ABSTRACT

Objective: To clarify true incidence of sensorineural hearing loss in ears with chronic otitis media (COM).

Methods: Bone conduction (BC) hearing thresholds of 180 preoperative patients (207 ears) with COM and 226 normal individuals (289 ears) were measured by audiometry, and the percentage of ears with BC thresholds being higher than normal range was evaluated in the COM group.   In the COM group, the size of the perforation on the eardrum (n=196) and the cross-sectional area of the mastoid air cells based on the axial CT image (n=103) were also measured and correlated with the results of BC threshold.

Results: The percentage of ears with BC thresholds being higher than normal range calculated from comparison to the control group tended to increase with age, ranging from 4.5% in the 20's to 34.1% in the 60's with an average of 26.6%.   The increase in the BC thresholds did not correlate with the size of eardrum perforation, but correlated well with the size of the mastoid air cells.

Conclusion: These results may suggest that all measures for early cure, including surgery, should be considered as early as possible for patients with COM.

Introduction

Sensorineural hearing loss (SNHL) due to chronic ear disease is now established morphologically [1, 2] as well as physiologically [3‑9] as a definite pathological entity, but is in some part still controversial. It has been reported to exist but has been found to be of questionable clinical significance [10-12]. It has also been suggested to reflect both the Carhart effect and high prevalence of sensorineural impairment, rather than damage to the inner ear by disease [13]. One of the reasons of the confusion in prognosis appears to lie in the difficulty in distinguishing SNHL caused by COM from that caused by aging. This has particularly proven true in the diagnosis of aged patients.

In the present study, in order to clarify the true incidence of SNHL caused by COM and to exclude SNHL due to aging, we evaluated the preoperative bone conduction (BC) thresholds of a large number of COM cases by comparing them with a control group made up of a large number of individuals of all ages.

Materials and Methods

Two hundred and seven (207) ears of 180 adults with COM were selected from 756 ears of 642 patients, who underwent myringoplasty or tympanoplasty at our department clinic from April 2000 to March 2007.   Selection criteria of these subjects were as follows: 1) patients with a diagnosis of COM with perforation of eardrum without otorrhea, 2) patients who underwent myringoplasty or type-I tympanoplasty for the first time, 3) patients who exhibited no specific cause of SNHL such as ototoxicity due to medication, noise exposure, or labyrinthitis due to inner ear invasion of cholesteatoma.   Ultimately the COM group consisted of 133 ears of female and 74 ears of male patients ranging in age from 20 to 79 with an average age of 52.0 years.

The control group was made up of 289 ears of 226 adults without any evidence of ear disease, history of noise exposure, previous ear surgery, or severe head injury.   The constitution of the control group was 115 ears of the unaffected side of the unilateral acoustic neuroma, 112 ears of normal volunteers, 56 ears of the unaffected side of Bell's palsy, and 8 ears of the unaffected side of traumatic ossicular disruption. The control group consisted of 151 ears of female and 138 ears of male patients ranging in age from 20 to 79 with an average age of 49.5 years.   The age distributions of the

two groups are shown in Table 1.   No statistically significant difference was found

between the groups (unpaired Student's t-test).

BC hearing thresholds were measured at 250, 500, 1000, 2000, and 4000Hz in

a sound-reduced booth by use of an audiometer (RION AA-71), calibrated according to

ISO standards.   Although BC thresholds were examined in all cases of the COM group,

but they were regarded as equal to air conduction thresholds in the control group when

only air conduction thresholds were measured and the value was within 30 dB.   When

the value of BC hearing threshold was scaled out, it was calculated as 10dB greater than

the values of the maximum sound given.   For BC thresholds of the control group,

normal range was calculated from the mean +- 2 standard deviations (SDs) in every

decadal age group (teens, 20s, 30s, etc.).   When the BC threshold value of the patient

with COM was found to be higher than the upper limit of the normal range, it was

defined as abnormal.

At first, in order to investigate sexual difference in the BC thresholds in

normal individuals, the BC hearing thresholds in the control group were compared at

each frequency using an unpaired Student's t-test.   In the COM group, the numbers of

ears with abnormal BC threshold at three or more frequencies were counted in each age group. Furthermore, in the COM group, the size of the perforation on the eardrum (n=196) and the cross-sectional area of the mastoid air cells based on the axial CT image (n=103) were measured and correlated with the results of BC thresholds. The size of perforation of the eardrum was divided into three grades by oto-microscopic findings, as a perforation located in only one quadrant, as a perforation located in two quadrants, and as a perforation located in three quadrants or more. The cross-sectional area of the mastoid air cell was measured by Scion Image Beta 4.02 (Scion Corporation, Frederick, Maryland.), using the slice on which the lateral semicircular canal was imaged most clearly as a round form on the axial temporal bone CT. This was subsequently divided into two groups based on whether its size was abnormally small ($>$ 2.0 cm^2) or within normal range ($<=$ 2.0 cm^2) according to data calculated from a large number of normal subjects in a previous study [13].   A correlation between these sizes and the mean BC thresholds at each frequency were analyzed statistically by an unpaired Student's t-test.   All the acceptance criterion for a significant addition to the explained variance was set at p values under 0.05.

Results

The results of measurements of the BC thresholds at each frequency in the control group and COM group are shown in Fig.1.   The BC thresholds were observed to be higher in higher frequencies and in older age in the COM groups, and the number of ears with abnormal BC threshold tended to increase with age.   The numbers of ears in the COM group with abnormal BC threshold in three or more frequencies in each age group are shown in Table 2.   The percentage of such ears tended to become higher with age except in the 70's, whereas only 18.5% of subjects exhibited abnormal BC threshold in three or more frequency which contrasted sharply with 34.1% in their 60's. Subjects in the 20's exhibited an extremely low 4.5% abnormal BC thresholds.   An overall average of 26.6% was found in this study.

The mean BC thresholds of each frequency of males and females in the control group are indicated in Table 3.   Although no significant difference was found in the mean age at each decade between male and female, the BC threshold at 4000Hz was found to be significantly worse in male than in female (unpaired Student's t-test, t =

-2.601, p = 0.0098).

The perforation of the eardrum in the COM group was located in only one quadrant in 79 cases, in two quadrants in 77 cases, and in three quadrants or more in 40 cases. There was no statistically significant difference between BC thresholds and the size of the perforation (Student's t-test, Table 4). Regarding the interrelation between the BC threshold and mastoid area, the BC thresholds of each and average frequency were significantly higher in the small-area group than in the normal-area group (Student's t-test, t=-2.216, p=0.0393, Table 5).

Discussion

When one makes the assumption that SNHL arises during the course of COM, a relationship can be seen between the duration of COM and SNHL. In previous studies, Tos [15] reported that postoperative results of audiological tests are better in patients younger than ten years old and worst in those over 60 years old. Paparella [16] evaluated 279 ears of 232 cases of COM and reported that BC impairment was found especially at higher frequency, and had a positive correlation with the diseased

period of time.   Cusimano [17] evaluated the mean sensorineural component in hearing loss in 195 cases with unilateral COM in relation to the age of onset and duration of the disease by comparing BC thresholds between the affected and non-affected sides, and reported that SNHL does not change with respect to the age of onset of COM, but found the duration to exert a significant influence.   Sakagami [18] reviewed hearing change in 23 patients with unilateral COM in order to clarify the effect of aging, and found that hearing deterioration was 0.13 dB/year in the normal side and 0.61 dB/year in the COM side ($P<0.02$).

In the present study, the percentage of COM ears with abnormal BC thresholds ranged from 4.5% to 34.1% with an average of 26.6% in total, and this may show the incidence of the SNHL caused by the COM.   BC impairment from COM becomes worse as the course of the disease progresses.

Another similar result we found was that mean BC thresholds were significantly worse in ears with poor pneumatization which may indicate that more severe otitis media or otitis media in earlier childhood has a stronger effect on sensorineural hearing function.   This finding is also in line with previous studies

indicating that the degree of SNHL due to COM is related to the duration of the disease.

In the control group (n=287), the BC threshold tended to become higher with age at higher frequencies.   This is in line with a previous study [19].   Although the sexual difference of BC hearing is still controversial [20, 21], the majority of studies have reported that male BC thresholds are worse than female BC thresholds, particularly at high frequencies [22-24].   This has been attributed to higher chance of noise exposure among male subjects [23].   The present results follow those of previous studies.

It was reported that the influence of the Carhart effect [25] should be considered when dysfunction of the inner ear is discussed, because BC thresholds of 500Hz -2000Hz are elevated in cases with fixation of the ossicular chain [13, 25, 26]. However, there are not many studies in which this point has been taken into consideration in the discussion of the BC threshold in COM.   Our present observations on COM ears without ossicular-chain problems also revealed significant elevations of BC thresholds, and moreover, those changes in BC thresholds were found at all frequencies including 4000Hz, in which the Carhart effect does not normally occur.

Considering the above, BC impairments in patients with COM are likely to be due mainly to actual inner ear damage caused by COM.

Conclusion

Statistical analyses of the BC thresholds of COM cases revealed that, even excluding the influence of age, BC impairment rose by approximately 26% in patients with COM, and that incidence increased with age. Also our study supports the conclusion of previous studies, indicating that the degree of BC impairment may be related to the duration of the disease, as was indicated by the poor pneumatization of the mastoid air cells.   These results would seem to indicate that all measures for early cure, including ear surgery, should be considered as early as possible for patients with COM.

References

1. Paparella MM, Brady DR, Hoel R.   Sensori-neural hearing loss in chronic otitis media and mastoiditis. Trans Am Acad Ophthalmol Otolaryngol 1970; 74: 108-15.

2. Walby AP, Barrera A, Schuknecht HF.   Cochlear pathology in chronic suppurative otitis media. Ann Otol Rhinol Laryngol Suppl 1983; 103 Suppl: 1-19.

3. Dumich PS, Harner SG.   Cochlear function in chronic otitis media. Laryngoscope 1983; 93: 583-6.

4. Paparella MM, Morizono T, Le CT, Mancini F, Sipila P, Choo YB, et al. Sensorineural hearing loss in otitis media. Ann Otol Rhinol Laryngol 1984; 93: 623-9.

5. Papastavros T, Varlejides S.   Reversible and permanent bone conduction threshold shift in cases of chronic suppurative otitis media. Am J Otol 1986; 7: 338-46.

6. Cusimano F, Cocita VC, D'Amico A.   Sensorineural hearing loss in chronic otitis media. J Laryngol Otol 1989; 103: 158-63.

7. Vartiainen E, Seppa J.   Results of bone conduction following surgery for

8. Blakley BW, Kim S. Does chronic otitis media cause sensorineural hearing loss? J Otolaryngol 1998; 27: 17-20.

9. El-Sayed Y.   Bone conduction impairment in uncomplicated chronic suppurative otitis media.   Am J Otolaryngol 1998; 19: 149-53.

10. Dommerby H, Tos M.   Sensorineural hearing loss in chronic adhesive otitis. Arch Otolaryngol Head Neck Surg 1986; 112: 628-34.

11. Levine BA, Shelton C, Berliner KI, Sheehy JL.   Sensorineural loss in chronic otitis media. Is it clinically significant? Arch Otolaryngol Head Neck Surg 1989; 115: 814-6.

12. Noordzij JP, Dodson EE, Ruth RA, Arts HA, Lambert PR.   Chronic otitis media and sensorineural hearing loss: is there a clinically significant relation? Am J Otol 1995; 16: 420-3.

13. Browning GG, Gatehouse S.   Hearing in chronic suppurative otitis media. Ann Otol Rhinol Laryngol 1989; 98: 245-50.

14. Ichijo H, Hosokawa M, Shinkawa H.   The relationship between mastoid

pneumatization and the position of the sigmoid sinus. Eur Arch Otorhinolaryngol. 1996; 253: 421-4.

15. Tos M. Tympanoplasty and age. Arch Otolaryngol 1972; 96: 493-8.

16. Paparella MM, Brady DR, Hoel R. Sensori-neural hearing loss in chronic otitis media and mastoiditis. Trans Am Acad Ophthalmol Otolaryngol 1970; 74: 108-15.

17. Cusimano F, Cocita VC, D'Amico A. Sensorineural hearing loss in chronic otitis media. J Laryngol Otol 1989; 103: 158-63.

18. Sakagami M, Maeda A, Node M, Sone M, Makino Y. Long-term observation on hearing change in patients with chronic otitis media. Auris Nasus Larynx 2000; 27: 117-20.

19. Tsuiki T, Sasamori S, Minami Y, Ichinohe T, Murai K, Murai S, et al. Age effect on hearing: a study on Japanese (In Japanese). Audiology Jpn 2002; 45: 241-50.

20. Kacker SK. Hearing impairment in the aged. Indian J Med Res 1997 Oct; 106: 333-9.

21. Berger EH, Royster LH, Thomas WG.   Hearing levels of nonindustrial noise exposed subjects. J Occup Med 1977; 19: 664-70.

22. Hinchcliffe R.   The threshold of hearing as a function of age. Austica 1959; 9: 303-8.

23. Corso JF.   Age and sex differences in pure-tone thresholds. Survey of hearing levels from 18 to 65 years. Arch Otolaryngol 1963; 77: 385-405.

24. Jonsson R, Rosenhall U.   Hearing in advanced age. A study of presbyacusis in 85-, 88- and 90-year-old people. Audiology 1998; 37: 207-18.

25. Carhart R.   Clinical application of bone conduction audiometry. Arch Otolaryngol 1950; 51: 798-808.

26. Tonndorf J.   Sensorineural and pseudosensorineural hearing losses. ORL J Otorhinolaryngol Relat Spec 1988; 50: 79-83.

Legends

Figure 1 A-F

Bone conduction (BC) thresholds of each decade as a function of frequency in chronic

otitis media (COM) groups are shown.   Large open circles connected with a line

indicate mean BC levels in the control group, and bars connected with a dotted line

indicate two standard deviations of BC thresholds in the control group.   A: 20's, B:

30's, C: 40's, D: 50's, E: 60's, F: 70's.
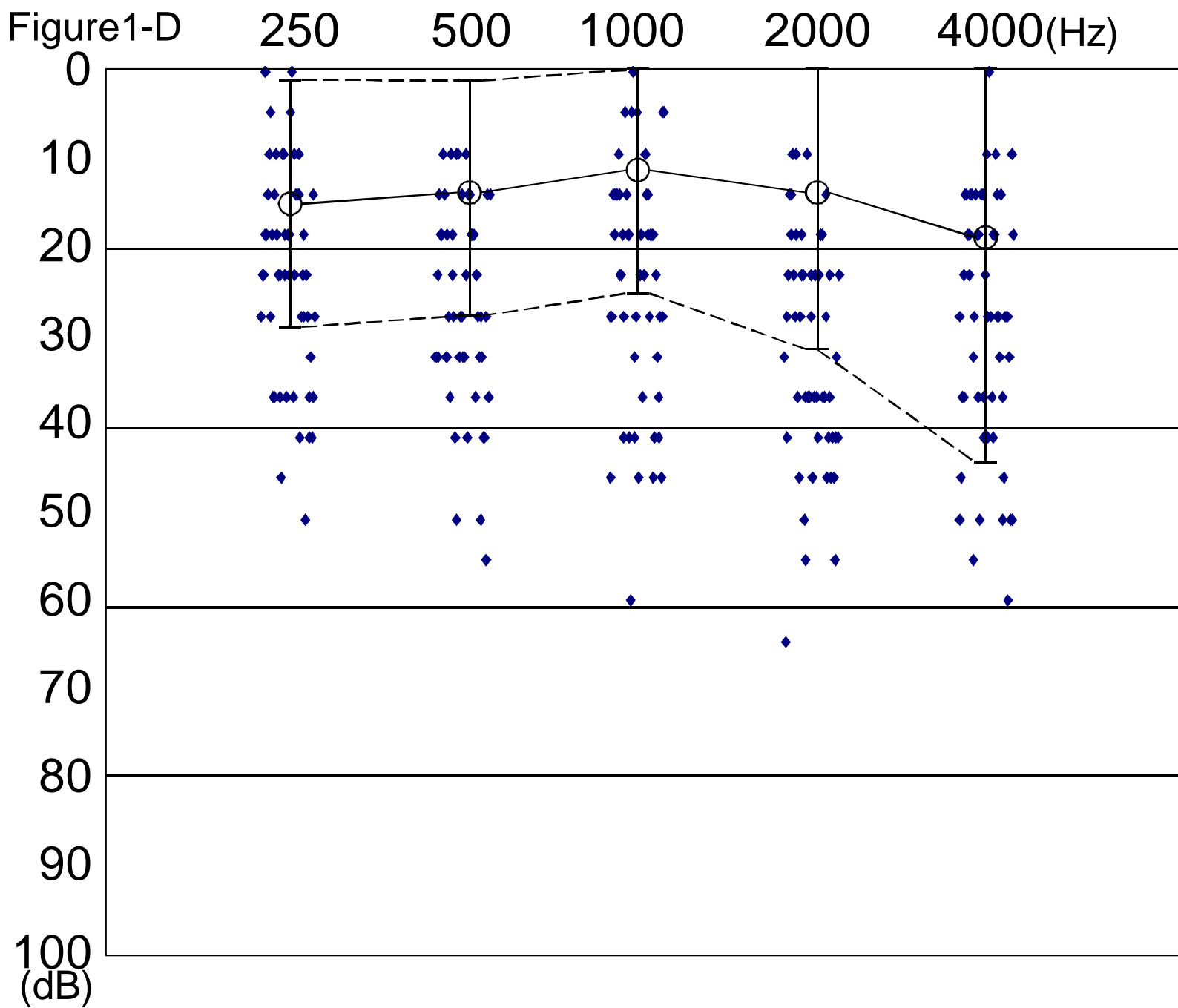
Figure1-A
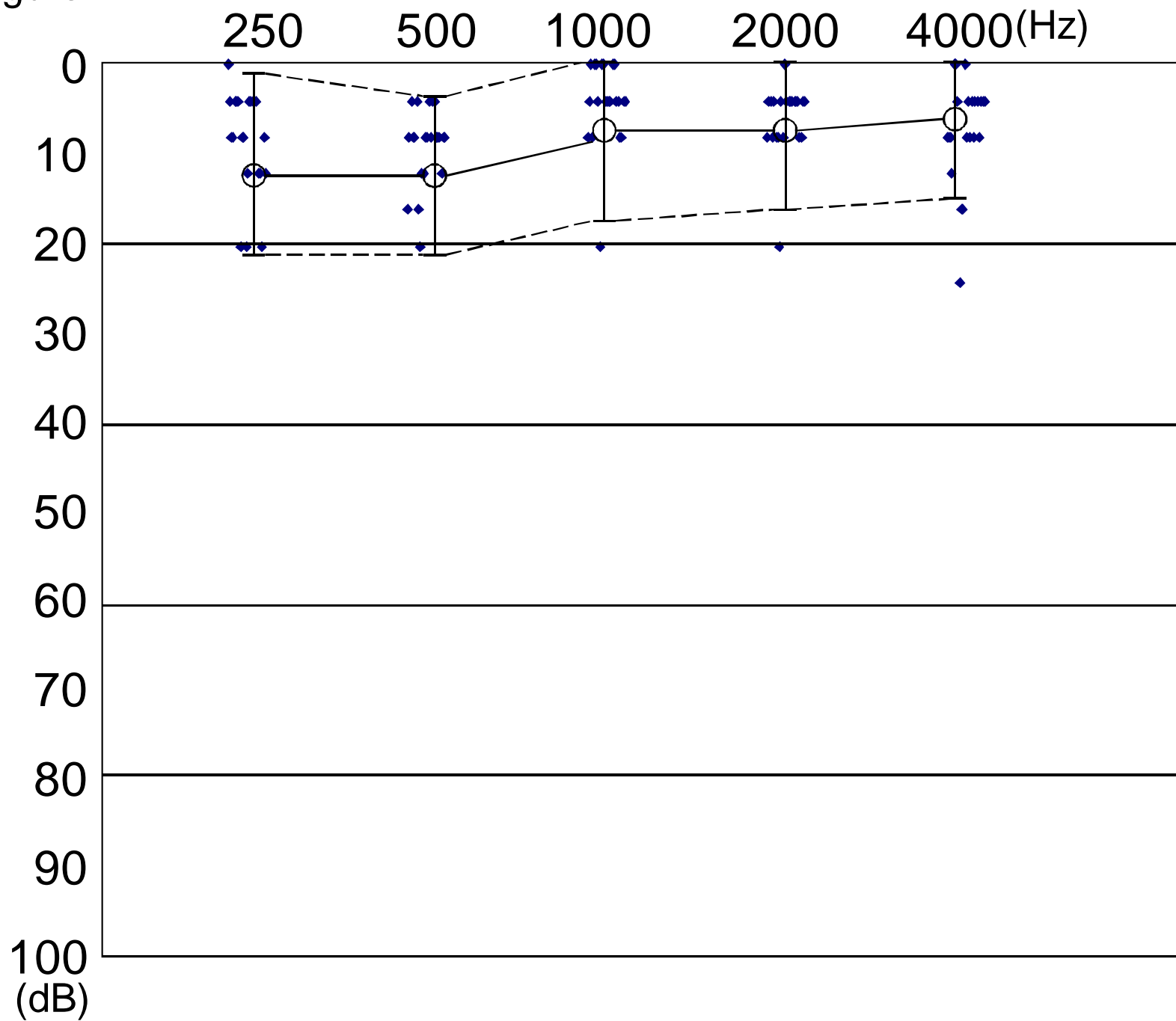
Figure1-B
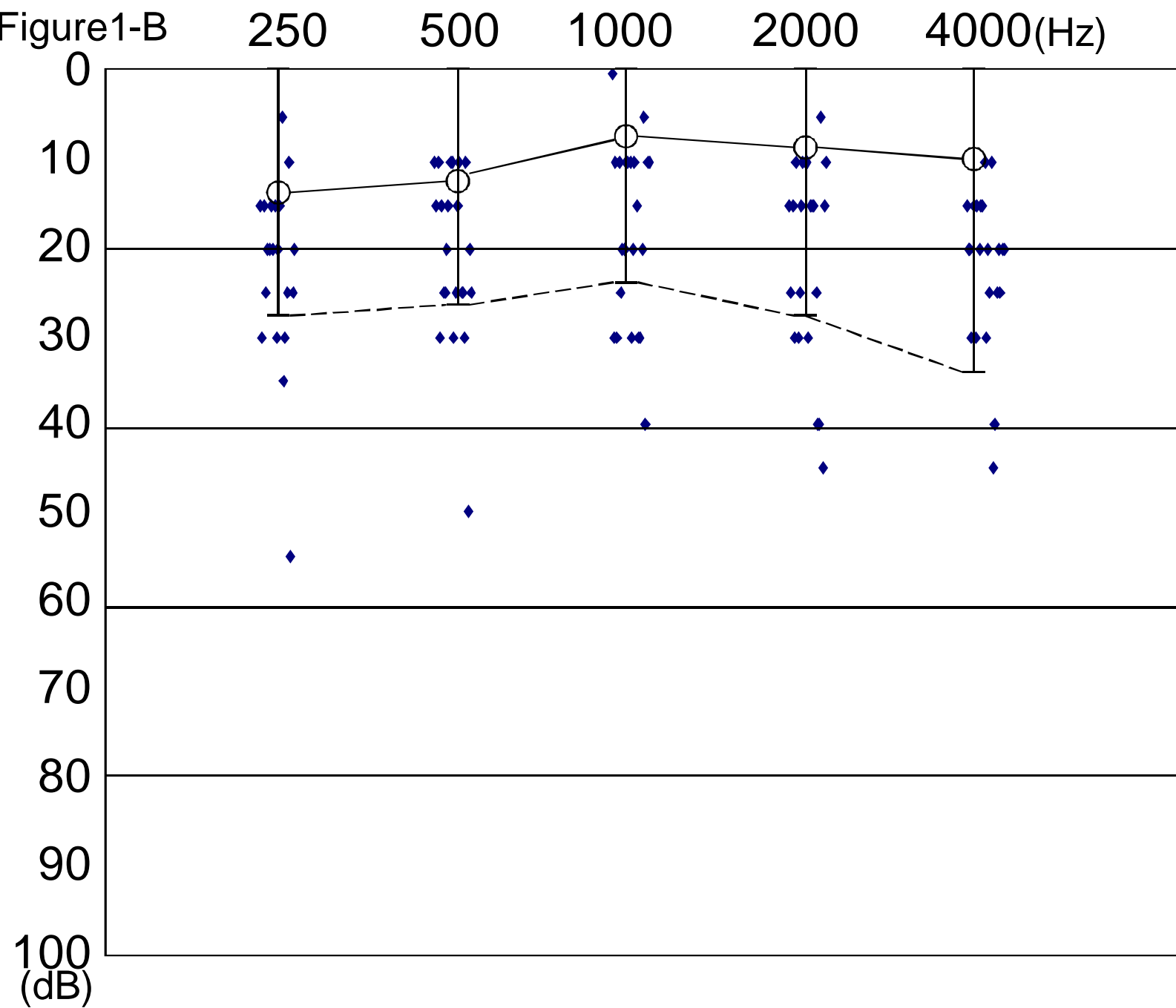
Figure1-C
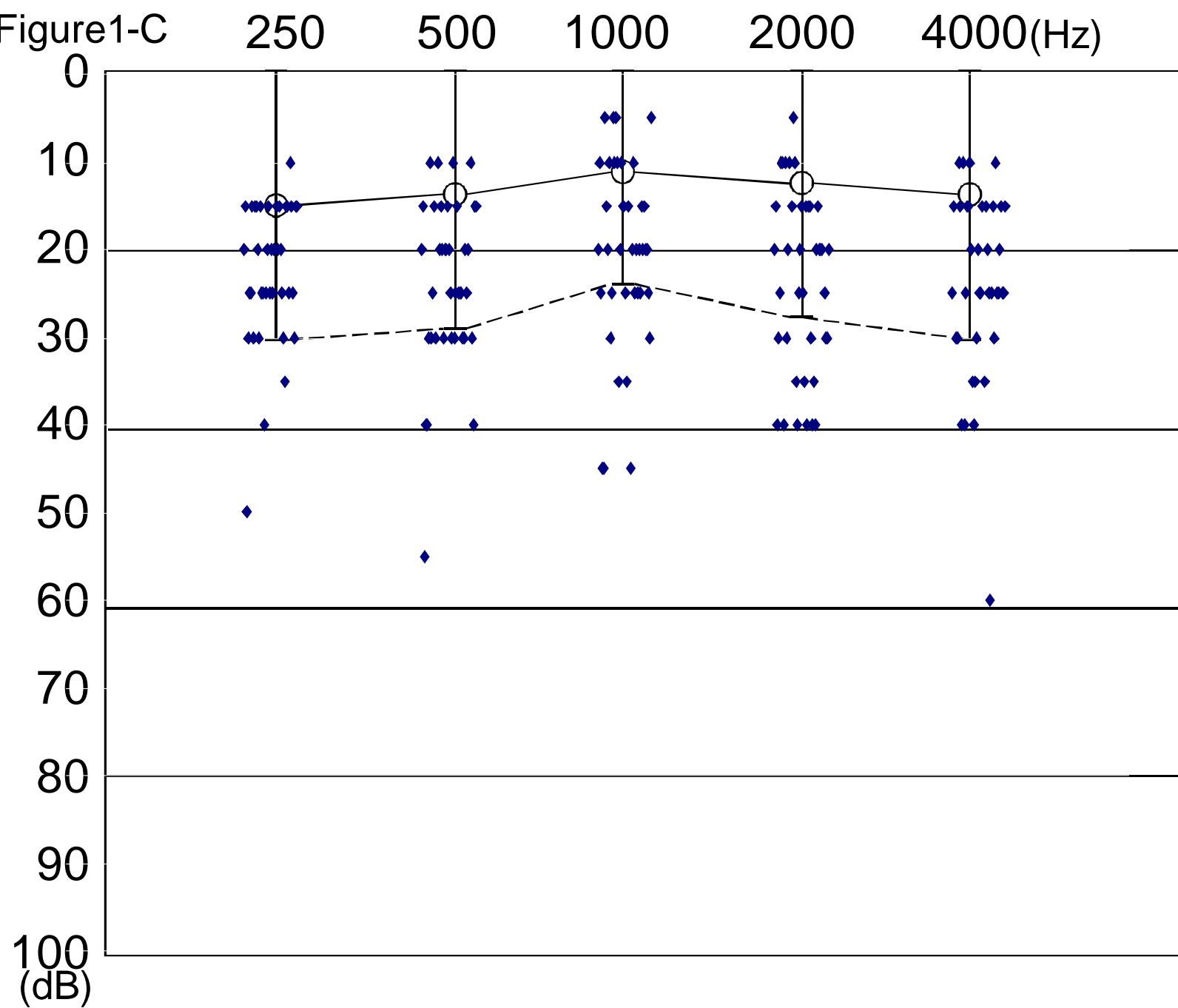
Figure1-D

Figure1-E
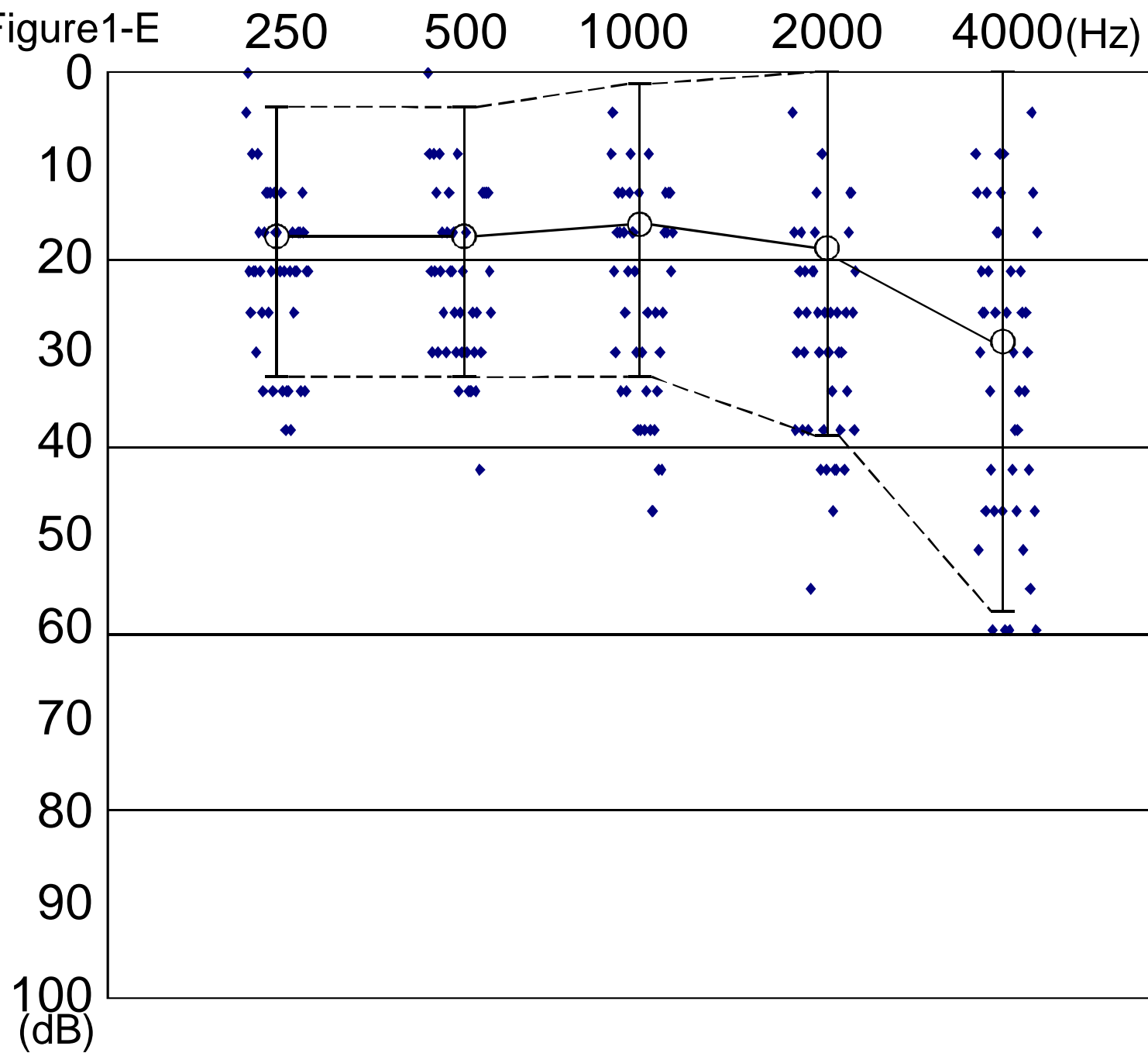
Figure1-F
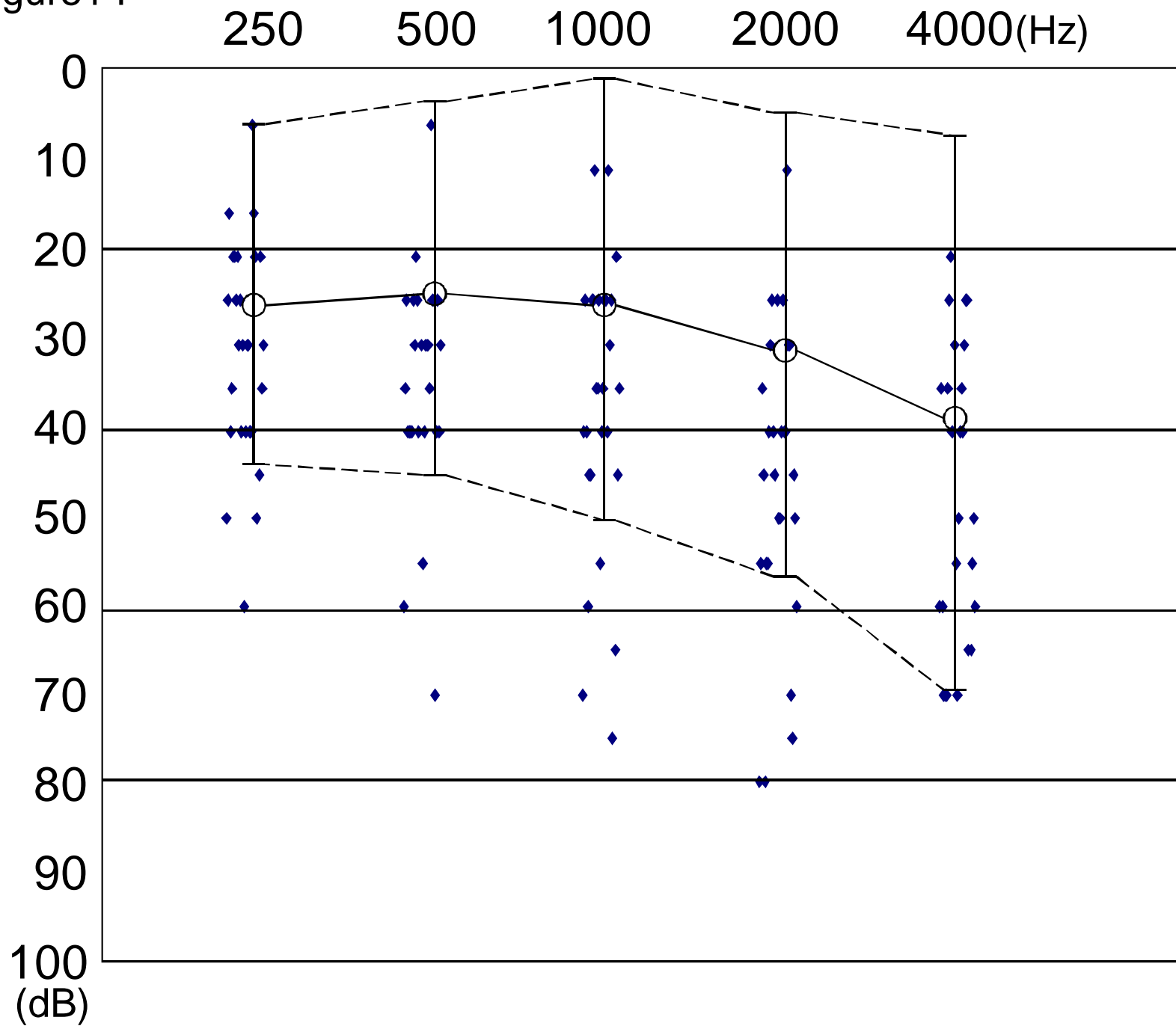
Table 1. Age distribution of the control group and the chronic otitis media (COM) group.

Age Range	Control			COM			P-Value
	Mean age	No. of ears, Male/Female		Mean age	No. of ears, Male/Female		
20-29	24.9	46	27/19	24.3	22	9/13	0.9032
30-39	34.9	44	24/20	34.9	22	7/15	0.6115
40-49	45.1	47	25/22	45.1	39	15/24	0.9436
50-59	53.8	58	21/37	54.6	53	11/42	0.7561
60-69	64.2	58	27/21	63.8	44	23/21	0.8666
70-79	73.7	36	14/22	74.0	27	9/18	0.6422
Total	49.5	289	138/151	52.0	207	74/133	0.4687

Table 2. Number of ears in chronic otitis media (COM) group of which bone conduction threshold was abnormal in three or more frequencies.

	Cases / Total (%)
20-29	1/22 (4.5)
30-39	5/22 (22.7)
40-49	11/39 (28.2)
50-59	18/53 (34.0)
60-69	15/44 (34.1)
70-79	5/27 (18.5)
Total	55/207(26.6)

Table 3. Bone conduction thresholds of males and females in the control group.

	250 Hz	500Hz	1000Hz	2000Hz	4000Hz
Male (Mean±SD)	15.6±6.6	15.1±7.9	13.3±10.0	15.6±12.4	22.1±17.8
Female (Mean±SD)	16.7±8.6	15.7±8.4	13.3±9.4	15.3±10.8	17.2±14.1
P-Value	0.2505	0.5814	0.9914	0.8600	0.0098*

*: statistically significant difference

Table 4. Results of the comparison between BC thresholds and the size of perforation of eardrums in the chronic otitis media group.

Area of eardrum perforation	Cases	250 Hz	500Hz	1000Hz	2000Hz	4000Hz
One Quadrant (Mean±SD)	79	22.5±10.7	24.2±10.4	23.8±13.1	29.5±13.6	30.8±16.3
Two Quadrant (Mean±SD)	77	25.6±12.0	27.7±12.0	26.2±15.7	30.7±16.9	31.9±19.5
Total Perforation (Mean±SD)	40	23.5±11.7	24.9±13.9	22.5±16.8	27.6±17.6	27.0±14.5

Table 5. Correlation between BC thresholds and the size of mastoid air cells in the chronic otitis media group.

Mastoid area	Cases	250Hz	500Hz	1000Hz	2000Hz	4000Hz	Average
<2.0 mm^2 (Mean±SD)	29	23.6±12.0	22.1±10.4	19.5±10.3	25.2±12.6	25.5±13.7	23.2±9.6
>=2.0 mm^2 (Mean±SD)	74	24.8±11.1	28.6±13.0	26.6±16.3	32.3±16.7	31.8±17.9	28.8±13.2
P-Value		0.6396	0.0181*	0.0318*	0.0397*	0.0929	0.0393*

*: statistically significant difference