be similar to the risk of a cochlear implant.

The vestibular implants have been developed to replace the function of vestibular system. The first vestibular implants were installed in three patients in Europe. These implants restore the function of the semicircular canals. Semicircular canals are thought to be the most important, and it is technically easier to restore their functions by putting electrodes into the ampullae of the canals.[13]

CONCLUSION

The deficits associated with severe bilateral vestibulopathy suggest that this treatment option would benefit the quality of life of patients. Vestibular implants will restore partial vestibular function in patients with severe bilateral peripheral deficit. Numerous challenges and queries remain unanswered, the most important being the ethical issues related to vestibular implants, the decision in making about the surgical approach for implants, and finally the effects of implants on hearing. With the progress in the field of vestibular implants and ongoing research, all these queries will be answered over a period of time. Justifying ongoing research efforts, all available data suggest that vestibular implants would benefit patients suffering from severe bilateral vestibular loss.

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