The Outcome of Various Amplification Strategies in Post-Lingual Sensorineural Hearing Loss Patients

Original Article

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ABSTRACT

Objective: To measure functional and audiologic outcomes in patient with severe to profound post-lingual sensorineural hearing loss using either binaural hearing aids, unilateral cochlear implant or bimodal hearing.

Patients and Methods: This observational cross-sectional study was conducted on 60 adult patients with post-lingual bilateral severe to profound SNHL with age range from 20-50 years divided into 3 equal groups; Group I: 20 patients using binaural regular powerful hearing aids, Group II: 20 patients with unilateral cochlear implant and Group III: 20 patients using bimodal hearing strategy. The functional outcome was measured by using the Categorical Auditory Performances (CAP) scale which is ranged from 0 to 7. The auditory outcome was measured by aided audiometry threshold and clear speech perception test.

Results: The CAP score showed higher score in group III as compared to the other groups and the number of participants with CAP score 5 and above was 0 in group I, 6 (30 %) in group II and 12 (60 %) in group III. This was a highly statistically significant difference in mean aided threshold among the 3 groups 42.5, 37.5 and 21.67 respectively. This was a highly statistically significant difference between the three groups in clear speech perception with increased performance in group III in both quiet and variable noisy situations.

Conclusion: Bimodal hearing is beneficial when there is a good selection and good optimization of the fitting criteria of the HA. Our study recommends putting guidelines for bimodal candidacy which maximize patient benefits.

Key Words: Bimodal hearing, CI, HA, post-lingual SNHL.

Received: 16 September 2020, **Accepted:** 4 December 2020

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ISSN: 2090-0740, 2024

INTRODUCTION

Sensorineural hearing loss (SNHL) is a permanent condition; moreover, hearing devices can be used by the patients with SNHL to aid auditory perception. The commonest types of hearing devices that exist are hearing aids (HA) and cochlear implants (CI). HAs are devices that can improve hearing through amplification. HAs are only useful when a region of hair cells in the cochlea is still intact with remaining residual hearing. When the degree of SNHL exceeds severe degree, the residual hearing is limited to a small frequency range and only the frequencies within this range can be usefully amplified[1]. There are many audiological problems can facing the SNHL patients using HAs, such as loudness recruitment, diminished speech perception abilities and problems in the perception of speech in noise as well as the social and psychological impact of hearing loss[2]. Patients with severe to profound SNHL who do not benefit sufficiently from hearing aids, may be fitted with a cochlear implant (CI). CI is a prosthetic device that can bypass the damaged cochlea and directly stimulate the auditory nerve via electric signals thus can partly restore hearing[3]. In the past CI was used unilaterally, however with the more and more advancement in the CI technology the bilateral CI is the role nowadays in the mainly in the developed countries. Unilateral CI still used as a result of financial, surgical or functional limitations for bilateral CI. As a result of the success of cochlear implantation, a large number of individuals with residual hearing in the non implanted ear can benefit from a HA in this non implanted ear, this is referred as a bimodal stimulation. There are several advantages of bimodal stimulation such as, improving localization abilities and the perception of speech, especially in noise[4, 5]. Bimodal stimulation prevents the effects of auditory deprivation in the non implanted ear. Despite the advantages of bimodal stimulation, some challenges are apparent in the combination of a HA and a CI. First, the differences between the two modes of stimulation of the auditory system may lead to discrepancies between the two ears. Another disadvantage of bimodal stimulation is concerned with the synchronization of the signals, that the two devices present the signal to the patient with a small delay, which impair speech perception[6]. Finally, a third problem of

 DOI: 10.21608/ejentas.2020.43127.1254

bimodal stimulation is related to the perception of loudness as the dynamic ranges of the HA and CI are different[7].

Whatever the patient with the severe to profound degree of SNHL used HAs, CI or bimodal stimulation, the question always exists what is the functional and audiological outcomes of these devices. So the rational of our study is to identify the outcomes of SNHL patients using either HAs, CI or both.

OBJECTIVES:

To compare the functional and audiological outcomes of different kinds of amplifications.

PATIENTS AND METHODS:

This observational cross-sectional study was conducted on sixty adult patients with post-lingual bilateral severe to profound SNHL attending the Audio-vestibular Unit, Sohag University Hospital, from February 2017 to July 2018. All the participants had the following inclusion criteria: age range from 20-50 years, using amplification devices either HAs, CI or both regularly for at least one year, with no associated medical problems or sensory disabilities. The sixty participants were divided into three equal groups as follow: Group I: including twenty patients using binaural regular powerful hearing aids (Naída V-UP Behind-the-Ear hearing aids). Group II: including twenty patients with unilateral cochlear implant (MEDEL CI) the other ear had residual hearing but not fitted with the HA post-operative. Group III: including twenty patients using unilateral cochlear implant (MEDEL CI) in one ear and the second ear had residual hearing and was fitted by powerful hearing aid (Naida hearing aids).

Ethical considerations:

The work was carried out in accordance with the ethical standards of the responsible committee on human experimentation in Sohag University and with the Helsinki Declaration of 1975, as revised in 2000 (available at http://www.wma.net/e/policy/17-c_e.html). After explanation of the reasons for conducting the study a written informed consent was taken from all the participants.

Procedure:

I) Measuring functional outcome:

This was done by the Categorical Auditory Performances (CAP) scale:

This scale measured the functional outcome and the auditory receptive abilities of the patients. The scale ranged from 0 to 7. 0 scale means no awareness of environmental sounds; 1 Awareness of environmental sounds, 2 Response to speech sounds, 3 Identification of environmental sounds, 4 Discrimination of some speech sounds without lip-reading, 5 Understanding of common phrases without lip-reading, 6 Understanding of conversation without lip-reading and 7 Use of telephone with known listener[8].

II) Measuring audiological outcomes:

This was done in a double-walled sound treated room using an audiometer (Interacoustics AD 629) and the signals were presented binaurally via loudspeaker at 0 azmius.

1- Aided audiometry:

The stimulus was a warble tone presented at frequencies 250, 500, 1000, 2000 and 4000 Hz. The average aided threshold was recorded.

2- Speech perception ability using clear speech strategy:

The stimuli used included speech sentences recorded in clear speech styles. The 144 sentences were separated into 18 lists; each list contains 8 sentences and 25 key words in each list. The first sentence in each list has four key words, and the remaining sentences have three. The criteria of clear speech sentences were: slower speaking rate, the duration was double that of conversational speech, more and longer pauses, increased energy in the 1000-3000 Hz range, targeted vowel formants, increased consonant intensity compared to adjacent vowels (more stress on consonant) and expanded voice pitch range[9]. The lists were presented at the most comfortable loudness level in both quiet and noise conditions. In noise conditions the sentences were mixed with a speech-spectrum shaped noise at different signal to noise ratios (SNRs) (+15, +5 and 0). All subjects were presented with stimuli and were asked to repeat the sentences in 4 conditions as follow: Condition No. I: clear speech sentences in quiet, conditions No. II, III, and IV: clear speech sentences were presented in noise at different SNRs (+15, +5 and 0). To familiarize the participants with the test materials and procedures, a short session with 3 sentences in quiet were conducted at the beginning of the test. For scoring, the examiner recorded the correct key words in each sentence and gives one point for each key word repeated correctly and the key words were underlined on the score sheets[9].

Statistical analysis:

Data was analyzed using IBM SPSS Statistics for Windows version 23.0. The statistical tests used in the analysis included mean & SD and ANOVA test. In all conclusions reached through the inferential analysis, the significance level = 5% was used.

RESULTS:

Sixty adult patients with post-lingual bilateral severe to profound SNHL were included in this study and classified into three equal groups Group I: using binaural hearing aids (Naída V-UP Behind-the-Ear hearing aids). Group II: implanted with unilateral CI (MEDEL CI). Group III: using unilateral CI (MEDEL CI) in one ear and Naida hearing aid in the second ear. The mean age was 33, 29 and 34 respectively.

Table 1: Categorical Auditory Performances (CAP) scores for the three groups:

CAP Score for the 3 groups	Number of patients	Percentage (%)
Group I		
0	5	25 %
1	6	30 %
2	4	20 %
3	2	10 %
4	3	15 %
5	0	0 %
6	0	0 %
7	0	0 %
Group II		
0	1	5 %
1	2	10 %
2	2	10 %
3	4	20 %
4	5	25 %
5	3	15 %
6	2	10 %
7	1	5 %
Group III		
0	0	0 %
1	0	0 %
2	0	0 %
3	6	30 %
4	2	10 %
5	4	20 %
6	5	25 %
7	3	15 %

The number & percentage of CAP scores in the 3 groups

Table 2: ANOVA study for aided audiometry and clear speech perception in the 3 groups:

Test	Group I Mean & SD	Group II Mean & SD	Group III Mean & SD	F	*P*
Aided audiometry	42.50+2.74	37.50+6.12	21.67+4.08	34.53	< .00001*
Clear in quiet	25.2+0.84	35+1	50.6+2.07	410.2333	< .00001*
Clear (SN +15)	16.2+0.84	21.4+0.89	41.4+1.14	948.2857	< .00001*
Clear (SN +5)	6.6+1.14	10.8+0.84	23.2+1.79	214.88462	< .00001*
Clear (SN 0)	2.2+0.83	5.8+0.84	9.2+0.83	87.52381	< .00001*

*There was a highly statistically significant difference between the 3 groups in aided audiometry and clear speech tests.

DISCUSSION

In patients with post-lingual SNHL, hearing deprivation can severely impact the social life and working environment of those patients[10]. The amplification provided by the hearing aids may be inadequate for those patients. In this situation CI is considered a successful technology for rehabilitation of that group[11]. In recent years, there is increasing numbers of patients using unilateral CI in one ear with severe to profound SNHL in addition to having residual hearing in the non implanted ear[12, 13] These patients can be managed by combining electric stimulation in one ear and acoustic stimulation in the other ear which is referred to bimodal hearing[14, 15].

In the current study CAP was used as a method of measuring the functional outcome of our participants, because it had a good inter-observer reliability and can be used across wide age groups[16]. The CAP score showed higher score in group III as compared to the other groups and the number of participants that able to understand common phrases without lip reading (CAP score 5 and above) was 0 in group I, 6 (30 %) in group II and 12 (60 %) in group III (Table 1). This means that bimodal hearing is associated with improvement in the functional outcomes of patients with severe to profound SNHL than other groups. This can be explained by that bimodal hearing leading to more activation of auditory associated brain activity in that group. This was agree with studies done by[17, 18, 19] which suggested that bimodal stimulation significantly improves outcomes in the domains of speech recognition, sound quality and sound localization compared to unilateral CI used alone.

The aided audiometry in the current study was compared among the three groups and we found that this was a highly statistically significant difference between them as the mean threshold was variable: 42.5, 37.5 and 21.67 respectively (Table 2). This means that the group who used CI has more threshold sensitivity in aided audiometry than those used HA even binaurally, and the bimodal hearing was more advantageous than unilateral CI.

ANOVA test was used to evaluate the performance of the three groups in clear speech perception both in quiet and noise. There was a highly statistically significant difference between the three groups with increased performance in group III than the other two groups in both quiet and variable noisy situations (Table 2). The performances were low in the three groups in noisy conditions as this represents a challenging condition for all groups, however, there was a statistically significant differences among the three groups. This improvement in the hearing ability as a result of bimodal stimulation had been noted in both quiet and noisy conditions in other studies done by[20, 21].

On the other hand, despite this clinical evidence of high performance associated with the use of bimodal hearing, other studies showed that not every patient had received all of these benefits.[22] Concluded that the perceived benefits of bimodal stimulation may vary due to sub-optimally fitted hearing aids.[23] Also reported that HAs were found to be malfunctioning in a large percentage (81 %) of the study population.

The current study suggested that there was a greater net benefit from bimodal hearing than other amplification solutions. The scenario analyses indicated that the benefits from bimodal stimulation compared to binaural HAs or unilateral CI were controversy. Some studies showed high benefits of bimodal hearing over unilateral CI, on the other hands other studies showed no differences.

CONCLUSION

In conclusion bimodal hearing is beneficial when there is a good selection for candidacy that had a sufficient residual hearing in the non implanted ear with good optimization of the fitting criteria of the HA.

Our study recommend putting guidelines for bimodal candidacy which can help in reducing non-use of the HA and maximize patient benefits.

CONFLICT OF INTEREST

There are no conflicts of interest.

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