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HEARING AIDS TESTED WITH AUDIOMETER

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***Abstract*—**Nowadays the hearing aids are vary various in form and in cost. Their main goal is to integrate subjects in their social environment. Our paper is oriented to make a review study of the literature and to study the results of using a hearing aid on a subject that suffers from hearing loss. In order to achieve the needed results it was used the equipment REDUS 95 with its specific software. The results indicate a very good improvement after using a hearing aid in comparison to those obtained before using the hearing aid. Also nowadays it is possible to adjust the hearing aid according to the audiogram.

***Keywords*—** hearing aid, hearing loss, Redus 95

I. Introduction

DEVELOPING modern auditory prostheses would not have been possible without the contribution of two of the most important inventors of the late 19th century, early 20th century. Alexander Graham Bell is the one who managed to amplify the sound electronically from his phone using a microphone carbon and battery - a concept that has been adopted by hearing aid manufacturers. In 1886 Thomas Edison invented the carbon transmitter, which changed the sound into an electric signal that traversed some wires and was converted back into the sound. This technology was used in the first hearing aid, by D. R. Welling and C. A. Ukstins [1]. Afterwards, the hearing aid devices used different principles such as: vacuum pumps, transistors later on becoming digital increasingly smaller with more complicated electronical systems included, by M.T. Maltby [2].

This article is aimed to study the hearing aids and their importance in the hearing process, knowing the fact that nowadays the devices are very different and accessible. Being a topic less discussed than glasses, they might be as important due to the informatics development which unfortunately affects hearing in the same manner as vision systems due to the lack of knowledge in the use of various electronical equipment. The fact is that the hearing aids are now much more diverse, there is a multitude of devices such as classical retro-auricular behind the ear (BTE), intra- auricular in the ear (ITE), which in turn are of different styles, invisible, and personalized according to the desire of each one. Among the newest types are bone-docked hearing aids and cochlear implants that are still at the beginning of their development. Hearing aids are now also accessible from a physical point of view, a few years ago these were quite difficult to take and they had very high prices.

These devices are very useful for the reintegration of the human subjects in the social environment health conditions which according to WHO (World Health Organization) "health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity", Constitution of WHO: principles(website) [3].

Hearing systems pathologies not only deal with the deficiency of hearing but also with equilibrium and instability of the human body as it is in close connection with the vestibular system which aids the body to detect the connection between the environment movement and the position of the human head and further on to the whole body. It has to be known that equilibrium depends not only on the muscular and bone system but also on the major systems: vestibular, vision and proprioception. All of them together with neurological system assure a good quality of equilibrium, balance, stability of the human body in various activities of basic life: such as locomotion, standing, working etc.

Hearing or deafness is the decrease in hearing acuity in one of the ears or to both. In the case of total hearing loss, it is an anacosis or bloating. Depending on the case of hearing loss, this may be of three types: transmission type when the way of transmitting to the ear through the external or the middle ear, of the neuro-sensorial type (called perception or reception hypoplasia) which is represented by a failure of the inner ear, insufficient transmission of the nervous flow, or an inappropriate and mixed type of cortical perception, when both mechanisms described above are affected on the same ear. Below we have an etio pathogenicity classification of hearing loss:

1) *Transmission type hearing loss as in fig. 1*
   a) *The external auditory tract is obstructed by:*
      i) *Foreign bodies*
      ii) *Atresia, stenosis*
      iii) *Benign or malignant tumors*
      iv) *Inflammation (external otitis, furunculous, pericarditis)*

b) Tympanic membrane:
  i) immobilizations of the tympanic membrane
  ii) Perforation due to otitis, otitis media or trauma
c) Oscillating Chain:
  i) Immobilization of osseous organs (fibrous otitis, malformations, tympanosclerosis, otosclerosis)
  ii) Oscillatory chain disruptions (post - traumatic, otic erosions and their sequelae)
d) Changes in air pressure in the middle ear:
  i) Bloody otitis
  ii) Barotrauma
  iii) Dysfunction of the Eustachio tube

2) Neuro - sensory hearing loss, as in fig. 2, is peripheral or central. Neuro - sensory hearing loss may be cochlear or radicular:
  a) Meniere's syndrome
  b) Vascular disorders
  c) Ototoxicoze
  d) Labyrinth
  e) Presbycusis
  f) Sound trauma
  g) Cochlear degeneration in the inner ear's affections
  h) Congenital malformations of the inner ear
  i) Mechanical trauma to the inner ear
  j) Neuro – labyrinth
  k) Nervous poisoning
  l) Meningo - do not come back
  m) Tumors of nevus VII or neighboring tumors leading to compression of the acoustic - vestibular nerve
  n) Shingles of the acoustic - vestibular nerve

3) Mixed-type hearing loss as in fig. 3 refers to the occurrence in the same ear of the transmission of hearing and that of the neurosensory.

4) *Neural hearing loss as in fig. 4 is a problem of the result of absence or impairment in auditory nerve. Nervous hearing loss is often profound and permanent. Hearing aids and cochlear implants cannot help because the nerve is not capable of transmitting information to the brain. In many cases, an auditory brainstem implant (ABI) may be a solution for treating this type of hearing loss.*

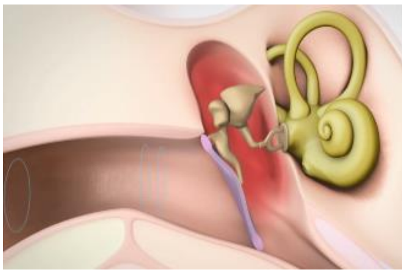


Fig. 1 Transmission type hearing loss

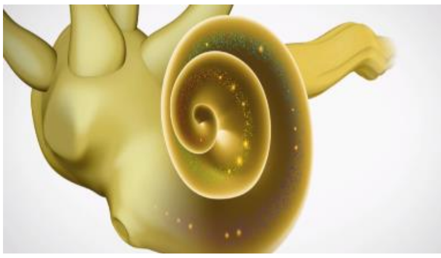


Fig. 2 Neurosensory hearing loss

Fig. 3 Mixed type hearing loss

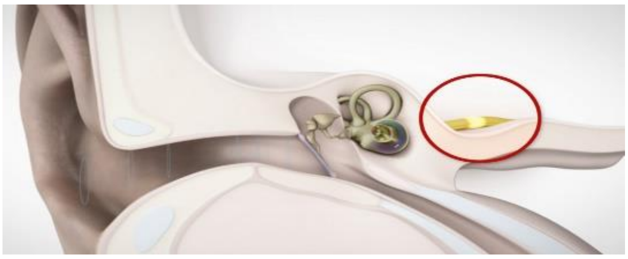


Fig. 4 Neural hearing loss

Hearing loss in terms of quantity is measured in decibels (dB), which shows the unit of measure of the sound intensity. The normal auditory frequency field of a human subject is between 16 (Hz) and 20 (kHz) and intensity between 1 and 120 (dB), as in fig. 5. In the case of mild or discrete hearing loss, hearing loss is between 15 and 30 (dB), moderate loss up to 50 (dB), accentuated hearing loss up to 70 (dB), and deep hearing loss to over 70 (dB). Hearing loss may vary at different frequencies. Transmission hearing loss may not have a loss of more than 65 (dB) and the normal voice during a conversation is perceived. Neurosensory hearing loss can have any values, including total hearing loss.

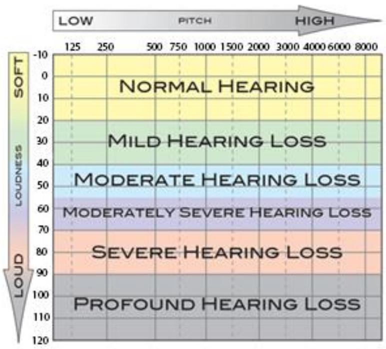


Fig. 5 Blank audiogram illustrating the degrees of hearing loss, by NHT Staff(website) [4].

Detection of these various pathologies can be using different devices one of them being the audiometer, which nowadays has become increasingly cheaper and easy to use due to the evolution and development of the electronic equipment and I refer here to the use of Arduino boards and android apps that offer the possibility to everyone to use the principles of the old audiometer.

II. Materials and Methods

Hearing evaluation was done with this audiometer, REDUS 95, using only air-cushioned headphones. In the first instance it was made an audiogram without linking to the software side, the results being made with the pencil on the sheet, as seen in fig. 7, following the pattern of an audiogram marking the points where the sound signal was detected, depending on the value of the decibel or frequency. Before proceeding to the results obtained through the experiment it is needed to explain some standard steps (ISO 6189: 1983) for making an audiogram:

1) *The minimum age at which a hearing test can be performed is based on the consistency between somatic and psychological development of the patient, and consideration should be given to the abnormal anomaly in the psycho-motor development of the patient (it is recommended that the patient should not be exposed to the noise three hours before hearing test)*
2) *Some patient data and hearing should be known before starting the test.*
3) *The patient is seated in the soundproofed cabin so that he is seated with the profile to the audiologist in order not to observe the movements made by him.*
4) *The patient will be explained how the test will take place*
5) *The patient is instructed to respond immediately as he hears the tone, even when he feels he only hears the sound and stops when he no longer hears it.*
6) *Signaling method: pushing the button when the patient is perfectly physically and mentally healthy; Lifting a finger; Verbal response (it is the last accepted answer because the voice can change the acoustics of the auditory conduit).*
7) *The patient must be reinstructed if he signals in the absence of sound.*
8) *Before testing, the hearing aids should be carefully examined.*
9) *Headphones should be centered on external auditory meatus, we need to make sure there is enough pressure, and the patient must remove his glasses or earrings.*
10) *The bone vibrator is placed on the mastoid without touching the ear pillar and not on hair.*
11) *Parts of equipment that come in contact with patients should be cleaned to prevent transmission of possible infections.*
12) *Electronically generated pure tones are used for testing, and the intervals between the frequencies of the tested signals are one octave.*
13) *Always start with the best ear. The test procedure targets conversational frequencies: 125, 250, 500, 1000, 2000, 4000, 8000 (Hz), and at the end resets to 1000 Hz, and if required, intermediate frequencies 1500, 3000, 6000, 750 Hz are also tested. Children generally test the frequencies: 500, 1000, 2000, 4000 (Hz).*
14) *Separate hearing of each ear in both air and bony conduction.*
15) *Airborne testing is done at headphones or speaker, and in bone driving with the oscillator.*
16) *After reaching thresholds in air conduction, the thresholds for bone conduction are searched and the frequencies 1000, 2000, 4000, 500, 250 (Hz) are tested*.

The device that was used to assess hearing loss and also the effect of the hearing aid is the audiometer REDUS 95, presented in fig. 6.

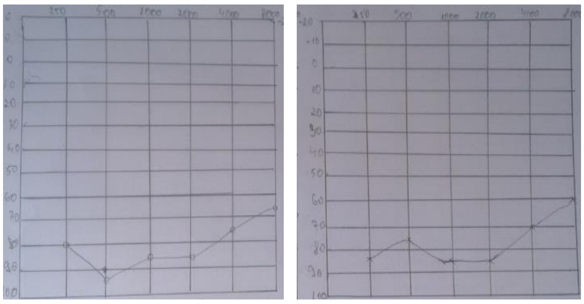
Fig. 6 Audiometer REDUS 95

In order to achieve the audiogram for the subject, we first started to accommodate it with a short period of no loud noise, then it was explained the testing procedures, I started testing with the 20 (dB) signal at the 1000 (Hz) frequency. After accommodating, I started the test with 20 (dB) at the lowest frequency of the REDUS 95 audiometer, ie 250 (Hz), and according to user response to the standard signal, I lowered or increased the intensity until the person responded to the stimulus. After the intensity was detected, I repeated again by increasing or decreasing the level to be sure that the intensity value is the one detected in the first. In this way we did the testing at each frequency level in increasing order from 250, 500 , 1000, 2000, 4000, to 8000 (Hz). Upon increasing each frequency level, we returned to the standard value of 20 (dB). The inconvenient was the hall where the tests were done, being a laboratory room without sound insulation, so background noise such as conversations with other people in the room or passing in front of the room, or weather conditions such as wind or thunder, altered more or less the results. But knowing the factors that might alter the results we minimalized them as much as possible.

Degree of hearing loss with PTA, Pure - Tone - Average hearing, can be determined based on the Goodman criteria:

1) *from -10 to 25 hearing loss within normal range*
2) *26 to 40 loss of light hearing*
3) *41 to 55 loss of moderate hearing*
4) *from 56 to 70 moderate hearing loss*
5) *from 71-90 severe hearing loss*
6) *from 91 to> deep hearing loss*

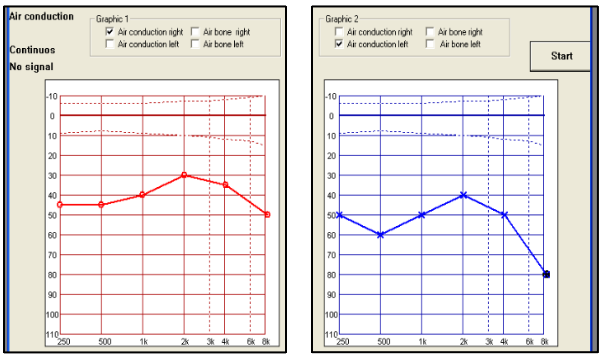
The subject was tested before using the hearing aid and the results are presented in fig.7.



(a) (b)

Fig. 7 Audiogram without hearing aid:
(a)-Air conduction right ear;
(b)-Air conduction left ear

It was noticed a degree of severe hearing loss with a slight tendency to deep loss in the range of decibels of the right ear being between 80 and 65 (dB). In the left ear we have severe hearing loss, the range of decibels being between 85 and 60 (dB) with a fairly high frequency oscillation. In this audiogram we notice that the person hears slightly better with the left ear than the right ear reaching 60 (dB) as opposed to the right one, and has a lower oscillation on the prebiscus curve. In conclusion, we have a severe bilateral hearing requiring strong, recommended retroreflective hearing aids BTE.



(a) (b)

Fig. 8 Audiogram with hearing aid: (a)-Air conduction right ear; (b)-Air conduction left ear

III. RESULTS AND DISCUSSION

As it can be seen in fig. 7 and fig. 8, hearing aids do not reproduce normal hearing, but even when they do not work optimally, they significantly improve hearing. Due to the fact that they have small problems there is a noticeable difference between the two ears. In the right ear, there is still a hearing loss, but this is moderate being between 45 and 50 (dB), and the left ear is also moderate hearing loss with the decibels between 40 and 75 (dB).

The current hearing aids are automatically adjusted after the audiogram so that they no longer need to be adjusted directly through the patient, requiring only slight adjustments, being very accurate. This is possible because the current hearing aids use more sound levels that can allow a much broader adjustment.

IV. CONCLUSION

The current audiometers are more advanced, allowing for a much easier interface with the subject, making a much easier connection with the PC, thus reducing the time of these procedures and the level of discomfort, avoiding otherwise the need for audiograms to be made on paper, but directly through a PC program, which is their modern solution.

These tests show that each ear react slightly different to the sounds, observing this with tests done with the REDUS 95 audiometer.

Depending on the degree of hearing loss, the type of hearing aid is also chosen. In the case of those suffering from mild hearing loss, a hearing aid is required, but if this is the case, an intra auricular prosthesis for appearance or even hearing glasses can be used if the subject is glass-carrying. In the case of moderate and moderate-severe hypoplasia, it is advisable to use intra-auricular prostheses but retro auricular prostheses are also a solution, not being as strong as the first ones but being cheaper. In severe and deep hearing loss, it is recommended to have powerful intra auricular or retro auricular hearing instruments, which are also more expensive. In the case of hearing loss over 90-100 (dB), it is recommended to switch to a cochlear implant.

We intend to design a low cost audiometer that might help everybody to diagnose their hearing loss. This will be made using an Arduino board and an Android app which are highly used nowadays.

V. ACKNOWLEDGEMENT

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VI. REFERENCES

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