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KLİNİK ARAŞTIRMA

The effect of fitting formulas in programmable hearing aids on speech discrimination in noise

Programlanabilir işitme cihazlarında farklı formüllerin gürültüde konuşmayı ayırt etme üzerine etkileri

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Objectives: This study was performed to compare three fitting formulas for programmable hearing aids in noisy environments using speech discrimination tests.

Patients and Methods: The study included 17 hearing impaired subjects (9 males, 8 females; mean age 28 years; range 15 to 45 years) with bilateral symmetrical sensorineural hearing loss. Speech discrimination tests were carried out at various signal-to-noise ratios (SNR) at +5, 0, -5 dB, based on the NAL (National Acoustic Laboratories), POGO (Prescription of Gain/Output), and Berger fitting formulas with programmable hearing aids.

Results: When the SNR was +5 dB, speech discrimination scores of NAL and Berger were similar. Both had significantly better scores than POGO (p=0.017). When the SNR was 0 dB, speech discrimination scores differed significantly between the three formulas, with NAL having the best score, and Berger having a better score than POGO (p=0.017). When the SNR was -5 dB, the scores were similar between NAL and Berger. Both had significantly higher scores than POGO (p=0.017).

Conclusion: Our results show that there are significant differences in terms of speech discrimination scores among the fitting formulas.

Key Words: Acoustic stimulation/instrumentation; auditory threshold; hearing aids; hearing loss, sensorineural; speech perception.

Amaç: Bu çalışmada programlanabilir işitme cihaz-larında kullanılan üç farklı kazanç formülünün gürültüde konuşmayı ayırt etme üzerindeki etkileri araştırıldı.

Hastalar ve Yöntemler: Çalışmaya, iki taraflı simetrik sensorinöral işitme kaybı bulunan 17 işitme engelli hasta (9 erkek, 8 kadın; ort. yaş 28; dağılım 15-45) alındı. Konuşmayı ayırt etme testleri, programlanabilir işitme cihazlarında NAL (National Acoustic Laboratories), POGO (Prescription of Gain/Output) ve Berger kazanç formüllerine dayalı olarak değişik sinyal/gürültü (S/G) oranlarında (+5, 0, -5 dB) yapıldı.

Bulgular: Sinyal/gürültü oranı +5 dB iken, NAL ve Berger kazanç formülleri ile elde edilen konuşmayı ayırt etme skorları benzer bulundu; iki formülle de skorlar POGO formülünden anlamlı derecede yüksekti (p=0.017). Sinyal/gürültü oranı 0 dB'de ise, skorlar anlamlı farklılık gösterdi; en yüksek skor NAL formülü ile elde edilirken, bunu Berger ve POGO formülleri izledi (p=0.017). Sinyal/gürültü oranı -5 dB iken, NAL ve Berger formülleriyle benzer skorlar elde edilirken, yine en düşük skor POGO formülüyle elde edildi (p=0.017).

Sonuç: Farklı kazanç formülleriyle elde edilen konuşmayı ayırt etme skorları anlamlı farklılıklar göstermektedir.

Anahtar Sözcükler: Akustik uyarı/enstrümantasyon; işitme eşiği; işitme cihazı; işitme kaybı, sensorinöral; konuşma algılaması.

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The use of fitting formulas in the selection of hearing aid frequency gain response is a common clinical practice. The evaluation of hearing aid fitting formulas such as NAL[1] (National Acoustic Laboratories), POGO[2] (Prescription of Gain/Output), and Berger[3] has been restricted to clinical tests. Hamill and Barron[4] evaluated hypothetical audiogram configurations and found no significant differences between different fitting formulas and suggested further investigation on the performance of the fitting formulas.

The aim of this study was to compare three fitting formulas for programmable hearing aids in noisy environments by using speech discrimination test in order to obtain more objective information about the differences between these fitting formulas.

PATIENTS AND METHODS

Subjects

The study included 17 hearing impaired subjects (9 males, 8 females; mean age 28 years; range 15 to 45 years) with bilateral symmetrical pure moderate sensorineural hearing loss. The patients were selected among the patient population of the ENT Department of Hacettepe University Hospital. Informed consent was obtained from all the subjects.

At their first visit, the subjects underwent routine ENT examination and for each ear, air conduction thresholds were measured at 125, 250, 500, 1000, 2000, 4000, and 6000 Hz using Interacoustics AC–5 and AC–30 audiometer, TDH39 headphones, and MX41/AR cushions. Bone conduction thresholds were also obtained using an Oticon 60273 vibrator.[5]

Experimental set-up

The patients were fitted with the Phonak PICS 232 X AZ hearing aid. Recordings of speech reception and speech discrimination tests were made in a fully digital and professional sound recording studio. All materials were recorded on compact discs. Speech reception test materials consisted of two lists of 25 words each and speech discrimination materials consisted of six lists of 25 words each. Recording was made at five-second intervals between each word. Coctail noise was given by a Technics RSTR-373 MR cassette player. Noise and sound stimuli were picked up by an Eurorack MX-602A mixer and connected to the audiometer.

Speech tests were made in free field using a Dali 2B-BL loudspeaker. The speech material and the noise were presented to the patient at 0° and 180°, respectively, through identical loudspeakers placed at one-meter distance (Fig. 1).

Experimental procedure

First, routine audiometry was carried out. Audiometric tests included the following:

Air conduction was measured at 125-6000 Hz (Table I), and bone conduction at 500-4000 Hz.

Speech reception threshold was determined by using word lists developed by Hacettepe University.

The most comfortable level was found.

Uncomfortable level was set.

Speech discrimination test was carried out at the most comfortable level using standard word lists developed for Turkish.[6]

Middle ear pressure was measured for each ear.

Ipsilateral reflex and contralateral reflex were found at 500-2000 Hz and 500-4000 Hz, respectively.

Ear molds were made for each subject. Then, subjects were taken into the hearing aid application room one by one. A pair of Phonak Piconet 232 X AZ hearing aids were programmed according to the NAL, POGO, and Berger formulas. At the end, speech discrimination was measured in a noisy environment with bilateral microphone hearing aids when signal-to-noise ratio (SNR) was +5, 0, and -5 dB.

Data were analyzed with Friedman test and Wilcoxon signed-rank test using the SPSS 9.0 software.

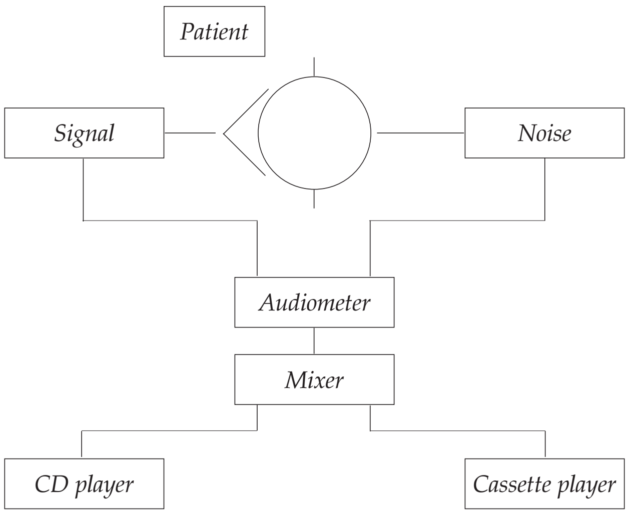

Fig. 1 - *The experimental set-up for the speech discrimination measurements.*

TABLE I

SCORES OF HEARING THRESHOLDS FOR RIGHT AND LEFT EARS

	Frequency	Mean±SS	Median	Minimum	Maximum
Right ear	125	36.47±9.15	35.00	25.00	55.00
	250	42.94±7.92	45.00	25.00	55.00
	500	5.88±5.07	50.00	45.00	60.00
	1000	59.71±5.99	60.00	50.00	70.00
	2000	66.18±4.85	65.00	55.00	75.00
	4000	71.18±6.5	70.00	60.00	85.00
	6000	77.06±8.67	80.00	60.00	95.00
Left ear	125	36.47±8.06	35.00	25.00	55.00
	250	44.71±6.95	45.00	30.00	60.00
	500	50.88±4.76	50.00	40.00	60.00
	1000	59.12±5.37	60.00	50.00	65.00
	2000	65.59±4.96	65.00	60.00	75.00
	4000	71.47±7.24	70.00	60.00	80.00
	6000	77.65±7.31	80.00	65.00	90.00

RESULTS

Speech discrimination tests with hearing aids that were programmed according to the NAL, POGO, and Berger formulas indicated that speech discrimination scores were significantly different among the fitting formulas (Table II). When the SNR was +5 dB, significant differences were found between NAL and POGO, Berger and POGO. Speech discrimination scores of NAL and Berger were similar. Both NAL and Berger had better speech discrimination scores than that of POGO (p=0.017).

When the SNR was 0 dB, speech discrimination scores differed significantly between the three formulas, with NAL having the best score, and Berger having a better score than POGO (p=0.017).

When the SNR was –5 dB, the scores differed significantly between NAL and POGO, Berger and POGO, but were similar between NAL and Berger. Both NAL and Berger had better scores than POGO (p=0.017) (Fig 2).

DISCUSSION

Selection and fitting of a hearing aid is required for well balance between art and science. Manufacturers of aid fittings should know about anatomy and physiology of the ear, hearing loss, sound physics, audiometric test protocols, electron-

TABLE III

SPEECH DISCRIMINATION MEASUREMENTS IN DIFFERENT SIGNAL-TO-NOISE RATIO (SNR) ACCORDING TO THE NAL, POGO, AND BERGER FORMULAS IN PROGRAMMABLE HEARING AIDS

Fitting formulas	SNR	Mean±SS (%)	Median (%)	Minimum (%)	Maximum (%)
NAL	5	74.35±5.49	76	64	80
	0	67.76±6.08	68	60	80
	-5	58.12±4.92	56	52	68
POGO	5	67.76±6.08	68	56	76
	0	60.24±6.24	60	48	72
	-5	51.06±7.42	48	36	64
Berger	5	72.94±7.00	76	52	80
	0	64.71±7.10	64	52	76
	-5	56.94±6.41	56	48	72

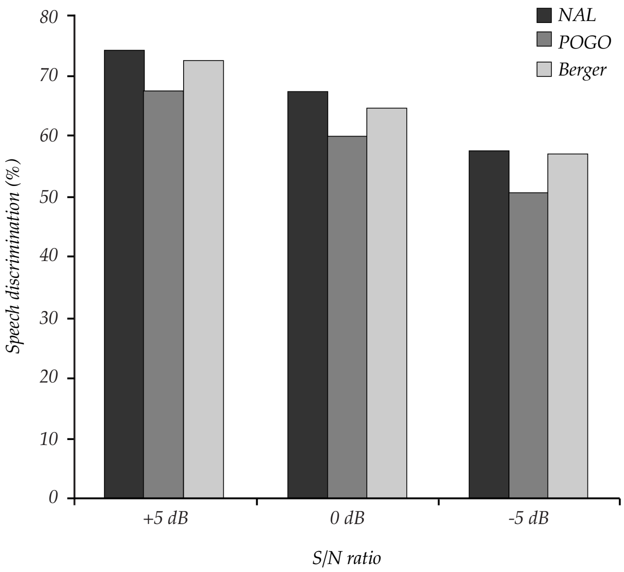

Fig. 2 - *Mean speech discrimination scores at different S/N ratios of NAL, POGO, and Berger formulas.*

ics, psychology of the hearing impaired, counseling, selection and fitting of a hearing aid, and fitting formulas. Nowadays, fast and substantial developments are being made in hearing aid technology. New products and fitting formulas are being produced continuously. It is very difficult to know which product is best for a hearing impaired individual among different kinds of hearing aids and fitting formulas.

In this study, the effects of different fitting formulas on speech discrimination in noise were investigated in individuals with bilateral moderate sensorineural hearing loss. Our results show that there are significant differences in terms of speech discrimination scores among the fitting formulas. When the SNR was +5 dB, NAL and Berger had similar, but significantly better scores than POGO. When the SNR was 0 dB, speech discrimination scores differed significantly between the three formulas, with NAL having the best score, and Berger having a better score than POGO. When the SNR was –5 dB, the scores were similar between NAL and Berger, and both formulas had significantly higher speech discrimination scores than POGO.

Berger[7] studied the differences between the NAL, POGO, and Berger formulas according to the Articulation index (AI). He found that the Berger formula produced the highest AI score for moderate hearing loss and POGO formula for moderately severe hearing loss. He also found that the NAL formula produced the lowest AI score. Our findings were different from his results in that the NAL formula produced the highest speech discrimination score.

Using fitting formulas in choosing gain and frequency response of a hearing aid is a well-known procedure in clinics. Van den Heuvel et al.[8] studied frequency gain responses and showed that the Berger formula had the lowest and NAL had the highest speech discrimination scores. We also found that the NAL formula had the highest score. However, our results were different in relation to the Berger formula, whose performance was better than that of POGO in our study. These differences may be associated with age, degree of hearing loss, and expectations of the subjects.

Berger[9] compared the NAL, POGO, and Berger formulas using soft speech and loud speech. Differences between the Berger and POGO formulas were less, whereas differences between the Berger and NAL, POGO and NAL formulas were greater. In our study, differences between the scores of the Berger and NAL formulas were less and there were significant differences between the Berger and POGO formulas.

Green et al.[10] compared NAL, Berger, a standard formula, and a formula they devised for speech discrimination. They found that NAL and Berger were more beneficial both in quiet and in noise than the other two formulas.

In conclusion, studies about fitting formulas show conflicting results with respect to the amount of gain produced by these formulas. These differences may be related to the subjects studied, the degree of hearing loss, and the methods used.

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