A COMPREHENSIVE APPROACH FOR ASSESSING THE EFFECTIVENESS OF FREQUENCY-LOWERING HEARING AIDS AND ELECTRIC ACOUSTIC STIMULATION (EAS) COCHLEAR IMPLANT FOR TREATING PEOPLE WITH A SEVERE-TO-PROFOUND HIGH-FREQUENCY HEARING LOSS.

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1 Introduction

Speech recognition tests have been used for many years to evaluate the effectiveness of hearing technologies and to make comparisons between different hearing aid or cochlear implant fittings. However, the use of speech perception measures alone for such purposes may not be appropriate. First, test settings and materials are not representative of a real-world communication environment. Also, many speech tests are vulnerable to learning and ceiling effects, particularly in the context of repeated measures. Moreover, the benefit from hearing technologies is known to be multidimensional, not only related to speech perception, but also to experienced hearing disabilities, limitations in social participation, quality of life and other personal factors [1].

In this article, results of a project where difficulties in speech measurements were encountered will be reported. The use of a more comprehensive assessment approach to circumvent those difficulties will be discussed. The project objective was to compare the effectiveness of frequency-compression (FC) and frequency-transposition (FT) hearing aids and of electric-acoustic stimulation (EAS) cochlear implant (CI) to improve speech perception for people with a severe-to-profound high-frequency hearing loss (HFHL).

2 Method

2.1 Participants

Ten adults, aged between 52 and 74 years old (6 women and 4 men), participated in the study. They were all candidates for an EAS implant considering their sensorineural severe-to-profound HFHL with aidable residual hearing in low frequencies. Participants had a previous experience with hearing aids of at least seven years.

2.2 Procedures

All participants tested FC and FT hearing aids following an ABAC single-subject design. A four to six weeks' baseline was first completed with their own hearing aids (phase A1), followed by an eight-week trial with one frequency-lowering (FL) device (phase B). Then, a second baseline of four weeks was repeated with their own hearing aids (phase A2). Finally, participants tried a second FL hearing aid for 8 weeks (phase C). Phases B and C were counterbalanced between subjects. After those trials, one participant also received an EAS implant. Consequently, follow-up time ranged from 16 to 32 weeks for all participants.

Speech recognition was measured each week, in free-field, using the Hearing in Noise Test (HINT). Sentences were presented at a fixed level of 63 dBA in quiet and in noise, at +10, +5 and 0 dB SNR, like many CI researches, and as it is currently done to assess CI candidacy in our clinic. Monosyllabic word recognition was also measured in quiet, at a presentation level of 60 dBHL.

The Glasgow Hearing Aid Benefit Profile (GHABP), the Abbreviated Profile of Hearing Aid Benefit (APHAB) and semi-structured interviews were used to collect participants' perspectives on the benefits of each technology. Questionnaires were completed after each trial; interviews were done at the end of the protocol.

Complementary data on EAS implant effectiveness were extracted from our database of EAS users. This data validated that the EAS participant was representative of our EAS users' population.

2.3 Analyses

Speech recognition data were first analyzed individually, using a visual single-subject method. Results of each test session were graphed, separately for each participant. A 95% confidence interval was computed around the mean of the second baseline and was used as a reference for performance comparison between technologies. Secondly, data from all participants were grouped by technology, and a group data analysis was done. Data from questionnaires were also analyzed individually, using published within-subject critical differences (APHAB) and norms (GHABP), and then grouped by technology.

Interviews were transcribed verbatim. Data were divided into meaning units, and then classified by themes and subthemes, using a qualitative inductive approach [2].

3 Results

3.1 Speech recognition

A summary of the individual effects obtained on the speech recognition tasks with the different technologies is shown in Table 1. The EAS implant allowed for the greatest improvement (+43%) when compared to conventional and

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FL hearing aids; no deleterious effect was noted with this technology. FC and FT hearing aids provided some benefit in comparison with conventional hearing aids (+9 to +10%), but negative effects were also observed with those technologies for 2 and 4 subjects with FC and FT hearing aids respectively.

Table 1: Summary of the individual effects measured with each tested hearing technology.

Technology	Effect vs conventional h/a
EAS implant	Up to +43%
FC hearing aid	-6 to +10%
FT hearing aid	-22 to +9%

Learning and ceiling effects were encountered during speech recognition assessments with most subjects. Data from subject 11 shown in figure 1 was typical. An improvement in performance during the first baseline with her own hearing aids can be observed. This improvement is also present when comparing the performance of the subject between the two baselines. Data from subject 2 showed a clear ceiling effect as his performance in any FL condition varied between 96 and 100%. Those observations suggest that speech materials, or procedure, used in this experiment may have been inappropriate.

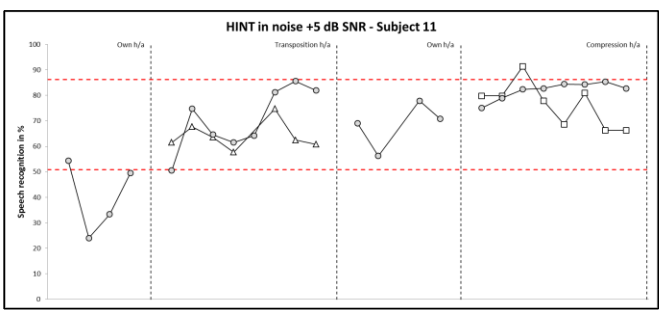

Figure 1: Speech recognition results to the HINT in noise at +5 dB SNR for Subject 11, for the complete 24-week follow-up.

3.2 Questionnaires

Eight and two participants reported a greater benefit with FL in the GHABP and the APHAB questionnaires respectively, in comparison with conventional hearing aids. No negative effect of FL was measured with the questionnaires. The EAS implant participant still reported a greater benefit with this technology. For four participants, results to the questionnaires matched speech recognition results; this was not the case for the other subjects. Five subjects did not get any improvement in speech recognition with FL hearing aids, but reported a significant improvement on the two questionnaires with those technologies.

3.3 Interviews

Nine participants experienced benefits with FL hearing aids. They reported better speech perception and listening comfort in everyday noisy situations (ex. in the restaurant, in the car, in a group conversation), and also improvements in environmental sound detection (ex. doorbell, microwave oven, birds). Those participants preferred FL hearing aids to their own hearing aids and would have kept a trial hearing aid if it were possible. Still, the participant with an EAS implant reported better benefit with this technology.

4 Discussion

Speech recognition results suggest that the EAS implant is the most effective hearing technology when compared to conventional or FL hearing aids. It allowed a greater gain than hearing aids, and no deleterious effect was observed with this technology. The gain provided by FL hearing aids was smaller. In fact, it was so small that it could probably have passed unnoticed in a standard clinical setting. Complementary data collected with standardized questionnaires and semi-structured interviews helped to demonstrate the importance of this effect, as these tools appear more sensitive to the effect of FL in real life, which was often undetected by speech recognition tests. This should be considered when assessing the effectiveness of hearing technologies and making clinical decisions.

Learning and ceiling effects imposed limits on the observable effect in this study. The measurement tools used may have been too repetitive or too easy for the study population, in the context of repeated measurements, or not enough representative of real life; they also may not be sensitive enough to the subtle effects of FL. Other alternatives should be considered for future research.

5 Conclusion

The EAS implant appears as the first indication for treating people with a high-frequency hearing loss. However, FL hearing aids can provide a significant benefit for some individuals. Even if the effect as assessed with traditional speech recognition measures is small, it can be significant from the perspective of the patient. In this context, and considering the potential risks and high costs related to cochlear implantation, trials with FL should be considered on an individual basis prior to implantation.

Results support the use of a more global approach when assessing benefits of hearing technologies. For this purpose, researchers and clinicians should consider not to rely entirely on speech measures, but to also use other data sources, such as standardized questionnaires and interviews.

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