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A Modified Hearing Aid Fitting Procedure Using Both Real Ear and 2cc Coupler Measurement System

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In order to reduce the test time in real ear hearing-aid fitting for children, the validity of applying the average real ear to coupler differences (RECDs) in prefitting procedure using a 2cc coupler measurement system was evaluated by checking whether the majority of people's RECDs might occur within 5 dB of the average RECDs (N=116) in each test frequency and age group. The percentages of occurrence were around 90% in test subjects' RECDs in saturation sound pressure levels (SSPLs) and around 70% in gain in each important test frequency. Appropriate test frequencies in prefitting are 500, 1000, 1500 and 2000 Hz.

Key Words: Hearing aid fitting, real ear to coupler difference (RECD)

A hearing aid is a device for amplifying sound to reach the area of an individual's residual hearing. However, too much amplification can diminish residual hearing and produce loudness discomfort. Moreover, if each specific frequency is not properly amplified to the residual hearing area, optimum use of an individual's residual hearing does not occur and one cannot distinguish speech sounds as well as he or she should. Recently, this type of selective amplification using a real ear measurement (REM) system has become popular. However, with all the positive aspects of the desired sensation level(DSL) method (Seewald and Ross,1988; Hawkins *et al.*[1] 1989) currently being used, it still needs some modification in order to reduce the test time for children who cannot sit still during a hearing-aid fitting.

The purpose of this study was to design a modified procedure for reducing the time to fit a hearing aid while obtaining the best gain and SSPL curves possible for each individual. This modification procedure was made feasible by introducing a prefitting procedure. That is, examiners were able to preselect a hearing aid from specification sheets and preset hearing aids, through the use of a 2 cc coupler measurement system, and then confirm or fine-tune it with a REM system. This method would be useful only if the majority of the test population showed similar trends in RECDs. The authors investigated whether RECDs would show any consistent trends in the test population when analyzed according to age and test frequency.

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MATERIALS AND METHODS

There were 116 test subjects between 1 and 76 years of age. They were divided into 3-year age increments. Each age group consisted of 25 or 26 persons under 9 years old and 6 or 8 persons among youths. There were 18 adults age 19 or over (Table 1). Adults were included for comparisons between age groups.

The Fonix 6500 hearing aid test system was used to measure both REM and 2 cc coupler measurements. For REM, each person's custom-made earmold was worn with a preselected hearing aid and a probe-tube microphone was inserted near the eardrum inside the ear canal. The hearing aid was fitted in order to reach DSLs in as many frequencies as possible both in SSPLs and gains. Each person's 2 cc coupler data was obtained as well as REM data for SSPLs and gains.

Since the differences in sound pressure levels (SPLs) are negligible when measured according to the differences in distance between microphone and eardrum at all of the important frequencies, that is, at 4000 Hz and below (Dirks and Kincaid, 1987), we did not measure the distance of the microphone from the eardrum, but only tried to insert the tube as near to the eardrum as possible. Scholars (Westwood and Bamford, 1995) claim that it is clinically impossible, impractical and unnecessary to measure this distance each time in a hearing-aid fitting procedure.

A 2cc coupler was used both in adults and in children because it made it unnecessary to introduce a redundant procedure of changing the coupler according to age and size of the ear canal, extending the test time only. The purpose of our study was only to investigate the trends in RECDs according to age and frequency.

RESULTS AND DISCUSSION

The greatest differences in RECDs concerning SSPL occurred at the frequencies of 1500, 2000 and 6000 Hz (Table 2).

The REM data were greater than the 2cc coupler data in all test frequencies and in all age groups, as

Table 1. Subjects

Age	Number
0~3	25
4~6	25
7~9	25
10~12	6
13~15	8
16~18	8
19~	18
Total	116

Table 2. Average real ear to coupler differences in SSPLs according to age and frequency

Frequency(Hz) / Age(year)	300	500	800	1000	1500	2000	3000	4000	6000
Feigin et al.(1989)(N=7)*		6	–	11	–	9	11	18	23
Westwood & Bamford (1995) (N=29)*		5	–	6	–	11	12	8	–
0~ 3 (N=25)	2	6	7	5	12	11	8	7	9
4~ 6 (N=25)	2	6	5	4	11	10	8	6	10
7~ 9 (N=26)	2	5	5	5	10	9	6	5	10
10~12 (N=6)	4	7	6	6	11	10	7	6	8
13~15 (N=8)	6	6	7	4	9	9	6	8	11
16~18 (N=8)	2	6	6	3	9	9	4	4	10
19+ (N=18)	2	5	5	3	8	8	5	4	11

*: below 1 year of age

was reported by Hawkins *et al.* (1990). The results concerning gain were similar to those in SSPLs (Table 3). Westwood and Bamford's report (1995) was similar to ours, although Feigin *et al.*'s report (1989) was very different from ours. The number of subjects in the former study was similar to ours (N=29), but the number of subjects in the latter study was only 7 (Table 2). While the two previously mentioned reports studied one year-old infants, the youngest subjects in our study were mostly 2 or 3 years-old. Also, the methods of study were somewhat different.

The average RECDs in SSPL at the frequencies of 1000, 2000 and 4000 Hz decreased as age increased, as was reported by Hawkins *et al.* (1990). However, the difference in the data between the youngest and the oldest age group did not exceed 5dB. Nonetheless, this difference of 5dB should not be considered as negligible, since a difference of 3 dB signifies twice the amplitude. At the lower frequencies, this difference by age did not occur. On the other hand, the importance of real ear measurement in children was again verified in this study, since the average RECDs for those under age 12 were 10-to-12dB at 1500, 2000 and 3000 Hz. This trend also occurred similarly in gain (Table 3).

In order to estimate the rationale for using the average RECDs in presetting with a 2 cc coupler, the authors computed the percentages of occurrence for subjects whose RECDs were within 5 dB of the average RECDs at each frequency and in each age group. The 10-18 age group was excluded from this computation due to its small number. The results were as follows: The rates were around 90% at 500, 1000 and 2000 Hz in SSPL (Table 4) in all age groups and were slightly reduced in gain (around 70%) under 9 years of age (Table 5). Therefore, using the average RECDs at these frequencies in presetting hearing aids could be a consideration in procuring a reasonably acceptable approximation to REM fitting in the majority of the test population.

RECDs were greatest at 1500 Hz under 12 years of age. RECDs at 2000 Hz were almost the same as those at 1500 Hz. This trend was similar to Barlow *et al.*'s report (1988). The greatest RECDs occurred at 6000 Hz over 13 years of age. But, since

Table 3. Average real ear to coupler differences in gain according to age and frequency

Age \ Frequency	300	500	800	1000	1500	2000	3000	4000	6000
0~ 3 (N=25)	0	5	7	6	13	11	10	8	10
4~ 6 (N=25)	-2	4	5	3	10	9	8	7	13
7~ 9 (N=26)	0	6	6	6	10	8	7	5	11
10~12 (N=6)	2	7	6	7	11	7	9	5	8
13~15 (N=8)	6	6	7	5	10	9	5	5	14
16~18 (N=8)	2	6	8	3	8	9	4	3	11
19~ (N=18)	1	5	6	2	8	10	5	5	15

Table 4. Percentages of persons with SSPL occurring within 5 dB of the average real ear to coupler differences

Age \ Frequency	300	500	800	1000	1500	2000	3000	4000	6000
0~ 3 (N=25)	68	96	92	76	88	88	76	64	33
4~ 6 (N=25)	76	96	88	88	92	96	80	76	40
7~ 9 (N=26)	77	92	92	96	92	88	100	81	62
19~ (N=18)	78	94	94	100	94	72	89	94	56

Table 5. Percentages of persons with gain occurring within 5 dB of the average real ear to coupler differences

Age \ Frequency	300	500	800	1000	1500	2000	3000	4000	6000
0～ 3 (N=25)	64	76	76	80	76	76	60	33	33
4～ 6 (N=25)	48	56	72	68	76	68	68	64	44
7～ 9 (N=26)	52	73	85	81	88	73	73	28	42
19～ (N=18)	83	39	94	89	89	89	78	83	61

most hearing aid users do not have residual hearing at this frequency, 1500 and 2000 Hz are the most important frequencies to be noted in prefitting. Therefore, 1500 Hz, though only a half-octave frequency in audiometric frequencies, should also be included in real ear fitting and prefitting computation. This frequency is not only the most important frequency in understanding speech, but most hearing-aid users also have residual hearing at this frequency. Therefore, if the gain and SSPL is not properly fitted at 1500 Hz, users of hearing aids would not only be unable to have optimum use of residual hearing, but would also be uncomfortable in a noisy environment due to the peak which occurs at this frequency. In addition, this peak produces the risk of noise-induced hearing loss. We noticed that this trend was consistent in all age groups and this frequency did not change in any age group.

Using this data, a presetting procedure can be accomplished in 5 steps, which should be followed by REM confirmation or fine-tuning:

1) DSLs of gain and SSPL are computed according to a pure tone audiogram.

2) DSLs minus average RECDs are computed according to age and frequency.

3) A hearing aid is arbitrarily selected from hearing aid specification sheets which approximate these data (2).

4) Tone, SSPL and volume controls are preset using a 2 cc coupler measurement system to approximate the computed data (2).

5) The preset fittings can be confirmed with REM, or minimal fine-tuning can be performed if necessary.

In conclusion, Presetting hearing aids using a 2 cc coupler measurement system with RECDs reduced hearing- aid fitting time for the majority of tested children, with the result of a reasonable approximation to REM fitting. This assumption should be verified by further study. The frequencies to be used in the prefitting step are 500, 1000, 1500, and 2000 Hz for both SSPL and for gain. The greatest RECDs in important frequencies occurred at 1500 Hz and 2000 Hz.

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