

# Current indications for cochlear implantation in adults and children

## Authors' Contribution:

A – Study Design  
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## ABSTRACT:

**Introduction:** Surgical treatment of deafness by cochlear implants is used for more than 40 years, and during this period permanently, gradual and significant expansion of indications for this surgery has been observed.

**Material and methods:** In our Department in the years 1994–2018 1480 cochlear implantations were performed, both in adults (647) and in children (883). In this study current indications and the rules for eligibility of patients based on 25 years of experience are presented.

**Results:** Indications for cochlear implantation in adults are: 1) bilateral postlingual deafness, 2) bilateral sensorineural hearing loss – in pure tone audiometry >70 dB HL (average 500–4000 Hz) and in speech audiometry in hearing aids understanding <50% of words for the intensity of the stimulus 65 dB, in the absence of the benefits of hearing aids, 3) bilateral profound hearing loss for high frequency with good hearing for low frequency, in the absence of the benefits of hearing aids, 4) some cases of asymmetric hearing loss with intensive tinnitus in the deaf ear. An indication in children is bilateral sensorineural hearing loss >80 dB HL confirmed by hearing tests, after about 6 months of rehabilitation with the use of hearing aids.

**Discussion:** Although cochlear implantation is used for more than 40 years, the indications for this treatment underlies constant modifications. They concern the age of eligible patients, implantation in patients with partially preserved hearing, as well as treatment for patients with difficult anatomical conditions. In many countries bilateral implantations are commonly performed, and more and more centers recommend this treatment in the case of unilateral deafness or asymmetric hearing loss, especially with the accompanying tinnitus in the deaf ear.

## KEYWORDS:

cochlear implantation, deafness, hearing loss, residual hearing

The history of surgical treatment of deafness using cochlear implants is over 40-years old [5, 6, 12, 15]. The method has led to a complete change in the approach to deaf patients. In the mid-twentieth century, deafness constituted an undefeated barrier for the medical world, whereas currently, the use of electronic devices in the form of inner ear prosthesis is the method of choice in the treatment of profound hearing loss [12]. Each treatment method comes with its indications and limitations. Many years of experience in the use of cochlear implants around the world have led to the modification of these indications and the introduction of new ones. The new medical technologies that have allowed for the development of further generations of electrodes and speech processors have had a great impact on this process. A highly important element determining the development of indications was the introduction of national and regional hearing screening programmes. They have allowed for initial detection of cases of congenital deafness or other hearing defects already in the 2–3th day of the new-born's life. In this regard, it is noteworthy that in Poland this programme was fully launched on January 1, 2003 and continues to operate today to cover over 96% of the entire population of live-born children. This programme puts us among world leaders in this field and has already included almost 6 mil-

lion tested new-borns. It is co-organized and partly financed by the Great Orchestra of Christmas Charity Foundation. Different specialists, including otolaryngologists, phoniatricians, audiologists, speech therapists, psychologists and acoustics have influence on the shaping of indications. It should be emphasised that comments reported by the users of cochlear implants, of whom there are several hundred thousand people in the world, are invaluable. Various countries and organisations responsible for creating and supervising the treatment process introduced and modified the indications for use of cochlear implants. This applies to countries in Western Europe, the USA, Canada, Australia and Japan. So far, it has not been possible to introduce such standards in Poland, where each centre, of which there are already about 10, using this method of deafness treatment, has developed its recommendations, often based on guidelines from other Western Europe countries.

## MATERIAL AND METHODS

The Department of Otolaryngology and Laryngological Oncology and the Department of Phoniatrics and Audiology at the Poznań University of Medical Sciences introduced a programme of surgical treat-

ment of deafness in January 1994. By the end of 2018, 1,480 different types of cochlear implants were established, both in adults (647) and in children (883). Devices of two medical companies were used: Cochlear and Advanced Bionics. After many modifications, 25 years of own experience has allowed to establish the current indications for the use of this method, which we would like to present in this work.

## RESULTS

### Cochlear implants in adults

#### *Indications*

1. Bilateral post-lingual deafness;
2. Bilateral sensorineural hearing loss – in pure tone audiometry >70 dB HL (average 500–4,000 Hz) and in speech audiometry, understanding of speech in hearing aids <50% for stimulus intensity 65 dB, with no benefits from hearing aids;
3. Bilateral profound hearing loss for high frequencies while maintaining low frequencies, in the absence of benefits from hearing aids – electroacoustic stimulation;
4. Asymmetric hearing loss with severe tinnitus in the deaf ears, which cannot be treated with other hearing aids such as the CROS/biCROS system or bone conduction implant, the treatment of patients with such deafness should be considered on a case-by-case basis.

#### *Research necessary for qualification*

1. Laryngological-otological examination;
2. Set of audiological tests with phoniatric examination, with the assessment of understanding speech and profit from hearing aids;
3. Imaging of temporal bones with the use of HRCT and sometimes also MRI, with the assessment of regular ear anatomy, as well as with the assessment of other possible defects;
4. Psychological and speech therapy (evaluation of patient's expectations) with assessment of cognitive processes (cognitive disorders are definitely a negative prognostic factor);
5. Anaesthetic assessment of the risk of surgery under general anaesthesia.

#### *Notes on special cases*

1. Quick qualification and intervention with bilateral implantation in patients after meningitis with hearing damage and with fibrosis within the cochlear fluid spaces;
2. Bilateral implantation in progressive amblyopia with significant hearing impairment, e.g. Usher syndrome;
3. Sudden bilateral deafness without improvement of hearing

after conservative treatment – implantation after 6 months from the disease after hearing stabilisation;

4. There is no upper age limit for implantation, however, the body's efficiency and the risk of systemic complications should be assessed before surgery, in the senior group of patients, assessment of central hearing damage is also important.

### Cochlear implants in children

Hearing disorders in children occur either as congenital or acquired hearing loss. Depending on the time of their appearance, prelingual, perilingual and post-lingual hearing loss is distinguished. In congenital deafness, the rule consists in the quickest detection possible, diagnosis and prompt intervention. In Poland, this is possible thanks to the Nationwide Programme for Newborn Hearing Screening which has been running since 2003. In acquired deafness, when disorders appear at a later time, apart from observation by parents the most important in making the diagnosis are objective hearing test methods, especially auditory potentials evoked from the brainstem. After diagnosis of deafness, the same rules of conduct apply as in congenital deafness (battle with time) presented below.

The indication for cochlear implantation in children is bilateral sensorineural hearing loss >80dB HL determined on the basis of hearing tests, after approximately 6-month rehabilitation with the use of hearing aids.

In congenital deafness, after completing diagnosis, the cochlear implant should be placed at the age of 12 months (except for children with congenital malformations requiring another specialist examination).

In some children with significant hearing loss, one must remember about the maturation of the auditory pathway, which may lead to improvement of hearing at a further period of time, which is why they require close monitoring and rehabilitation with repeated objective tests. After stabilisation of response, the decision about implantation should be made, which should take place in the second year of life at the latest.

In the case of asymmetric hearing loss, the inferior ear should be implanted. In children, unilateral implantation should be combined with prosthetisation of the other ear with hearing aid.

Bilateral implantation in children is constantly under discussion in the world. There is no doubt that such treatment must be used in children with visual impairment, with incipient problems of cochlear obliteration, as well as in children whose unilateral implantation did not give the expected auditory effects. In bilateral cases of deafness, bilateral implantation with a delay of no more than one year should be done to ensure bilateral hearing with all its positive consequences.

Meningitis with signs of cochlear obliteration and hearing loss is an indication for urgent implantation.

Diagnostic tests should be similar to those performed in adults but extended in congenital deafness to include MRI with assessment

of the presence of auditory nerves and exclusion of congenital malformations of the middle and inner ear, and if possible genetic testing, as well as behavioural audiometry in audiological tests. In most cases, auditory neuropathy does not constitute a contraindication to cochlear implantation.

Children with mental retardation require special care and assessment of the state of intellectual development and very individual decision-making regarding implantation with prognosis of effects. In this group of children, it is recommended to conduct diagnostics towards autism and Asperger syndrome (about 1 year of age), as well as further logopaedic and psychological diagnostics with psychopedagogical diagnosis of the family environment.

## DISCUSSION

Although cochlear implantation in the treatment of patients with bilateral deafness and profound sensorineural hearing loss has been used for over 40 years, there is a continuous, gradual and significant widening of the indications for this procedure. This results from many years of observations showing clear benefits of using this method, modification and introduction of new surgical techniques (smaller incision, atraumatic electrode insertion, different techniques in special cases), as well as technological progress [5, 6, 10, 12, 18]. The changes concern the age of qualified patients, implantation in patients with partially preserved hearing as well as procedures in patients with difficult anatomical conditions. In many countries, bilateral implantations are commonly performed, and more and more centres recommend this procedure in unilateral deafness or asymmetric hearing loss, especially accompanied by tinnitus in the deaf ear.

Although cochlear implantation was used in children after the age of two, nowadays the lower age limit is considered to be 12 months of age. Treatment at such a young age is possible due to the fact that at the time of birth, the cochlea is of the same size as in adults, and the facial nerve recess is only slightly smaller. The importance of early implantation for the development of speech and language has been proven in many papers [2, 11]. It should be remembered that in the case of prelingual deafness, the results of implantation performed after the period of speech development are significantly worse and the qualification for implantation in such a situation is highly controversial [4, 6]. Implantation before the first year of life, though routinely used in some centres [13], is commonly recommended only in special cases such as cochlear ossification after meningitis [5]. It involves a whole range of surgical risks, such as: 1) worse pneumatisation of the mastoid process leading to greater blood loss and greater risk of facial nerve paralysis, 2) lower thickness of cranial plates resulting in a higher risk of exposure and injury of the dura mater, difficult fixation of implant transducer and risk of implant migration after surgery, or 3) lower thickness of soft tissues that poses a risk of interrupted continuity over the implant after the procedure. Moreover, there is a risk of numerous anaesthetic problems in this group, and confirmation of deafness/profound hearing loss by means of available audiological tests as well as implant programming in very small children is much more difficult [5, 15]. At present, an increasing

proportion of implanted patients are adults with post-lingual deafness, including the elderly, and the only limitation is the general condition and biological age, not nominal age.

Cochlear implantation in patients with preserved residual hearing has been the subject of discussion for many years. While initially this procedure was reserved for patients with bilateral deafness or profound sensorineural hearing loss, over the years it has gradually began to be used also in patients with severe sensorineural hearing loss who have not benefited from hearing aids. Many years of observations have shown that the preservation of residual hearing during implantation is possible, and the implanted patients usually achieve better hearing results than patients with comparable hearing loss using hearing aids [6]. Literature emphasises the important role of speech audiometry in the qualification process [8, 16]. Dowell et al. indicate that a high chance of improvement in hearing after implantation should be expected in patients who do not achieve 70% understanding in open sentence tests performed in silence with optimally fitted hearing aids and 40% in the ear planned for implantation [8]. Sladen et al. emphasise that verbal tests are better than sentence tests in the qualification process [16]. As a qualification criterion for cochlear implantation in adults, in addition to the average hearing threshold  $> 75$  dB HL (250-4,000 Hz), Lenarz indicates an understanding below 45% of words at a 65dB stimulus level in hearing aids using the Freiburg monosyllabic speech test [12]. A special group is constituted by patients with profound high-frequency hearing loss and preserved hearing in the low-frequency range. In these patients, it is very important to preserve the existing hearing during surgery by using an atraumatic surgical technique, especially an extremely delicate opening of the cochlea and slow insertion of a properly selected thin, sometimes shorter electrode – the so-called hybrid implants [5, 14]. In such patients, postoperative electroacoustic stimulation (acoustic stimulation in the low frequency range and electric in the high range) allows better understanding of speech in noise as well as perception of music [6, 15].

Difficult anatomical conditions have constituted a challenge for surgeons for years and initially also a contraindication to cochlear implantation. However, nowadays thanks to better imaging and the use of specific surgical techniques, cochlear implantation has become possible in various inner ear defects (such as Mondini dysplasia, dilated vestibular aqueduct, partial or complete semicircular canal aplasia, cochlear hypoplasia or in the case of common cavity), post-inflammatory cochlear ossification or patients after middle ear surgery due to cholesteatoma (including open surgery) [5, 6, 10, 18].

In recent years, a significant increase in bilateral implantation has been observed. Numerous studies have shown that they allow better understanding of speech in noise and directional hearing in both children and adults [3, 5, 6, 15]. Both ears can be implanted at the same time (simultaneously) or as independent treatments (sequentially), but in this case the time interval between treatments should be as short as possible (ideally less than a year) [12, 15]. However, it should be remembered that in some countries the refund of second implant may constitute a serious problem, and when the number of implants is limited, it should be a priority to unilaterally plan as many candidates as possible, and only then im-

plantation of the other ear should be performed [5, 15].

The new indication for cochlear implantation which has not yet been fully accepted by the environment of otologists are certain cases of unilateral deafness and asymmetric hearing loss. In recent years there have been many works demonstrating the benefits of this procedure both in adults and children [1, 7, 19]. In a group of 95 patients, Arndt et al. showed that cochlear implantation is effective and gives greater auditory benefits than the previously applied standard solutions, i.e. the conventional CROS/biCROSS system and implantation of bone conduction systems [1]. What is more, it was confirmed that cochlear implantation in patients with unilateral deafness significantly improves their quality of life [7]. A particular group are patients with unilateral deafness and persistent tinnitus, in whom cochlear implantation gives a double benefit – it allows not only to improve hearing, but also in most cases to significantly reduce noise [15, 17].

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## CONCLUSION

From the beginning, cochlear implantation has been associated with strictly defined qualification criteria, which have, however, changed significantly over the years and still differ between individual countries or centres. The existence of such criteria certainly facilitates the qualification of patients, and constitutes the basis for reimbursement in many places in the world. However, it should be remembered that they are only temporary, they do not always keep up with the latest research results and may sometimes limit access to this method of treatment in patients who could also benefit from it [9]. This paper presents the current qualification rules applied at the Poznań clinic, which have been developed in the course of 25 years. They should be treated as general guidelines and each questionable case should be considered individually based on own experience, patient expectations and the latest literature reports.

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