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MCI (P) 073/06/2018

Newsletter for distribution to healthcare professionals

Hong Kong, Indonesia, Malaysia, Philippines, Singapore, Taiwan, Thailand and Vietnam

July 2018

Hearing Loss

Otosclerosis and the Latest Treatments

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Otosclerosis is a disease of abnormal bone metabolism affecting the stapes, oval window and the otic capsule. It results in progressive fixation of the stapes footplate and eventually sclerosis of the cochlea in advanced cases.

Pathophysiology

The most common location of bony involvement is the bone just anterior to the oval window in a small cleft known as the fissula ante fenestram. The abnormal deposition and hardening of the bone in this region leads to fixation of the stapes footplate with concomitant conductive hearing loss. This active bone remodeling may progress to involve and damage the cochlea, through the release of proteolytic enzymes or from direct injury to the cochlea and spiral ligament. Sensorineural hearing loss may therefore result in advancing otosclerosis.

Clinical Diagnosis

The onset of hearing loss usually starts between the ages of 15 and 45, and thereafter slowly progresses. In most cases, the hearing loss affects both ears. Women are more often affected than men. Certain ethnic groups are more prone to otosclerosis, especially Caucasians and Indians. It is less prevalent amongst the Chinese and Malays. Clinical examination usually reveals an unremarkable external ear canal, tympanic membrane and middle ear space. Rarely there may be Schwartz sign, which is a faint reddish hue seen over the cochlear promontory visualised through the tympanic membrane. A Rinne's Tuning Fork test would be negative, and Weber's tuning fork test lateralises to the affected side.

Investigations

A Pure Tone Audiogram would reveal an "Air-Bone Gap" wherein the Bone Conduction thresholds are better than the air conduction thresholds. The gap may be as small as 10dbHL or as large as 50-60dBHL. However, this gap narrows at the 2 KHz frequency in a pattern known as "Carhart's notch". High Resolution CT Temporal Bone Imaging is nowadays commonly performed to help confirm the diagnosis radiologically and to exclude other middle ear pathologies. CT scans show up lucency in the area of the fissula ante fenestram (fenestral otosclerosis) as well as any cochlear involvement of disease.

Medical Treatment

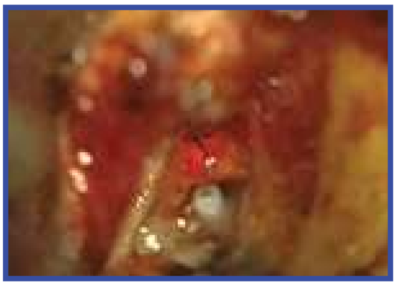
There is some research to suggest that the use of sodium fluoride is able to impede the progression of the disease. The administration of fluoride replaces the hydroxyl radical with fluoride leading to the formation of fluorapatite crystals instead of hydroxylapatite crystals which would otherwise lead to stapes fixation. However in Singapore, this medication is not readily available and not commonly prescribed as the benefits of this therapy remained controversial.

Amplification

Conventional Hearing Aids can be used to improve hearing but does so only when the device is worn. The otosclerosis tends to progress, leading to a need to adjust the hearing aids as the hearing deteriorates. As the condition usually affects those in the young adult to middle age groups, a significant number of patients are concerned with the stigma and cosmesis of wearing a hearing device.

Surgical Treatment

The conventional surgical treatment of otosclerosis used to be a procedure known as Stapedectomy. In this operation, the entire stapes including the footplate is removed and the exposed oval window covered with a vein graft. A tiny prosthesis called a stapes piston is attached to the incus long process and the other end is applied over the vein graft to transmit the acoustic vibrations. This surgery has now been mostly replaced by a procedure known as Stapedotomy. In this operation, the stapes suprastructure is removed leaving the stapes footplate intact. The footplate in then fenestrated using a laser or microdrill through which, the stapes piston inserts into the vestibule. The benefits of using a laser stapedotomy for fenestration is that it is a non-touch technique, leading to less sensorineural trauma to the inner ear which happens during microdrilling. There have been advances in the design of stapes pistons over the years and now there are new pistons which are able to automatically crimp onto the incus upon application of heat leading to easy and more reliable incus attachments. When performed by an experienced ENT Otologist, the success rate of these operations is close to 90% and affords continuous good hearing 24 hours a day without any need to wear hearing devices.



Picture taken during a laser stapedotomy operation

Advanced Otosclerosis

When otosclerosis becomes advanced and causes severe to profound sensorineural hearing loss, conventional hearing aids and stapedotomy operations would not be able to correct the hearing loss. In these patients, thankfully cochlear implantation has been shown to be a highly effective method of restoring the hearing.

Management of Sudden Sensorineural Hearing Loss

Sudden sensorineural hearing loss (SSNHL) is defined as sudden hearing loss of at least 30 decibels over 3 consecutive frequencies over 3 days. Idiopathic SSNHL (ISSNHL) makes up the majority of cases and is defined as SSNHL with no identifiable cause despite adequate investigation. The pathogenesis of ISSNHL has been ascribed to a range of different causes including viral, vascular or immune-mediated processes. Up to two-thirds of patients with ISSNHL recover spontaneously, with the greatest recovery seen in the first 2 weeks. Non-idiopathic causes that must be excluded include acoustic neuroma (vestibular neuroma), stroke and malignancy.

Medical management

A myriad of therapies has been proposed and used for the medical treatment of ISSNHL. The evidence and recommendation for these based on current guidelines, are discussed.

Glucocorticoids

Current guidelines support the use of oral glucocorticoids as initial treatment. Prednisolone is usually prescribed at a dosage of 1mg/kg/day (usual maximal dose 60mg/day) as a single dose for 1 to 2 weeks. Treatment appears to offer greatest recovery in the first 2 weeks of hearing loss, with little benefit seen after 4 to 6 weeks. Intratympanic steroid as salvage therapy when patients have incomplete recovery after initial treatment, is also recommended. Dexamethasone is commonly given either through repeated injections into the middle ear or through a ventilation tube, every 3 to 7 days for a total of 3 to 4 sessions. The benefit of intratympanic steroid together with oral steroid as initial treatment is unclear. Intratympanic steroid alone however may be valuable in patients who cannot tolerate or have medical conditions that contraindicate systemic steroid therapy.

Hyperbaric oxygen therapy (HBOT)

Current guidelines suggest clinicians may offer HBOT within 3 months of diagnosis of ISSNHL. Evidence shows benefit of early adjuvant HBOT with greatest effects seen in younger patients and those with at least moderate to severe hearing loss. There is no standardised schedule and therapy typically involves five to ten 1- to 2-hour sessions over days to weeks.

Other pharmacologic therapy

Antivirals, thrombolytics, vasodilators, vasoactive substances, growth factors and antioxidants have been studied and there is currently no or insufficient evidence to support their routine use in the management of ISSNHL.

Audiological rehabilitation

Non-surgical options

Hearing aids and hearing assistive devices may be offered either as a means of bridging the period of time that hearing is impaired during treatment or if recovery is not possible. Monaural hearing aids may be an option for patients with hearing loss that can still benefit from amplification. Otherwise, CROS (contralateral routing of signal)-style or BICROS (bilateral contralateral routing of signal)-style hearing aids that route sound from a microphone in the hearing-impaired ear to the normal or better-hearing ear may be recommended.

Bone-conduction hearing aid that transmits sound via vibrations in the bone to the better-hearing cochlea, is an option for patients whose hearing loss cannot be amplified and who do not want or are not fit for surgery. The bone conductor/ vibrator is fitted on a soft head band but may also be fitted onto the arm of specially strengthened spectacles. Newer modern designs for bone-conduction hearing aids, likening that of bone-conduction music headphones, are also now available.

Hearing assistive devices are useful as an adjunct to improve communication in specific listening environments. This typically involves the use of a handheld or lapel-worn microphone that can directly transmit sound either through hardwire or wireless technologies (such as infrared or frequency modulation, FM) to the listener. Other types of hearing assistive devices include those that provide auditory, visual or tactile alerting systems.

Surgical options

Bone-anchored hearing aids (BAHA) are surgically implanted into the skull behind the affected ear. BAHAs may either consist of an abutment screw to which the sound processor is attached or may be completely under the scalp and attached to the processor via magnet. Compared with non-surgically implanted bone-conduction hearing aids, BAHAs are more comfortable and provide better sound transmission.

Cochlear implants are increasingly being performed in patients with unilateral severe to profound hearing loss. Sound from the processor directly stimulates the cochlear nerve via an electrode inserted into the cochlea (see Figure 1). Tinnitus (a common associated complaint with ISSNHL) has been found to be reduced, sound localisation is better and hearing in noise is improved. Studies comparing the success of cochlear implants and traditional modalities such as CROS/ BICROS hearing aids and BAHAs, are ongoing.

Figure 1. *Schematic diagram of a cochlear implant (photo from Cochlear® website). Sound processor (1) worn behind the ear transmits digitally-coded sound through the coil (2) on the outside of the head to the implant. This then converts the digitally-coded sound to electrical impulses and sends them along the electrode (3) to the cochlea to directly stimulate the cochlear nerve (4).*

Summary

In summary, prompt diagnosis and management of ISSNHL may improve patient's prognosis and quality of life. Oral steroid remains the mainstay of initial treatment with intratympanic steroid as a salvage option. HBOT may be offered as an adjunct in early ISSNHL. There is currently no or insufficient evidence to support the routine use of antivirals, thrombolytics, vasodilators, vasoactive substances, growth factors or antioxidants in the management of ISSNHL. Audiological rehabilitation options need to be discussed early on with patients.

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Cognitive maintenance and rehabilitation with better hearing

Introduction

Cognitive functions often deteriorate with age due to a reduction of sensory, motoric and intellectual stimulation. In particular, hearing loss has been identified as a major contributor to cognitive decline. By providing more auditory stimulation, one reduces the risk and even assists in reversing cognitive decline. Unfortunately, hearing loss is commonly associated just with the inability to hear and process language, leading to the false assumption that only once this ability is impaired, hearing loss is present. As a result, hearing loss is often identified decades too late.

Hearing problems & cognitive decline are progressive

Peripheral hearing loss and cognitive function are subject to a vicious cycle of cause and causality. This cycle begins as a reduction of input from peripheral hearing, reducing neural activity, leading to less neural capacity and increased stress on the neural system, impacting short and long-term memory capacity, which can result in the inability to function in social context, often leading to withdrawal and isolation, resulting in even less neural stimulation.

Auditory and cognitive therapy with hearing aids

Hearing aids alone do not solve these complex problems, but they are an important tool in a sometimes very long process of auditory adaptation and recovery. Instrumental for success is the selection of hearing aids based on an ***objective prescriptive method***. The prescription for hearing aids has to fulfil two initial conditions: Sufficient amplification of the full dynamic and frequency spectrum, and acceptance of environmental sound that do not exceed a patient's central auditory ability and comfort. Following this, the rehabilitation process must ultimately reach a patient's full auditory capability with gradual and imperceptible expansion of the hearing aid's acoustic parameters.. Once achieved, the cycle of auditory deprivation influencing cognitive decline is interrupted.

It is time to re-evaluate how we approach hearing and cognitive health care in light of an aging population. Examining what timely intervention means and how to approach problems holistically, with objectively-selected hearing aid technology, and with a sustainable, long-term rehabilitation strategy to aid in central auditory and cognitive recovery.

Manfred Stoifl
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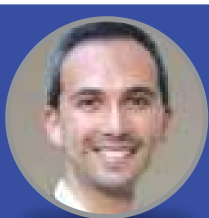

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Cochlear Implants: Giving Hearing to the Deaf

Cochlear Implants are surgically implantable devices that are able to restore hearing in patients who have been deafened. This technology has been commercially available since the early 1980s but the first few successful cochlear implantations in Singapore began in 1997. Since then, it is estimated that more than 700 cochlear implantations have been performed locally to aid a wide variety of patients with sensorineural hearing loss.

How does it work?

Sound is picked up by an externally worn speech processor. The sound is digitally processed within the processor and the signals transmitted to a magnetic coil which couples to the magnet of the internal receiver stimulator complex through the skin of the scalp. The digital signals are then transmitted as electrical impulses, down a long electrode array which is inserted within the cochlea. The intracochlear portion has a number of tiny metallic discharge plates from which the electrical impulses will discharge and directly stimulate the adjacent nerve endings within the cochlea. These nerve endings then transmit the electrical impulses through the cochlear nerve and the central auditory path to the auditory cortex thereby enabling the brain to hear.

Image courtesy of Cochlear Ltd

These multi-channel cochlear implants utilise the tonotropic organisation of the cochlea. Different parts of the cochlea are responsible for hearing different frequencies and are arranged from the high frequency basal turn to the low frequency apical turn. Therefore, if a high frequency sound is heard, only the channels at the basal turn will discharge electrical stimulus to stimulate the high frequency cochlear nerve endings. Similarly, channels at the apical regions of the cochlea will be used for low frequency sounds. The same tonotropic organisation of the cochlear nerve endings connect to precise tontotropic organisation in the brain to allow for accurate hearing.

Who can benefit from a Cochlear Implant

Many children who are born deaf, or those who develop severe to profound sensorineural hearing loss later in life can benefit from a cochlear implant. The large majority of such patients have abnormal function of the hair cells of their cochlea, leading to inability of the cochlea to convert acoustic sound energy to signals that activate the cochlear nerve endings. In such patients where the hearing loss is so severe, the acoustic amplification provided by conventional hearing aids is insufficient or the sounds provided are too distorted to be useful. A cochlear implant bypasses the damaged hair cells and directly stimulates the nerve endings to enable hearing again. Patients will usually undergo a series of audiometric evaluations and a trial of hearing aids before they are assessed as suitable candidates for cochlear implantation.

Factors affecting hearing outcomes of Cochlear Implants

Cochlear implants restore transmission of sound signals to the brain. However, the brain needs to learn the language from the speech it hears. In pre-lingual children, there is a need for intensive auditory habilitation after implantation to allow their brains to develop language skills from the auditory input it receives. The brain has a time-limited "plasticity" to develop these language skills.

For good outcomes, it is therefore imperative that cochlear implantation be performed in the early years of life before the brain loses that plasticity to learn. Upon confirming the diagnosis and severity of the hearing loss in children, they should be started on a trial of hearing aids by the age of 6 months. Those who are not helped by hearing aids should be prioritised for early implantation.

When these children receive a cochlear implant followed by intensive therapy before they are 18 months old, their hearing outcomes are better than children who receive implants when they are older. Those implanted before 18 months old develop language skills at a rate comparable to children with normal hearing, and many succeed in mainstream classrooms.

In post-lingual children and adults, their language abilities have been developed in the brain so there is less urgency for implant. Nonetheless, long periods of auditory deprivation may denigrate the transmission ability of the cochlear nerve and auditory pathway, thereby leading to poorer outcomes after implantation.

It is therefore advisable to implant suitable patients early to avoid this neural degeneration. Studies have also shown that bilateral cochlear implantation has superior hearing outcomes compared to unilateral implantation, and that simultaneous bilateral implantation is superior to sequential implantation.

Cochlear Implant Surgery and Postoperative Management

Cochlear implantation is performed under general anesthesia through a small 4 to 6cm postaural incision and is completed usually within 2 to 3 hours, followed by an overnight inpatient stay with a compression bandage. This is removed on the first postoperative day and the patient is discharged. A week post-surgery, the sutures are removed (for adults; children have absorbable sutures) and the wound examined. The implant is activated/ switched in 2 to 3 weeks post-op, followed by a regular series of audiology appointments to programme the device and with the auditory verbal therapists for auditory habilitation.

Improvements in Technology

Miniaturisation of the external speech processors have led to smaller speech processors that can be worn on the ear as compared to previously bulky ones that were shoulder slung or belt worn. Some companies have designed an integrated speech processor as part of the magnet that can be worn off the ear directly over the internal magnet. Internal components have become smaller and thinner. Numerous improvements in digital signal processing have resulted in better sound and music appreciation. There is now wireless connectivity and synchronisation with compatible hearing aids or another cochlear implant worn on the opposite ear to allow for 2-ear hearing and which improves hearing in noisy environments.

Expanding Indications for Cochlear Implantation

Besides patients with bilateral severe to profound sensorineural hearing loss, it is now acknowledged that a wider group of patients will benefit from cochlear implantation. This includes patients with partial deafness where there is good residual low frequency hearing but severe to profound hearing loss in the high frequencies (Ski Slope Audiogram pattern).

Such patients benefit from a special cochlear implant called a Hybrid or Electroacoustic Stimulation Implant which combines an acoustic hearing aid to amplify the low frequency sounds and electrical stimulation of the high frequency sounds in the cochlea.

Another group of patients who may benefit are those with single sided deafness. Cochlear implantation in these patients, especially if they have concomitant disabling tinnitus has shown promising benefits with tinnitus control and better hearing in noise and sound localisation.

Conclusion

Cochlear Implants help to restore hearing to a wide group of hearing impaired patients who, thus far, would not have not been sufficiently helped with hearing aids. It allows them to reconnect socially with friends and appreciate our beautiful world that is filled with a myriad of meaningful sounds.

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Ossicular Chain diseases and Ossiculoplasties

Ossicular Chain Pathologies:

Diseases of the middle ear often affect the ossicles leading to bony erosions and discontinuity of the ossicular chain. Congenital ossicular chain abnormalities are usually a result of abnormal embryological development of the ossicles and middle ear. These may or may not be associated with external ear abnormalities like microtia and vice versa. They present with poor hearing that is detected with newborn hearing screening or speech and language delay.

Acquired causes of Ossicular chain disruptions are more varied. The most common causes are recurrent otitis media and otomastoiditis as well as Cholesteatomas that result in erosion of the ossicles, especially involving the long and lenticular processes of the incus. Other causes like temporal bone fractures and benign tumours like glomus tympanicums can also disrupt the ossicular chain.

Conductive Hearing Loss

Patients would have conductive hearing loss with Tuning Fork tests showing better Bone Conduction hearing than Air Conduction hearing. Rinne's Tuning Fork would be negative and the Weber's Tuning Fork test would lateralise to the affected side. If a surgery is required to treat the underlying middle ear disease, an ossiculoplasty to restore continuity of the ossicular chain can be performed at the same time. An ossiculoplasty would be to afford natural acoustic hearing 24 hours a day without the need to use any hearing device.

Ossiculoplasty

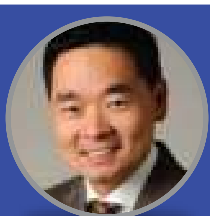
Ossiculoplasty is a surgical procedure to restore the continuity of the ossicular chain. The incision is a small end-aural incision, located between the tragus and root of the helix of the pinna. New techniques like the Endoscopic Transcanal approach allows for potentially no visible incisions and better visualisation of the middle ear. The tympanic membrane is lifted, the deficit examined and measured and surgery performed to surgically reconnect the ossicular chain. Hearing restoration success rates of this operation can be as high as 90%.

Ossicular chain replacement materials

The missing or dislocated portions of the ossicular chain can be replaced by autologous materials including any remnant ossicles, cartilage from the tragus or pinna, or cortical bone harvested from the temporal bone. These materials are reshaped and carefully inserted to connect the remaining ossicles. Alternatively, we can use synthetic prostheses made of metallic alloys or fluoroplastics known as Total or Partial Ossicular Replacement Prosthesis (TORP/PORP) that are specially designed to replace either the entire or part of the ossicular chain.

PORP prosthesis to replace missing malleus and incus. *Photo courtesy of Heinz Kurz GmbH Medizintechnik*

PORP prostheses of different designs. *Photo courtesy of Heinz Kurz GmbH Medizintechnik*



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Benefits of Hearing Aids for the treatment of Hearing Loss

Image courtesy of Widex

Hearing loss cannot be seen. It often goes undetected for a long period of time, leading to misunderstandings between family members. Often people push hearing concerns aside and develop maladaptive strategies such as pretending to hear or dominating a conversation.

Hearing loss can have a huge negative impact on your life, from your work to your relationships. If someone often asks for repeats, they should see an audiologist for a hearing test and if necessary to recommend suitable technology. Technology like hearing aids can make a big difference, especially if you pick the right ones and get help adjusting to them.

How Hearing Aids Help

A hearing aid is a battery-powered electronic device designed to improve sensitivity to sounds. Some are small enough to be hidden in the ear canal while others are tucked behind the ear. They work to make sounds louder to compensate for the degree of loss. Hearing aid technology is constantly advancing. A common feature in hearing aids allows ambient noise to be dampened while amplifying speech. Other features such as wireless accessories allow you to stream your phone calls or music via your smartphone. The audiologist can help to pick suitable features of hearing aids catering to the specific needs of individuals.

Hearing aids for children

Universal Newborn Hearing Screening (UNHS) detects hearing loss in children at infancy. Early detection is followed with appropriate early intervention such as fitting of hearing aids. This provides access to sounds and minimises impact of hearing loss on a child's development.

About one in 1,000 babies has significant hearing impairment at birth and is at risk for delay in speech, language and emotional development. Audiologist works closely with parents, their children and Auditory Verbal Therapist, with a goal to allow child to hear speech and meaningful sounds in their daily life so that children can develop age appropriate speech and language.

For children, Behind-The-Ear hearing aids are usually recommended because the ear molds can be replaced as they grow older. Pediatric features such as battery lock and safety clip should be provided for safety. There is a wide variety of colors and design to cater to children.

To support learning and education needs, assistive listening devices (ALDs) such as frequency-modulated (FM) systems are important to enable hearing in noisy environment. The FM system uses radio waves to deliver speech signals directly from the speaker's mouth to the listener's ears.

Image courtesy of Phonak Singapore

Hearing aids for elderly

Age related hearing loss (presbycusis) is on the rise. Presbycusis can impact on productivity and quality of life, especially as employment age increases beyond 65 and silver generation is empowered to engage in lifelong learning. This also affects connections they have with their community.

Presbycusis cannot be remediated and hence optimal management of presbycusis requires early detection and rehabilitation by the audiologist. Hearing loss and its impact on the individual's cannot be measured solely by a hearing test. It is important to factor the individual's hearing needs, impairment in daily life and its impact in communication among family members. Elderly with hearing loss have increased risk of developing dementia.

Common hearing needs include:

Environmental awareness: *Elderly wish to maintain their independence and often go out alone*

Essential day to day communication with significant others: *Grandparents often act as important caregivers to their grandchildren*

Medical Needs: *With more medical appointments with age, it is important to hear their doctors during consultations for better communication and management of chronic diseases.*

Challenges with hearing aids

There are some common complaints faced by elderly even with prescription of hearing aids. One of which is the complaint of not understanding speech despite being able to hear sounds with hearing devices.

Current research highlighted the limitations in speech understanding due to loss of outer and inner hair cells in the hearing organ (cochlear), poorer memory with age and degree of loss. In the management of hearing loss, the solution is more than hearing aids. Instead of only technology, aural rehabilitation focus on individual; adjusting to hearing loss, making the best use of their hearing aids, exploring assistive devices and management of communication breakdowns in conversations.

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Achieving Best Speech & Language Outcomes with Hearing Aids and Hearing Implants through Auditory-Verbal Therapy

Traditionally, communicating with a person with hearing loss meant using gestures, written communication or sign language. However, sign language is not universal. Different communities around the world have their own unique sign language, with its own grammar and lexicon. In Singapore, this is further complicated by multilingualism, where different members of the family could be using different languages to communicate. Those who do not speak English may find it a challenge to learn the English signs.

Additionally, an American study by Mitchell and Karchmer (2004) found that 8% of children with a hearing loss have at least one parent with a hearing loss, while only 4% have parents who both have a hearing loss. 92% are from families with two hearing parents. It is likely that in Singapore, majority of children with hearing loss are born to hearing parents.

When given a choice, the hearing parent would want their child to communicate with them and their extended family in their home language, which is English or a mother tongue, in Singapore's context. Unsurprisingly, Singapore School for the Deaf, which used sign language as the medium for instruction, was closed due to the drop in enrolment. This decline was attributed to the advancement of medical intervention and technology, as reported in "Singapore School for the Deaf to close due to dwindling enrolment" (The Straits Times, September 17, 2017). The school originally "had about 300 pupils in the 1980s to early 1990s learning sign language. That number dropped to fewer than 20 in the last decade".

In the same period of the declining enrolment at the School, Auditory-Verbal Therapy (AVT) was established for the first time in a hospital, in 2001. AVT was offered as a (re)habilitation programme for children with hearing loss, at the Singapore General Hospital. AVT has given parents an alternate way to communicate with their children, other than using sign language.

AVT is evidence-based practice, where it seeks to improve outcomes and quality of care by providing standardised intervention. Kaipa & Danser (2016) have found that several studies suggest that AVT can have a positive impact in the speech and language development of children with hearing loss. Goldberg & Flexer (2001) found that the majority of those who graduated from AVT programmes in America and Canada were well integrated into typical learning and living environments. This suggests that AVT is effective in helping children with hearing loss to realise their potential "to become independent, participating, and contributing citizens in mainstream society."

The Auditory-Verbal Therapist is the professional who provides Auditory-Verbal Therapy. With relevant academic qualifications (a master degree in Audiology, Speech and Language Pathology or Deaf Education) one can undergo a period of training of typically 3 years, undertake the necessary continuing education credits, and qualify for a certification exam to become a Listening and Spoken Language Specialist (LSLS Cert AVT). The Auditory-Verbal Therapist works closely with a team of Allied Health Professionals, as well as medical specialists, to provide holistic care for the child.

During the AVT session, the Auditory-Verbal Therapist coaches and guides the parent (or primary caregiver) in using hearing as the child's primary sense modality in developing language, without any sign language or emphasis on lip-reading. The parent is the primary facilitator of the child's listening and language learning, as they learn through participating actively in each individualised session. For the therapy to be effective, the child's residual hearing is monitored and maximised. Hearing aids or hearing implants are prescribed and fitted as early as possible. Parents learn that they need to help their child develop natural developmental patterns of audition, speech, language, cognition, and communication, by integrating listening and spoken language in every aspect of their child's daily lives. The children in turn, learn to monitor their own speech through listening. The Auditory-Verbal Therapist administers formal and informal ongoing diagnostic assessments, so as to develop individualised treatment plans, as well as to assess the effectiveness of these plans. All these support the goal of helping the children access mainstream education.

In the past 17 years, many children from the AVT programme at the Singapore General Hospital had indeed been successful in integrating into mainstream education. Some of them are even starting their tertiary education in local as well as prestigious universities overseas. This truly attests to the success of the AVT maxim, where each child's potential can be maximised, through effective and early intervention.

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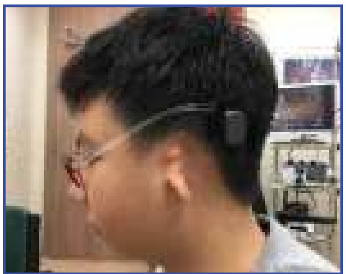
Bone Conduction Implants and Hearing Devices

Bone Conduction Implants and Hearing Devices are a special class of hearing devices, which generate sound vibrations that are passed through the skull bone directly to the inner ear.

Such hearing devices are particularly useful in two types of hearing loss: Conductive Hearing Loss and Single Sided Deafness. In normal hearing, soundwaves travel through the external ear canal, vibrate the tympanic membrane and ossicles, eventually transmitting these vibrations to the inner ear fluids, which activate the hair cells to enable the cochlea to sense sound.

Image courtesy of Cochlear Ltd



Picture of a child with Microtia using a Transcutaneous Bone Anchored Hearing Aid

Conductive Hearing Loss

In conductive hearing loss, there is a problem with the normal conduction of soundwaves through the external and middle ear, leading to a loss of energy transferred to the inner ear fluids. This results is an "Air-Bone Gap" in the Pure Tone Audiogram. Bone Conduction hearing devices bypass the external and middle ear entirely and rely on bone conduction of sound vibrations through the skull bone directly to the cochlea. Patients that benefit include children born with microtia of the ear or abnormal ossicles, patients with chronically discharging ears and those with repeated mastoidectomy operations. Wearing hearing aids may be difficult in these patients or predispose them to further infections.

Single Sided Deafness

Patients can suffer from single sided deafness due to idiopathic sudden sensorineural hearing loss, acoustic neuromas, Meniere's disease, trauma and a variety of other causes. The remaining hearing ear oftentimes has normal hearing. When used on the deafened side, Bone Conduction hearing devices transmit vibrations through the skull directly across to the normal ear, allowing it to hear sounds coming from the deafened field. This provides "pseudo-binaural hearing", where the only hearing normal ear hears sounds from both hearing fields.

Non-Surgical Bone Conduction Devices

Vibrating Bone conduction sound processors can be applied to the skull non-surgically in a variety of ways. Certain models may stick onto the hairless skin behind the ear via an adhesive sticker and contain a snap on adapter that connects to the sound processor. There are also direct pressure applications using headbands, spectacle frames or modern looking sports bands that apply pressure onto the temporal bone. These are transcutaneous solutions and there is approximately 10dB of energy loss when the vibrations have to travel through skin and subcutaneous tissue before reaching the underlying bone.

Surgical Bone Conduction Implants

Surgical Bone Conduction Implants may either be percutaneous or transcutaneous. Percutaneous implant solutions have a small screw that is surgically implanted into the skull bone behind the ear that extends through the skin to attach to the vibrating sound processor. The screws are made of special materials that allow for osseointegration. Since there is direct coupling of the vibrations to the underlying bone, there is minimal loss of energy lost and maximum sound perception.

For those bothered by the cosmesis of an exposed screw, there are transcutaneous solutions, where the internal components are entirely embedded underneath the skin and there are no exposed components visible through the skin. The sound processor has a magnet that allows it to be coupled with the internal magnet over the skin when in use. Certain processors vibrate directly onto the underlying magnet and transmit the vibrations. Other processors do not vibrate but instead sends the signals to the Bone Conduction Floating Mass Transducer (BC-FMT) that vibrates. This is anchored to the bone some distance away via screws. Being invisible under the skin, these solutions are cosmetically more appealing.

In conclusion, Bone Conduction hearing devices are easy to use and can help a wide variety of patients. With their reducing size and detachable sound processors, they offer a useful and discreet looking alternative to hearing aids.

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