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Recent advances in cochlear implants

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Implantation at a young age is highly recommended because hearing is important for language development



What is a cochlear implant?

A cochlear implant is an electronic device that takes over the work of the human ear in converting sounds to electrical signals that the brain understands as sounds and delivers them to the brain via the hearing nerve, after fine tuning the sound much like the graphic equalizer on a music system, via an electrode array surgically implanted into the inner ear.

Who does it benefit?

Both children and adults who have severe to profound hearing loss in both ears wherein even wearing hearing aids the person will have difficulty in understanding normal speech even at very loud volumes, and without the hearing aids would maybe only detect the loudest shout.

New criteria include people who have lost some frequencies of sound much more and can hear sound when its loud but cannot understand it (little or no benefit even with hearing aids).

Implantation at a young age is highly recommended because hearing is important for language development and because research has shown better outcomes for children implanted at an early age (Brain plasticity or adaptability)

Older children and adults with previous speech and language development generally perform better with a cochlear implant than children with severe to profound sensorineural (nerve) hearing loss in both ears. Age at implantation may be as young as several months, depending on individual circumstances and local practices. Here children are divided into prelingual (A **prelingual** deaf individual is someone who was born with a hearing loss, or whose hearing loss occurred before they began to speak. Infants usually start saying their first words around one year. Perilingual (during the ages of development of speech and language), or post lingual (deafness after age at which speech and language has developed).

In what circumstances does it not work?

Since the cochlear implant replaces the part of the ear that converts sound to electrical signals, it works only if the nerves going to the brain and the areas of the brainstem carrying the signal and the hearing recognition areas of the brain are functioning. An analogy would be like using voice recognition on your phone where the microphone (cochlear implant) works but the cable to the phone is damaged or software is corrupted and does not work.

How does one detect severe to profound hearing loss in a child or adult?

1. At the newborn stage Hearing screening by AABR(Automated Auditory Brainstem Response) {clicks or tones through soft earphone in babies ears and hearing nerve and brain response measured by electrodes creating a graph on a screen), (OAE{otoaccoustic emmissions which measures sound waves in the inner ear by a tiny probe in the ear measures electrical

activity in response to sound}). Point to be noted here is failing this test does not necessarily indicate deafness or hard of hearing unless it is confirmed by further testing. This includes a test called ASSR (Auditory Steady State Response Brain activity measured in response to sounds in a totally quiet room with patient lying very still or sedated}.

2. From newborn to 3 months , not being startled by or not responding to sudden loud sound or everyday sounds music or voices, not soothed by soft sounds, not waking up at the sound of nearby noises when sleeping in a quiet room , not making vowel sounds like oooh at age 2 months, or not quietening down at sounds of familiar voices are all an indication there may be a hearing problem and must be checked.

3. From 4 to 8 months of age , not turning head to sounds baby cannot see the source of , no change of facial expression at the sound of a voice or loud sound when in a quiet room, getting no pleasure out of shaking rattles or ringing bells or squeezing noisy toys, and not imitating sounds at age six months all indicate a possible hearing problem . In addition, child who does not babble (talk nonsense) back to herself or others who are speaking, does not respond to "no" and changes in tone of voice, pays attention mostly to sounds that are more vibration than sound are also red flags to a possible hearing loss.

4. From 9 to 12 months of age a child who does not turn quickly or directly towards a soft noisy toy or someone saying ssssshhh, or respond to his or her name , babbles on in the same pitch of voice with no variation, and does not use mmm or pah or buh or g, does not respond to music by listening bouncing or singing along, and at one year does not say dada or mama, is a candidate for hearing testing and screening.

5. At one year, wake up call signs are when the child does not produce many consonants at the beginning of words, does not understand words for common household or clothing items, or commands like come here or go there.

6. In children of school going age , the subject will not hear important elements of the class discussion including key context and content without visual cues, will have a smaller or more limited vocabulary than their same age peers, not hear all the sounds in a word, commonly leaving off 's', 'ing' and 'ed' in their speech and their writing , will have problems pronouncing some speech sounds, particularly those in the high frequency such as ‘s’ or ‘p’. They will also become very tired towards the end of sessions that have required intense concentration or were conducted in noisy environments

Very often, they misinterpret what is said although they 'hear' the speaker’s voice (they know that someone said something but couldn’t hear clearly enough to understand what was said)

There is a limited understanding of colloquial language, such as 'pull up your socks', and in normal conversations , they have difficulty understanding complex sentences, have poor vocal quality, have trouble explaining their ideas to other people, and have limited background knowledge and experiences in a range of areas which can affect learning and social skills.

7. Warning signs in this age group are when child hears fine sometimes only, wants tv volume raised all the time, says "what?" all the time or turns one ear towards sounds and call it his good ear, school grades fall or the teacher notes they do not seem to hear or respond as well in class, things have to be repeated and the child says they didn't hear, when it appears the child is distracted and just not paying attention, when the child talks really loud all the time , and looks intensely at someone speaking all the time . Mother’s intuition, where a parent feels there is something wrong but cannot put a finger on what it is a good time to get hearing and developmental milestones checked.

Who is a candidate for a cochlear implant?

A person who has severe to profound hearing loss in both ears, has a functioning hearing nerve which is detected by medical tests, has lived at least a short while without hearing, has no medical reasons to avoid surgery, has no benefit from the best hearing aids , and has a good support group at home .

What are the components of a cochlear implant?

A cochlear implant consists of an external device that looks like a hearing aid which has the function of capturing sound, tuning the sound like the graphic equalizer on a music system, using software, and then transmitting the sound like a radio station to the surgically implanted device.

The surgically implanted part consists of an antenna like a radio antenna which picks up the sound from the external device , a processor which like a music system output, takes the sound and sends it to different parts of the electrode which is implanted In the inner ear, much like a surround sound music system delivers sounds to different speakers in a room .

The electrode array which is like Diwali lights, where depending on the processor, different lights at different points on the cable switch off and on. In this case different electrodes switching off and on cause different parts of the hearing nerve ends to

receive stimulation that the brain perceives as sound of different frequencies.

What has changed in cochlear implants since they were introduced in India since 1987?

External device has become smaller, lighter in weight, more microphones to pick up sound and better software with faster processors to process more sound and give clearer and more focused sound to the patient. Also, it has become smarter, able to send and receive data from the implanted device to diagnose problems and improve efficiency of sound transmission to the brain.

Implanted device also has become smaller, lighter in weight, electronically smarter, wherein the implanted device can send diagnostic information back to the external device.Also it occupies less space and requires less surgical exposure . The electrode array has more electrodes and is slimmer and less damaging to the inner ear structures resulting in more information delivered to the hearing nerve while preserving residual hearing, which has resulted in better speech and sound understanding even in noisy environments. Also, the materials used have advanced to a stage where the body rarely rejects the implant.

Surgery has become more precise and less invasive resulting in quicker healing and shorter hospital stays for the patient.

Sound processing software has advanced and is still advancing , enabling doctors after surgery to fine tune the patients hearing and create software environments wherein even in noisy environments speech and sound understanding is getting even better all the time .This has resulted in less and less speech and sound training required after surgery and more natural sounding hearing.

Cost factor-Both surgery and implantation costs are decreasing all the time as devices are being mass produced and surgical techniques are less invasive requiring shorter surgical time and less hospital stay.

How much does the entire surgery and other related costs add upto?

Implant prices vary from 6.25 to 14 lakhs depending on the make and model chosen. Investigations and surgery and vaccinations and follow up depend on the hospital and the package chosen and the class of rooms and amenities chosen. On an average basic package would be 7.5 lakhs and postoperative rehabilitation of 2 to 4 years depending on the package and implant chosen would be around Rs 50 thousand to 2 lakhs.

Are there any sponsorships available?

Tata trust and Maharashtra Cm sponsor cochlear implants. Government of India has ADIP scheme for 500 implants per year. Airports Authority of India sponsors cochlear implants via the CRS initiative. In addition, insurance companies also sometimes cover the cost if due to congenital deafness. A number of private charities and trusts also sponsor implants with some private individuals . Ci surgeons usually can provide a list of the same.

Assistance to Disabled Persons for Purchase / Fitting of Aids and Appliances (ADIP Scheme). The scheme is implemented through implementing agencies such as the NGOs, National Institutes under this Ministry and ALIMCO (a PSU). The main objective of the Scheme is to assist the needy disabled persons in procuring durable, sophisticated and scientifically manufactured, modern, standard aids and appliances that can promote their physical, social and psychological rehabilitation, by reducing the effects of disabilities and enhance their economic potential.

Eligibility of Implementing Agency under the Scheme

The following agencies would be eligible to implement the Scheme on behalf of Ministry of Social Justice and Empowerment, subject to fulfillment of laid down terms and conditions:

- Societies, registered under the Societies Registration Act, 1860 and their branches, if any, separately.
- Registered charitable trusts
- District Rural Development Agencies, Indian Red Cross Societies and other Autonomous Bodies headed by District Collector/Chief Executive Officer/District Development Officer of Zilla Parishad.
- National/Apex Institutes including ALIMCO functioning under administrative control of the Ministry of Social Justice and Empowerment/Ministry of Health and Family Welfare.
- State Handicapped Development Corporations.
- Local Bodies- Zilla Parishad, Municipalities, District Autonomous Development Councils and Panchayats.
- Hospitals registered as separate entity, as recommended by state/central government
- Nehru Yuvak Kendras.

A person with disabilities fulfilling following conditions would be eligible for assistance under ADIP Scheme through authorized agencies:

- He/she should be an Indian citizen of any age.
- Should be certified by a Registered Medical Practitioner that he/she is disabled and fit to use prescribed aid/appliance. Holds a 40% Disablement Certificate.
- Person who is employed/self-employed or getting pension and whose monthly income from all sources does not exceed Rs. 20,000/- per month.
- In case of dependents, the income of parents/guardians should not exceed Rs. 20,000/- per month.
- Persons who have not received assistance from the Government, local bodies and Non-Official Organisations during the last 3 years for the same purpose. However, for children below 12 years of age this limit would be 1 year.

Quantum of Assistance

Aids/appliances which do not cost more than Rs. 10,000/ - are covered under the Scheme for single disability. However, in the case of SwDs, students beyond IX class, the limit would be raised to Rs.12,000/. In the case of multiple disabilities, the limit will apply to individual items separately in case more than one aid/appliance is required.

The quantum of assistance and income limit under the ADIP scheme is as follows:

Quantum of assistance and income limit under the ADIP scheme

Total Income	Amount of Assistance
Up to Rs. 15,000/- per month	Full cost of aid/appliance
Rs. 15,001/- to Rs. 20,000/- per month	50% of the cost of aid/appliance

Travelling cost would be admissible separately to the PwD and one escort limited to bus fare or railway, subject to a limit of Rs. 250/- each person, irrespective of number of visits to the Centre.

Further, boarding and lodging expenses at the rate of Rs. 100/- per day for maximum duration of 15 days would be admissible, only for those patients whose total income is upto Rs.15, 000/- per month and the same will be allowed to attendant/escort.

Motorized tricycles and wheelchairs for severely disabled and for Quadriplegic (SCI), Muscular Dystrophy, Stroke, Cerebral Palsy, Hemipeligia and any other person with similar conditions, where either three/four limbs or one half of the body are severely impaired. The extent of subsidy provided is Rs 25,000. The minimum age for availing motorized tricycle and wheelchairs is 16 years. The assistance will be provided once in 10 years.

For providing modern assistive devices for all categories of PwDs both physical and mental and multiple disability impaired groups, e.g. Daisy Book players and other Talking Devices, Net Book Laptop and Digital Magnifiers for visual impairment and Behind the Ear (hearing aid) for hearing impairment, the items will be decided by an Expert Committee constituted in the Department of Disability Affairs with the approval of Minister for Social Justice & Empowerment.The extent of financial support would be limited to Rs. 10,000 for each disability and Rs. 12,000 for students with disabilities in respect of devices costing upto Rs. 20,000. Further, all expensive items costing above Rs. 20,000, except cochlear implant, eligible for assistance under the scheme, subject to income ceiling, would be listed out. Government of India shall bear 50% of cost of the items thus listed by the Committee and the remainder shall be contributed by either the State Govt. or the NGO or any other agency or by the beneficiary concerned subject to prior approval of Ministry on case to case basis; limited to 20% of the Budget under the Scheme.

Ministry of Social Justice and Empowerment has recognized Institutes of national stature from each zone to recommend children eligible under the Scheme for cochlear implant, with a ceiling of Rs.6.00 lakh per unit to be borne by the Government. Ministry has also identified and recognized the Institutes in the zones wherein the surgery will be undertaken. Ministry will identify suitable agencies for providing cochlear implant (500 children per year) under the Scheme. Income ceiling for the beneficiaries will be same as for other aids/appliances.

Current scenario of cochlear implants in India.

Today there are around 200 state-of-the-art cochlear implant centers across India, in each major city, with talented professionals and well-equipped habilitation units for comprehensive management of deaf individuals. The Cochlear Implant Group of India which was conceptualized 15 years ago based on the British Cochlear Implant Group, has successfully created awareness regarding CI and has provided guidelines and support for its propagation and implementation across the country. Almost 30, 000 implants have been done in India with one million children still awaiting implants.

Selection Process

Screening of candidates

Adults

- Individuals 18 years of age or older, with Moderate to profound sensorineural hearing loss in both ears. (severe hearing loss where even very loud sounds are not heard)
- Limited benefit from amplification (hearing aids) defined by hearing test scores of ? 50% sentence recognition in the ear to be implanted and ?60% in the opposite ear or binaurally1

Children (2-17 Years) Same as for adults but including

- Multisyllabic Lexical Neighborhood Test (MLNT) or Lexical Neighborhood Test (LNT) scores ? 30%

Children (12-24 Months)

- Profound sensorineural hearing loss in both ears
- Limited benefit from binaural (both ears) amplification

New Important Considerations:

- Remember that many individuals with residual low frequency hearing are CI candidates and can benefit from CI.
- When appropriate, discuss use of acoustic hearing: Does your patient have a passion for music? Work in noisy or reverberant environments? What are lifestyle demands?
- Determine motivation to experiment with hearing aids, in both the implanted and/or contralateral (opposite side) ears.
- Discuss the opportunity to use acoustic hearing to manage expectations and rehabilitation options, when appropriate.

Financial Discussions are an important part of the selection as patients have to afford spares and repairs in addition to the surgery. Poor patients are given a list of charities while the affluent are educated to the expenses and time and energy postop that will go into the process of rehabilitation. Poorer patients have options of several government hospitals linked to colleges teaching audiology and speech therapy, while the more affluent have the option of availing the same services in corporate and private hospitals

What guarantees do Cochlear implants offer?

Cochlear implants guarantee hearing sound but do not guarantee how well a person will perform. In addition implants can be rejected by the body and like all electronic devices can occasionally fail, companies guarantee devices and replacements within the guarantee period. However, with new technology these are uncommon incidences.

Surgery and Post Surgery

Surgery for cochlear implants can be done by any surgeon well versed with routine ear surgeries. In western countries it is often an outpatient procedure whereas in third world countries some days of hospital stay is required. Typically, it is a two hour surgery. Following the surgery some amount of dizziness and ringing in the ears is normal. Bandages are removed a few days after surgery and post which a hair wash is allowed..The implant is switched on when healing is complete, usually 2 to 4 weeks later when a programming (tuning) is done which balances the loudness of different frequencies as per the patient .

Surgical complications

Usually have to do with **surgical** technique which include skin over the implant, loosing blood supply, improper electrode placement, and rare facial nerve problems. Minor issues include opening of wound line, infection, facial nerve stimulation, dizziness, ringing in the ears (tinnitus) . All these complications have simple solutions which are applied when needed.

Rehabilitation

This refers to training the cochlear implant patient to hear sound and understand speech. electronic sound is different from normal sound. it is like learning a new language like a small child does from hearing sounds to recognizing them to being able to identify the source and then to learn alphabets, vowels , consonants , words , sentences , paragraphs and so on.

Insurance

Quite often Cochlear implants are not covered in India - these often are reported on the following terms for non coverage -

1. The hearing loss is on account of congenital disease which is an exclusion in many policies. Hence any treatment of an excluded disease is also not covered.
2. Part of the implant resides outside the ear - the exclusion quoted by insurance companies is - any external durable or appliance is an exclusion under the policy
3. There is a specific exclusion in the policy on not covering cochlear implant.

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