VERIFICATION OF THE USEFULNESS OF SHORT INCREMENT SENSITIVITY INDEX (SISI) TEST IN DETERMINING BONE CONDUCTION THRESHOLDS

K. NARENDIRAN*

Swisher, Stephens and Doehring (1966) suggested that the SISI test might be interpreted as an indirect measure of bone conduction thresholds. Swisher *et al* (1966) also showed that normal and non-adapting sensorineural impaired ears discriminated a signal of 1 dB or less equally well at equivalent SPL. The study by Young and Harbert (1967) showed that at SPL's of 45 and above every normal subject showed a SISI score of 65 per cent or higher for all frequencies. In general, a high SISI score occurs when at least 60 dB SPL reaches the inner ear. Sound pressure level (SPL) reaching the inner ear is the determining factor in the perception of 1 dB increments (Young and Harbert, 1967; Harbert, Young and Weiss, 1969; Martin and Salas, 1970).

If the inner ear receives an audible signal of 60 dB SPL or higher there is essentially no difference in the performance on the SISI test of ears with normal hearing, those with conductive pathology, or those with non-adapting sensorineural hearing loss. If the residual signal is greater than 60dB SPL after the conductive barrier is subtracted, the conductivley impaired ear behaves like a normal ear. In conductive and mixed deafness, the conductive barrier in dB should be added to the 70 dB SPL test signal to obtain a positive score (Young and Harbert, 1967). Higher test frequencies yield higher SISI scores. A study by Martin and Salas (1970) showed that normal ears did not give high scores on the SISI test when tested at the same loudness as pathological ears. Their study shows that high SISI score began to occur in the good ear somewhere between 55 to 65 dB SPL. Katinsky, *et al* (1972) reported that both their clinical experience and recent research have substantiated (Harbert, *et al* 1969) that positive SISI scores rarely are obtained if the test signal presentation is less than 50 to 60dBSPL. Pushpa (1974) found that a majority of normals obtained 100 per cent SISI scores at 65 dB HL.

In 1974, Byers described 'Conductive SISI test,' an indirect procedure to estimate bone conduction threshold for middle ear patients. A series of SISI tests were run beginning at 20 dB SL and increasing in 10 dB steps until a 100 per cent score was obtained. The following equation to predict the bone conduction threshold was suggested:

BC dB=60 dB+Air Conduction (dB)-H.L. dB (100 per cent SISI). The results of 25 conductive SISI tests on a conductive hearing loss group indicated that the equation approximated the bone conduction thresholds. They report that there was no statistical difference between the predicted threshold and

•Speech Pathologist and Audiologist, Institute of Oto-Rhino-Laryngology, Govt. General Hospital, Madras.

measured bone conduction threshold for the group. The conductive SISI test has the advantage over the conventional bone conduction measurements in that it overcomes some of the sources of errors of the latter.

To know whether the technique enables us to get a valid bone conduction threshold an attempt is made here to verify the usefulness of the SISI test as a clinical tool in determining the bone conduction thresholds. The purpose of the study was to test the following hypotheses:

(a) All the ears without abnormal tone decay respond to 1 dB increments when the energy reaching the cochlea is around 60 dB.

(b) The bone conduction thresholds obtained by conductive SISI test do not significantly differ from the bone conduction thresholds obtained by conventional bone conduction measurements in conductive hearing loss, mixed hearing loss and in sensorineural hearing loss patients

Methodology

This study comprised the following parts: *(a)* obtaining pure tone air conduction and bone conduction thresholds for all the subjects, *(b)* To find the hearing level at which 100 per cent SISI scores are obtained in normal hearing subjects, (c) Comparison of bone conduction thresholds by conductive SISI method and conventional method in clinical groups (Conductive hearing loss, Mixed hearing loss and Sensorineural hearing loss). The subjects were tested for the frequencies in the order of 1000 Hz, 2000 Hz, 4000 Hz and 500 Hz.

Subjects; Two groups of subjects were chosen. First group consisted of ten normal hearing male subjects who had thresholds of 20 dB (ISO. 1964) or less, bilaterally. A clinical group of 28 m.des and 5 females which included 43 ears with conductive hearing loss of various pathologies such as C.S.O.M., serous otitis media, dry perforation, otosclerosis, ossicular rupture, tympanosclerosis etc., 9 ears with mixed hearing Iossand3 ears with sensorineural hearing loss formed the second group. Depending on the involvement both ears or a single ear was selected for testing. In the clinical group, the subjects age ranged from 15 years to 57 years with a mean age of 29.39 years.

Equipment and test environment: Throughout the study a Beltone 15 CX clinical audiometer was used to get air conduction thresholds and to administer SISI test. Madsen audiometer model to get none conduction thresholds was used. With Beltone 15 CX clinical audiometer TDH 39 earphones mounted in MX-41/AR cushion were used. With Madsen audiometer, Denmark A39 bone conduction vibrator was used. Both the audiometers were calibrated using Bruel and Kjaer instruments. Necessary correction was applied to the obtained audiorretric values wherever needed. The linearity of the attenuator was checked and found to be in order. The SISI unit of Beltone 15 CX audiometer was also calibrated in terms of increment size, the rise and decay time and the signal duration. The calibration was checked at regular intervals. All the testing was done in a sound treated room. Noise levels in the audiometric room were satisfactory.

Test Procedure: For all the subjects pure tone air conduction thresholds, bone conduction thresholds and the hearing level at which 100 per cent SI SI scores were obtained was determined. All the subjects in clinical group had otological examination before testing. In normals, in conductive hearing loss and in mixed hearing loss subjects the SI SI test was given initially at 40 dB above the conductive barrier. In sensorineural loss patients the test was started at 10 dB S.L. Whenever the subjects failed to give response for 1 dB increments, the carrier tone was raised in 5 dB steps. The hearing level at which the subject gave 100 per cent SISI score was determined. The contralateral ear was masked whenever necessary. For all the subjects, ten 1 dB increments were presented as suggested by Yantis and Decker (1964) and Owens (1965). After getting the air conduction thresholds and the hearing level at which 100 per cent SISI was obtained, the bone conduction thresholds were calculated by using the formula;

BC dB=60 dB+AC (DB)-H.L. dB. (100 per cent SISI)

as given by buyers (1974) bone conduction thresholds obtained by conductive SISI test were compared with conventional bone conduction thresholds.

In SISI test administration, first, five practice events of 5 dB, 4 dB, 3 dB, 2 dB, and 1 dB increments were given in order to familiarise the subjects. Then ten 1 dB increments were presented which were superimposed on a sustained tone. Randomly a control event of 5 dB or 0 dB was given depending upon the subjects' response. The hearing level at which the subjects could detect all the ten increments were found out and it was considered as the HL dB (100 per cent SISI).

To check the reliability, tests were repeated on five normal subjects after sufficient time interval to avoid the practice effect.

Results and Discussion

In the first part, to verify the hypothesis,"All the ears without abnormal tone decay respond to 1 dB increments when the energy reaching cochlea is around 60 dB', twenty ears of ten normal hearing subjects were given the SISI test. The hearing level at which 100 per cent SISI score obtained was found out for all the ten subjects. This score was obtained in normal hearing subjects, at a mean value of 65.12 dB HL.

Table 1 gives the mean air conduction thresholds, range of hearing levels for 100 per cent SISI and mean hearing level at which 100 per cent SISI was obtained in normal hearing subjects.

Young and Harbert (1967) reported that in general, a high SISI score occurred when at least 65 dB SPL reaches the inner ear. Intensity level reaching the inner ear is the determining factor in perception of the 1 dB increments. Harbert,

TABLE 1: Indicating mean air conduction thresholds, range of hearing levels and mean hearing levels for 100 per cent SISI

Frequency	Mean air conduction thresholds	The range of hearing levels for 100% SISI	Mean hearing levels for 100% SISI
500 Hz	6.25 dB HL	55-80 dB HL	67.0 dB HL
1000 Hz	6.5 dB HL	55-75 dB HL	66.0 dB HL
2000 Hz	6.75 dB HL	55-75 dB HL	64.0 dB HL
4000 Hz	5.50 dB HL	50-70 dB HL	63.5 dB HL

Young and Weiss (1967) reported that in normals nearly 100 per cent SISI score occurred at 60 dB SPL and also that low SISI scores occurred when the subjects received the signal at 55 dB SPL or below.

A studyby Martin and Salas (1970) also showed that high SISI scores occurred in normal ears somewhere between 55 and '>5 dB SPL. Pushpa (1974) observed that 75 per cent of normal hearing subjects obtained 100 per cent SISI scores at 65 dB HL and the remaining 25 per cent obtained 100 per cent SISI scores within 80 dB HL. The results of this study closely agrees with the above mentioned studies indicating that in normals an average of 65.12 dB HL is required to get a 100 per cent SISI score. Below 55 dB HI, at 500 Hz, 1000 Hz and 2000 Hz and below 50 dB HL at 4000 Hz ,no subject sc red 100 per cent SISI score.

In the second part of the study the null hypothesis, 'the bone conduction thresholds obtained by conductive SISI test do not significantly differ from the bone conduction thresholds obtained by conventional bone conduction measurements in conductive hearing loss, in mixed hearing loss patientsand in sensorineural hearing loss patients' is verified. The obtained results of the clinical group are analysed by dividing them into the following groups: *(a)* Total clinical group (Conductive hearing loss, mixed hearing loss, and sensorineural hearing loss); *(b)* Conductive hearing loss; (c) Mixed hearing loss; *(d)* Sensorineural hearing loss.

Total Clinical Group: For the clinical group inclusive of all the frequencies, 203 bone conduction measurements were made by both conductive SISI method and conventional method. For some ears in the clinical group, bone conduction measurements by conductive SISI method could not be computed for all the four frequencies because of audiometric limits.

In general, bone conduction thresholds ranged from -10 dB HL to 55 dB HL for conductive SISI method and -5 dB HL to 60 dB HL for conventional method. Results showed that there is no significant difference between the means by the conductive SISI test and by the conventional bone conduction test at 0.01 level. The variability within which the individual performed was similar in both the groups. So the null hypothesis for all the frequencies for the total clinical group has been retained.

***Conductive Hearing Loss Group**:* The analysis of the results of this group showed that there is no significant difference between the two mean bone conduction thresholds for the frequencies 500, 1000 and 4000 Hz at 0.01 level. But at 2000 Hz, for this group there is a significant difference between the mean bone conduction thresholds by conductive SISI test and by conventional method at 0.05 level. At 2 KHz, the mean bone conduction threshold by the conductive SISI method was less than the conventional method. As for general purpose 0.05 level is taken into consideration because it covers 95 per cent of the population the difference at this frequency between the two methods can be considered as significant.

The difference between the two methods at 2 KHz may be attributed to Carhart notch which might explain the increased mean value in conventional method. This shows that conductive SISI test is not influenced by the mechanical distortion unlike conventional bone conduction method.

Subjects with conductive hearing loss are similar to those with normal hearing in detecting 1 dB increments when the conductive barrier is overcome, is again supported by this study. At 2 KHz the conductive SISI test yielded better (lower) thresholds than the conventional method.

Mixed hearing loss and Sensor ineural hearing loss groups: In these two clinical groups, the results showed that at all the four frequencies there is no significant difference between the two means.

Only in mixed hearing loss group at all the four frequencies the mean conductive SISI bone conduction thresholds dropped below the conventional bone conduction thresholds. Dirks and Malmquist (1969) stated that cases with mixed hearing loss may be misdiagnosed because the effects of middle ear impairment depress bone conduction thresholds. Probably better conductive SISI bone conduction thresholds in mixed hearing loss cases at all the frequencies may be explained on the basis of the observation made by Dirks and Malmquist (1969).

On ten normal hearing ears, the test to find the hearing level at which 100 per cent SISI scores are obtained was repeated after sufficient time interval. The variation was within $\pm$5dB for all the ears except for one ear at 2 KHz. Reliability was statistically computed by using the Rulon method and the test-retest reliability was found to be high for all the frequencies.

Conclusions

1. The significant difference in bone conduction thresholds between conventional and conductive SISI methods at 2 KHz for conductive hearing loss group may be attributed to Carhart notch.

2. Conductive hearing loss ears behave like normal ears in detecting one dB increments of SISI test when the conductive barrier is overcome.

3. There is no significant difference between these two methods conventional and conductive SISI at any of the frequencies employed in this study for mixed hearing loss and sensorineural loss group.

4. Conductive SISI scores are reliable.

5. Conductive SISI test has value when bone conduction measurement by conventional method is questionable and when direct measurement of bone conduction is not possible.

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