COMPARISON OF SHELL AND SKELETON EARMOLDS OF BEHIND-THE-EAR HEARING AID USERS BY INSERTION GAIN AND COUPLER MEASUREMENTS

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REG NO.M9206

AN INDEPENDENT PROJECT SUBMITTED AS PART FULFILMENT OF 1st M.Sc(SPEECH & HEARING), TO THE UNIVERSITY OF MYSORE, MYSORE

ALL INDIA INSTITUTE OF SPEECH AND HEARING: MYSORE - 570 006.

MAY 1993

MY PARENTS

Who gave me

my fundamental values & dispositions

AND

my everloving sibblings

- Babuettan and
- Sendhumol

Who tought me.

What is

LOVE & AFFECTION

CERTIFICATE

This is to certify that the Independent Project entitled: "Comparison of shell and skeleton earmolds of behind-the-ear hearing aid users by insertion gain and coupler measurements" is a bonafide work done in part fulfilment for the First Year Degree of Master of Science (Speech and Hearing), of the student with Reg.No.M9206.

Mysore
May 1993

Dr.(Miss) S.Nikam
Director
All India Institute
of Speech and Hearing,
Mysore-6.

CERTIFICATE

This is to certify that the Independent Project entitled: Comparison of shell and skeleton earmolds of behind-the-ear hearing aid users by insertion gain and coupler measurements has been prepared under my supervision and guidance.

Mysore
May 1993

Dr.(Miss) S.Nikam
GUIDE

DECLARATION

I hereby declare that the Independent Project entitled: Comparison of shell and skeleton earmolds of behind-the-ear hearing aid users by insertion gain and coupler measurements is the result of my own study under the guidance of Dr.(Miss) S.Nikam, Prof. & Head of the Department of Audiology, & Director, All India Institute of Speech & Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore

May 1993 Reg.No.M9206

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PROLOGUE

Deafness is worse than blindness, so they say it is the loneliness, the sense of isolation, that makes it so and the lack of understanding in the minds of ordinary hearing people, the handicap of the silent world - the difficulty of communicating with the hearing and speaking world.

These devastating effects on deafness on an individual can be alleviated to a great extend by a small amplification device called the hearing aid. Hearing aid is an electro-acoustic device which aids in amplification of sounds. But having a hearing aid is not sufficient enough. One need to have a coupling device which enables the receiver of the hearing aid as the hearing aid itself to sit in the ear. This coupling device is termed earmold.

Earmold sometimes called the earpiece, is a plastic insert designed to conduct the amplified sound from the hearing aid receiver into the ear canal as efficiently as possible (Langford, 1975).

"The earmold is half of the fitting". As Bhue (1975) aptly puts it - '70 discuss the role of earmold in successful hearing and fitting in somewhat like discussing the role of the engine to the successful operation of an automobile or the role of wings to the successful flight of an airplane.

The role of an earmold may be summarised as:

1) Linking the hearing aid to the patient,
2) Conveyor of sound from the output transducer of the hearing aid to the external auditory meatus,
3) Anchoring the ear level hearing aids affording retention of the aid to the ear.

Among many others another role is the acoustic modification of the output signals which is beyond the circumscription of the electrical controls of the hearing aid. The acoustic modification can be achieved by -

1) Changing the earmold configurations
2) Varying the earmold dimensions
3) Using the acoustic modifiers.

While on looking into the earmold configurations, based on the physical style options, earmolds can be categorized into -

a) Receiver mold - This is a full solid mold with a metal or plastic snap ring for the appropriate sized nubbin to hold the receiver directly on to the earmold.

b) **Sliell mold** - This is the earmolds used for hearing aids with internal receivers, with or without helix, its use is dictated when fitting high gain ear level aids. Its acoustic properties are similar to those of the standard earphone coupled mould, but physically all its possible bulk is removed from the bowl ensuring comfort.

It has a full canal and a thin shell covering the bowl of the ear. Tight seal and thick walled tubing is necessiated in lieu of the acoustic feed back.

c) Skeleton or perimeter earmold - This is used with post-auricular hearing aids. This is similar to the shell mold except that the centre portion of the concha has been followed out, leaving only the rim. It offers more comfort to the wearer owing to the increased air circulation in the concha when compared to shell mold. This is used with moderate gain instruments and is adaptable to the short canal, open bore fitting, as the concha rim sustains the earmold in the ear. The earmold has a standard tubing of constant diameter which opens into a large hollowed out sound bore. Canal is short. The body of skeleton earmold has less bulk than the standard earmold, and more than open earmold.

Earmold, though it seems in significant when compared to the hearing aid, research has shown that quality of sound output from hearing aid can further be modified at the level of earmold.

Reports on the significance of the earmold have been made by a number of authors since the early 50s, but the first measurement of the sound pressure level in the ear canal, in order to investigate the acoustic characteristics of earmold were reported in 1956, Commonly used procedures for the purpose of studying the characteristics of earmold or rear ear insertion gain measurements, coupler measurements and functional gain measurements.

Coupler measurements are mainly used to find out the electroacoustic characteristics by means of a 2cc coupler which was first described by Ramanow (1942). The most generalized form of 2cc coupler is the HA-I. In this form# there is a relatively large opening, in the sound entrance face. Any tubing, earmold or an ITE or ITC aid can be mounted in the coupler with a suitable formable material.

In order to compare the gain given by the two earmolds. We can compare the electroacoustic characteristics measured from a hearing aid by using those two earmolds. But the major and most important disadvantage with 2cc coupler is that it yields an artificial resonance in the frequency response curve because of the hard walled cavity which occurs at a lower level ir/ears of patients wearing a hearing aid, and also a 2cc coupler does not accurately simulate actual ear canal resonance (Jerger, 1974). Moreover it does not tell anything about head shadow and pinna effects, concha and canal resonance.

Thus, gradually the increased use of earmold acoustic systems has changed the trends to making the measurements of the actual ear canal of a person. This real ear probe tube microphone system is very much useful in measuring the insertion gain, when different earmolds are used along with hearing aid.

The term insertion gainwas introduced by Ayers (1953) It is the increase in sound pressure level at the eardrum with the operating hearing aid in place compared to the SPL at the eardrum without the hearing aid and with the ear canal and concha unoccluded. It takes into account of the loss of natural gain due to head diffraction and concha and ear canal resonances, when the ear canal is closed with an earmold (Shaw, 1974).

But the literature till today has very little to say about the influence of earmold configuration (types) on the electroacoustic characteristics and insertion gain of the hearing aids.

Sweetno (1991) compared the insertion loss produced by a variety of BTE coupling configurations and found an increasing order of insertion loss are displayed, when a BTE coupled to a free field earmold, a maximum vented SAV and finally a closed shell mold. This shows that "each configurations of earmold has get its own individual characteristics". We can also consider the following studies to support the above statement.

Saul (1985) compared the functional gain using various earmold configurations and found the functional gain of shell mold to be around 26.9 dB. Functional gain was not improved over the conventional shell type earmold by the CFA (11.2 dB) followed by Libby horn (7.5 dB).

Kewin, Geenberg and Simmons (1981) conducted a study by using four different earmolds like occluding earmold, skeleton earmold with long canal, skeleton earmold with short canal and free field mold on hearing aid response and found that earmold having the longest canal portion exhibit greater SPL in the frequency range from 800-2700 Hz as compared to the earmold with short canal. Below 2000 Hz the skeleton earmold provides more amplification than the free field earmold. The largest different observed when comparing the skeleton earmold to the free field earmold was 7 dB at 1000 Hz.

Although there is ample information regarding the gain measurements, the literature regarding the amount of signal reaching the ear and the benefits derived by them with different earmold types like shell and skeleton earmolds which is used for the behind-the-ear hearing aids are lacking. Hence a need was felt to study the performance of ' behind-the-ear' hearing aids, when used with different coupling devices like shell and skeleton earmolds, which is normally distributed to the clients.

The objectives of the present study were:

1. To compare the coupler gain with different acoustic couplers like shell and skeleton molds and to study their effects on BTE hearing aid performance.

2. To compare the real ear gain measurement, in the BTE hearing aid users with their gain requirement, when used with shell and skeleton earmolds.

METHODOLOGY

The methodology of the present study is discussed under the different headings:

- subjects
- test environment
- instrumentation
- procedure,

Selection of subjects:

A total of ten ears (5 males and 5 females) of average age 53 years, with hearing loss and who use behind-the-ear hearing aid were used for the purpose of the study.

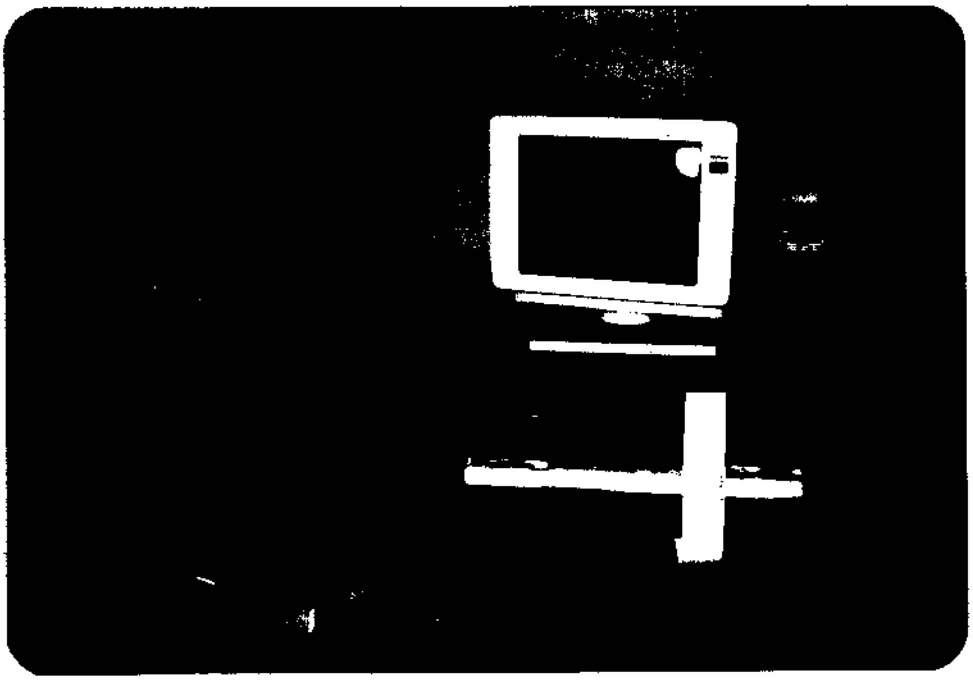
Test environment :

The test was conducted in partially sound treated air conditioned room. Power sources was the main AC supply. The instrument was kept in a quiet room.

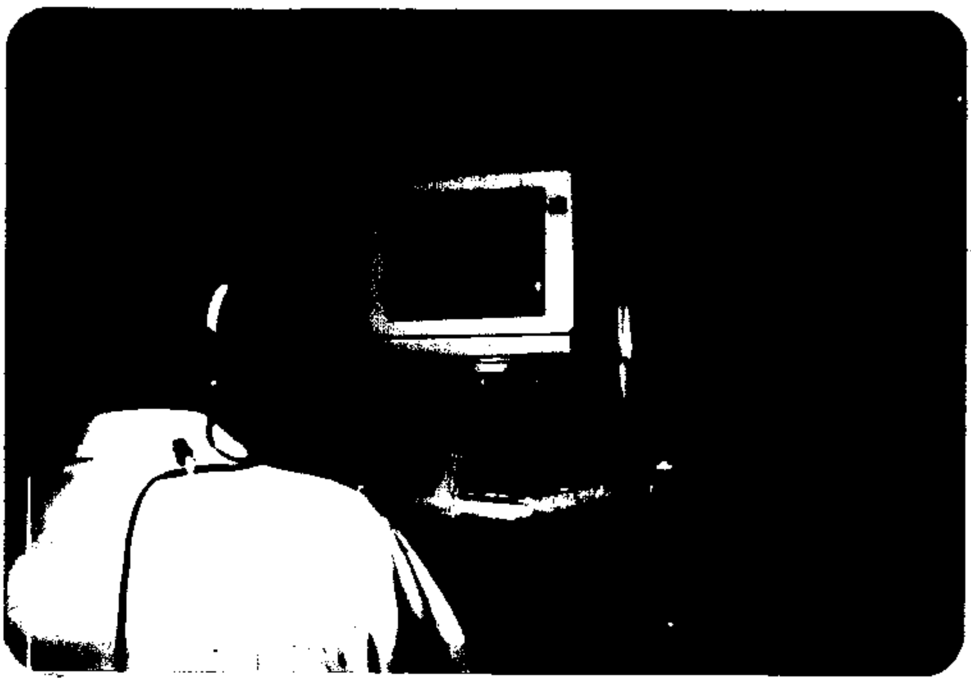
Instrumentation:

The instruments used for the study are as follows:

a) Hearing aid test system (FONIX 6500). This instrument had a built in computerized program and had facilities for automatic testing of the hearing aids.



Photograph-1: Set-up of instruments for coupler measurements.



Photograph–2: Set-up of instruments for Insertion Gain Measurements.

b) ½" test microphone (No.M1550)

c) Standard HA-2 2cc couplers

d) Ear-level hearing aid adapter snaps into the ¼" diameter cavity in the HA-I 2cc coupler.

e) BTE hearing aids

f) Shell and skeleton earmolds.

Inside the hearing aid test box (FONIX 6500) the different connections made were.

The test microphone was kept at the left side of the reference point.

The test microphone was connected to coupler, which was connected to the heating aids by means of an adapter. The hearing aid was given a constant power supply of 1.5 volts.

The test microphone was connected to the HA-1 coupler to which the ear molds werecoupled. To the tip of the tubing of earmold, the ear hook of the behind-the-ear hearing aid was attached.

Procedure:

- <u>Calibration and levelling;</u>

Calibration was done before the instrument was used for the present study. The sound chamber lid was opened and the instrument was kept on for around 30 minutes for allowing the instrument to warm up. The levelling was done using the instructions in the manual, everytime the Instrument was switched on.

Real ear insertion gain measurements:

A probe tube system was used to measure hearing aid insertion gain using different earmolds.

Real ear acoustic gain was calculated from sound pressure level measured in the ear canal with probe tube microphone in unaided and aided conditions at levels well above the ambient room noise by using shell and skeleton earmold.

Here the subj ects were seated in a chair approximately 12" from the loud-speaker of probe tube system. The frequency modulated tone from the loud-speaker was kept at a constant level of 60 dB SPL in the area of the patient's ear as it swept through the test frequencies. The soft rubber tube connected to the probe microphone was inserted into the ear canal. The signal emitted from the loud-speaker was then measured in the ear canal and the resonance curve of the external auditory meatus was determined. The hearing aid with shell mold was then inserted into the ear with the probe tuba placed at the same depth in the ear canal but between the earmold and the canal wall. The sound pressure level relative to the unaided condition was then measured in the ear canal,for different frequencies ranging from 200 Hz to 8000 Hz. The same procedure was used to measure sound pressure level when the skeleton earmold was used with related to the unaided condition. Then the gains measured for the shell and the skeleton earmolds were compared.

Coupler measurements:

The coupler measurements were obtained using the hearing aid directly coupled to the microphone with the help of an adapter and 2cc coupler.

Hearing aid was kept at 'M' position. Volume control of the hearing aid was turned to full-on position and hearing aid microphone kept at reference point. The lid of the hearing aid test box was then closed. IS mode was selected. The screen display of the Max.OSPL 90, HFA OSPL 90, HFA-FOG VALUES, RTG values, EIN, Frequency range F1 and F_2, Harmonic distortion at 500 Hz, 1000 Hg, and 1600 Hz were noted down.

Then the hearing aid was connected to a HA-I coupler by means of day, and the measurements were done in the same way as done for the previous condition.

Then change the earmold to skeleton type and all the above mentioned characteristics of the hearing aid was noted down.

Repeat the same procedure for all the hearing aids. Then compare the characteristics measured between shell and skeleton earmolds,

mm

RESULTS AND DISCUSSION

The aim of the study was to find out if there was any significant difference between the shell and skeleton earmold on the electroacoustic characteristics in coupler and insertion gain measurements of body level hearing aids.

The data was collected based on the methodology given in the previous chapter. The data was tabulated, mean and standard deviation values were computed. These values are shown in Table-I and Table-II.

Statistical analysis was carried out using paired 't' test to investigate for any significant different among the shell and skeleton type earmold for behind-the-ear hearing aids.

Although the graphical representation of mean values using multiple bar diagrams showed difference on several electroacoustic characteristics, none of them were found to be significantly different.

But the results of insertion gain measurements showed a significant difference between shell and skeleton earmolds at 6 KHz and 7 KHz, where the mean values of skeleton earmold

Table-Is Results of paired 't' test for the real ear insertion gain measurements

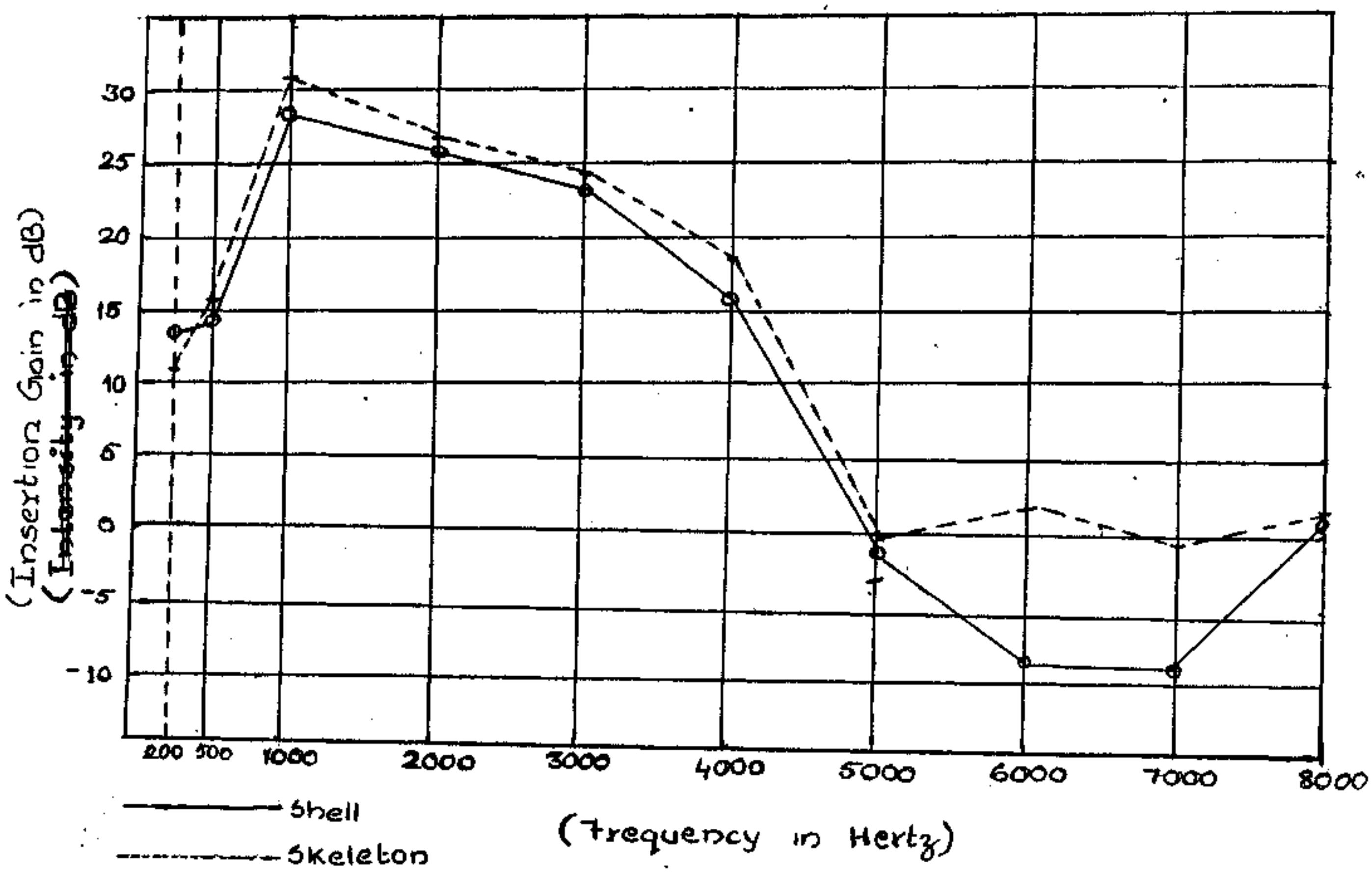
		Frequency in Hz									
		200	500	1000	2000	3000	4000	5000	5000	7000	8000
	Mean	13.87	14.72	29.76	25.32	22.91	15.36	-3.62	-8.43	-8.52	2.06
	S.D.	11.47	9.19	8.77	4.98	11.04	9.85	12.65	12.84	11.88	13.83
	Mean	11.47	15.66	30.4	25.73	24.18	17.75	-2.08	1.03	-1.33	1.13
	S.D.	7.81	7.62	9.38	5.69	9.67	8.08	10.24	12.11	15.10	17.48
t[1] Value		.652	-.419	-.27	-.24	-.493	-.89	-.355	-3.29	-2.17	.119
SD/NSD		NSD	NSD	NSD	NSD	NSD	NSD	NSD	SD	SD	NSD

SD - Significant difference; NSD - No significant difference.

Table-II: Results of paired 't' test for the electroacoustic measurements of gain

	Max OSPL 90	HFA OSPL 90	FOG (Max)	FOG (HFA)	RTG	R.L	P.F	EIN	Frequency range F2	Frequency range F2	Harmonic distortion Frequency(Hz) 500	Harmonic distortion Frequency(Hz) 1000	Harmonic distortion Frequency(Hz) 2000
No mold	126.9	**121.8**	51.41	54.3	43.2	78.7	3.02	34.6	318.6	5411.1	3.27	0.65	**4.48**
SHELL Mean	126.3	**118.82**	45.64	**48.73**	40.37	83.4	2.24	38.16	306.22	5822.66	3.19	**1.38**	5.6
SHELL S.D	2.53	**2.62**	6.86	5.99	2.65	4.92	1.06	16.28	113.17	1675.39	7.42	**1.36**	3.80
SKELTO Mean	124.57	117.76	**44.24**	46.22	39.19	79.9	1.94	35.03	307.22	5666.67	1.33	.933	5.2
SKELTO S.D	4.51	3.64	6.08	5.99	4.87	4.76	1.21	16.74	125.39	1267.87	2.07	.46	3.62
t-value	1.17	.814	.944	1.92	1.24	2.01	.660	1.06	-2.27	.376	.687	.95	2.22
SD/^ISD	NSD	NSD	NSD	NSD	NSD	NSD	NSD	NSD	NSD	NSD	NSD	NSD	NSD

SD-Significant difference: NSD - No significant difference



Graph, (i) Showing the mean values of Insertion *Gain* measurements at different frequencies for both Shell and skeleton ear moulds.

dominates over that of the shell earmold at the two frequencies. And also we see a higher gain for skeleton mold when compared to the shell mold between the frequencies 500 Hz - 8000 Hz(Table-Il).

The significant difference at higher frequencies (6000 Hz and 7000 Hz) for the skeleton earmold could be attributed to the resonance frequency of the concha (at 6000 Hz) which is being exploited by the structure of the shell mold.

For speech,frequencies important are upto 2000 Hz hence shell mold is preferable compared to skeleton molds as this is more durable.

However, we cannot compare these results with previous studies as there are few studies on comparison of shell and skeleton earmolds for the behind-the-ear hearing aids.

SUMMARY AND CONCLUSIONS

An experimental study was conducted in order to find the effect of earmold type (shell and skeleton earmold) on the electroacoustic characteristics of ten behind-the-ear hearing aid and insertion gain measurements of ten subjects who were using behind-the-ear-hearing aid.

The hearing aid test system (FONIX 6500) along with HA-I 2cc coupers were used to do the electroacoustic measurements of all the hearing aids. The parameters taken into account were:

1. Maximum output sound pressure level at 90 dB input (OSPL-90)
2. High frequency overage output sound pressure level at 90 dB input (HFA OSPL-90)
3. Maximum full-on gain (Max FOG)
4. High frequency average full on gain (HFA FOG)
5. Reference test gain (RTG)
6. Total harmonic distortion at 500 Hz.
7. Total harmonic distortion at 1000 Hz.
8. Total harmonic distortion at 1.6 KHz.
9. Equivalent input noise (EIN)
10. Intermodulation distortion at 1 KHz (DF)
11) Low frequency limit of the frequency range (Fl)
12. High frequency limit oE the frequency range (F2)

All the measurements were at the N setting of the tone control.

Same instrument (PONIX 6500) was used to find the insertion gain for shell and skeleton earmolds of behind-the-ear hearing aid users. The insertion gain at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 5000 Hz, 6000 Hz, 7000 Hz, 8000 Hz was tabulated and analysed.

The statistical analysis of the collected data has been done by using paired ' t' test. The following conclusions seem warranted.

1. There is no significant difference in the coupler measurements between the shell and the skeleton molds with respect to electroacoustic characteristics of the B.T.E. hearing aids.
2, There is no significant difference between the shell and skeleton earmolds except for the frequencies 6 KHz and 7 KHz in the insertion gain measurements of the BTE hearing aid users, where the skeleton mold predominates over shell mold at the two frequencies. This could be therefore of the resonance of concha which is at higher frequency and this is affected more with shell molds.

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