(RE)HABILITATION AFTER COCHLEAR IMPLANT
BEST PRACTICE IN WESTERN EUROPE
(Monika Lehnhardt, Germany)

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Special Aspects:
The concept of fitting severely hearing-impaired children
with cochlear implants
(Bodo Bertram, Germany)

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Profile Dr. Bodo Bertram
1. Introduction

Cochlear implants have revolutionized the treatment and prognosis of children with severe to profound sensorineural hearing loss who receive limited or not benefit from hearing aids. Children who receive cochlear implants at a very young age – preferably before 1 – 2 years of age – can be expected to reach their normal age-equivalent developmental milestones and have higher chances to fully integrate into mainstream educational settings. With the positive outcomes after cochlear implantation and the continuous improvements in technology and surgical techniques, candidacy for cochlear implantation in children has been expanding to include hearing impaired children with significant residual hearing, single-sided deaf, severe inner ear malformations, multiple handicaps such as mental retardation or visual impairment, and auditory neuropathy (synaptic disorder). Furthermore, bilateral cochlear implantation has become “state-of-the-art” in many European countries, thus providing the children with the benefits of binaural hearing. As the candidacy criteria expand, cochlear implant programmes including pre-operative evaluation, surgery, pre-surgery and post-operative (re)habilitation have become one complex. Therefore, a multidisciplinary approach is needed, children should receive the treatment in experienced clinics and rehabilitation centres where teams of experts provide adequate services.

2. Early Identification-Neonatal Hearing Screening

Statistics worldwide agree: Deafness is the most frequent deficiency in newborns. 1 – 2 out of 1.000 are severely hearing impaired or deaf, another 2 – 4 suffer from a moderate hearing loss.

Experts worldwide agree: Deafness does not only mean „not hearing sounds“.

The deprivation of the auditory system may or will have dramatic effects on the anatomical, physiological and psychological maturation.

Congenital deafness is not visible, does not cause pain and without neonatal hearing screening remains undiscovered possibly until the child is 2 or even 3 years of age. At the same time we know that the first year of life is most important for language development.

We should bear in mind what happens during the first couple of months after birth.

Between 0 – 3 months the baby is irritated by sudden loud noises, recognizes and calms to mother´s voice

between 3 – 6 months the baby begins to turn eyes or head to sounds, stops crying when spoken to and begins making vowel sounds

between 6 – 9 months she/he looks for family members when her/his name is called, normally turns head towards sound, will respond to her/his name, responds to simple requests with gestures, uses voice to get your attention

between 9 – 12 months the baby understands „no“, „bye, bye“, responds to soft sounds, looks at pictures when named, repeats simple sounds that we make, uses voice when playing alone.
A deaf baby, whose severe hearing loss or deafness have not been identified and who does not get the adequate level of attention and support from their parents will not show many of these reactions.

Deafness – congenital or pre-lingual – is not a negligible disability. The impact on the whole development of the child is disastrous. Deafness means exclusion, being excluded from the verbal communication within the family and friends, excluded from the possibilities of higher education and from the free choice of a profession.

“The earlier the better” is a hypothesis that has been proven over the last 20 years (see research by Yoshinaga-Itano, Anu Sharma, Paul Govaerts, Maree Doble, Anne Geers, Manuel Manrique, Svirsky, John Niparko, the Nottingham group with Sue Archbold, Dimity Dornan et al.)

Carol Flexer makes her point by saying: “Identification of newborn hearing loss should be considered a neuro-developmental emergency”.

The importance of identifying congenital hearing loss during the first few months of life has been recognized more than 65 years ago. Ewing&Ewing say in their publication 1944: “There is an urgent need to study further and more critically methods of testing hearing in young children. During the first year, the existence of deafness needs to be ascertained …. Training needs to begin at the earliest age that the diagnosis of deafness can be established”.

Audiometers were introduced in the 1940ies and they are the pre-requisite for professional fitting of hearing aids.

The pioneering work of Marion Downs had a great impact.

In 1969 the Joint Committee of Infant Hearing (JCIH) was established with the goal of improving early identification of congenital hearing loss. At that time, however, appropriate hearing screening technology was not available. Therefore the JCIH focussed on screening only high-risk babies.

In 1978 David Kemp in the UK measured otoacoustic emissions (OAE), which became one of the methods used for routine neonatal hearing screening. Eight years later, 1986 the first AABR (Automated Auditory Brainstem Response Equipment) became available.

During the years 1988 – 1999 there were several Federal Initiatives to support Early Hearing Detection and Intervention in the US. Position Statements were published by the Joint Committee of Infant Hearing in 1994 and by the WHO in 1995. The first European Consensus Conference was held in Milano in 1998 and resulted in a widely recognized Consensus Statement, which comprises 10 points. The last point says ”Although the healthcare systems in Europe differ from country to country in terms of organization and funding, implementation of neonatal hearing screening programmes should not be delayed.
This will give new European citizens greater opportunities and better quality of life into the next millenium”.

Unfortunately, it took much longer to implement this appeal than the signatories of the Consensus Statement would have hoped for.
In Germany, one of the most developed countries with a very high level of health care, it took nearly 10 years of lobbying until finally in early 2009 a law to introduce UNHS was passed. The responsibility for implementation, however, lies with the federal countries and still differs as a consequence.
Countries in Europe still differ in the method they apply, OAE only, AABR only or – and this is “state of the art” by now OAE and AABR.
In some countries only one ear is tested, which seems insufficient in view of several studies documenting that children with single sided deafness are facing additional difficulties at school and are delayed in their development.

As major obstacles to a high quality implementation in general we identified lack of suitable equipment, insufficiently trained personnel, lack of central data processing and administration, insufficient counselling of parents and serious problems in financing.

Loss to follow-up varies dramatically, not only in the US but also in many European countries. It varies from 2% to more than 50%. A high percentage in loss to follow-up destroys the cost-effectiveness of the programme and can only be avoided by professional counselling of parents.

Neonatal hearing screening fulfils all the criteria requested by the American Academy of Paediatrics in the year 1999.
It is non-invasive, objective and not expensive.
Adequate equipment (OAE and AABR) is available.

Leading manufacturers confirm that the sensitivity of their equipment is 99% and the specificity 97%. This would mean that we have only 1% false negative (the baby is deaf but this was not found) and 3% false positive (the baby has normal hearing but there was a false alarm).

It is of paramount importance to keep these percentages as low as possible. The consequence of false negative is that parents believe to have a normal hearing child and do not seek any treatment and communicate with their child in a way that is not adequate. The consequence of false positive is that parents are shocked and will be under this impression until another assessment in a professional diagnostic centre will correct the result of the screening. This may take up to 6 months depending on the local circumstances.
The UNHS should be structured in a way that all neonatal departments of hospitals are connected by Internet and deliver the data of their measurements to a central institution that collects all reliable epidemiological data and monitors the “tightness” (make sure that really all newborns are subject to the screening) and the quality.

The screening for congenital hearing loss should preferably be implemented on the 2\textsuperscript{nd} or 3\textsuperscript{rd} day after birth when mother and baby are still in hospital. We know exceptions in countries like the Netherlands where the majority of babies are born at home.

In case the baby fails to pass the test a retest can be done the following day. Should the baby fail to pass again she/he is referred to a Diagnostic Centre, where audiologists and/or ENTs provide an in-depth analysis and identify the kind and level of a potential hearing impairment.

As we believe that family support is one of the most if not the most important factor in helping the hearing impaired child to learn to listen and talk, we have to ensure professional and empathic counselling for the parents. They need to understand what means “pass”, “fail”, “referral”, “alarm” and what is the difference between screening and diagnosis. They should also be aware that when their baby has passed there is still a possibility of late onset of hearing loss and they should insist on a new hearing screening at pre-school age. Progressive and late onset losses are underestimated. The prevalence of deafness doubles in children at the age of 9 years. If we included single sided deafness if would increase by another 50%.

The parents need to get unbiased information about early intervention options and different approaches in (re)habilitation.

In conclusion: Universal hearing screening for hearing loss must be obligatory for newborns!

As Martyn Hyde expresses his view: “Infants cannot complain of lack of hearing and cannot seek intervention we would surely not deny ourselves. We can and we must do their complaining for them. Infants and families have a fundamental right to early and effective communication.

3. Early / Pre-surgical Intervention

Once a hearing loss is recognized habilitation should start immediately. The neural plasticity is at its highest at this age and we must use this “window of opportunity”. Between diagnosis and possible cochlear implant surgery babies often get generic powerful digital hearing aids. According to one of the leading experts in this field, Dr. Sandro Burdo, this is useless and a waste of money. He proposes the use of cheaper, medium level hearing aids (that can be rented) to provide strong amplification at low frequencies and a definite,
well-structured habilitation programme to activate communicative verbal skills and to prepare the child to taking advantage of the implant (later) very quickly. During the pre-surgical period the acoustic perception should enable the child to activate awareness of the environmental sounds, acoustic attention and detection to support lip reading and to improve the process of perception (discrimination, identification, recognition and comprehension).

According to Dr. Burdo sound amplification alone is sometimes not enough and he recommends a combination with a presternal (worn on the breast) vibrator (mono-channel devices). The brain is the target and not the ear! We want to support cognitive maturation. This is also highly positively influenced by offering classical music (preferably Mozart or Vivaldi) to the baby during waking and sleeping hours.

We want prosodically emphasized communication (babies understand through feelings) and we want to use sound toys. Video taping and analysis will help the parents to monitor progress.

Dr. Burdo and his team believe that a structured pre-surgical habilitation programme is a basic pre-requisite to reduce the duration of post-surgery intervention and – above all – for a really successful communication outcome.

We must not forget: the effects of deprivation are worsened in congenitally deaf children because they lack also fetal hearing.

UNHS clearly presented new challenges for the development of hearing systems and adaption software for children who now receive medical care between 0 – 6 months. Very small, yet child-safe dimensions as well as new acoustic couplings are required. After a trial of 6 months with bilateral hearing aids it should be clear whether the baby has a benefit or not. If this is not the case parents should be offered the solution of cochlear implant.

4. Early / pre-operative diagnostics

The entire diagnostics is under the responsibility of the surgeon and follows the latest State of the Art.

Minimum requirements are

for adults

- General status, anamnesis including ENT specific anamnesis
- ENT status, especially eardrum microscopy
- Sound and speech audiometry
Controlling of hearing aid devices and their optimization. Survey on supply of hearing aid devices with audiometric proceeding in free sound field

Consideration of psychological aspects

Objective examinations on hearing

- TEOAE/ DPOAE
- Impedance audiometry
- Electrocochleography (optional)
- Promontory test

- Functional test on the acoustic labyrinth including caloric control
- Neuro-audiological diagnostics (high resolution temporal bone -CT)
- High resolution MRI of temporal bone and cerebellopontine angle

Through MRT and/or CT highly detailed images of the Cochlea should be provided to detect its anatomy and content of liquid. Hereby the technical possibilities should be exhausted according to the individual issue, but should also be weighed on with regard to required time for examination as well as to radiation exposure during CT.

Additional examination in individual cases could be useful like

- Functional MRI
- Positron Emission Tomography (PET)
- Amplitude Modulation Following Responses (AMFR)
- CERA
- Notched-Noise BERA

Moreover, the following additional examinations and preoperative measures could be provided

- Logopedic-phoniatric, pedagogical and psychological examinations with regard to communication ability, expectations, motivation, learning ability and the psychosocial
situation of the patient as criteria to provide Cochlear Implants

- Consiliary examinations to clarify risk factors like suitability for surgery, possibly prognostically relevant concomitant diseases
- Control of vaccination status (HIB, pneumococci, meningococci)
- Vaccination against pneumococci and Haemophilus influenzae type B to minimize risk on Meningitis, all in accordance with the current STIKO recommendation for risk exposed patients, if possible 4 weeks prior to surgery

Finally extensive consultation and information of the patient about

- Process of a supply with a CI
- Various CI systems
- Operative procedures and risks of a surgery
- Rehabilitation
- Evaluation of prospect of success
- Individual therapy planning
- Information from and contact to persons concerned

**Children and Adolescents**

Clarification of the medical status is equivalent to the proceeding with adults. Depending on the age and ability of the child to cooperate it might be necessary to execute part of the examination under anaesthesia and if necessary do paracentesis as well as adenotomy.

- On suspicion of existing residual hearing one should test whether hearing aids are beneficial prior to CI surgery. This could also excite the hearing function
- In principle a hearing impaired- pedagogical, phoniatrical- paedaudiological and logopedical evaluation of hearing, the status of hearing, speech and language and the speech development and communication skills have to be made.
- Collaboration with Cochlear Implant Center and other supporting organizations is advantageous in the process of deciding on the indication
- Alternative modes of communication have to be presented to parents concerned and adolescents

**Additional examinations and pre-operative measures**

- Diagnostics on development
Development related additional neurological examinations, e.g. to discover any further disabilities or disorders (an additional stationary hospitalization in a specialized facility might be necessary)

Psycho social diagnostics

Intensive personal consultation and counselling of parents, children and adolescents

Pre-operative counselling (risks of surgery)

Rehabilitation

Evaluation of prospect of success

Individual therapy planning
  Procedure of providing a CI

CI systems

Information about post-operative imaging – specifically MRI

Information from and contact to persons concerned

Pre-operative examinations on adults can be performed on outpatient mode or stationary. The justification for a stationary admission depends on the intensity of the examinations and consultations in individual cases and on local and social circumstances.

Pre-operative examinations on children can be performed on outpatient or in-patient mode as well. The decision on the necessity for a stationary admission depends on the projected intensity of examinations and consultations as well as on local and social circumstances. Especially for children the performance of examinations under stationary conditions could become necessary to develop a sustainable indication through intensive examinations and observation.

5. Indication

The indication will be decided by the surgeon taking into consideration all medical findings and in coordination with the experts for pre-operative assessment and post-operative advisors. Patients who are considered suitable for receiving a Cochlear Implant are those who most likely will develop with Cochlear Implants a better hearing and speech
comprehension than with hearing aids. The proper functioning of the auditory nerve and of the auditory pathway has to be confirmed by the pre-examinations. In case of bilateral indication implantation on both sides has to be performed.

For brain stem implants the central auditory pathway has to be intact.

Children, adolescents, and adults who lose their hearing post-lingually (after developing speech) and those who are severely hearing impaired are principally suitable candidates.

In special cases an implantation could be indicated for adults who became deaf before developing speech (pre-lingual).

For children with pre-lingual deafness and for those who lose their hearing during developing speech (peri-lingual) or suffer from severe hearing impairment an early implantation should be preformed within their first years or immediately after diagnosis.

For children with suspected residual hearing the decision for CI should only be made after an observation period including suitable therapeutical measures (optimised supply with hearing aid devices combined with early intervention)

After bacterial Meningitis there is a considerably high risk of obliterative Labyrinthitis, which makes an intra-cochlear implantation significantly more difficult. In this case the audiological and neuro-audiological diagnostics have to be initiated immediately in order to perform Cochlear Implantation in these children as early as possible ("emergency case")

**Contraindications**

Absolute contraindications for providing a CI are

- Missing Cochlea or missing auditory nerve
- Non secured post-operative rehabilitation/care
- Lack of candidate’s ability for rehabilitation
- Central deafness with functional disorders within the area of the central auditory pathways

Relative contraindications for providing a CI are
Middle ear infection (after curing implantation possible)
- Negative result on subjective promontory test
- Severe systemic diseases
- Therapy resistant epilepsy

“In 20 years an implant will be the treatment of choice for anyone with a hearing loss greater than 50dB”. This was a rather courageous statement by Dr. Jay Rubenstein in 2004. When we started to provide deaf children with CI in 1988 (Ernst Lehnhardt – the girl was 1 ½ years old) the general opinion was, that the child had to have a hearing loss of around 100 or even 120 dB, which means totally deaf with no benefit from a hearing aid.

Factors supporting the dramatic changes in indication are:

- Continuous advances in technology (diagnostic equipment, Hearing Aids, Implants, FM systems, assistive listening devices)
- Improved imaging and surgical techniques
- User friendly software for fitting and trouble shooting
- Proven (re)habilitation methods (oral, AVT)

What has changed?

Age is not a limiting factor any longer (the youngest child was 4 months at the time of surgery, 6 months is fully accepted; he oldest patient so far came from Nottingham with 102 ears of age).

Severity of hearing loss has changed dramatically from “totally deaf” to “severely hearing impaired” to “partially deaf”.

Bilateral deafness is not a “conditio sine qua non” any longer, single sided deafness is considered to be an indication

From unilateral CI we moved to bilateral CI, to bimodal CI with Hearing Aid either on the other or on the same ear

Mother tongue is not important any more – there are many children with CI who use their mother tongue at home but grow up in an environment with a second language

Multiple handicaps, even autism is not a contraindication any longer

Deaf children with deaf parents are now considered to be suitable candidates
6. Decision for Cochlear Implant

Before the 1970ies deafness was considered to be an irrevocable blow of fate. With the introduction of cochlear implants 30 years ago the pathway to hearing has been opened for deaf people.

Prof. Thomas Lenarz, MHH Hanover recently said that the estimated number of CI recipients worldwide is 450 thousand (in Hanover 6450, in Freiburg …..)

There are four major manufacturers producing various models of implants and speech processors. Cochlear – the world leader – from Australia, Med-El from Austria, Advanced Bionics (Sonova) from the US and now Switzerland, Neurelec now Oticon from France and now Denmark.

In most countries in Western Europe the CI candidate has the chance to choose the clinic where he wants to be operated, the surgeon in this clinic and also the kind of implant system. The vast majority of clinics offers at least the products from two of the manufacturers, many offer from three and some even from four.

Patients are counselled pre-operatively about the specific features and advantages of the various models.

Depending on the anatomy of the inner ear of the patient the surgeon then selects the electrode type, which he/she considers to be most suitable.

“The earlier the better” is the message that is well understood and fully accepted by all experts worldwide. This applies to identification and intervention and therefore also to providing the CI for suitable paediatric candidates.

There is compelling evidence for CI for children younger than 12 months of age.

“Speech perception, production and language outcomes for children who receive the CI under 12 months: A multicenter study” Toronto 2016 (Shani Dettman, Wendy Arnott, Dimity Dornan et al).

The conclusion from this study is that when the CI is provided
< 24 months speech perception can be optimized
< 12 months speech production is facilitated
< 12 months language acquisition is enabled to be in the same range as normal hearing peers’. 80% of these children demonstrated receptive vocabulary within the normal range by school entry.

Children implanted < 2,5 years (with no significant cognitive deficits) made normal language progress but retained a delay approx. equal to their age of implantation.

Another conclusion from this study is that hearing impaired children who receive their CI below the age of 3 years may benefit from the CI if their PTA HL (pure tone average hearing loss) is > 60dB bilaterally.

“Bilateral/Binaural is better than unilateral” is another statement which is shared by all
experts worldwide.

Why is binaural hearing important?

The ability to localize sound as well as the ability to detect speech in complex acoustic environments is achieved by the central auditory systems’ ability to calculate minute differences in the characteristics of sound arriving at each ear.

Bilateral CI recipients have an improved sound localization. The mean angular error for unilateral CI recipients is 67 degree, for the bilateral 24 degree (published by Verschuur CA et al 2005). It means the precision more than doubles.

With a 2nd CI speech understanding in noise can increase by a factor of 9.

Functional (“perceived” / “felt”) benefits of bilateral CI are:
- feel safer because of better sound localization, higher awareness of sound environment
- join in based on better speech understanding in noise, more socially interactive in conversations
- relax because listening becomes easier, more balanced sound can be enjoyed, “incidental learning” is made possible!

Objective benefits of bilateral CI are:
- Head shadow effect (physical phenomenon): the benefit from adding the ear with the more favourable signal-to-noise ratio when listening in spatially separated speech and noise. There is an improvement of 10dB in critical SNR for 50% speech recognition for the Oldenburger Sentences Test (R. Laszig et al 2004).
- Binaural squelch: the benefit of adding the ear with the less favourable SNR gives up to 3 dB improvement in SNR for speech recognition
- Binaural redundancy: two ears are better than one when listening to speech in quiet or in noise presented from the same location. There is a 1 – 2 dB increase in perceived loudness

The results obtained for sound localization and understanding in noise (21% sentences scores in noise and 24 degree instead of 67 degree localization error) in “Evidence Based Medicine Evaluation” John Murphy, Gerard O’Donoghue are similar to those reported by Laszig et al 2004.

Another important question is “When to progress from bimodal (CI on one side and Hearing Aid on the other side) to bilateral CI?”

For children an optimally fitted HA in the non-implanted ear will enable some maturation of the auditory pathways. It depends on the degree of residual hearing.

The effectiveness of the HA for this purpose can be monitored with CAEP = P1 latency (cortical acoustic evoked potential) measurements.

In children whose CAEP fails to show a time course of development, CI is the only way to achieve central binaural development.

Another question to be answered is: “Should the provision with CI be simultaneous or sequential?”

Bauer PW, Sharma et al already in 2006 made this statement: “Our data suggest a high degree of plasticity of the central auditory pathways seen only after early implantation of bilateral implants”.

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Gordon KA et al in 2007: “Clear differences in auditory brainstem responses were seen in sequentially implanted children even when the delay of the 2\textsuperscript{nd} CI was under one year”. There is evidence that in children under 8 years of age the “gap” in speech perception for the 1\textsuperscript{st} and the 2\textsuperscript{nd} ears is closed within the first 6 – 12 months. In older children a gap closure is not seen.

Some parents ask the question: “Should we save the second ear for future technology?” The answer is: Given that binaural hearing depends on bilateral input during a critical development period, if the 2\textsuperscript{nd} ear does not receive auditory input during this critical period of cortical development, alter technology, no matter how advanced, will only provide input to a cortex incapable of receiving it.

Similar to neonatal hearing screening (Consensus Statement 1998) there is an Expert Consensus from 2007 which was then signed in Marseille. It says

Most would benefit from binaural CI
“Window of opportunity” in children is not understood / well defined yet
Surgery is low risk, simultaneous can be done from 6 months on
Insurance companies and governments should fund bilateral CI

“Implantation as young as possible should minimize any language delay” Leigh J.R., Dettman S.J., Dowell R.C., 2016

Children with hearing loss and CI using an AVT approach were able to progress in development of listening, speech and language at the same rate of progress as a matched group of children with normal hearing (same initial hearing age) over 4 years and 2 months of time. Dimity Dornan et al 2010.

7. Surgery

Requirements for the surgeon and clinic where the CI implantation takes place

- Long term continuous experience in special microsurgery of the ear and earlier surgical performance at a clinic specialized in CI surgery with a sufficient number of Cochlear Implant operations under the supervision of an experienced CI surgeon
- The implant clinic has to publish the number of surgeries and the statistics on complications within the framework of a quality report.

At the operating clinic a sufficient number of implantations per surgeon should be performed annually to ensure routine and quality. Although there is currently no scientifically secured knowledge about the correlation between number of surgeries and
their quality one can assume that apart from other factors also the number of surgeries at the center has an impact on quality and result of the Cochlear Implant surgery.

**Special requirements on facilities in an ENT operation theatre**

- Intra-operative EMG monitoring of Nervus facialis
- Special OP instruments for Cochlear implantation
- Cochlear implants as well as back-up and special implants
- Location to measure intra-operatively the functionality of the implant and the auditory pathway
- Possibilities for intra-operative imaging

**Stationary period of hospitalization**

Implantation will be performed under stationary conditions The period of hospitalization is decided according to professional medical as well as social patient related criteria, whereby controlling complications in particular wound healing is required.

**Risks of surgical procedure**

In principle the surgical procedure is almost without complications, its risks should not exceed those of a middle ear surgery.

The following can occur in particular

- Infection of the middle ear (possibly spreading towards inner ear and subarachnoid space which may cause meningitis, obliteration of the inner ear, possible damages to afferent auditory nerve fibres)
- Wound healing disorder
- Dizziness
- Damage of the facial nerve
- Disfunction of sense of taste
- Tinnitus
- Loss of possibly still existing residual hearing
- Technical complications and defects of implants
- Rarely there could occur a long term degradation of electrical stimulation, for instance through progressing ossification of the Cochlea after Meningitis
Misplacing of electrodes

Adverse stimulating effects on other brain nerves (e.g. facial nerve, equilibrium nerve)

Intolerance of implant material

Liquor fistula

**Intra-and post-operative controls**

Intra-operative:

- Control of functionality of the implant by use of Telemetry
- Intra-operative monitoring of Nervus facialis
- Measuring physiological responses to electrical stimulation, e.g. stapedius reflex or neural responses especially on children
- Radiological control of electrode placement in surgical problem cases

Post-operative:

- Radiological control of electrode placement
- Careful control of wound healing to discover any complication at an early stage

The duration of a unilateral CI surgery is nowadays approx. 1 – 1 ½ hours when performed by an experienced surgeon. In the early days it would take up to three hours. The shorter duration is definitely an advantage as we have very young CI candidates (below the age of one year) for whom a shorter anesthesia is obviously an advantage. The same applies to the elderly patients (older than 80 years) for whom a long anesthesia is also an increased risk. Experts already discuss the possibility of local anesthesia for elderly people. First cases have been done.

The technique has changed significantly. The “Heerman” cut was a large incision providing a very good view, which was considered to be important as there was not much experience yet. Today it is a very small incision, shaving of the hair is not necessary any more. Drilling of the bed depends on the type of implant, insertion length of the electrode array depends on the patency of the scala tympani of the cochlea. Fixation with cement has become very rare. Whether the opening of the cochlea is done via cochleostomy or round window approach is often a personal preference of the surgeon, sometimes necessitated by anatomical circumstances. Intra-operative monitoring (e.g. of the facial nerve) increases the safety of the surgery.
Pre-operative imaging of the cochlea helps the surgeon to decide which model of electrode array to take. It is quite feasible that in the future there will be tailor-made electrode arrays based on these pre-operative imaging techniques.

Intra-operative measurement of hearing thresholds is mandatory and provides the audiologist / engineer with valuable information for the first fitting to avoid any risk of overstimulation.

We will see whether this prognosis will become true:

“In the future possibly robots will “do the job” faster and more reliable”
quote David Proops, Birmingham in Suzdal, Russia in December 2011

8. Fitting of the speech processor – Tune-up/ Switch on and further fittings

According to the German “Cochlear Implant Guidelines” the first fitting of the speech processor should be done 5 weeks post-operatively, during 3 – 5 days, preferably in a Cochlear Implant Centre. This is a special institution, which can have different financial supporters. The most important factor is that in these CICs there is a team of pedagogues, logopeds (speech therapists), engineers, ergo-therapists, music therapists, psychologists etc. In most cases these centres are attached to an implant clinic and therefore medical treatment and post-operative medical care is ensured.

The phase of first fitting lasts until a stable programme / a stable map has been established in the speech processor. This is dependent on the age of the child.

Recently many clinics have shortened the time between surgery and first fitting significantly. Depending on the healing process of the wound a first fitting can be done already 8-10 days post-operatively.

Alex Teichrieb, an expert in the Freiburg Cochlear Implant Centre holds the view that fitting becomes more difficult as the children get their CI at a younger and younger age. Conditioning by using play and distraction audiometry is essential. Close monitoring of the behaviour of the child is important.

Helpful are definitely the results of Stapedius reflex measurements and impedance of the electrodes.

The start is always with very low stimulus levels (avoid overstimulation!) followed by a cautious increase of stimulus levels.

What to do in case of problems?
The child does not show any reaction despite of high stimulation.
Maybe the stimulus level is too low
Maybe the child ignores the unknown sound which is simply perceived as noise
Maybe there is an additional handicap

What can we do?
We can increase the stimulus level to maximum of the Stapedius Reflex level. If even then there is no reaction we use conditioning by applying distraction audiometry, we show pictures in parallel to providing sound. If again there is no reaction it is important to make sure that the child at least wears the device and that the parents observe carefully the behaviour of the child-safe. When we see a first reaction we provide the same stimulus repeatedly and we try other electrodes. The “best case scenario” for the first fitting is that we can get C-levels (comfortable levels) on all electrodes. We can then test low sounds.

Another challenge for the audiologists / engineers is fitting for recipients who wear a CI on one ear and a HA on the other ear. An evidence based clinical guideline with practical fitting strategies is desirable.

9. (Re)habilitation
   Basic Therapy and post-operative Care
   Auditory Verbal Approach
   Tele-Practice

Post-operative basis therapy and subsequent therapy

Apart from the described intensive pre-operative diagnostics post-operative clinical basis therapy and subsequent therapy to ensure the success of rehabilitation have a high significance. They are an integrated part of a CI provision. The subsequent therapy has to be offered in the framework of a continuous care as long as the implant is used. Altogether with the supply of Cochlear Implants we are dealing with a multi-disciplinary way of proceeding, which has to be performed in centers with related professional expertise. Therefore, only clinics are suitable for CI implantations, which can perform the clinical basis therapy on their own or which have related CI centers and Reha centers at their disposal, which can take over the subsequent therapy in close cooperation and under continuous surveillance and responsibility of the medical management of the clinic. The service has to stay throughout the year if needed even stationary. Basis therapy, post-operative therapy and post-operative care follow the structure of an interlocked process of a multi-disciplinary team. All disciplines are involved in the daily processes of basis therapy/post-operative therapy as well as in issues related to the after care and cure the patient collectively.

Basis therapy
Therapy generally starts from 5 weeks post stationary stay

**Contents of the post-operative clinical basis therapy**

- Medical post-operative treatment
- First mapping of the speech processor
- Step by step optimizing of the speech processor settings
- Initial auditory and speech training
- Speech therapeutical measures
- Technical and audiometric controls
- Hearing tests, with speech as well
- Speech test in quiet and in noise
- Psychological care (e.g. to solve conflicts, which are hampering the therapy)
- Documentation and Evaluation of the results
- Training on handling (care, maintenance, trouble shooting) and usage of accessories (e.g. telephone adapter, battery charger, additional microphone, infrared or FM system, induction or T- coil)

**Subsequent Therapy**

During the following period the auditive perception has to adapt and get used to the new artificial stimulation which - based on the achieved progress – requires a closely interlocked and near time combination of training and repeatedly performed fitting of the speech processor as well as audiometric control. Basis and subsequent therapy are generally performed at the center which undertakes the implantation. Those therapeutic actions which started during the basis therapy will be continued during the subsequent therapy dependent on the individual progress of the therapy. Controls can be executed on outpatient, stationary or partly stationary mode depending on the complexity of the required treatment and social circumstances. The number of necessary technical and clinical controls as well as of executed settings of the implant depends to a high degree on age, ability to cooperate, the cause and duration of deafness and, therefore, is individually very much varying.
Basically the following effort has to be considered

- During the first month after the first fitting 4-8 days of aftermath treatment
- From the second until the sixth month after the first fitting 1-2 sessions per month
- From six months after the first fitting (as long as the Cochlea Implant system is functioning) approx. 2-6 days of aftermath treatment per year

Re-implantation and sequential bilateral implantations are in this regard treated equal to first implantations. The procedure could require bigger efforts in comparison to basis and subsequent therapy. Bilateral provision is normally more demanding.

Hearing and speech tests including in noise, technical and medical controls, and optimizing of CI setting should be carried out on a regular basis. In principle the following timely intervals (calculated beginning with the first fitting of the Cochlear implant system) are 3 months interval in the first year. In the second year appointments are recommended to take place in a 6 months interval thereafter starting from the third year annually.

**Special features of basis and subsequent therapy**

**For adults**

During the first fitting (basis therapy) for adult CI recipients the focus lies on providing first impressions of hearing, transmitting noise, sounds and speech through the Cochlear implant. For this adults need a therapy in small steps and individually adapted. This often is especially successful in the protected environment of a CI center changing between computer supported fittings, audiometric controls, and measurements. The subsequent therapy then comprises of a gradual set up of noise and sound perception as well as speech recognition of single words at the beginning and small sentences within a closed set up to an open set understanding of speech under simulated daily life conditions. Main goal of the therapy for grown up CI recipients is the professional and social inclusion as well as the active possibility to communicate in spoken language.

**For children**

Goals of the basis therapy:

- After Cochlear implantation it is an essential goal to embed hearing as an integrated part into the child's life and to develop its communication skills, speech and language competence permanently improving them throughout the years.

- Intensive involvement of the parents, reference persons and pedagogues of the supporting facilities during therapy sessions is mandatory

- First fitting and optimization require child-oriented and age appropriate parameters to
perform behavioural and play audiometry and is based on close cooperation between implant clinic, audiologists, ENT medical experts, phoniatrists/ pediatric audiologists, therapists, and parents.

- Evaluation and resetting through observation of child's behaviour and with the help of audiometric controls throughout the entire therapy period

- Training of parents and children on handling Cochlear implant system (care, maintenance, trouble shooting) and usage of accessories (e.g. FM system, recording devices, MP3 player)

Methodologies currently applied working with children with CI

It is a very broad spectrum of various methodologies applied by professionals working with paediatric CI recipients.

- Sign language can be of more or less importance, depending on the country or the institution, In Sweden e.g. parents of children with CI are more than encouraged to learn sign language. Some parents strongly oppose this approach and speculate that this is only because teachers in schools for the deaf are frightened to lose their job in view of the fact that there are no more deaf children without CI (neonatal hearing is in place, in most cases bilateral CI is provided at a very early age) and children with CI do not need a school for the deaf.

- Cued speech and “total communication” are still in use, especially in the US

- Verbo-tonal or the Guberina method, which is also called SUVAG (Méthode Système Universel Verbototal d’audition Guberina) is popular in Russia, Eastern European countries, but also in France, Italy and in the “La purissima” institutions in Spain. Other therapists – like Gisela Batliner, Dimity Dornan et al. – believe that this method is obsolete. It is focused on training speech and pronunciation and not on verbal communication and – most importantly – children with CI can hear in all frequencies.

- Natural Auditory Oral or Natural Aural is advocated by therapists like Batliner, Morag Clark, Gottfried Diller et al. Advocates of this method do not teach the mother tongue. They help parents to provide an environment in which the child is surrounded by mother tongue and thus has the chance to learn it. They make full use of residual hearing and(or the CI and they make sure that the child learns to listen. We can call this “incidental learning” and this is what normal hearing children do.

- Auditory Verbal is basically very similar and the ambassadors of this method say more or less the same. The difference is probably that this method is more directive. Therapists consider themselves as coaches, the parents take the leading role. Some parents may be stressed and feel guilty that they cannot do what the professionals expect them to do.

Parents get home works and the AV therapist expects them to do the exercises and come prepared for the next session. Some of the most well known champions are Susann Schmid-Giovannini, Warren Estabrooks, Dimity Dornan, Judi Simser.
Regardless which methodology is applied – the most convincing argument is the success of the therapy. The German ENT society defined the goal as follows:”After cochlear implantation it is an important goal to establish hearing as an integral part of the child’s life, to develop her/his communicative and verbal skills and improve them continuously over the years”.

We believe “90% of children with CI will be successfully integrated into mainstream kindergartens and schools, provided they have no additional handicap and they get adequate (re)habilitation with family support which is Auditory Verbal Therapy”.

Todd Houston emphasizes that early immersion in audition and spoken language will result in the same results regardless of type of hearing loss, degree of hearing loss, socio-economic level and other factors. It permits a natural development instead of remediation.

Dimity Dornan, Brisbane Australia describes the goal of AVT: We want full inclusion of these children who received a CI and AVT in mainstream kindergarten and school. One of the major objectives is to empower parents to listen and speak, to have competent and capable parents instead of depending on professionals.

Judy Simser: “When parents learn how to integrate AVTs into everyday meaningful activities and experiences, their children have the best opportunity to achieve good listening and language outcomes. Parents can become the professional’s greatest allies. To ignore their contribution is to compromise a child’s future”.

The ten principles of AVT are:

1. Promote early diagnosis of hearing loss in newborns, infants, toddlers and young children followed by immediate audiological management and Auditory Verbal Therapy this means to ensure neonatal hearing screening and follow-up visits, 1 – 3- 6 model, (screening at one months at the latest, diagnosis at 3 months, intervention at 6 months), more time for audiological management and wearing the technology 24 hours 7 days a week
2. Recommend immediate assessment and use of appropriate, state-of-the-art hearing technology to obtain maximum benefits of auditory stimulation.
3. Guide and coach parents to help their child use hearing as the primary sensory modality in developing listening and spoken language. This means weekly AVT sessions, come prepared to learn, the entire family must be supportive, daily individual play time with the child in a quiet environment (1 hour minimum)
4. Guide and coach parents to become the primary facilitator of their child’s listening and spoken language development through active consistent participation in individualized AVT
5. Guide and coach parents to create environments that support listening for the acquisition of spoken language throughout the child’s daily activities.
6. Guide and coach parents to help their child integrate listening and spoken language into all aspects of the child’s life. 
This means control back noise at home, designated time each day for talking, reading, goals are integrated during daily routines like bath time, dinner, go for a walk  
7. Guide and coach parents to use natural developmental patterns of audition, speech, language, cognition and communication. 
This means auditory learning instead of auditory training 
8. Guide and coach parents to help their child’s self-monitor spoken language through listening. 
This means parents must understand that they are the primary consumers of the AV approach not the child  
9. Administer ongoing formal and informal diagnostic assessments to develop individualized AV treatment plans, to monitor progress and to evaluate the effectiveness of the plans for the child and family. 
This means the child’s progress is measured against the progress of hearing peers, progress should be at the same level or higher, develop auditory feed-back loops, understand that the sessions are diagnostic in mature, but not “testing” the child every time  
10. Promote education in regular schools with peers who have typical hearing and with appropriate services from early childhood onwards. 
This means parents are actively involved in the transition process from elementary to public or private schools, mainstreamed education is the goal  

The key elements of AVT are the form of parent/child intervention, early diagnosis, early access to spoken language through listening, modern hearing technology, parents are the main focus and they are always present, the sessions are on an individual basis. 
By using modern hearing technology it is possible to have an early auditory brain access and to support the maturation of the brain. 
“The brain is the major organ of hearing. The ears are only the way in” said Carol Flexer already in 2007. 
“When babies are born their brains are already pre-wired to learn language through listening. Stimulation of the brain influences the organization of auditory brain pathways so they are etched permanently” Boothroyd 1997  
“Parents can be trained to provide the quality, frequency and intensity of speech input that has the potential to promote brain development at the same rate as children with normal hearing” Dimity Dornan, 2010  
The most important thing is to love and talk to the baby, eye contact is key (see also Gisela Batliner), interact and smile!!  

“By 4 years, typically, children need to have heard 46 Million of words to be ready for school” Hart & Risley 1999. 
“20.000 hours of listening are necessary in infancy and early childhood as a basis for reading” Dehaene 2003.
“Aggressive audiological management” means to adhere to a strict protocol as recommended by the Alexander Graham Bell Foundation. It means best amplification by using hearing aids / cochlear implants / FM systems.

The sessions are on a one to one basis (only one child with parent and therapist), twice a week and they last 1-1 1/2 hours.

To create a good listening environment means that the therapist is close to the microphone or to the better ear, she/he sits beside the child, background noise needs to be minimized, present rich suprasegmental quality, motivate the child to listen, follow the child’s interest level in age and stage, offer appropriate activities with specific targets, reinforce the expectation that with AVT a child WILL learn to listen.

What does it mean to see parents as partners?
We need to develop confidence in the parent-child interactions, we need to make informed decisions, parents advocate on behalf of their child.

Some years ago we conducted a survey and we asked several questions like

- “Where does rehabilitation happen: in the hospitals or outside? In a health care facility or an educational facility? In a special Cochlear Implant Rehabilitation Centre?”

We got a most heterogenous picture depending on the country and on the individual clinic. In Germany there are quite a few specialized CI centres (e.g. Freiburg, Hannover, Friedberg, Güstrow etc.) where CI recipients stay with an accompanying person for five days, twelve times during two years and this is fully reimbursed by the insurance companies. The first was established by Ernst Lehnhardt in Hannover 1989.

- “Is the surgeon globally responsible for the CI recipient or only for surgery?”

Again huge differences between countries. In Germany the surgeon takes the overall responsibility (at least the ones who follow the “guidelines”), in Austria similar to Germany, in Switzerland they are not really responsible but some are very interested in the progress of their little patients, in Eastern Europe most surgeons are not involved in the rehabilitation process.

Obviously every professional (medical doctor, audiologist, therapist and psychologist) is responsible for his/her work. In the ideal case the head of the implant clinic takes overall responsibility. If this is not the case, it can be a coordinator who ensures that an interdisciplinary approach is implemented. In Germany this is the case in clinics with a very high number of annual implantations. A similar situation we find in the UK, in Poland and in Latvia e.g.

- “Is the rehabilitation a health care activity or an educational activity?”

In Germany is is regarded as a health care activity and this is reflected by the fact that it is paid for by the health insurance companies (Krankenkassen). The Ministry of Education pays only for local support of auditory training, mobile services and schools for hard of hearing.

In the UK rehabilitation for CI recipients is regarded as a health care activity in the early phase and as an educational activity long-term. Again views in various countries differ significantly.
What about the educational background / degree of the specialist in rehabilitation for the deaf CI recipient”
Again, there is a broad variety. We find pedagogues for hearing impaired, logopedists, audio therapists, psychologists, ergo therapists, teachers, social pedagogues, music therapists, paedaudiologists etc. In Germany, Austria and Switzerland there is no legal requirement for a special degree but most of the professionals working with CI recipients have a degree from college, academy or University in the field of special pedagogy more or less close to special pedagogy for hearing impaired. Interestingly, 90% are female. The situation is similar in other European countries.

Medical aftercare

Provision with a Cochlear Implant requires life-long medical aftercare by the implant clinic and a CI center. Medical aftercare serves for medical and technical controls and counselling as well as for reassessing hearing, speech and language competence including documentation aiming at stabilizing and optimizing the individual ability to communicate.

It is needed for documenting long term effects, complications, for adjusting to new technical standards and for assisting in providing additional communication tools and accessories.

Medical aftercare secures the results of the therapy and ensures quality management as well as the indication for further diagnostic, therapeutical and rehabilitative services.

The involvement of hearing aid audiologists in the local technical service is possible as long as they are particularly qualified. However, the cooperation excludes fitting and mapping of speech processors by a hearing aid audiologist unless he is a cooperative member of the CI center or the implant clinic.

Medical aftercare will usually be undertaken in outpatient or partly stationary mode and will last for a period of one to two days. It has to take place minimum once a year or if necessary on short-term notice.

Telepractice

What is Tele-practice?

According to the definition of the American Speech-Language-Hearing Association, 2004: “The application of telecommunications technology to deliver professional services at a distance by linking the clinician to the client, or Clinician to clinician for assessment, intervention and / or consultation.
What are the benefits?

- provides access to qualified professionals
- decreases time and costs for travel
- reduces cancellations of sessions because of health problems
- facilitates the access to interpreters
- coaching strategies can be more family-centered
- involvement of family members is simplified
- team-work is more feasible

What are the challenges?

- access to high quality internet connection is required
- parents and professionals need to feel comfortable in using the technology
- a quiet place at home is a necessity
- providers need to have the necessary skills in using the technology and the intervention
- reimbursement is still an open issue in the vast majority of countries worldwide

Telepractice is not meant to replace but to complement traditional clinical care to enhance quality and ensure a broader reach and coverage at reasonable costs. Free human resources and have them concentrate on providing what can only be provided by human beings: Empathy for people in need.

The discussion whether Remote Fitting (via Internet) is a viable option is still very controversial in Germany.

Prof. Dr. med. Anke Lesinski-Schiedat, DHZ Hanover is pro. She agrees that online fitting for the individual patient in a Remote Care Center that is close to his/her home together with a highly specialized clinic is possible. She considers this to be a way to increase patients’ satisfaction and to respect the necessity of working cost-effectively in health care.
Dr. Barbara Streicher, CIC, University Clinic Köln is contra. She believes only a few selected patients are satisfied with the quality of remote fitting and it should be restricted for emergency cases: per Skype during vacation or in the home for elderly people or in a hospital. However, it is never an alternative to CI – (re)habilitation and annual long-term-care.

**Structural parameters**

Quality management of CI provisions requires suitable and sufficient number of rooms, equipment and personnel throughout the year. It is only secured by provision in centers with adequate equipment and qualified personnel. As it deals with provision of an active medical implant, the therapy has to be consistently under medical surveillance. The centers have to develop a defined structure of quality management as it is required for any certification process.

The following personnel is collaborating in a CI clinic/CI center

- ENT medical expert / phoniatrician, pedaudiologist
- Engineer/audiologist, medical technical assistant on functional diagnostics
- Pedagogue/speech therapist
- Psychologist

The following facilities should be available apart from the clinical surgical requirements of an ENT clinic

- Doctor's room
- Room for fitting sessions
- Rooms to perform audiometry
- Rooms for therapy sessions including group therapy

For the treatment of children additional requirements are

- Adequate lodging of accompanying persons within the framework of a center for stationary treatment as well as recreation facilities for outpatient and partly stationary care
The following equipment has to be provided

- Sound and speech audiometer with free field, noise, and speech audiometry, equipment to measure spatial hearing
- Audiometric equipment for children
- Impedance audiometers
- ERA System to obtain electrically evoked potentials
- Promontory testing device
- Device for measuring otoacoustic emissions
- Device for intra-operative monitoring
- Special surgical instruments
- Implants and back-up implants
- Special implants for anatomically special cases
- Fitting hard- and software for all implants, offered by the clinic
- Equipment for radiological diagnostics (intra-operative)
The concept of fitting severely hearing-impaired children with cochlear implants

Bodo Bertram

Introduction:

The modern approach to early therapeutic support of severely hearing-impaired children encompasses, as a necessity, interdisciplinary work and such constituent parts as early recognition and diagnosis as well as technical and rehabilitation support which result directly from that. This holistic approach is of key significance, since any kind of delay works negatively on the language, cognitive and social-emotional development of the hearing-impaired child.

We must also keep in our scope the fact that, unlike hearing children, their hearing-impaired age-mates have already missed out on 4 months of hearing experience at the time of birth, the exact period depending on the severity of the hearing loss. Just with that in mind, delaying further intervention is unacceptable – in fact, it would be inexcusable. Early therapy for severely hearing-impaired children is at its best within a holistic and family-oriented approach. Therefore, cooperation with the parents is an essential part of this concept. This is where informing, counselling and follow-up regarding the child’s development take center stage.

An adequate fitting with hearing solutions, together with use of appropriate rehabilitation methods such as audioverbal therapy and the Natural Language Approach, in combination with rhythmic-musical support and psychomotoric therapy are all activities which contribute to the ability to negate, or at least to curb, the consequences of hearing loss already before the 2\textsuperscript{nd} year of life.

This is also true for children whose hearing loss was, unfortunately, only recognized and diagnosed later. An immediate fitting with modern hearing aids makes possible the sensory-specific excitation of the central nervous system and does, though belatedly, contribute to postnatal maturation of the auditory pathway. The purpose of all this activity is to stimulate the residual potential of hearing, which is then made available for a hearing-based acquisition of spoken language.

In case the hearing aid fitting and hearing and speech therapy are not successful, there shouldn’t be a significant delay before a transition is made to cochlear implant fitting, given that the parents are both prepared for this and supportive of the method.

The children who become deafened after meningitis are to be regarded as absolute emergencies, since experience shows that a quick obliteration of cochlea may follow (sometimes within the space of a few weeks). Sadly for the affected children, there is often insufficient knowledge to take this into account. Such children should be sent for immediate evaluation into an ENT clinic.

In the past 30 years the cochlear implant (CI) has become established as a proven functional replacement of the faulty inner ear both in severely hearing-impaired or postlingually
deafened adults as well as in deaf-born or deafened children. The current number of CI recipients worldwide stands at more than 400,000. The CI fitting of deaf-born or deafened children has led to a paradigm shift in hearing loss pedagogy (despite initial doubts) and opened up new education pathways for affected children that would have been unimaginable before. The implants are extremely reliable and robust. From the medical side, there are only very few postoperative complications compared to the number of implanted devices. Risks are further diminished by non-invasive surgical techniques (Ernst, Todt 2009). New implants and electrode arrays, new sound coding strategies and delicate surgeries enable an increasingly better hearing quality post-operatively.

**Implant survival and reliability**

One cannot overestimate the importance of implant reliability, because every device failure is connected with a new surgery. A reimplantation takes a huge emotional toll on the children and their parents (Bertram, Mayer, 2002). That is why manufacturers must conform to high reliability standards set by the law. These figures have a significant influence in the decision-making process on the side of patients or parents. At the same time, anyone being implanted with a CI must accept the risk that it might fail, for a number of reasons. These could be impact to the implant area, electronic failure or sealing issues. An explantation and reimplantation are regarded as acceptable and safe treatment options. An implant failure is defined as follows:

*The failure of the implant to perform its designated function, which can be graded as either total failure, which leads to the complete loss of clinical benefit, and in deviations from technical specifications which don’t lead to the loss of clinical benefit.*

We must keep in mind that “cochlear implants are technical systems, which can be faulty despite any measures taken to ensure the contrary, develop flaws or fail altogether”. A measure of implant reliability is cumulative survival rate (CSR). It conveys the percentile likelihood that “an implant will remain functionally operational until an X moment after implantation (ISO 5841/2-2000) and is calculated on the basis of the number of implant failures within a time period. CSR combines both parameters: the time of failure post-implantation and the percentile failure rate of a certain model“ (Battmer, 2009).

As shown in the study (Battmer et al. 2009), the risk that an implant will be damaged due to impact is relatively higher in children than in adults. Comprehensive and clear as well as comparable data about the frequency of implant failures is an important support factor during individual decision-making of a candidate. The data is also helpful to CI users, professionals in CI clinics, customers, healthcare professionals and the manufacturers themselves. The weaknesses identified will be useful clues for manufacturers to improve their products.
The physiology of hearing with a CI

A cochlear implant is an electronic inner ear prosthesis which replaces the compromised function of the inner ear through providing electric stimulation. The process uses the phenomenon of specific sensory energy, formulated by Johannes Muller in 1822. The idea is that “a perception of hearing is provided through electrical stimulation of the hearing nerve. These neural responses, generated as responses to artificial stimuli, are further processed in the central hearing system and, together with cognitive processes, lead to a comprehension of the perceived sound”. (Lenarz, 1998, 10)

On the subject of cochlear implant development, Lehnhardt (1998) points out that “bioelectric currents, or microphone potentials, are involved in the transmission of the acoustic signal from the sensory organ to the hearing nerve (15.Wever u. Bray 1936). Should we be successful in replicating the auditory samples through hearing nerve stimulation, then a hearing perception may be reached even by the defunct inner ear. The next question would then be: how can this hearing be converted into comprehension – i.e. which speech coding strategies are required for electrical stimulation”.

In the meantime, multiple sound coding strategies have been developed by cochlear implant manufacturers, but they are left outside the scope of this paper.

Klinke (2006, 27) notes that “The ear provides the brain with another possibility in evaluating sound. The action potentials in the hearing nerve are coupled to specific phases of the sound... The action potentials arising from the sound excitation appear at specific phases of the sound excitation. This mimics the periodic structure of the sound. The brain can evaluate that pattern, and thus receives information about the temporal structure of the sound”. Therefore, the capacity of the brain that helps it to fully carry out sound analysis is also the foundation for speech understanding with a CI. Through this, previously unaccessed brain structures can be made to fulfil their function, and to so benefit the implanted patient.

Concerning the importance of hearing and speech

Hearing is one of the five sensory capabilities available to man. It gives us the ability to perceive and interpret the sounds of our immediate environment. The sensory modality of hearing allows us to adequately respond to sounds signalling danger and helps in orientation. Whether in darkness or over long distances, we perceive acoustic information with the help of the specialized receptor organ, the ear. Hearing and speech understanding enable communication and information exchange with other people. Spoken language is one of the many interaction media between the individual and his surroundings.

There is another, extremely significant additional role that hearing plays: namely, it is to let us hear and express warmth and cordiality and the emotional contexts connected therewith in our spoken messages – it is through hearing and speech that we convey and perceive compassion and emotive coloring of the message.

This sensory function also lets us differentiate between voices. They can sound:
“endearing or not, decisive or weak, genuine or counterfeit, boring or fascinating, merry or sad” (Richtberg, 1990, 22) and elicit different types of feedback from the listener. Additional information is conveyed via face expressions, gestures, rhythm, articulation and the speed of speaking. The information contained in sound causes a change in nerve potentials and delivers them to the brain (Reception).

The brain, in turn, is in the position to process the information being fed to it, to undertake a conscious processing of what is heard, to compare it against existing experience and to take note of new information (Apperception).

Spoken language is there to be heard, but also to be used by us for self-expression and for conveying our messages. It is acquired through higher cortical function, and carries immense socio-cultural significance.

Language is spread as cultural heritage throughout the language community in which the child is growing up. Spoken language acquisition is vulnerable to unfavorable social circumstance as well as limited functionality of an organ or underlying psychical processes. The ability of speech is difficult to understand, since it is intertwined in psychology (Homburg, 1989).

From the viewpoint of psychology, these are described as functional constants of human activity. Action, communication, interaction, cognition, emotion, sensorics and motorics operate together in all actions man has developed. Our human activity is based on two levels of conditions:

1. Individual physical and psychological circumstance
2. Political, economic, cultural and social circumstance (Homburg 1989, 41)

Through speech, children express needs, transport ideas into the minds of others and give shape to their joys, hopes and dreams.

“Through speech, a child can express the possible, the fantastical and the absurd, as well as the past, the present and the future. This is possible because speech is not constrained by a rigid cause-and-effect link, and obeys no then-now logic. Speech is connected to reality via symbols. A symbol means not itself, but an entity that stands behind it”.

(Homburg 1989, 49)

In the process of spoken language acquisition, “inner (biological and psychological) regularities as well as exogenous (social and socio-cultural) factors play an important role in the maturation of speech competence, according to data of psycholinguistics research” (Richtberg, 21).

Impairments existing in different parts of the hearing system affect this process in various ways, or make it altogether impossible.

Hearing ability has five main functions:

- Alertness
- Orientation
- Communication
- Social and emotional perception
- Psychodiagnostics (Richtberg, 18-23).
Basing on this list of functions, it becomes clear that a hearing impairment entails not only a compromised spoken language development. The impact is much more than that: it leads to widespread impairments and failings in the individual overcoming of hearing loss, the way the child relates to itself and its own family and society. A person’s resilience, their attitude to the hearing disability and their use of more or less successful coping strategies will eventually determine whether hearing loss allows for “a relatively unburdened life in happiness or unhappiness, success or lack of it, independently of the hearing loss, so that a person’s destiny simply takes its normal charted course” (Richtberg, 1989)

With this it becomes clear that it would, from a pedagogic and therapeutic viewpoint, be a shame and a loss to limit the upbringing and education of hearing-impaired children to only speech acquisition and the imparting of general knowledge. What matters much more is that we provide them with coping strategies which will, in the process of their maturation, lend them the capacity to overcome the challenges of daily life for a hearing-impaired person, even as they stay fully conscious of their disability and even once they have exhausted their inner powers.

This is valid despite the fact that hearing solutions doubtlessly make life in the hearing society much easier. All the same, sufferers remain hearing-impaired, and the availability of a cochlear implant or a hearing aid is by no means a guarantee for overcoming the daily frustrations of existence without a sweat. Children with cochlear implants have a long way to go until they have reached spoken language competence. This road is littered with many stones and will not be overcome with ease by all the children. They will have to muster endurance, patience and strength. Parents and teachers must stand by their side with their love and support, and remember to let them enjoy a childhood on this long road.

There is more to learn than just hearing and speaking. Among other abilities, the following aspects of speech must be mastered:

- Content (semantics, lexicon)
- Ordering (grammar and syntax)
- Units (non-content bound founding blocks, such as phonemes)
- Speech environment (pragmatics), related to time, place, persons, cultures etc (Wendler et al 1996, 1921).

Therefore, severe or profound hearing loss has an extremely debilitating effect on spoken language acquisition. The impact is dependent on the type and degree of the hearing loss. Thiel (2000, 39) has summarized typical audiogenic disorders of communication and speech development in the following way:

- Impaired speech reception and production
- Skewed semantics and comprehension
- Limited active and passive vocabulary
- Flawed syntax and morphology (disgrammatism)
- Flawed tone and breathing rhythm
- Unusual voice and prosody
Limited competence in both oral and sign language

The fitting of a cochlear implant

Modern cochlear implant treatments are based on decades of experience and may be regarded as standard therapy.

CI fitting of severely or profoundly hearing-impaired children especially requires a very close cooperation of various professional disciplines. The same concerns the candidate selection process as well as the postoperative rehabilitation and long-term aftercare.

The following professionals are involved in the process:

- ENT doctors
- Pediatricians
- Neurologists
- Pediatric audiologists
- Teachers of the deaf in early intervention, kindergartens and schools
- Logopedicians, or SLPs
- Ergotherapists
- Motorics experts
- Music therapists

(see also Bertram 1991, 1992, 199)

The implanting ENT clinics should wield a broad medical expertise regarding the CI surgeries and work after standardized criteria. The same requirements are valid for professionally weighted and complete preoperative diagnostics which determine the extent and type of hearing loss, the evaluation for candidacy as well as an appropriate operating technique, a post-operative rehabilitation stage and long-term care for the patient.

Lifelong medical and technical care (regular sound processor fittings, technical checks and maintenance of the system, provision of assistive technologies and hearing tests) combined with pedagogical and therapeutic care (logging and evaluation of hearing results, counseling) are essential and deciding ingredients in CI fitting.

Testing pre-cochlear implantation

Hearing device fitting for severely or profoundly hearing-impaired children is preceded by a comprehensive ENT medical evaluation. This helps clarify the indications. A thorough audiometric analysis is conducted along with anamnesis, including social environment, general medical as well as ENT tests and a vestibular check. Further comprehensive objective diagnostics should confirm evidence of an intracochlear hearing loss and assure of the possibility of a CI fitting for the child from the ENT and audiological viewpoints (BERA, SN 10, CAP, CM). Central nervous defects (of cortical hearing structures) are counter-indications (Lenarz, 1998).

As more and more very young children undergo CI evaluation (due to widespread availability of newborn hearing screening), an immediate fitting with hearing aids will follow if a hearing threshold of 70 dB or greater is diagnosed.
After a period of 3, 6 and 12 months a BERA test is made to control the further development of the hearing loss. This allows for a diagnostics of a progressive hearing loss. A CI surgery is eventually offered as the next option to consider.

Clearly, a clinic offering the treatment must meet both requirements on premises and an excellent technical environment as well as all the possibilities for comprehensive ENT and audiological diagnostics and all the medical, technical and surgical prerequisites for a highly qualified CI surgery.

The importance of early therapists, kindergarten carers, teachers and other educators in the search for solutions in the course of ongoing post-operative special pedagogic diagnostics

From the viewpoint of deaf pedagogics, a cooperation with locally-based pedagogys is crucial and helpful in the decision-making process when it comes to pre-operative CI diagnostics.

They can make helpful contributions on how the children have been doing after their primary fitting with hearing aids, on the usage frequency as well as the results regarding spoken language development. They are in the best position to point out cognitive, emotional and social traits peculiar to their proteges and can form an opinion regarding the readiness of the family home for postoperative care and support. Likewise, the experience can lead to certain things of a pedagogical nature being said regarding the child’s future development.

Ongoing special pedagogical diagnostics during postoperative rehabilitation is secured by cooperating closely with educators locally. This will make important guidelines regarding optimising the basis therapy available to the CI center, which will seek to introduce respective support therapies (ergotherapy, psychomotorics, play therapy).

The preliminary pedagogical conversation

A clinic should either contain a department providing training and therapy, or there must be a long-term postoperative care center capable of delivering speech therapy.

These are the grounds for a preliminary talk with parents from a special pedagogical viewpoint. This conversation is regarded as very significant within the framework of a preliminary ENT evaluation. In additional to professional information and tips, this meeting should support parents in their feelings of anxiety and helplessness, as well as present them with education pathways for their hearing-impaired child.

This introductory talk will present parents with pedagogical and therapeutic facts on the great potential of CI fitting for hearing-impaired children, but will also definitively outline its limits regarding hearing-based spoken language acquisition.

This conversation must make it very clear to the parents that, together with their decision for a cochlear implant, they are taking upon themselves a great responsibility and some duties. An implantation carries the risk of a re-implantation happening in the future. The number of cochlear implant failures is very low, reliability high and biocompatibility proven in worldwide research. However, in the event that a failure does occur, it will put a significant psychological stress on the parents and the child.

Professionals must ask specific questions regarding the motivation and the expectations of parents, as well as bring to their attention the child’s need for postoperative hearing and
speech therapy. The psycho-social situation of the family and its bearing on the child should be very closely considered and discussed together. A very good support in these conversations can be found in video demonstrations of children with CIs showing various results. This gives parents an unbiased view of both possibilities and limits of spoken language acquisition. Parents should also be actively advised to get into contact with parents of children already wearing a CI – and that before they make their final decision. Options of staying at the CI center should also be included into the information (Bertram 1996). No one, under any circumstance, may push the parents to decide in favor of a cochlear implantation for their child. Experts are duty-bound to provide the parents with all necessary information that encompasses both the possibilities and the clear limitations of cochlear implantation. Sometimes multiple preliminary meetings are required before a decision is reached in favor or against (Bertram 1996, 1999). The clinic’s implantation team, pedagogues in the rehabilitation facility and the rehabilitation center experts bring together the results of the tests, evaluate them, and on this basis either recommend, delay or, in very few cases, deny a cochlear implantation. Needless to say, parents are thoroughly informed regarding the reasons for such a decision (see Table 1).

Table 1. The decision-making process
The rehabilitation center

This type of center should be well-equipped and appropriately staffed. It will need to have facilities for:

- Hearing and speech therapy
- Sound processor fitting
- Audiometric tests
- Psychomotoric and musical therapy
- Ergotherapy
- Halls of residence for parents

Audiologists, electroacoustic engineers, SLWs, deaf teachers, ergotherapists and other professionals are essential building blocks for the team.

The surgery and pre-training on first sound processor fitting

A cochlear implant is implanted under general anaesthesia in a clinical environment during a procedure typically lasting 2-3 hours. Afterwards the child will stay in the clinic for another 3-5 days. During this time, a pre-training on sound processor activation is strongly advised. The parent and child have the opportunity to be present during the sound processor fitting of another child. This approach has proven extremely beneficial, since it helps establish trust, deconstruct reasonable fears and give the mother and child an idea about the activation process.

Basic postoperative hearing and speech therapy

Basic therapy is typically provided in a cochlear implant rehabilitation center or in a follow-up care department of the clinic. Its duration is roughly 60 days in the course of the next 2-3 years. Depending on possibilities, it can be done either on an inpatient or outpatient basis. The rehabilitation center maintains close links with the implanting clinic and operates under its medical supervision.

The basic therapy is a critically important activity that can by no means be left out – immediately after the surgery, it starts to introduce the CI-implanted child to its first experiences in the world of hearing and spoken language acquisition. Thus the center secures the above-mentioned practice of long-term care, and so the opportunity to take advantage of the best of technological progress.

The following is offered within basic therapy:

- Pre-training on sound processor fitting
- Activation and follow-up fittings
- A comprehensive and interactive hearing and speech therapy
- Additional offers basing on facilities
- Ongoing therapeutical, technical and ENT diagnostics
- A tight cooperation between the center, the clinic and the local teachers

The therapy is focused on hearing, speech and language development as well as cognition. It is based on what we know about spoken language acquisition in hearing children. Deaf pedagogy and speech-language pathology approaches are also woven in.
Key points:
Hearing perception includes a number or areas that enable a child to perceive the multitude of hearing impressions from their everyday surroundings, to classify and to process them. The training of central nervous abilities, such as
- Auditive attention
- Auditive selection
- Differentiation between useful sound and noise, background and object
- Auditive discrimination, identification and collation of acoustic signals
- The auditory feedback mechanism
- And the ability to control one’s own voice’s pitch, duration, loudness and stress

Are targeted both in the everyday hearing acquisition process and in specific hearing and speech therapy. The process also involves
- Training hearing memory (attention span) and the ability of sequencing.

A tightly linked development of hearing, speech, language and cognition (such as symbolism, categorizing, memory) are areas central to a comprehensive and early support of hearing-impaired children. From the neurophysiological viewpoint, it brings about neural changes in various areas of the brain.

Through the use of modern therapy techniques combined with a CI, many deaf-born children are able to achieve a very good hearing-based speech competence. All the same, rehabilitation results and spoken language scores do vary. Factors affecting success include age at implantation, pre-operative hearing experience, post-operative hearing quality, language learning profile, state of the hearing nerve and additional impairments as well as support by parents or therapists (Bertram 2005).

Parents, therapists in the rehabilitation center and teachers must together secure the following:
- That the CI system is operational and fault-free at all times
- That the sound processor is fitted to meet the individual needs of the child, as the program activated is a foundation of optimal hearing quality
- That the sound processor is on and worn all day
- That the child can use the CI system in a favorable acoustic environment
- That the child is provided with opportunities for hearing and building oral dialog throughout the day

Weaknesses of cognitive, i.e. linguistic ability could be responsible for a more or less stilted spoken language. A weakness area specific to CI-implanted children could be morphology and syntax. The earlier it becomes clear that we may expect certain deficits in spoken language acquisition, the earlier we must introduce specific interventional measures and additional communication systems. This is especially true for children with additional impairments, such as syndromes, who might need specific speech therapy, sign language support, communication cards, finger alphabet, electronic communication etc. However,
despite using additional means of communication, hearing must remain the leading sensory modality. Daily natural communication with other children as well as specific hearing training contribute to:

- Speech segmentation;
- Aural perception of speech structures;
- Recognition of spoken parenthetical structures;
- Perception of rhythmic, melodic and dynamic features;
- Development of predictable schemes for comprehending spoken language

being developed and fixed.

The following facts should be kept in mind additionally:

- Congenitally deafened children have no experience whatsoever with the sensory modality of hearing. Even in case of very early implantation at 5-6 months old, we must keep in mind the months of sensory deprivation. Remember: normally hearing children can perceive sounds since 4 months of intrauterine development.
- Hearing is an uncharted phenomenon until the sound processor is switched on.
- A bilateral fitting presents further challenges in equalizing loudness for both implants to contribute to a harmonious sound image.

Therefore, a first sound processor fitting is an important focal area that reflects individual psychoacoustic fitting data and their optimization, as well as a support in postoperative CI therapy and hearing-based spoken language learning.

**Difficulties in SP fitting of very young children**

A first fitting and follow-up sessions with very young children are normally very low-key, since babies show few visible indications that they hear. An overstimulation of the hearing nerve, especially during the first fitting, should be avoided at all costs. The fitting must be done always jointly by the audiologist and pedagogue – this is a practice-proven method. The pedagogue keeps a close eye on the child’s behavior, and can give the audiologist important cues. The following should be kept in mind:

- Responses to aural stimulation in small children may remain unstable for a long time – that makes fine-tuning difficult in the beginning.
- Electrical stimulation of the hearing system is connected with a late maturation of hearing pathways and the central nervous system – the process takes a long time and must be approached individually.
- As a result, to have an optimal hearing quality with a CI, a SP fitting should take double so long as with older children.

SP fitting plays a special role in the budding speech development and the emerging abilities of sound differentiation, sound analysis and synthesis. With time, an increasingly fine-honed tuning will be done, supported by ongoing analysis of speech and language development by speech therapists (tip: sounds are not discriminated sufficiently, speech development is delayed and hearing quality is poor etc).
Hearing, speech and language development in very young children

- The following is true for hearing children: their hearing evolves from reflexive to sense-analytical within around 1-1.5 years. The foreground is taken up by developing speech comprehension (reception).
- In this time frame, typical patterns of the mother tongue become internalized and then form the foundation for recognition of words and active speaking. Usually, children need roughly 1 year before they start making their own words, and those will often only be understandable to the parents.
- Early implanted children also go through the pre-verbal phase in a similar way and within a similar time frame (1-1.5 years, Szagun 2006).

In both very young and older children, development of hearing, speech, spoken language competence; cognitive, motor and psychosocial maturation cannot happen synchronously. Hearing must be integrated into sensory activity at a later stage. The basis of speech development in hearing children is largely completed by the age of 4 years. CI-implanted children cannot do this faster or at the same rate.

Despite the advanced technology, hearing with a CI is different from hearing with an intact ear. Hearing impressions are not nearly as differentiated, and background noise as well as additional handicaps have a negative and long-lasting effect on hearing and speech development.

The special situation of parents of young CI-implanted children

The parents carry a heavy burden when it comes to overcoming the child’s hearing loss, since in case of early implantation there is little time left for coping with the disability (the shock phase), and the parents do not yet fully realize the effect of the situation on future communication ability and the cognitive and psychosocial effects connected therewith. This all should be taken into consideration when planning postoperative therapy.

Parental introduction

Is very significant, since it is the parents who are the main driving force in their children’s language and cognitive development. They need relevant support on how to transfer the key points of basic CI therapy into the family daily life.

Parental counseling concerns:

- The impact of the hearing loss on the family and the social network;
- Peculiarities of spoken language acquisition by hearing impaired children and the influence of the hearing loss on the language, social-emotional and cognitive development of the children affected;
- Models of pedagogical intervention and therapy as well as long-term education and upbringing arrangements for the hearing-impaired child;
- Daily care and maintenance of the functionality of the CI system’s external components;
- Empowerment and encouragement of parents to a natural speech behavior specially accentuated by exaggerated speaking patterns; reinstatement and strengthening of faith in parental competence;
• Encouragement to use multiple daily situations around the household (daily rituals) as a foundation for hearing-based speech and language development; which are all indispensable parts of the basic therapy.

Long-term care
Because the CI will provide lifelong electric stimulation therapy of the hearing nerve, a continual ENT supervision of the child is necessary. What is indispensable as well is a constant monitoring of validity of psychoacoustic fitting data, functional checks of external parts as well as a continual ongoing monitoring of the child’s speech and language development. Through a close cooperation, the clinic and the reha center guarantee an all-encompassing long-term therapy for the child’s benefit.

Peculiarities of language development in CI-implanted children
One of the world’s most comprehensive studies on language development in children with a CI was undertaken by a team supervised by Prof. Szagun (2006, 2012) at Oldenburg University in cooperation with the Wilhelm Hirte CI Center in Hannover between 1996 and 2000. It involved a long-term observation of 22 children using a CI.

Szagun (2006 ebenda) summarizes her expectations and prognosis in the following way:
• A language acquisition similar to the natural pattern is possible;
• However, it is not warranted;
• Making a prediction for a specific child is difficult;
• It makes little difference whether the child is implanted in the second or third year of life. “The earlier, the better” is hardly valid in such a short time span and with such young children;
• Children with prior experience with a hearing aid make a better start in language learning;
• The language spoken by parents can have a positive effect on the learning process, and this effect grows as the learning progresses;
• With natural language acquisition, it will take roughly two years from the surgery to the moment the child freely speaks in short sentences.

Even in the best-case scenario of language acquisition, it is probable that small glitches in language will remain. However, they will probably be successfully overcome with later written language acquisition. If there are no short sentences 3-3.5 years post-surgery, language acquisition is not progressing naturally.

How is language development of CI-implanted children different?
According to Szagun, language acquisition of CI-implanted children differs from that of normally hearing children in the following ways:
• “CI-children vocalize more;
• CI-children have more irregularities in articulation;
• CI-children repeat more after others;
• CI-children can be very different among each other”
Szagun (2012) further establishes that CI-implanted children “experience particular difficulties with grammar, specifically
- Articles;
- Sentence patterns”

She explains these difficulties with the fact that articles are not pronounced clearly. “This makes them particularly challenging for children with compromised hearing”. As for issues with sentence patterns, according to the author they are connected with the article issue since “these are helpful in recognition of grammatical relations”.

**Articulation**

This topic has been almost completely forgotten in the recent years and even acquired something of a fringe status. This is partly due to the fact that many SLPs are no longer skilful in it, and because there is a prevailing belief that with modern digital hearing aids and cochlear implants articulation is of no real importance.

That is not so. A number of children with a CI have significant articulation issues despite the modern technology – the reasons are many. To leave them out altogether would be wrong, since when they reach adolescence and are supposedly able to articulate well, the skill is in reality very often absent. Experience with CI fitting of very young children has taught us that they perceive their own voice and control it, and perceive the voices of others. That enables them to articulate normally and even carry regional accents. However, this is preconditioned by excellent hearing, speech and language therapy, a good hearing environment and a thoroughly fitted and constantly functional speech processor, as well as an intact implant.

Appropriately timed and professionally managed articulation classes, especially for older children who need them most, protect them from the danger of not being understood later on.

*A cochlear implant makes it possible “to get an input that is clearly structured and profiled enough to generate articulation patterns and speech motorics from spoken samples. Suprasegmental profiling, that is, prosodically marked speech, leads to a clear articulation and creates better original conditions for spoken language perception. Mothers worldwide employ this knowledge intuitively when speaking to infants and toddlers”* (Schlenker-Schulte, 2004, 46).

If we follow this advice, we will keep our CI-implanted protegees safe from later difficulties in this area.

**Parents and integration**

Many children with CIs are able to attend a mainstream kindergarten or school for normally hearing children. All the same, the institution where they are to be educated should be chosen with care, and the choice should result from an intensive discussion and eventual agreement among parents, special teachers and mainstream teachers. Here we should ask the question: should integration come at any cost? Often the environment is more favorable if the child is first integrated into an institution for the hearing-impaired, as classes will be
smaller and experts are available for in-depth speech and language development. Later the CI-implanted child can make a smoother transition into mainstream schooling, and will be better equipped for it. The teachers in the school they transition to should definitely receive counseling from teachers of the deaf.

What parents need in our changing world is enough time to show love and appreciation, as well as the willpower to employ these virtues in the interests of the child. That is the most precious gift they can give to it.

The TV, computer and Xbox may be interesting, but they are no fitting replacement for a conversation with the mother, father or sister and brother. They do not convey the loving warmth of a talk together and the cordiality that the child experiences from that. Parents should learn to trust in their child’s power to develop. If, in conjunction with a sound hearing and speaking competence, the learning needs and experience of the child are matched with a balanced education package and bound up with a skilful pedagogical support, there is a good chance that the abilities dormant in the child have every potential to develop (Bertram 2009).

“A therapy that targets hearing is distinguished through aspects such as the leading role of hearing training. A child with hearing loss with a CI is not treated as hearing-impaired. Its whole personality is taken into consideration, and the emotional, cognitive, social and family situation as well as parental counseling and cooperation are woven into a natural speech behavior with specific focus laid onto intoned speech and differentiated ongoing supervision” (Diller 1997, 95)

“For a child, its family is a place of trust, security and belonging. It is exceptionally close. Only in this loving atmosphere can language grow and flourish naturally. The child’s daily
needs are the beacon for the parents and their motivation for dialog-based behaviors and shared activities – for a living language” (Bertram 2009)
“There should be no lack of playmates with hearing loss, either. Togetherness makes stronger. A hearing-impaired child might have a difficult time living among hearing peers. Children also need friends outside the kindergarten and the daily school life – with whom they can make contact naturally and exercise their social skills – in other words, they should be like the rest of us – and we benefit from spending our free time with good friends with whom we share our joys and sorrows.
Parents should also have faith in their abilities as mother and father. They support their child while relying on its inner resource, which they nurture with love and attention. And so they open to the child an opportunity for self-realization. When the child knows it is loved and cherished, when it feels it can depend on the parents’ shoulder of support and helping hand, it will walk the long road towards an own identity with confidence” (Bertram 2009)

2. **Bertram B. Meyer V.**: Psychological Aspects of Re-implantation in Children from The Parents’ Point of View; Vortragsmanuskript Internationaler CI-Kongress Las Palmas 2002


11. **Thiel, Monika M.**: Logopädie bei kindlichen Hörstörungen, Springer 2000, 39


20. Schlenker-Schulte, Ch.: Zu Wort kommen....In: Hör-Päd, Jahrgang 58, Nr.2, 2004, 46


Monika Lehnhardt was born in Vienna and graduated from the University Alma Mater Rudolphina. She obtained her PhD in philology, psychology and philosophy. During her professional career she has held various positions in German, American and Swedish companies. 1987 she established Cochlear Europe in Basel, Switzerland and served as CEO for more than ten years. She gained broad experience in all aspects of treatment for hearing impaired people – various products (e.g. cochlear implants, bone conduction hearing aids, middle ear implants), surgical interventions, audiological services (e.g. hearing screenings, diagnostics, fitting of speech processors), rehabilitation concepts and methods and economical aspects (cost-effectiveness and cost-utility studies) over a period of more than 20 years.

Her extensive traveling through Europe, the US, Australia and most countries of CIS strengthened her multi-cultural competence. Her language skills (German, English, Russian, French and Polish) are essential in establishing direct contacts to key opinion people in the field (surgeons, audiologists, speech therapists, surdopedagogs, economists and politicians).

Since 2002 she has been Chairwoman of the Professor Ernst Lehnhardt-Foundation. She has also served as a member of the Board of Auditory Verbal International, Inc. (AVI, Inc.). 2007 she established her own company under the name Monsana AG in Basel, Switzerland to help patients find the most suitable clinic / surgeon / medical doctor in Germany, Austria and Switzerland.

In July 2007 she was awarded the title of Honorary Doctor by the International Academy of Otorhinolaryngology -Head and Neck Surgery, St. Petersburg.

Monika Lehnhardt lectures at scientific conferences and organizes congresses for professionals and parents of children with cochlear implants and / or hearing aids. She is a published author on various topics related to CI. She has also contributed to the development of educational and training material: The QESWHIC Project (Qualification of Educational Staff Working with Hearing Impaired Children, 2002 - 2005) under the sponsorship of the European Community as a Comenius II Action. See: http://www.monsana.ch/info/downloads.html

In 2006 the Lehnhardt-Academy initiated a similar project – HICEN (Hearing Impaired Children – Elementary Needs in Pre-school Care and Education) – see http://www.lehnhardt-akademie.net/hicen/

In 2009 Monika Lehnhardt inaugurated PORA! The HICEN material has been translated into Russian and made accessible online. The innovative aspect is the use of a weblog and a LiveOnline Room, in which participants from all over the world can see and discuss presentations by the authors and exchange their experience. The other novelty is that parents are invited to actively participate in this teaching and learning process – see www.lehnhardt-akademie.net/weblog
Profile Bodo Bertram

Dr. rer. biol. hum. B. Bertram, born 1945, graduated 1964;

University studies at the Martin Luther University Halle (Saale) and the Institute of teacher training. University studies to be a pedagogue for hearing impaired children at the Humboldt-University of Berlin, Section Pedagogic Rehabilitation and Communication Science.

WORK EXPERIENCE

Started work as educator at the school for the deaf „Albert Klotz“, Halle (Saale) and as educator and teacher at the school for the deaf „Albert Gutzmann“, Berlin;

1989 started work at the ENT clinic of the Medical University of Hanover and helped develop the first Post-Op Pedagogic-Therapeutic Rehabilitation Program for children with cochlear implants in Germany.

1990 onwards – director of the Cochlear Implant Center Wilhelm Hirte in Hanover (CIC);

1996 – promotion for the Dr. rer. biol. hum. at the ENT clinic of the Medical University of Hanover.

1994 – 2007 – lectureship at the School for Speech Therapists at the Medical University of Hanover.

1996 – 2008 – lectureship at the Ludwig Maximilian University Munich, University of Bielefeld, Heidelberg, Dortmund and Hanover (courses of studies -Teacher for Deaf Children, Teacher for Children with Speech Disorders)


1990 onwards – many lectures for teachers, therapists, students and other specialists in Germany, Europe and worldwide and numerous presentations about Cochlear Implant Rehabilitation of Children in international conferences in Europe, Asia, USA and Australia;

Co-editor of two books 1. with Prof. Dr. Dr. Ernst Lehnhardt; 2. with Prof. Thomas Lenarz and Prof. Dr. Dr. Ernst Lehnhardt

Publications in national and international professional journals about children with cochlear implants and children with special needs.

With the end of November 2008 retired.


Now works as consultant for the ENT department (chairman Prof. Dr. med. A. Ernst) of the UKB (Clinic For Emergency Berlin-Marzahn) and Hearing Therapy Centre for Hearing Impaired People (adults and children) with Cochlear Implant in Potsdam. In addition works in an honorary capacity with terminally ill children in a hospice.

2009 onwards – presentations and lectures in Bahrain, Saudi-Arabia, Kuwait, Switzerland and Germany about post-op rehabilitation of children with cochlear implants.

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