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## TESTING OF A SPEECH AUDIOMETRY TEST IN THE KAZAKH LANGUAGE TO FACILITATE HEARING AID ASSESSMENTS

**Resume:** Speech audiometry enables to make the quantitative hearing assessment by determining the speech intelligibility at its various intensities.

Selecting the hearing correction method and assessing the hearing aid effectiveness, including the cochlear implantation, it is required to use the speech audiometry test.

In spite of the wide indications for speech audiometry testing, it is practically not used currently in our country, because there are no any developed methods and speech materials in the Kazakh language.

As many studies of the foreign authors show, the speech audiometry test preferably shall be made in the native language of the patient in question.

**Methods:** 100 patients at the age of 45-59 years old (56 females and 44 males) have been enrolled into the study. These patients had the normal otoscopic pattern and tympanogram of type A. 20 patients had the normal hearing (control group) and 80 patients had the second and third degree chronic bilateral sensorineural hearing loss.

**Results:** The absolute agreement of the interclass single measurement of the coefficient of correlation was 0.95 (Confidence Interval – 95% [0.86; 0.93]); it confirms the high retest reliability. The total test scores and individual test scores were significantly higher in the group than in the control group ( $P < 0.001$ ). Total test scores and individual test scores in the post-treatment group of patients were significantly lower than scores before treatment ( $P < 0.001$ ). Use of single-syllable words and multi-syllable words in silence was the principal category to identify the effectiveness of hearing aids during Kz-test.

**Conclusions:** The Kz-test has been successfully developed and validated for use among the Kazakh-speaking population. The test is inexpensive with strong internal consistency, a high retest rate, good reliability, and optimal clinical validity.

**Keywords:** hearing aids, speech audiometry test, chronic sensorineural hearing loss.

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ЕСТУ АППАРАТТАРЫН БАҒАЛАУДЫ  
ЖЕҢІЛДЕТУ ҮШІН ҚАЗАҚ ТІЛІНДЕ СӨЙЛЕУ  
АУДИОМЕТРИЯСЫ ТЕСТІН ТЕСТІЛЕУ

**Түйін:** Сөйлеу аудиометриясы әр түрлі қарқындылықта сөйлеудің анықтығын анықтау арқылы есту қабілетін сандық бағалауға мүмкіндік береді.

Есту қабілетін түзетуді таңдау және есту протезінің, оның ішінде кохлеарлық имплантацияның тиімділігін бағалау кезінде сөйлеу аудиометриясының тестін қолдану қажет.

Сөйлеу аудиометриясы тестін қолданудың ауқымды көрсеткіш-

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ПРОВЕДЕНИЕ ТЕСТА РЕЧЕВОЙ АУДИОМЕТРИИ НА КАЗАХСКОМ ЯЗЫКЕ ДЛЯ ОЦЕНКИ ЭФФЕКТИВНОСТИ СЛУХОПРОТЕЗИРОВАНИЯ

**Резюме:** Речевая аудиометрия позволяет производить количественную оценку слуха путем определения разборчивости речи при различной ее интенсивности.

При выборе коррекции слуха и оценке эффективности слухопротезирования, в том числе кохлеарной имплантации необходимо использования теста речевой аудиометрии.

Несмотря на обширные показания к применению теста речевой

теріне қарамастан, бүгінгі күнге дейін біздің елімізде ол іс жүзінде қолданылмайды, өйткені қазақ тілінде әзірленген әдістемелер мен сөйлеу материалы жоқ.

Шетелдік авторлардың көптеген зерттеулері көрсеткендей, сөйлеу аудиометриясының сынағы зерттелушінің ана тілінде жақсы орындалады.

**Әдістер:** Зерттеуге 45-59 жас аралығындағы 100 пациенттер (56 әйел және 44 ер адам) қатысты. Бұл науқастарда қалыпты отоскопиялық көрініс және А типті тимпанограмма болды, пациенттердің 20-сында қалыпты есту (бақылау тобы), ал пациенттердің 80-второй екінші және үшінші дәрежелі созылмалы екі жақты сенсорлық есту қабілетінің жоғалуы болды.

**Нәтижелер:** Сыныптар арасындағы корреляция коэффициентін бір реттік Өлшеудің абсолютті сәйкестігі 0,95 болды (сенімділік аралығы— 95% [0.86; 0.93]); бұл қайта тестілеудің жоғары сенімділігін растайды. Жалпы тест ұпайлары мен жеке тест ұпайлары бақылау тобына қарағанда топта айтарлықтай жоғары болды ( $p < 0,001$ ). Емдеуден кейінгі пациенттер тобындағы жалпы сынақ ұпайлары мен жеке сынақ ұпайлары емдеуге дейінгі ұпайлардан айтарлықтай төмен болды ( $p < 0,001$ ). Кз сынағы кезінде есту аппараттарының тиімділігін анықтау үшін үнсіздікте бір буынды және көп буынды сөздерді қолдану негізгі категория болды.

**Қорытындылар:** Сыныптар арасындағы корреляция коэффициентін бір реттік Өлшеудің абсолютті сәйкестігі 0,95 болды (сенімділік аралығы— 95% [0.86; 0.93]); бұл қайта тестілеудің жоғары сенімділігін растайды. Жалпы тест ұпайлары мен жеке тест ұпайлары бақылау тобына қарағанда топта айтарлықтай жоғары болды ( $p < 0,001$ ). Емдеуден кейінгі пациенттер тобындағы жалпы сынақ ұпайлары мен жеке сынақ ұпайлары емдеуге дейінгі ұпайлардан айтарлықтай төмен болды ( $p < 0,001$ ). Кз сынағы кезінде есту аппараттарының тиімділігін анықтау үшін үнсіздікте бір буынды және көп буынды сөздерді қолдану негізгі категория болды.

**Түйінді сөздер:** есту аппараттары, сөйлеу аудиометриялық сынағы, созылмалы сенсорлық есту қабілетінің жоғалуы.

**Introduction.** Speech audiometry is the most informative method for evaluating the effectiveness of hearing aids, including implants. Speech audiometry is performed in a free sound field at a volume comfortable for the test subject using various articulation tables. One of the major problems faced by hearing aid users is hearing under conditions of interference.

Conducting speech audiometry to assess the effectiveness of hearing aids in patients with deep forms of prelingual hearing loss has several difficulties, which are associated with impaired speech abilities in addition to auditory functions, and there is often the presence of concomitant pathology.

According to global statistics, the majority of hearing aid users are elderly people. Hearing function deteriorates

audiometry, do not currently exist in our country. It is practically not used, as there are no developed methods and speech material in the Kazakh language.

As shown by numerous studies of foreign authors, the speech audiometry test is best conducted in the native language of the subject.

**Methods:** The study included 100 patients aged 45-59 years (56 women and 44 men). In these patients, a normal otoscopic picture and a type A tympanogram were observed. In 20 patients, normal hearing (control group), and in 80 patients, chronic bilateral neurosensory hearing loss of the second and third degrees.

**Results:** Absolute correspondence of single measurement correlation coefficient between classes was 0.95 (confidence interval – 95% [0.86; 0.93]); this confirms the high reliability of repeated testing. Overall test scores and individual test scores were significantly higher in the group than in the control group ( $P < 0,001$ ). Overall test scores and individual test scores in the patient group after treatment were significantly lower than before treatment ( $P < 0,001$ ). Use of single and complex words in quietness was the main category for determining the effectiveness of hearing devices during the Kz-test.

**Conclusions:** The Kz-test was successfully developed and validated for use among the Kazakh-speaking population. The test is affordable, has high internal consistency, high frequency of repeated tests, good reliability and optimal clinical validity.

**Key words:** hearing devices, speech audiometry test, chronic neurosensory hearing loss.

with age, and most older people suffer from hearing loss, mainly in the high-frequency region. However, an increase in the hearing threshold is not the only factor influencing the deterioration in speech perception that is often observed in older people [1].

A binaural interaction test in the format of interleaved binaural speech and an assessment of the effectiveness of auditory exchange in a free sound field using speech audiometry revealed a strong positive correlation (Pearson's correlation coefficient  $> 0.456$ ) between binaural speech comprehension in the interleaved binaural speech test and speech comprehension in the free voice field with and without a hearing aid. This relationship was manifested to a greater extent when using a hearing aid ( $r > 0.463$ ) and presented with speech behind noise ( $r > 0.684$ ). This fac-

tor can also be used to predict the effectiveness of hearing exchange.

Very often, hearing aids do not meet their requirements owing to the specific features of the auditory perception of a hearing-impaired patient or the wrong choice of amplitude-frequency characteristics of the device. There are several formulas for calculating amplitude-frequency parameters when fitting a hearing aid (e.g., Keller, Libby, NAL, Berger, and POGO) that provide their own gain values for frequency range variations depending on hearing, hearing terrain characteristics, comfort threshold, and discomfort [2]. Until now, the criteria for calculating the amplitude-frequency characteristics of the input gain of the hearing aid remain open. Sensorineural hearing loss uses non-linear forms of gain adjustment, of which various versions of the NAL formula are most commonly used in adults [3].

In this study, a speech audiometry test in the Kazakh language was tested to assess the effectiveness of hearing aids. The test was performed in a free sound field in silence and against a background of standardized noise. Based on the results of the studies, a clinical and audiological system was developed to examine the patient before the start of hearing aids. [4].

Speech audiometry is widely used to compare the acoustic properties of various hearing aids and hearing aid adjustment methods. Currently, many analog hearing aids have been replaced with digital hearing aids, channel-free hearing aids and multi-channel hearing aids with signal separation into individual frequency domains and the required amplification with a various compression in each channel. These hearing aids enable to make the level-specified and frequency-specified amplification to achieve the principal goal – to make sounds audible and comfortable.

However, multi-channel compression systems, improving the comfort of audible signal perception, may reduce the speech intelligibility due to formant smoothing, especially against the background of noise. Channel-free processor analyzes and processes signals at a high speed, providing the level-specified and frequency-specified amplification, preserving the spectral sound contrast; it shall significantly improve the speech intelligibility. [6,7]

It was found that the speech intelligibility in the group of patients with similar hearing characteristics differed insignificantly within one track, using channel-free, double-channel and multi-channel hearing aids. Generating the speech signal in silence, the patients with only peripheral forms of hearing loss, as the patients with the central parts of auditory system affected by pathological process, demonstrated the high speech intelligibility after prosthetics with all types of hearing aids.

Based on the results of the studies, a clinical and audiological system was developed to examine the patient before the start of hearing aids. [4].

**Materials and methods.** Ethical approval This study was approved by the Local Ethics Committee of S. D. Asfendiyarov Kazakh National Medical University (identification

number: 14-2020), and the study protocol was registered with the ClinicalTrials.gov Protocol Recording and Results System (ref: NCT05296655). Study participants were fully informed of the purpose of the study and signed an informed consent form.

**ASSESSMENT of Kz-test for hearing aid evaluation**

100 patients at the age of 45-59 years old (56 females and 44 males) have been enrolled into the study. These patients had the normal otoscopic pattern and tympanogram of type A. 20 patients had the normal hearing (control group) and 80 patients had the second and third degree chronic bilateral sensorineural hearing loss. Audiogram of 80 patients had the flat or moderately descending configuration (difference between the adjacent frequencies was no more than 15 dB, threshold at all frequencies), and air-bone gap did not exceed 15 dB at speech frequencies. Interauricular difference at the average threshold (four frequencies – 500 Hz, 1, 2, 4 kHz) was no more than 15 dB. The patients have never used the hearing aids.

Thereupon, the hearing aids of various technology levels with suitable amplification and output parameters have been selected and adjusted according to target amplification formulas (hearing aid programmer noahLink wireless). Speech audiometry test has been conducted in the Kazakh language in free acoustic field with/without any noise interferences, without hearing aids and with variants of hearing aids to assess the hearing aid selection and adjustment adequacy in accordance with the individual hearing indicators of patients.

Hearing aid use effectiveness, determined as the speech intelligibility improvement using any specific model of hearing aids, has been assessed as follows:

- “poor” – if difference in speech intelligibility is 0-10%;
- “low” – if difference in speech intelligibility is 10-20%;
- “satisfactory” – if difference in speech intelligibility is 30-40%;
- “good” – if difference in speech intelligibility is 50-60%;
- “excellent” – if difference in speech intelligibility is 70% and more.

The studies have been conducted by stages:

- the 1st stage – speech intelligibility measurement on “naked ear” without any hearing aids in noise;
- the 2nd stage - speech intelligibility measurement with the selected hearing aids binaurally, without any noise;
- the 3rd stage - speech intelligibility measurement with the selected hearing aids binaurally, with signal-to-noise interference +3 dB;
- the 4th stage – calculation of speech intelligibility percent difference.

Speech intelligibility percent is calculated as the number of correctly repeated words from 20 given words.

Statistical analysis

Statistical analysis has been conducted using IBM SPSS Statistics software – 8.0.

**Results.** The absolute agreement of a single measurement of the interclass coefficient of correlation was 0.95% (Confidence Interval – 95% [0.86; 0.93]); it confirms the

high retest reliability. The total test scores and individual test scores were significantly higher in the group than in the control group ( $P < 0.001$ ). Total test scores and individual test scores in the post-treatment group of patients were significantly lower than scores before treatment ( $P < 0.001$ ). Use of single-syllable words and multi-syllable words in silence was the principal category to identify the effectiveness of hearing aids during Kz-test.

**Discussion.** One of the performance indicators of hearing aids (auditory prosthesis) is the speech intelligibility. Asfendiyarov Kazakh National Medical University NJSC assesses the speech intelligibility of all Kazakh-speaking patients in need of hearing aids (auditory prosthesis), using the speech audiometry test in the Kazakh language in a free audible field at the comfortable level of volume. The advantage of this method is the use of algebraic numbers rather than absolute numbers to assess the effectiveness of hearing aids (auditory prosthesis). Therefore, the study becomes less sensitive to the calibration errors and acoustic environment errors.

It is very important to assess the level of auditory analyzer damage prior to select the hearing aids, including the assessment by speech audiometry test. The central hearing disorders significantly restrict the hearing aids (auditory prosthesis) possibilities. The timely diagnosis of central hearing disorders permits to avoid the excess expectations from using the hearing aids by patients and serves as the basis for the special drug therapy prescription.

Hearing aids (auditory prosthesis) effectiveness in the adults is assessed by speech audiometry test in a free audible field, including the noise interferences, and by filling in the special questionnaires with the subjective evaluation of hearing aids used by the patients.

It should be noted that the speech audiometry is the most informative method of hearing aids (auditory prosthesis) effectiveness assessment, including implantation. Hearing in the conditions of various interferences is one of the

most serious issues faced by the users of hearing aids. Timely use of hearing aids is the important aspect in deciding whether to make auditory prosthesis or not.

Investigators from many countries developed the audiometry to assess the hearing loss in their populations. Symptoms and consequences of hearing loss treatment are assessed by test questionnaires in many languages. The first version of hearing test in the Kazakh language was checked within the framework of our study. This test is easy-to-use diagnostic instrument allowing the doctors to find symptoms not mentioned by the patients as the primary complaints, and it may be used by both general practice doctors and ENT specialists. Test questionnaire is also the suitable instrument to manage the patients with suspected hearing loss. On this basis, according to grammar and phonetic characteristics of sounding and writing, the speech audiometry test has been developed for some countries, in particular, in Russian, Turkish, English and Chinese languages; and our work is audiometry in the Kazakh language.

#### CONCLUSION

Kz-test may be used to assess the effectiveness of hearing aids (auditory prosthesis).

#### DATA AVAILABILITY

Subject to the patient's consent form, patient data may be used for the scientific purposes only by the project team members.

#### STUDY REGISTRATION

Study protocol is registered in the Protocol Result and Registration System ClinicalTrials.gov (reference: NCT05296655).

#### ETHICAL DECLARATION

The local Ethics Committee of the S.D. Asfendiyarov Kazakh National Medical University has approved this study (study ID: 14-2021).

#### CONFLICT OF INTERESTS

The authors deny any conflict of interests.

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