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Comprehensive approach to the National Network of Teleaudiology in World Hearing Center in Kajetany, Poland

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Abstract

To improve the quality of patient care, the Institute of Physiology and Pathology of Hearing (IPPH) developed and implemented into the clinical practice in 2009 the National Network of Teleaudiology (NNT). NNT is a specialized network allowing the use of the internet and modern IT tools to provide medical care, rehabilitation and technical support for patients visiting a one of the affiliated policlinics of the Institute. This was the basis for the development and implementation of the implant fitting procedure, using modern internet and telediagnostic technologies - telefiting. This procedure, implemented in several centers throughout the country and aboard, solves the growing need for constant specialist care, check-ups and periodic reviews of speech processors. Clinical engineers, through teleconferencing links, can carry out the whole process of assessing and fitting the cochlear implant assisted by auxiliary staff of the cooperating center.

Material of this study consisted of 316 cochlear implant users scheduled for telefitting in one of 8 centers selected for this study. Each patient underwent a teleconsultation procedure. After telefitting the patient was presented with a questionnaire consisting of questions relating to the quality and time effectiveness of telefitting and the preparation process, assessment of the ease of contact with the audiologist, the sense of security and calm during the session, and an overall assessment of its usefulness as an alternative to different kinds of standard visits.

Significantly smaller distances that have to be overcome by patients to cooperating centers have significantly reduced the travel time. The benefits of the telefitting program include the results of surveys, the satisfaction of which was reported by majority of them.

Keywords: cochlear implant, remote fitting, telemedicine, health technology

Introduction

Telehealth applications are often provided to underserved communities because of social and economic needs. These communities are often rural in nature but may include urban settings lacking comprehensive healthcare services. Telemedicine applications are utilized in growing range of services including patient

counseling, surgery, healthcare diagnostics and remote programming of medical devices (such as hearing aids and cochlear implants). For the effective use of telemedicine technology, it is important to optimize the IT infrastructure for services and to create new tools adapted to the specific activities of telemedicine. It is normally beneficial to use broadband computer networks for recording, storing and archiving large quantities of text, image and video data. Regardless, of the applications used, it is very important to cultivate the cooperation of IT professionals and healthcare practitioners. Continuous education and training is required to maintain knowledge of changes in technology and potential clinical applications [1]. While telehealth technology has been used for over a century, teleaudiology research began in the mid-1990s. Teleaudiology research in this era was often administered via synchronous applications to conduct videootoscopy, hearing aid and implant fittings, otoacoustic emissions testing and pure tone threshold testing. By 2000, a number of investigators had completed projects in remote computing with OAE, pure tone audiometry and hearing aid programming [2-4]. The first international hearing test was likely by Schmiedge in 1996 [4] who administered DPOAEs testing from Minot, North Dakota (USA) to individuals in their homes in rural Saskatchewan, Canada using a telephone connection and remote computing software. The first Transatlantic teleaudiology test was performed in April 2009 when Dr. James Hall tested a patient in South Africa from Dallas [5].

In Poland, starting in 2000, Henryk Skarzynski and his team developed and implemented a modern telemedicine program in Poland [6]. At that time, Skarzynski and his team conducted one of the first teleconsultation consultation programs in which video-otoscopy images of the ear were transmitted via Internet connections to other medical centers for teleducational purposes. The telemedicine efforts by Institute Psychology and Pathology of Hearing (IPPH) team continued to develop to address the sophisticated services required of hearing health care for diagnosis, rehabilitation and long term intervention in Poland and on an international basis. Frequently these services were provided to patients who were fitted with various kinds of hearing prostheses (hearing aids and cochlear implants) who had unique, long term and complex needs. These individuals frequently lived in rural communities which resulted in considerable client hardship including loss of wages and travel costs. These issues resulted in the formation of a multidisciplinary team experienced manage follow-up visits using teleaudiology services. To provide these services on a large scale, the National Network of Teleaudiology (NNT) was established in 2009 at the World Hearing Center in Kajetany, Poland [6]. The establishment of the NNT was launched in close collaboration with several clinical centers in the country (figure 1) to cultivate cooperation of both clinical and new research activities.

The overall goal of the National Network of Teleaudiology is to provide a wide range of telehealth applications such as telefitting, telediagnostics, telerehabilitation, or teleeducation. It presently consists of 21 cooperating centers in Poland and four abroad in the Ukraine (Odessa and Lutsk), Belarus (Brest) and Kyrgyzstan (Bishkek). The NNT, housed in the IPFS in Kajetany permits experienced specialists to provide necessary telemedicine services for patients seen at affiliated NNT clinics. The abroad centers provides diagnostics and health care for the patients within the scope of otorhinolaryngology and rehabilitation of hearing and speech. Fitting and servicing of cochlear implant, as well as the selection, fitting and servicing of hearing aids are provided in these Center. In addition, IPPH team started the remote ABR testing [7] in patients from abroad Centers. Over the years, NNT services proven useful particularly with cochlear implant telemedicine sessions (telefitting).

There are many goals of the NNT [8]:

- the versatile care for patients with cochlear implants, auditory brainstem implants, middle ear implants, bone conduction implants and also modern hearing aids using digital technology.

- coordination of the hearing rehabilitation process that is necessary for development of sound perception and interpretation abilities, and through systematic training, enhancing oral communication skills with other people.

• the realization of social, educational, and professional development programs based on knowledge of the multidisciplinary team of specialists in the IPPH

• cultivate knowledge about cochlear implants and the rehabilitation process of implanted patients.

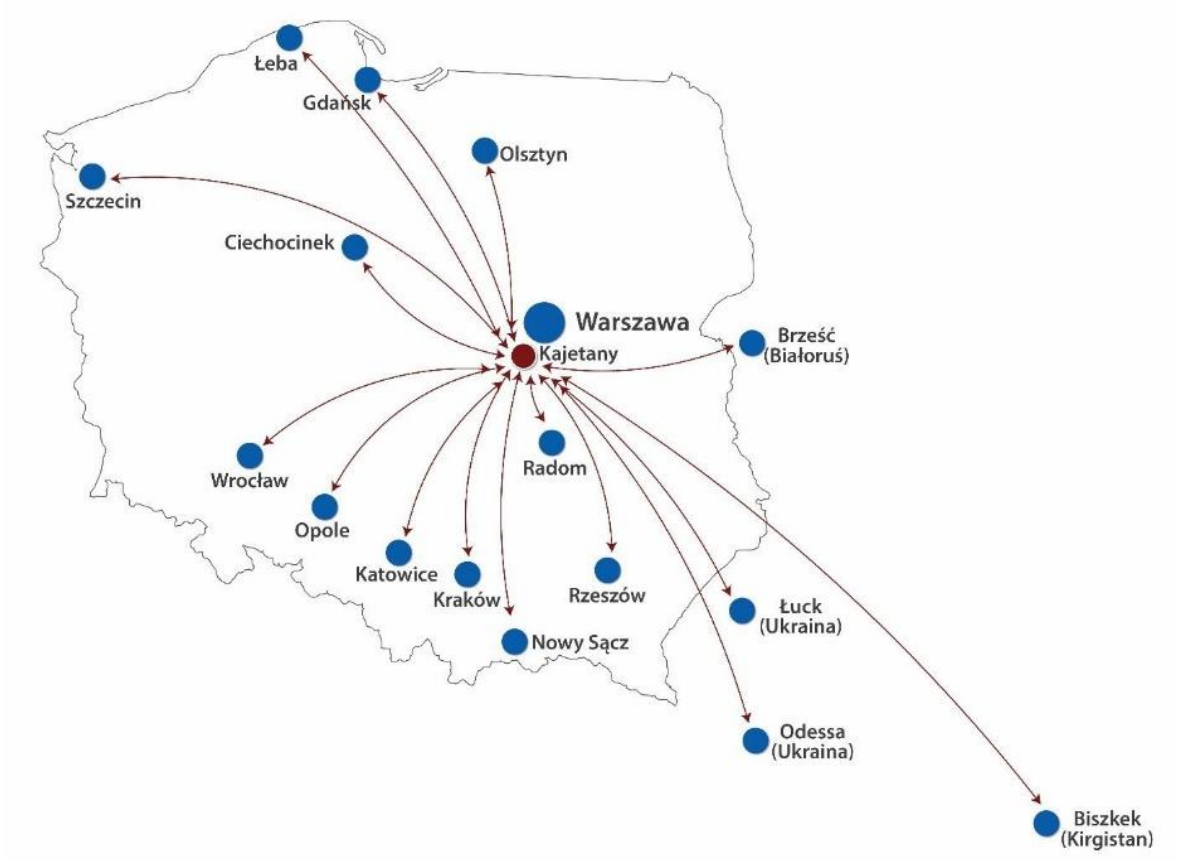

Figure 1. The National Network of Teleaudiology (NNT).

Tele-diagnostic procedures conducted in NNT

Audiology centers in most European countries routinely use auditory brainstem response (ABR) and otoacoustic emissions (OAEs) to supplement diagnostic procedures for comprehensive hearing evaluations. While all objective test procedures can be difficult to use clinically, the very technical nature of the auditory brainstem response (ABR) can lead to many errors by new clinicians learning this procedure. OAEs, while generally easy to administer, can also yield results which are misinterpreted. A number of NNT affiliate clinics have enhanced their services with ABR and OAEs testing in the Ukraine, Belarus and Kyrgyzstan [7]. To support these programs, consultants were made available over the NNT to mentor clinicians in the administration and interpretation of objective audiometric procedures. It is this consultation model NNT continues to be used to today supporting clinicians of various skill levels as they provide services in the Ukraine, Belarus and Kyrgyzstan.

This NNT consultation program included in-service training to prepare for advanced test procedures in ABR and OAEs testing. Specifically, clinicians and technicians working at the international sites completed comprehensive training courses including client instruction,

earphone placement, OAEs probe insertion, electrode application, electrode montages, launching of the appropriate software and interpretation. Documentation concerning these issues were prepared and distributed to participants

Telefitting

A cochlear implant is a type of electronic auditory prosthesis that enables the perception of sound in people with total or partial deafness [9,10]. Thanks to the direct electrical stimulation of the endings of the auditory nerve, it is possible to replace the function of the damaged organ the cochlear receptor [11]. The cochlear implant system consists of two parts - internal, placed surgically in the niche of the temporal bone under the dermal patch and outer, carried behind the ear [9]. The internal part consists of: a receiver and a stimulator electric, i.e. implant capsules, and electrodes inside cochlear. The outer part is digital speech processor [9,12,13]. The principle of the cochlear implant is based on proper electrical stimulation of the auditory nerve endings. The function of the auditory cells, or exchange sound on neural impulses, is replaced by implant system. The speech processor microphone receives an acoustic signal and then converts it into an analog electrical signal that is fed to the input an analog-digital converter and converted into a digital signal, which in turn is converted into an electric stimulus, and then transmitted via a transmitter to the internal part via radio waves implant [8]. Hearing implants' fitting is a clue component of postoperative patients' health-care, by providing the optimum auditory nerve electrical stimulation parameters. Unique method of remote cochlear implant system fitting was developed and introduced to the clinical practice in the IPPH. Using new internet communication and videoconferencing applications, the specialist can perform necessary tests and fitting session with patient who visits suitably equipped in affiliated NNT clinics.

The teleconsultation procedure in IPPH includes ENT examination, preparation stage, and telefitting itself. During the preparation stage, a support specialist does a structured interview with the patient concerning hearing benefits, communication skills, and usage schemes in daily life. The next step is psychoacoustic measurements – free-field audiometry and speech audiometry with monosyllabic words in quiet and noise (SNR 10 dB), according to the patient's skills. The last stage of preparation is consultation with a local speech therapist, when hearing and communication problems can be addressed [6].

In order to conduct telefitting for cochlear implants remotely, the patient's speech processor is connected to the clinical interface on computer at the local NNT clinic. As research conducted and documented by different researchers Ramos et al. [14], Mc Eleven et al. [15], Wesarg et al. [16], Hughes et al. [17] indicate, the results of telefitting are in line with the results when the procedures were carried out directly in the clinics. The fitting specialist working on computer in the IPPH attains control of the patient computer via a high speed internet connection and with remote computing software. Once these actions are completed, it becomes possible to open the fitting the software and to perform any actions necessary for measurements and fittings. The communication between the specialists and the patient occurs with a secured Internet connection through the interactive video system available at local and distant sites. On the patient's site there are also support specialists (speech therapists) providing help for the client in the process of communication with the specialists. While technically complex, the remote computing process has a feel of a face to face encounter and is achieved using commercially available remote computing. Once the session is completed, the support specialist the patient site disconnects the processor from the interface and provides the patient with newly programmed processor. Once the tuning is validated at as effective, the NNT staff terminate the remote computing session.

Telerehabilitation

NNT in connection with expert experience imply the rise of the remote programs of care for patients from different age groups and with different types of health problems. In relation to persons with hearing loss, in-

cluding users of hearing aids and/or hearing implants, rehabilitation activities are also included in programs categorized as teleaudiology or telehealth. Telerehabilitation is used for both children and adults, who are diagnosed with partial deafness, and who have qualified for cochlear implant treatment. Users of cochlear implant can participate in a telerehabilitation service during postoperative care. According to our experience [18] among children, the majority of patients are diagnosed limited reception, differentiation and recognition of subject and speech sounds; receiving verbal messages with the support of the visual channel. In addition, mastering the lexical resource at the appropriate developmental age with limited phonological awareness of the language plane and problems with the application of grammatical rules that organise the statement, and disturbances in terms of pronunciation of sounds, especially from the high frequency area and disturbance of speech prosody while maintaining or developing verbal communication.

Material and methods

Three hundred and sixteen cochlear implant users were scheduled for telefitting participated in the study. The participants ranged in age from 12 to 86 years, mean age was 34.5 years; Me = 30.5 years; SD = 16.9 years. All patients were experienced users of the cochlear implant system, the time of using the system ranged from 14.3 months to over 12 years (= 56.5 months, s = 31.8 months). Inclusion criteria also included the patient's ability to reliably evaluate the course and results of the remote fitting and the ability to complete questionnaires, which is why only adults and older children who are able to meet these requirements are included.

Firstly, each patient underwent a teleconsultation procedure developed for CI and introduced into clinical practice in the NNT. The purpose of the procedure was to closely emulate the standard procedure used during face-to-face visits in the IPPH. Next part was remote fitting – an engineer from the IPPH discusses with the patient and the support speech specialist the results of the questionnaire. The telefitting was carried out in accordance with the previously described procedure.

After a remote fitting the patient was presented with a questionnaire. The first question concerning the quality of the audio-video connection. Another important indicator of transmission evaluation and assessment of the telefitting method is the assessment of good cooperation with specialist from IPPH. In question 2 addressed to the child: my child cooperated with a support specialist and clinical engineer as well as during the traditional processor setting in the IPPH in Kajetany or analogues addressed to adults: during teleconsultation (programming the processor) I had a good contact with clinical engineer, as in the IPPH in Kajetany, the respondents were asked to compare their cooperation and commitment during a visit to the telefitting center with a visit they had at the IPPH in Kajetany. In addition, patients or parents / caregives of children who were physically rehabilitated using the telefitting method assessed the time that they were devoted to during the remote fitting of the cochlear implant. CI users assessing also satisfied with the course and effects of teleconsultation, perception of the development of cochlear implant fitting technique by means of telefitting and benefits related to travel time.

Results

While assessing the quality of the connection and a good understanding of the clinical engineer, over 96% of the respondents indicated the answer definitely yes. Only 2.5% of the respondents were dissatisfied with the remote fitting process, while only 2 people (0.6%) were definitely dissatisfied. All result was presented in Table 1.

Similarly to the assessment of the quality of the connection, also contact with the clinical engineer was as good as during the traditional visit to the WHC in Kajetany. Only 4.5% of respondents did not indicate which method was better. Worse contact during remote fitting visits was indicated by 16 respondents (5.1%), while 10 patients (3.2%) stated that cooperation with a clinical engineer during telefitting was definitely worse.

As the data from table 1 shows, less than 5% of the surveyed patients or parents / caregivers of children

Table 1. Results of questionnaires.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Quality of audio-video connection is good	180 (57%)	124 (39.2%)	4 (1.3%)	6 (1.9%)	2 (0.6%)
I had good contact with audiologist	115 (37%)	156 (50.2%)	14 (4.5%)	16 (5.1%)	10 (3.2%)
I felt safe and secure during telefitting	151 (47.8%)	150 (47.5%)	7 (2.2%)	7 (2.2%)	1 (0.3%)
I'm satisfied with the course and effects of telefitting	162 (51.3%)	142 (44.9%)	4 (1.3%)	5 (1.6%)	3 (0.9%)
Telefitting is an alternative for standard fitting	154 (48.9%)	145 (46%)	12 (3.8%)	3 (1%)	1 (0.3%)
Telefitting allowed for saving in time and money	233 (74%)	76 (24.1%)	4 (1.3%)	1 (0.3%)	1 (0.3%)

stated that the time needed to conduct the procedure by telefitting was insufficient. Only one patient was definitely dissatisfied with the time devoted to the study.

More than half of the respondents (51.3%) of patients were definitely satisfied with the telefitting visit, 44.9% were satisfied. There were only 5 (1.6%) dissatisfied patients in the study material, while definitely less than 1% of the surveyed patients were dissatisfied.

As in the previous questions, also the answer to the question whether fitting the implant via the Internet may be an alternative to visits to the IPPH in Kajetany, nearly 95% of them stated that definitely yes or no. Only 4 patients from the study group considered that the examinations in IPPH were better.

Obtained results clearly show that the use of implant fitting with the use of the Internet is beneficial in the perception of patients time saving. Only two patients did not observe the benefits associated with participating in the program.

Discussion

The American Society for Speech, Language and Hearing defines telemedicine as "telecommunications technology that provides specialized distance services by enabling the doctor to communicate with a patient or physician with a doctor for diagnosis, intervention and / or consultation" [19]. Telemedicine provides patients with access to medical services through telecommunications and Internet technology. This type of medical care has been dynamically developed over the dozen years and now includes various specialties such as cardiology, dermatology, pediatrics and audiology.

The results of this study, including subjective feedback from CI users, audiologists and clinicians, suggest that the telefitting procedure used in the IPPH is a viable alternative to the stationary fitting procedure. Most of the patients felt comfortable in the remote assembly settings, and the results of the remote session were as satisfactory as the results of the local fitting [10,11]. Adaptation of the implant system is aimed at reducing the negative effects of hearing loss by creating conditions for activity and restoring full participation in life situations. An unquestionable basis for fitting the implant system is the selection of appropriate electrical

stimulation parameters to compensate for the loss of hearing loss [20].

The methods used during telefitting in the NNT include: telemetric measurement of the internal part of the cochlear implant system, examination of the auditory nerve response (ART/NTR/NRI - abbreviations denoting the same measurement in various cochlear implant systems) and reflex test of electrically impeded stiff muscle (eSR) and also programming of electrical stimulation parameters to the patient's speech processor [16, 21,22].

In studies conduct in 2009 by Ramos et al. [14] indicated no significant differences between the most-comfortable loudness level (MCL) measurements performed using the standard method and using telemedicine programs. There were also no differences between measurements of free field hearing thresholds and speech perception tests performed on the basis of fitting using both methods.

Mc Elveen et al. in 2010 [15] compared the average hearing thresholds in pure tone audiometry before and after implantation and speech perception in two groups of patients (one of them participating in the traditional method of fitting implants and second using telefitting). There were no significant differences between the perception of speech in both groups, but the difference in the results of pure tone audiometry after implant surgery performed on the basis of the fitting using both methods was indicated.

According to Wesarg et al. [16] compared the level maps determined using the traditional method of fitting and using telefitting. Also in this study there was no clinically significant differences between the results of measurements made with both methods.

In 2012, Hughes et al. [17] compared telefitting and the traditional method of fitting cochlear implants, including such factors as: electrode impedance measurement, psychometric thresholds using adaptive methods, speech processor programs and conducted speech perception tests. There were no statistically significant differences between impedance measurements of electrodes made with both methods. The study of speech perception via telefitting gave significantly worse results than the study of speech perception in a traditional way (probably due to the lack of audiometric cabins in telefitting centers).

The programs for fitting cochlear implants using teleconferences are described by Polovoy [23] and Franck [24]. They draw attention to possible difficulties (for instant difficult contact with the patient, problems with internet connection, delay in transfer), but also emphasize the benefits of fitting the cochlear implants via teleconferencing (among others saving time, reducing costs , the opportunity to help more people). Franck [24] also states that fitting cochlear implants via telemedicine may not be possible in all patients. In small children, in the case of which it is important to observe the reaction, programming the implant during a teleconference can be very difficult. In 2003, Wesendahl [25] indicated the need for a qualified and experienced hearing care professional in a telemedicine center (in order to ensure adequate quality of services). In NNT we included stationary training in the IPPH and video trainings for the medical staff (for example audiologist, speech therapist), as well as detailed training on the equipment for complex fitting.

Campos et al. [26] indicate that the total time of consultations with telemedicine was shorter or the same as the consultation time during a traditional visit to the doctor's office. However, the process of programming and verification of hearing aid programs via teleconsultation required more time compared to the traditional method. However, there are not significant differences in the clinical practice. According to the result of questionnaires, our patients confirm reduction of travel time and the convenience of not traveling to routine visits in the IPPH.

According to Lorens [27] postoperative care after cochlear implantation should be based on the latest functional disability model, which was created for the needs of the International Classification of Functioning, Disability and Health - ICF. This model assumes that disability is a holistic term, including damage, limitations of activity and restrictions on participation.

The results of this study, including subjective feedback from CI users, audiologists and clinicians, suggest that the telefitting procedure used in World Hearing Center is a viable alternative to the stationary fitting procedure. Most of the patients felt comfortable in the remote assembly settings, and the results of the remote session were as satisfactory as the results of the local fitting [6,8]. There are no significant clinical differences between the traditional method of fitting the cochlear implant and the telefitting method. This is confirmed by studies conducted by various authors who have assessed the possibility of using telemedicine in the care of patients after the implantation of the cochlear implants [15, 20-26].

Conclusion

The efforts of the IPPH in Kajetany last more than ten years. The use of telemetry and tele-IT system in audiology reduces travel time and costs of the patient attending the clinical centre. It contributes to improving access to a specialist and the ability to detect hearing defects faster and improves the quality of life of patients. In addition, NNT allows to achieve benefits like shortening the travel time of the patient to the clinical center. In addition, reduction of costs incurred by the patient in the relationship-towards visits to a clinical center away from place of residence. It contributes to improving access to a specialist and the ability to detect hearing defects faster. Moreover, satisfaction of patients with completed visits and improving the quality of life of patients.

Considering the frequency of use as a measure at-the clinical date of the methods and techniques used in teleaudiology, the most useful are otoacoustic emission test (OAE), examination of auditory brainstem responses (ABR), telemetry measurement for users of the cochlear implant system, examination of the response from the auditory nerve to users of the cochlear implant system and examination of reflex of electrically-induced stapes (eSR) in users of the cochlear implant system.

The efforts by the Institute of Physiology and Pathology of Hearing at the World Hearing Center in Kajetany span over a decade. Vision ultimately ended with creating an international space enabling quick and comfortable cooperation of scientists and clinicians, working together for the best possible quality of patients with various health burden. Such and provide for efficient services resulting in considerable cost savings for both patient and clinicians.

The program continues to be a leader in a broad number of telemedicine/teleaudiology applications in hearing health care including tele-education, screening, diagnostic, hearing aid and cochlear implantation technology. It is likely these efforts will continue to grow both regionally and internationally with the goal to serve any client anytime and anywhere.

Declaration of conflicting interests

The authors disclose no conflicts of interest.

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