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Editorial

The Future of Otology

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Introduction

Otology is evolving with new innovation in science and medicine. Artificial intelligence and Automation can make life easier. The most challenging system to study is the inner ear. There are many advances occurring in recent years with new scientific tools and methods like auditory genetics and gene therapy, organ of Corti regeneration, neural prostheses, ototoxic chemoprevention that can bring challenging difference in otology with innovative therapies for untreatable ear diseases in the recent future.

Artificial intelligence and robots

Evolution of robots will replace humans in tasks that need simple and repetitive works. Artificial intelligence systems can reduce the tiresome keyboarding that burdens today's clinicians. Automated systems will be able to both execute interviews, do imaging like CT scan based on programmed criteria such as ossicular displacement, scutum erosion, tegmen erosion, semicircular canal fistula etc. indicative of cholesteatoma and deliver standard advice in the doctor's own voice, thus reducing the work of medical practice. Robotic surgeries are evolving at rapid pace to treat patient [1,2].

Ear surgery of the future

Stapedotomy: Stapes surgery is very delicate surgery which leads to 1 per cent deafness. So controlled manipulation is needed on the scale of microns rather than millimetres. Stabilised robotic instruments in recent future can bring sea change by their calibrated fine movements in stapedotomy and other middle-ear operations [3-5].

Tympanoplasty: Healing of tympanic membrane perforations can be done in near future by regenerative therapy like applying biogenic growth factors to the edges of tympanic membrane [6-8].

Ossiculoplasty: The results of ossiculoplasty tends to deteriorate over time, partially due to mechanical instability, others due to poor middle-ear ventilation, scar tethering of the prosthesis or recurrent disease. Therefore, well pneumatized healthy mucosal lining of middle ear can be made by combination of mucosal regeneration, scar inhibition and tubal function restoration [9].

Cholesteatoma: Recurrence in cholesteatoma is very common. Molecular imaging techniques that highlight inapparent islands of keratinising squamous epithelium can bring wide difference in future. Repeated retraction may occur inspite of occlusive cartilage graft, in such case biological inhibition of epithelial migration or mechanical impediment by application of biocompatible membrane to the outer surface of a cartilage graft with nanoscale spikes may be applied to reduce the recurrence rate in future [10,11].

Cochlear implants: Cochlear nerve stimulation may be photonic in future, in which arrays of minute light-emitting diodes control small groups of auditory neurons. Hybrid devices that electronically stimulate the high frequencies (basal turn) and maintain acoustic stimulation of the lower frequencies (more apical) are also in process [12,13].

Microscopes, endoscopes and exoscopes: We are already familiar with microscope and endoscope in various surgeries of ENT. Recently, exoscopes - remotely positioned high-definition cameras that form a three-dimensional image - applied to skull base surgery. Exoscope will develop an increasing role in ear and skull base surgery with the increase in its resolution in near future [14].

Image-guided surgery: It will additionally aid in surgeries by visual cues overlain on real-world images in the form of interactive holograms anchored to specific points in physical space [15-17].

Inner ear surgery: Developing methods to manipulate inner ear, taking care of its structure and physiology is a very challenging thing. There are ushering methods to chemically dissolve bone atraumatically that will avoid drill-induced vibratory trauma. Endocochlear access can be made by transplanted cells and gene therapy vectors which will allow targeted application of drugs to inner ear. Retrieval of dislodged canaliths, repair of Reissner's membrane ruptures and depletion of the dark cell population to alleviate endolymphatic hydrops will be done by Micromanipulator-guided procedures. Manoeuvrable micro-endoscopes like in optical coherence tomography will be used perhaps in future to visualise on a micron scale [18-20].

Auditory genetics and gene therapy: Congenital sensory hearing loss accounts for 1 - 3 of 1000 live births, of which 50 per cent has known genetic aetiologies. Thus, in future, the entire genome will be stored in the medical records that will enable to identify the known genetic causes of hearing impairment. CRISPR/Cas9 gene editing technology will be used to rescue genetic phenotypes of hearing loss using different modes of delivery like viral vectors, lipid vesicles or nanoparticles [21,22].

Inner-ear drug delivery: Drugs injected into the middle ear through the tympanic membrane reaches the inner ear via diffusion across the round window, but it is not accurate in the amount that reached inner ear. Hydrogels will deliver medications to the inner ear in a more calibrated and sustained way. Access to inner ear via the blood stream, overcoming the blood-labyrinth barrier, can be done using nanotechnology based vesicles with very specific targeting strategies using RNA sequences to affect only particular cell types [23-25].

Ototoxicity prevention: There are three methods to reduce ototoxicity it includes monitoring, chemoprevention, and chemical modifications. The ideal way of preventing ototoxicity is to modify the drug molecules (chemical modification) so that they maintain their pharmacological effect and also eliminate the ototoxicity [25,26].

Tinnitus remediation: Studies are directed to localise areas of spontaneous activity within the auditory cortex and interventions are directed to disrupt synchrony within the auditory nervous system, such as acoustic co-ordinated reset modulations to reduce tinnitus. Deep brain stimulation can be used in future for the suppression of synchronous signals [27,28].

Inner-ear regeneration: Regeneration of a functional organ of Corti by proliferating hair cell progenitors, restoration of auditory function by correct localisation of the regenerated cells, proper orientation and correct polarity can bring sea change in future when cochlear hearing loss will become as treatable as conductive hearing loss [29,30].

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