Tukkies for the hearing impaired

The University of Pretoria is at the forefront of research and development relating to deafness

While some people are born deaf – often because of complications or exposure to disease during pregnancy, but also due to genetic factors – others experience loss of hearing to varying degrees during the course of their lifetime. In children, this may result from illnesses such as measles, mumps or meningitis, but teenagers and adults are more susceptible to noise-induced hearing loss from loud music, sporting events and working environments. Head injuries, neurological disorders such as strokes and multiple sclerosis, and certain medications and chemicals can also cause hearing impairment, plus hearing deteriorates as part of the ageing process.

Here, *Quest* highlights some of the contributions by University of Pretoria researchers and specialists in assisting the hearing impaired.

Ossicle implants

In March 2019, Professor Mashudu Tshifularo from the university's Department of Otorhinolaryngology (ear, nose and throat [ENT] surgery) made headlines when he

HOW WE HEAR

Sound waves enter the ear and travel through the ear canal to the eardrum, causing it to vibrate. The vibrations move the middle ear's three tiny bones, or ossicles, which are formally named the malleus, incus and stapes, but commonly called the hammer, anvil and stirrup.

This movement in turn causes the fluid in the inner ear's cochlear to move, setting the hair cells in motion.

The hair cells change the movement into electrical impulses that are sent through the auditory (hearing) nerve to the brain.

The auditory cortex of the brain interprets these electrical impulses as sound, and processes the information.

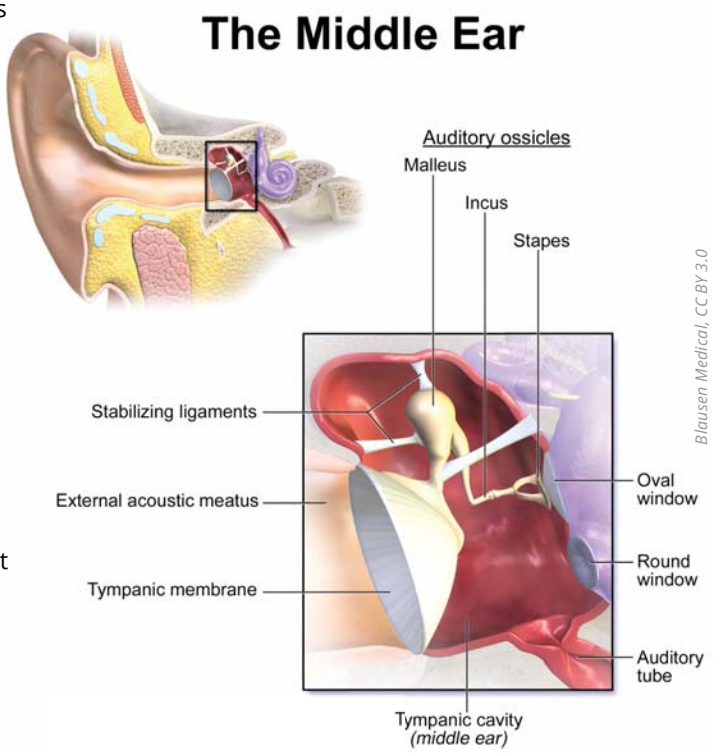
Prof. Mashudu Tshifularo during the world's first implant of 3D-printed ossicles at Steve Biko Academic Hospital in Pretoria in March 2019.

performed the world's first implant of 3D-printed ossicles at Steve Biko Academic Hospital.

Prosthetic implants for ossicular replacement have long been commercially available for this surgical procedure, and are made from a variety of materials including fluoroplastics such as Teflon, polyethylene, or metals like stainless steel, nickel alloys, platinum and titanium. Total implants replace the entire ossicular chain – malleus, incus and stapes – with a Total Ossicular Replacement Prosthesis (TORP), but a Partial Ossicular Replacement Prosthesis (PORP) can be used where the stapes is still present. These implants come in a variety of sizes for optimal fit, and have some strange shapes that look nothing like human ossicles!

Prof. Tshifularo used a different approach, as he worked with medical product development firm BunnyCorp and 3D printing specialists Promake International to construct a tiny titanium prosthetic that more closely resembles the real thing.

The operation was featured on Carte Blanche and can be viewed on YouTube (search for '3D-printed middle ear transplant'). According to a news post on the University of Pretoria's website in mid-July, the operation largely restored the hearing of the patient, but ethics approval must now be obtained before proper clinical trials are conducted. The operational procedure, together with the likely outcomes and possible complications, will also be written up.



Blausen Medical, CC BY 3.0

BunnyCorp

A computer-generated render of the 3D-printed titanium ossicle implant that replaced the patient's malleus, incus and stapes.

Cochlear implants

People who are profoundly deaf or severely hard of hearing may benefit from a cochlear implant. This is an electronic hearing device consisting of an external part that is worn behind the ear, and an internal part that is surgically positioned. While hearing aids essentially amplify sound, cochlear implants are designed to bypass the damaged cochlea by electrically stimulating the auditory nerve.

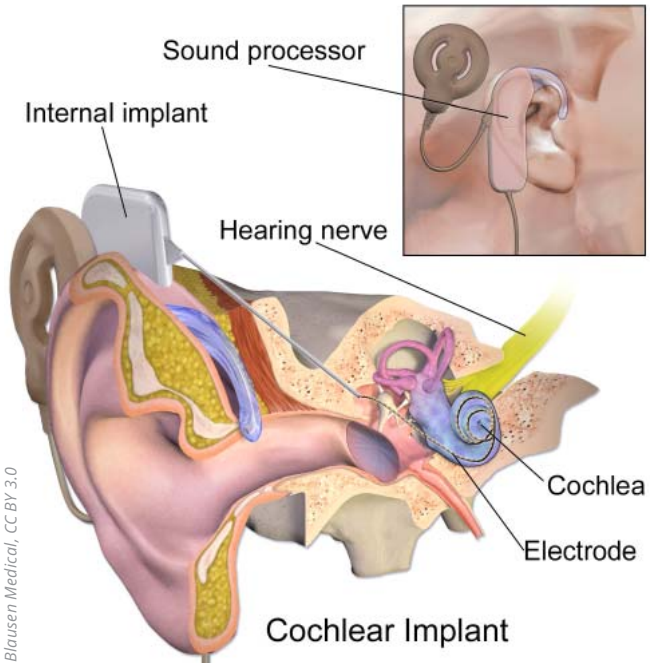
Cochlear Aqua Plus, CC BY-NC-ND 2.0

Accessories for modern cochlear implants even allow for water-based activities.

The process is as follows. The external sound processor picks up sounds and converts them into digital information, which is then transferred through the coil to the internal implant. The implant converts the digital information into electrical signals and sends these down to the electrode array in the cochlea. The electrode array stimulates the hearing nerve, which sends information to the brain.

Cochlear implants do not restore hearing to 'normal' because the hearing experience is quite different from natural acoustic hearing, so it takes time for recipients to adjust. But they can help with understanding speech and hearing sounds in the surroundings, and also offer young children the opportunity to learn to communicate through spoken language. They are extremely expensive, though, both for the initial implantation and ongoing maintenance and support, requiring a lifelong financial commitment. In South Africa, this means that most cochlear implant recipients – or their parents in the case of children – need to have significant financial resources and/or membership of a private medical aid scheme. There are a few government-funded cochlear implant programmes, but recipients must meet strict criteria to be eligible for selection.

Dr Talita le Roux (in beige jacket) and some of the postgraduate students she supervises at an international conference to present their research related to cochlear implants.



A cochlear implant works as follows. The external sound processor picks up sounds and converts them into digital information, which is then transferred through the coil to the internal implant. The implant converts the digital information into electrical signals and sends these down to the electrode array in the cochlea. The electrode array stimulates the hearing nerve, which sends information to the brain.

The University of Pretoria's Department of Speech-Language Pathology and Audiology has a close association with the Pretoria Cochlear Implant Unit. Dr Talita le Roux and the postgraduate students she supervises conduct research related to cochlear implants, such as the predictive factors of positive implantation outcomes, the health-related quality of life of adult and paediatric recipients, and family-centred care during the the paediatric cochlear implantation process.

Hearing assessment apps

In March 2016, the free hearZA® app was launched in South Africa to coincide with World Hearing Day. Developed and validated by a team of researchers led by Professor De Wet Swanepoel of the university's Department of Speech-Language Pathology and Audiology, this mobile app allows members of the public to test their hearing using any Android or iOS device with

CURRICULUM CORNER

LIFE SCIENCES: GRADE 12
Responding to the environment: Humans

PHYSICS: GRADE 10
Sound waves; Pitch and loudness

earphones or headphones. The two-minute test is easy to use and generates a hearing score on completion, but is only accurate for people who are at least 16 years old. The app detects users' location, and refers those who fail the test to their closest hearing healthcare provider for further assessment and assistance.

HearZA® is a digits-in-noise (DIN) hearing test, in which recorded digit triplets (e.g. 5-3-7) are played over background white noise. People who are hard of hearing typically struggle to follow conversation in noisy settings, so this is a type of speech-in-noise (SIN) test. Traditionally, SIN tests use sentences, but this can be challenging in a country like South Africa, where so many languages are spoken. The first DIN test for landline telephone use was developed in the Netherlands in 2004 and subsequently implemented in other countries, but relatively few people in South Africa have access to landlines, hence the development of hearZA® – the world's first smartphone-based DIN test.

Since then, Prof. Swanepoel and his team have been involved in the development of a number of other mobile applications. In October 2018 a version for use in the United States, called hearScreen USA, was launched with the American Academy of Audiology, and in March 2019 the hearWHO app developed for the World Health

Prof. De Wet Swanepoel demonstrating the hearZA® app to a user.

Organisation was released on World Hearing Day. They have also developed clinical (medically regulated) apps that are not available on app stores, but are provided to healthcare providers as affordable and mobile hearing assessment tools for pure tone audiometry. These tests, made available in partnership with the hearX Group, determine hearing sensitivity using tones played at different pitches.

2019

Quest Volume 15 Number 4 2019

Academy of Science of South Africa (ASSAf)

Academy of Science of South Africa (ASSAf)