Speech Discrimination And Impedance Audiometry In Stapedectomized Patients

LALITHA

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR
IV SEMESTER M.Sc. IN SPEECH AND HEARING
OF THE
UNIVERSITY OF MYSORE, KARNATAKA
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Dedicated to
my beloved parents

CERTIFICATE

This is to certify that the dissertation "Speech discrimination and Impedance audiometry in Stapedectomized patients" is the bona-fide work in part fulfilment for IV Semester M.Sc., in Speech and Hearing, of the student with Register No.5

Director
A.I.I.S.H.,
Mysore.

CERTIFICATE

This is to certify that this dissertation has been prepared under my supervision and guidance.

(M.V.SUSHEELA)
Guide.
27.7.79

DECLARATION

This dissertation is the result of my own study undertaken under the guidance of Dr.(Miss) M.V.Susheela, Reader in E.N.T., All India Institute of Speech and Hearing, and has not been submitted earlier at any university for any other diploma or degree.

LALITHA.

Register No.5

Mysore
Date:

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CHAPTER I
INTRODUCTION

Deafness refers to any significant impairment of hearing sensitivity which is of short to long duration. This definition rests on the presence of reduced sensitivity than on the conditions that give rise to the reduction and implies that some forms of deafness can ben temporary (Guliek, 1971).

Deafness has been classified in many ways depending upon the severity, site, duration, aim, philosphy of rehabilitation and so on. Medically and audiologically, it has been classified into three main groups, viz., conductive impairment, sensori-neural impairment and other hearing disorders.

(1) When the loss of hearing function is due to pathos logy in the inner ear, or along the nerve pathway from the inner ear to the brain stem, the loss is referred to as a sensori-neural impairment.

(2) Mixed impairmenta(both conductive and sensori-neural), central deafness, and functional or non-organic hearing loss are grouped under the classification- other hearing disorders.

(3) Any dysfunction of the outer or middle ear in

the presence of a normal inner ear is termed as conductive impairment of hearing. In other words, the difficulty is not with the perception of sound but with the conduction of sound to the analyzing system(Newby, 1972).

Otosclerosis is one of the several etiological factors which leads to conductive deafness. Otosclerosis is an abnormal growth of soft, spongy immature bone, replacing the hard, natural, mature bone, usually in the area of the anterior margin of the oval window. It produces a progressive hearing loss through the fixation, or ankylosis, of the stapes in the oval window, owing to the invasion by the spongy bone. Actually, otosclerosis is a misnomer for this condition, since 'sclerosis' means 'hardening'. Some authorities have proposed the term 'otospongiosis' as being more descriptive of the disease process.

Factors responsible for the formation of the otosclerotic bone are not known, but the tendency is known to be inherited. It is found to affect females more often than males. Commonly the onset is between the ages of 20-30 years and very rarely observed before 10 years of age (Paparella and Shumriek, 1973; Ballenger, 1977). Hormonal changes, local factors, constitutional factors, vascular and vasomotor factors have been related to the onset and progress of the disease. Studies indicate that it is a mono-hybrid autosomal inheritance with a penetrance of 40-50%(Ballenger, 1977).

Otosclerotic foci have been noticed in all portions of the labyrinthine capsule. Mostly the focus occurs anterior to the stapes footplate in the region of fissula ante fenstram - "the site of predilection." The next most frequently involved site is the border of the round window(McLay, 1957; Nager, 1969). In most of the cases there is a single focus, and in the rest two or more foci (Paparella and Shumrick, 1973; Ballanger, 1977).

Generally, the otosclerotic focus consists of irregular areas of new bone formation with many vascular channels occurring on and within the dense bone of the labyrinthine capsule. The borders of the lesion are sharply defined but irregular, with projections along the vessels of the surrounding normal capaular bone. A border of blue-staining bone (with hematoxylin-eosin) is seen around a few of the vascular channels in the focus. These are called "blue mantles" which are typical of the otosclerotic lesion.

Otosclerosis has its onset in early adult lift, although the hearing loss may be ignored until Middle age. Hearing deficit is progressive in nature. Onset or rapid progression is reported by female patients during or shortly after pregnancy. Although the hearing loss may be quite severe, speech discrimination is preserved. In case of cochlear otosclerosis, where there is inner ear involvement, speech discrimination may range from 50-80% depending on the severity of the problem.

Patients report of paracusis willisiana (i.e., hearing is better in noisy environment than in quiet). Tinnitus of low frequency type is frequently reported. A positive family history of hearing loss occurring in early adult or middle age may be obtained.

Otoscopic examination reveals a normal tympanic membrane. In some cases, it is lustreless and pinkish in appearance. This pinkish flush is called the Schwartz sign which is probably due to reflection from the highly vascular bone on the promontory of the oval window (Morrison, 1971). The Eustachian tube is patent (Birrell, 1977).

If stapedial otosclerosis is present, the following results may be anticipated when 256 or 512 Hz tuning forks are used:

Rinne negative, (BC better than AC)

Weber - lateralized to the ear which has more conductive problem.

ABC (Absolute bone conduction) - normal or near normal(Prescod,1978).

Bezold's symptom-complex, or triad, constitues the classic picture of otosclerosis:

(1) Low frequency air-conduction hearing loss;

(2) Increase of bone conduction as tested with the meatus of the patient and of a normal person not occluded;

(3) Rinne's test is negative (Stewart et al., 1968).

Differential audiology is crucial for the purpose of proper assessment and management of otosclerosis. Carhart(1964) has shown that the first symptom of ote-sclerosis is the appearance of a low-frequency air-bone gap. A reversible bone-conduction hearing loss called Carhart's notch ia seen. This notch was found to be at 2 KHz (Kacker, 1978). The hearing loss is progressive in nature. When the stapes has become completely fixed, there will be a reduction of sensitivity in the high frequencies, thus flattening the audiogram. The loss ia often bilateral and symmetrical.

Speech discrimination Score varies depending on the extent of cochlear involvement. With pure stapedial oto-sclerosis, the speech discrimination score is often excellent from 88-100% (Prescod, 1978).

A substantially reduced compliance and increased resistance are observed in impedance audiometric results of otosclerotics. The acoustic reflex disappears early in otpsclerosis, even in unilateral cases. A shallow type, i.e.,As type of tympanogram was obtained in majority of otoselerotics(Jerger, 1970; Kulkarni, 1975; 1977).

Once the growth process has started it is difficult to stop its progress by medication. However, there are reports of intriguing success of growth arrest with the use of sodium fluoride treatment(Shambaugh and Scott, 1964). Overdosage of sodium fluoride may cause numerous side effects, such as, gastric irritation with fatal consequenece(Morrison, 1971).

Therefore, surgical approach is the one generally followed by surgeons to restore the hearing function mainly. There are three surgical procedures for oto-selerosis, viz., stapes mobilization, stapedectomy and fanestration. Out of these, stapedectomy is mostly followed because of its various advantages.

Post-operative audiometric findings of stapedec-tomy have shown closure of air bone gap in almost all cases(Rosenberg, 1959; Monour et al., 1963; Cody, et a1., 1967; Owens et al., 1972). Studies have shown that typical Carhart's notch, found in bone conduction thresholds, disappeared following stapedectomy(Carhart,1950; Wood, 1950; Causse et al., 1974; Kacker, 1978; Prescod, 1978). There have also been reports that there is a slight high frequency loss in pure tone audiogram after surgery. This has been attributed to the surgical trauma (Rosanberg, 1959; Antoli-Candela, 1969; Ballantyne, 1976).

Comparisons by pure bone testing before and after surgery are not qualitative unless they are validatad by equal results in speech tests. The essential question is how well the patient hears and understands speech. The great damage to the cochlea is reflected in the area of speech discrimination. Studies have shown that speech discrimination is either found to be reduced or remain same after the operation (Rosenberg, 1959; Shaehy, 1962; Monour et al., 1963; Oppenheimer et al., 1963; Guilford, 1964; Cody et al., 1965; Ginsberg, 1965; Robinson, 1967; Hardick et al., 1969; McGee, 1969; Kos, 1969; Cody, 1971; Owens et al., 1972; Sooy et al., 1973).

The reduction in apeech discrimination score post-operatively may be due to one or more of the following reasons:

(1) Postoperative high frequency hearing loss (Rosenberg, 1959; Schuknecht, 1962; Robinson, 1967; Ballantyne, 1969) which may be due to revision stapes operations (Sheehy et al., 1962; Shambaugh, 1963; Shea, 1963; Cody et al, 1967; Cody, 1971), or type of prosthesis used (Guilford, 1964; Antoli-Candela, 1969; Kos, 1969; Sooy et al., 1973), or labyrinthine infection (Cody et al., 1967).

(2) Mode of presentation of the speech material, i.e., recorded versus monitored live voice (Portmann et al., 1961; Carhart, 1965; Brandy, 1969).

(3) Type of speech material used (Travis and Ramus, 1931; Mase, 1946; Templin, 1957; Perozzi, 1969; Schwartz, 1974).

(4) Familiarity of the list used (Oyer and Doudna, 1960; Owens, 1961; 1964; Schwartz, 1974).

Robinson (1967), Hardick et al.,(1969), Owens et al., (1972) and many others have shown that there is a speech discrimination loss following stapes surgery even after the closure of air bone gap by elevating the air conduction thresholds.

In India, no study has been reported regarding the speech discrimination following stapes surgery. From clinical experience, it haa been observed that majority of patients report "better discrimination" after surgery, which is in contradiction with the experimental evidences available in the literature when speech discrimination ia considered.

Thus the present study was undertaken to find out the postoperative speech discrimination in relation to pure tone audiometric findings, and to compare them with that of preoperative ones.

Since the literature lacks the information regarding the postoperative impedance findings for stapedectomized cases, the present study also includes a comparison of pre- and post-operative impedance audiometric findings.

The objectives of the study were to verify the following hypotheses:

(1) There is no significant difference between the speech discrimination scores preoperatively and one-week postoperatively.

(2) There is no significant difference between the speech discrimination scores preoperatively and 3 - months postoperatively.

(3) There is no significant difference between the speach discrimination scores one-week and 3-months postoperatively.

(4) There is no significant relationship between the subjective opinion of the subjects about the change in speech discrimination ability and the change in the objectively obtained discrimination scores, one-week and 3-months postoperatively.

(5) There is no significant relationship between the change in speech discrimination score(both in amount and direction) and the change in AC slope, following stapedectomy.

(6) There is no significant difference between preoperative and 3-month postoperative impedance audiometric findings.

Brief plan of the study:

The study consists of mainly two parts. In the first part, pre-operative and one-week postoperative audiometric (pure tone, speech, and impedance) results were collected from the A.I.I.S.H. case files of surgically confirmed otosclerotic cases.

In the second part, those operated otosclerotics were called for a 3-month postoperative re-evaluation. Post-operative history and subjective impression regarding the success of surgery were collected by using a questionnaire. Later, they were subjected to pure-tone, speeeh and impedance audiometrix evaluation.

Definitions of the terms used:

Speech reception threshold(SRT) - by spondees is defined as the hearing level at which the patient can repeat 50% of the words correctly.

Speech discrimination score - is the percentage of test items a person can identify correctly by ear(Carhart,1965).

Tympanogram:- is the graph shwoing pressure-compliance relationship of the middle ear.

Static compliance - is that compliance which results from the volume displacement per unit pressure(Kulkarni,1975).

Acoustic reflex threshold - is the intensity in dBs above the threshold of simulated ear which is just capable of inducing a reflex contraction of stapedial muscle as induced by compliance change in the impedance of tympanic membrane.

AC slope - Air condaction slope is dB/octave

$$= \frac{(HL_{1\ Kc/S} - HL_{0.5\ Kc/s}) + (HL_{2\ KC/S} - HL_{1\ KC/S})}{2}$$

<u>Carhart notch</u> - is the depression in bone conduction curve particularly at 2 KHz seen preoperatively in otosclerotic patients whose cochlear function is actually unimpaired.

CHAPTER II
REVIEW OF LITERATURE

Conduction, obstruction, or impedance deafness refers to hearing impairments caused by conditions in the outer ear or middle ear cleft which interferes with the passage of sound waves to the inner ear (Levine, 1960).

Brief anatomy of external and middle ear:

The external ear is that portion of the ear, external to the tympanic membrane. It consists of the auricle (or pinna) and the passage leading to the tympanic membrane, called the external auditory canal (or meatus).

The external auditory canal is formed in its outer one-third by an extension of the cartilage of the auricle and in its inner two-thirds by the tympanic and squamous portion of the temporal bone. It is bounded medially by the tympanic membrane.

The external auditory canal is about 2.5cm. in length in the adult, from the bottom of the concha to the tympanic membrane. The canal runs a tortuous S-shaped course, its general direction being inwards and slightly upwards and backwards in the outer cartilaginous part; inwards and slightly downwards and forwards in the bony part. This curvature serves as a protection to the tympanic membrane.

The tympanic membrane is composed of three layers, the squamous layer continuous with the skin of the external ear medially, the mucosal layer bounding the middle ear laterally, and the fibrous layer lying between. The fibrous layer is composed of both circumferential and radial fibers and gives the tympanic membrane its shape and consistency. The radial fibers insert into the periosteum of the malleus handle and into the fibrous annulus creating the functionally significant conical shape.

The most prominent landmark in the tympanic membrane is the manubrium (handle) of the malleus whose superior limit is marked by the lateral or short process. The manubrium ends at the apex or umbo of the tympanic membrane. The tympanic ring is incomplete superiorly, and the fibrous layer is bounded by the anterior and posterior mallear folds. The segment of tympanic membrane superior to the mallear folds and bounded by the Rivinian notch is called pars flaccida. The larger, inferior portion is called the pars tensa of the tympanic membrane.

The middle ear cleft consists of the eustachian tube, the tympanic (middle ear) cavity, the aditus ad antrum, the mastoid antrum and the pneumatic systems of the temporal bone.

The eustachian tube is about 3.75cm. long in the average adult. Its lower opening is in the lateral wall of the nasopharynx and its upper opening is in the anterior wall of the tympanic cavity.

The middle ear (tympanic) cavity lies between the external and inner ears. The cavity has lateral and medial walls, a roof and a floor, and anterior and posterior walls.

The lateral wall consists mainly of the tympanic membrane, and partly of bone above and below the membrane.

The medial wall is readily distinguished by the presence of the promontory, a smooth rounded bony projection covering the basal turn of the cochlea.

The fenestra ovale (oval window, discovered by Ingrassia, 1546), lies above and slightly behind the promontory. The niche of the oval window measures 2.5mm. by 1.2mm. and has a depth of 3mm. It opens into the vestibule of the inner ear and is closed in life by the footplate of the stapes and its annular ligament.

The fenestra rotunda (round window, discovered by Ingrassia, 1546), lies below and behind the promontory. It opens into the scala tympani of the basal turn of the cochlea and is closed in life by the secondary tympanic membrane.

The anterior wall presents four openings, which are, from above downwards: (1) The small ofifice of the canal of Huguier, through which the chorda tympani escapes from the middle ear. (2) The canal for the tensor tympani muscle. (3) The tympanic orifice of the eustachian tube. (4) The glaserian fissure, containing the tympanic artery and the anterior ligament of the malleus.

The posterior wall presents an opening (the aditus ad antrum) which leads from the epitympanum into the mastoid antrum. Below this is the pyramid, a small, hollow conical projection through which emerges the tendon of the stapedius muscle, which passes forwards to be inserted into the neck of the stapes.

Besides air, which fills the middle ear cavity, it contains: (1) the auditory ossicles; (2) two muscles; (3) the chorda tympani nerve; and (4) the tympanic plexus of nerves.

The auditory ossicles form a system of bony levers and columns which transmits vibratory mechanical energy to the periotic fluid. The system consists of the malleus (hammer), the incus (anvil) and the stapes (stirrup).

The stapes, discovered by Ingrassia in 1546, is the smallest bone in the body. It has a head and a neck; anterior and posterior crura; and a footplate which is held in the oval window by the annular ligament. The stapedius tendon is inserted into the posterior surface of the neck.

The superior margin of the footplate is convex, whereas the inferior margin is relatively straight, occasionally concave, thus giving the base a reniform outline.

The anterior crus is usually more slender and straighter than the posterior crus.

The intratympanic muscles are (1) the tensor tympani muscle and (2) the stapedius muscle.

The tensor tympani muscle, described by Eustachius in 1562, arises mainly from the bony tunnel above the osseous part of the tube and passes backwards and laterally through this tunnel. In the middle ear cavity, its tendon turns at right angles around the processus cochleariformis and passes laterally, to be inserted into the medial surface of the malleus, just below its neck.

The stapedius, described by Varolius in 1575, is a relatively short, bulky muscle. It occupies the pyramid and the canal which curves downwards from it. Its tendon enters the tympanic cavity through the aperture on the summit of the pyramid and is inserted into the back of the neck of the stapes. It is supplied by a branch of the seventh cranial nerve, and its contraction pulls the stapes posteriorly and slightly outwards, around a pivot at the posterior end of the footplate.

Physiology of sound conduction:

The wound conducting mechanism extends from the pinna to the organ of Corti. The pinna functions as a sound collector, intercepting sound energy and deflecting it into the auditory canal. The auditory canal permits the air-borne sound waves to reach the tympanic membrane.

As the fluids of the inner ear offer much greater acoustic impedance than does the tympanic membrane and middle ear system, one of the functions of the lighter tympanic membrane and middle ear mechanism must be to overcome this impedance difference.

In the intact middle ear a considerable degree of impedance matching is brought about, so that, while the amplitude is greatly reduced at the oval window as compared with amplitude at the tympanic membrane, the force of the vibrations at the oval window is increased in the same proportion. This effect depends on: (1) the ossicular chain lever ratio and (2) the areal ratio of the tympanic membrane and the oval window. If there is a mismatch between the specific acoustic resistances of air and fluid (in the inner ear), then there will be a loss of 30dB.

Stapes fixation:

Reduced mobility of the stapes due to disease results in increased stiffness and increased frictional resistance at the oval window. According to the severity of the condition, the transformer mechanism will be impaired. At 30dB hearing loss the transformer effect is lost altogether. Provided that some portion of the annular ligament remains flexible reciprocal cochlear fluid movement can take place. But now the aerotympanic route and the round window membrane become the principal avenues far sound conduction. When the total fixation occurs involving the whole of the annular ligament as well as the footplate, reciprocal vibration of the cochlear fluid columns is gravely limited even though the round window membrane remains normal. Residual hearing for air-conducted sound probably now depends upon the compressibility of the inner ear blood vessels.

If compressional mechanism of bone conduction is operating, fixation of the oval window will not affect the hearing by bone conduction.

Otosclerosis is one such disease wherein the stapes is fixed. Otosclerosis is a common hereditary localized disease of the bone peculiar to the otic capsule. Mature lamellar bone is replaced by unorganized woven bone of greater thickness, cellularity and vascularity, in otosclerosis. An otosclerotic focus may cause no symptoms and its presence may be detected by post-mortem histological examination(called 'histological' otosclerosis); or it may replace the footplate of the stapes causing progressive osseous ankylosis and conductive deafness (called 'clinical' otosclerosis); or it may involve other parts of the labyrinthine capsule giving rise to sensorineural changes, both cochlear and vestibular (called 'cochlear' otosclerosis); or it may produce a combination of these effects.(Morrison, 1971)

History:

In 1683, Du Verney described conductive deafness in the presence of a normal tympanic membrane, and in 1704, Valsalva related deafness to stapedial ankylosis. The occurrence of progressive deafness in non-suppurating ears of young adults was described by Pilcher in 1838, and the familial nature of the disease was noted by Toynbee in 1824, and Magnus in 1876 (Schuknecht et al., 1974). Magnus, in 1876, gave an early description of the macroscopic pathology (Morrison, 1971).

The word 'otosclerosis', coined by von Troltsch in 1881, was in the mistaken notion that sclerosing changes in the tympanic mucosa caused fixation of the stapes. When Politzer in 1893 demonstrated that this was not so, and that a primary disease of the labyrinthine capsule caused ankylosis of the stapes, the name otosclerosis should have been abandoned. Siebenmann in 1912 proposed the far better name of otospongiosis noting that the focus of new bone that fixes the stapes is more porous and less dense than the ivory hard normal capsule that it replaces (Shambaugh Jr., 1973).

The first microscopic proof of stapes ankylosis diagnosed during life has been credited to Katz in 1890. Haberman, in 1894, first demonstrated that more than one focus may occur (Lindsay, 1973).

Passow in 1897 reported the first operation (fenestration) for otosclerosis in which the fixed stapes was bypassed by drilling a hole into the promontory. Stapes mobilization was first employed by Kessel in 1878. Holmgren in 1917 introduced the use of the operating microscope in otosclerosis surgery. Stapedectomy in a fenestrated ear was originated by Schuknecht and popularized by Sheehy. John Shea in 1956 revised the stapedectomy operation for otosclerosis and replaced the stapes bone with a polyethylene tube prosthesis and vein graft (Lindsay, 1973).

Pathology: Sites of Development:

The petrous part of the temporal bone, which incorporates the otic capsule, is considered as the hardest bone in the body and consists of three layers: (1) an outer periosteal layer; (2) a middle endochondral layer which contains a number of fibro-cartilaginous nests; (3) a thin endosteal layer.

The areas of residual cartilage are the sites of origin of otoslcerotic foci and most important of these is the fissula ante fenestram, a slit of fibro-cartilage, found only in man, passing through the whole thickness of the otic capsule from the vestibule of the middle ear, anterior to the oval window and posterior to the processus cochleariformis (Bast and Anson, 1949). The next most frequently involved sites are fissula post fenestram (Morrison, 1971); border of the round window (McLay,1957; Nager, 1969; Morrison, 1971); rarely the infracochlear region below the internal auditory meatus and the areas of otic capsule surrounding the semi-circular canals (Morrison, 1971), and the footplate of the stapes itself (Guild, 1944; Nylen, 1949).

Histopathology:

The mature lamellar bone, in what is sometimes called the active phase of otosclerosis, is replaced by immature bone of increased thickness, vascularity and cellularity. In the histologically quiescent phase there is an attempt at organization into Haversian systems but the bone remins greatly thickened and cellular. When involving the stapes the 'healing process' probably increases the ankylosis.

Clarke(1969) used scanning electron-microscopy and demonstrated microscopic osteophytes and crystal-like projections on the vestibular surface of otosclerotic footplates.

Macroscopic pathology:

Stapedial ankylosis arises from any focus involving the footplate, annular ligament and adjoining otic capsule. Later the focus spreads to the crura and gradually the oval window. Morrison (1971) observed four stages in the development of stapedial otosclerosis:

Stage 1: is seen as a thin growth limited to at least half of the footplate.

Stage 2: the growth extends to the whole footplate but can still be removed.

Stage 3: there is a marked thickening around the footplate, but the footplate itself and the margin of the oval window niche is still discernible.

Stage 4: in this final stage the bony growth covers the entire area of the crura completely obliterating the otic capsule. It was at this stage that complete ankylosis of the footplate in the oval window occurs (Prescod, 1978).

Generalized otosclerosis of the otic capsule might also involve the spiral ganglia or compress the contents of the internal auditory meatus. For sensorineural loss to occur the otosclerotic focus must spread to involve the endosteal layer of the otic capsule adjacent to the spiral ligament. Vascular shunts develop between the vessels of the spiral ligament and the vascular otosclerotic bone, and these in turn lead to degenerative changes in the spiral ligament, stria vascularis and hair cells.

The explanation of these changes is still uncertain; they could result from vascular stasis and anoxia, from abnormal toxic metabolites entering the perilymph and endolymph; or from alteration of electrolytes leading to changes in the electrical potentials (Morrison, 1971).

Race, sex and incidence:

Otosclerosis has only been demonstrated in homo sapiens (Morrison, 1971) and it does not exist in animals (Sercer and Krmpotic, 1966).

It is rare in Negroes and uncommon in Chinese and Japanese. It is very common in Indians and Whites. Higher incidenoe is seen in Jews (Friedmann, 1974).

Otosclerosis was found to be 2.1 times as common in Caucasians as in the Japanese (Joseph and Frazer, 1964).

It ia very common throughout Europe, the Middle East and India, Caucasian people of North and South America, Australia, New Zealand, South Africa and elsewhere. It is relatively rare in mongoloids and negroid man (Morrison, 1971).

It is more common in females; microscopical incidence of otosclerosis in routine postmortems is about one in 8 middle-aged white females, and one in 15 adult white males (Guild, 1944). The female sexual life stages seem remarkably associated with the disease. It has been noted that during such periods as puberty, pregnancy, childbirth and menopause, there is a marked increase in the occurrence of the disease among females (Prescod, 1978).

Age:

The disease commonly occurs between the ages of 20 and 30 years (Lindsay, 1973; Ballenger, 1977; Prescod, 1978). It is rare before the age of 10 years (Shambaugh, 1961; Prescod, 1978). Majority of cases are seen between the ages of 15 and 45 years, with the peak in the third decade (Shambaugh, 1961; Morrison, 1971). The age of onset is the same for males and females.

Mode of inheritance:

In majority of families the evidence is in favor of an autosomal dominant inheritance. Most thorough family studies indicate that otosclerosis is a monohybrid autosomal dominant inheritance with a penetrance of 40-50% (Ballenger, 1969).

Cochlear otosclerosis, either without stapedial involvement or with minimal fixation also follows a dominant hereditary pattern. Pure cochlear otosclerosis is rarely encountered in families whose other members all have clinical stapedial otosclerosis, yet it does occur in 2% of families investigated. Combined stapedial and cochlear otosalerosis is a common familial phenomenon (Morrison, 1971).

Progression of deafness:

Morrison (1967) has shown that the disease may progress more rapidly in females in the first 20 years.

Shambaugh(1963)) from his extensive experience, considers that both stapedial and cochlear otosclerosis do not progress inexorably in all cases. Of his patients with untreated stapedial disease 96% showed no increase in conductive deafness over 10 - 23 years, and 27% showed no progression of sensorineural loss but three-quarters did show a progressive sensory deafness.

In cases with malignant otosclerosis, the onset is usually in adolescence, the progression rapid, the

Schwartze sign positive, the sensori-neural involvement severe within a few years, and the family history similar (Morrison, 1971).

Clinical features:

A detailed history is the first step in examination, and this should include enquiry about the age of onset of deafness, its rate of progression, the degree of social and occupational handicap, if relevant the influence of pregnancy, the presence or absence of vertigo or tinnitus, the presence of paracusis willisiana, and family history of hearing loss.

The patient with otosclerosis usually experiences persistent tinnitus (Ginsberg et al., 1975; Prescod, 1978). It is usually a low frequency conductive type frequently accompanied by an audible pulse. Occasionally it is a high pitched ringing most often correlated with the presence of a high tone cochlear dysfunction(Ballenger,1969).

The patient may be able to hear better in a noisy environment than in quiet which is known as 'paracusis willisiana'. The patient often has a quiet voice of good tone. If sensorineural loss supervenes, paracusis usually disappears but the relatively quiet voice may persist even in patients with marked combined otosclerosis (Morrison,1971).

A positive family history of hearing loss occurring in early adult or middle age may be obtained in 50-60% of the cases. (Ballenger, 1969)

Otoscopic examination will generally reveal a tympanic membrane which is essentially normal and sometimes it is lustreless and occasionally it is pinkish in appearance. This pinkish flush is called the Schwartz sign which is probably due to reflection from vascular bone on the promontory of the oval window (Morrison, 1971). The eustachian tube is patent (Lindsay, 1973).

In pure stapedial otosclerosis, tuning fork tests reveal the following results!(1) Rinne test is negative; (2) in unilateral or asymmetrical deafness the Weber is lateralized to the poorer side; (3) Absolute bone conduction test is normal. In pure cochlear otosclerosis, (1) the Rinne is positive; (2) the Weber is lateralized to the better ear; (3) the absolute bone conduction is reduced (Morrison, 1971; Prescod, 1978).

Bezold, in 1885, observed the immobility of the stapes macroscopically and manometrically in a patient in whom, during life, the characteristic tuning fork findings had been a negative Rinne test, elevation of the lower tone limit and prolonged bone conduction, along with a normal eardrum and eustachian tube. These findings were afterward known as the "Bezold triad" (Stewart et al.,1968; Lindsay,1973).

In Gelle test, the loudness of a bone-conducted tone is assessed in relation to an increase of air pressure in the ear canal. Normal-hearing subjects; with mobile stapes will experience a decrease of loudness when the air pressure increases. In cases with stapes fixation as well as in cases with disruption of the ossicular chain, no such change in loudness takes place (Liden, 1972).

Pure tone audiometry:

Differential audiology is crucial for the purpose of proper assessment and management of otosclerosis.

In the pathogenesis of otosclerosis, as a typical anterosuperior lesion increases the stiffness of the stapediovestibular joint, there is a progressive increase in threshold for low frequencies, and a 'stiffness tilt' is seen in the pure-tone air-conduction audiogram, as a drop in the low-frequency hearing level (Fowler, 1945; Goodhill, 1971). As the disease progresses, the footplate becomes completely fixed and the increased mass of the otosclerotic footplate introduces a 'mass tilt' to the air-conduction pure tone level. Thus there will be a lowering of the high frequency hearing level which leads to straightening out of the total air-conduction level line. In the next stage, frictional elements enter into the picture and leads to a drop in the high-frequency air-conduction hearing level and an increasing drop in hearing level throughout the range at all frequencies. In few patients, superimposition of a cochlear otosclerotic lesion (moat usually at the basal turn of the cachlea) adds a further high-frequency component by both bone conduction and air-conduction (Goodhill, 1971).

Campbell(195O) has stated that 'hearing for the higher frequencies might be even better than normal.'

Carhart(1964) has found that alterations in the inertia of the ossicular chain produced by even partial fixation, changes the normal bone-conduction response. This artifact varies significantly from patient to patient, but on the average it causes the bone-conduction readings to appear poorer than the true sensori-neural sensitivity by 5dB at 500Hz., 10dB at 1000Hz., 15dB at 2000Hz., and 5dB at 4000Hz, This anomaly of bone-conduction is called the Carhart's notch. This notch is reversible.

The most popularly accepted theory for this phenomenon is that sound energy causes the skull to vibrate totally, along with other structures within the head such as the ossicles and the tympanic membrane. These in turn enhance the bone conducted sound transmission reaching the cochlea. If there is stapes fixation, then the contribution by bone conduction is greatly reduced giving rise to the notch at 2000Hz; i.e., due to the fixation of stapes, an absolute bone conduction is obtained. The release of the stapedo-vestibular otosclerotic block as a result of operation reverts the condition to relative bone conduction, which explains the disappearance of the Carhart notch. However, it is not clear why 2000Hz is more affected than the other frequencies (Causse et al., 1975; Prescod, 1978).

Naunton and Valvassori(1972) have proposed a formula for calculating the value of the Carhart notch, which is as follows:

$$\text{Notch value} = 2Kc \quad \frac{1.0Kc + 4.0Kc}{2}\ \text{dB},$$

where 1.0, 2.0, and 4.0Kc refer to the bone conduction hearing losses present at each of these test tone frequencies.

In the early stages, pure-tone audiometric configuration is basically a conductive loss. As the disease progresses and involves the cochlea, there will be mixed loss (Morrison, 1971; Prescod, 1978). The loss is often bilateral and symmetrical (Carhart, 1962; Prescod, 1978).

Farrior(195S) has found out various types of audiograms associated with different locations of otosclerosls.

"Anterior footplate and anterior crural otosclerosis tend to present a flat or ascending air conduction audiographic curve with nearly normal bone conduction. As the fixation of the footplate progresses, the Carhart notch develops. Loss of high tones indicates complete footplate fixation. Flat curves are also noticed in complete footplate fixation. But the flat curve persists only so long as good strong free crura are transmitting vibrations to the fixed footplate. When the sides of both crura are transmitting vibrations to the fixed footplate, a flat curve persists. When the sides of both crura become fixed and the crus is no longer capable of transmitting to the footplate, then there is loss of the high tones (2000, 4000, and 8000) and progression of the Carhart notch, with diminution of the air bone gap at 2000. This has occurred when crural fixation was associated with complete footplate fixation. More important, this high tone loss has occurred in combined marginal and bicrural otosclerosis when the opposite half of the footplate was a perfectly normal translucent blue; that is, incomplete footplate fixation but complete loss of crural transmission."

"The patients with combined oval and round window closure have been severely deaf and audiometrically have shown only a little residual air conduction and bone conduction for the lower frequencies. However, such an audiogram does not always indicate round window closure."

Speech Audiometry:

Speech discrimination testing, which might vary considerably, is dependent on the extent of auditory involvement. With pure stapedial otosclerosis, the speech discrimination score is often excellent from 90-100% (Morrison, 1971; Prescod, 1978). With pure cochlear otosclerosis, it is 80-90% in moderate deafness; 50-80% in more severe cases and 0-30% in subtotal loss. In combined stapedial and cochlear otosclerosis, poor speech discrimination is seen (Morrison, 1971).

Sanders(1965) found that patients with cochlear otosclerosis usually had good speech discrimination.

Bone conduction speech discrimination test score was found to be a better predictor of cochlear function than air conduction discrimination test score (Robinson and Kasden, 1970).

Special hearing tests:

In pure stapedial otosclerosis, the Bekesy is Type I (where there is an interweaving of interrupted and continuous thresholds throughout the audiogram, and the tracking amplitude usually averages 10dB; such audiograms typify normal hearing and lesions of the middle ear); tone decay is absent or minimal; the SISI score is low (0-10%); loudness discomfort levels cannot be obtained; and in unilateral deafness there is no recruitment on binaural loudness balance. The reflex is not elicited.

In pure cochlear otosclerosis, the Bekesy is usually Type II (where there is separation of the continuous from interrupted around 1000Hz and the continuous threshold travels parallel to the high frequency end of the audiogram, and the separation usually does not exceed 20dB; such audiogram is characteristic of cochlear pathology); there is moderate tone decay of upto 20dB at the frequencies involved; the SISI score is high (60 - 100%); loudness discomfort may be present at 100-110dB with affected frequencies; and in unilateral cases full recruitment is present (Sanders, 1965; Morrison, 1971). Stapedial reflex is present.

In combined stapedial and cochlear otosclerosis, the Bekesy is Type III, there is marked tone decay of upto 45dB; the SISI score is low at some frequencies, and the results are variable on the loudness balance (Morrison, 1971).

Gunnar Liden(1972) hag included the sound probe test as a test for stapes fixation. The sound probe test is carried out by placing the probe first on the umbo and then on the meatus. The probe, with its bone vibrator, is connected to the bone conduction output of the audiometer and the frequencies 500 to 2000Hz are used. In stapes fixation, hearing ia better on the umbo than on the osseous meatus.

Impedance audiometry:

The diagnostic information from the acoustic impedance measurement goes considerably beyond that which can be derived from otoscopic examination and routine audiologic tests.

Impedance audiometry has four parameters:

(1) Tympanometry: The graph showing pressure-compliance relationship of the middle ear is known as tympanogram.

(2) Static compliance: is that compliance which results from the volume displacement per unit pressure.

(3) Acoustic impedance: is the resistance offered to sound and is measured in acoustic ohms.

(4)Acoustic reflex threshold: is the intensity in dBs above the threshold of stimulated ear which is just capable of inducing a reflex contraction of stapedial muscle as induced by compliance change in the impedance of the tympanic membrane.

> "If the compliance at Omm. pressure is lower than normal but the configuration of the curve is similar to the normal tympanogram, and the static compliance is on the stiff side and the absolute impedance is greater than 4000 acoustic ohms, then the curve is indicative of otosclerosis of tympanosclerosis, classified as A type tympanogram."
>
> (Kulkarni, 1975)

Studies have shown absence of stapedial reflex in otosclerotics (Burke et al., 1970; Kulkarni, 1977). Reduction of compliance has been observed (Zwislocki, 1963, 1968; Feldman and Zwislocki, 1965). Resistance is somewhat increased due to a reduction of energy transmitted to the cochlea, resulting from fixation of the footplate (Feldman, 1963; Feldman and Zwislocki,1965; Burke and Nilges, 1970). Tensor tympani muscle reflex is present (Liden, 1972).

Treatment:

Majority of patients with otosclerotic deafness can be managed by either surgical or non-surgical methods, and even those with total or subtotal deafness can be given some support and guidance.

Since surgery is not helpful in the management of pure cochlear otosclerosis, Shambaugh and Scott(1964) suggested oral therapy with sodium fluoride in an attempt to promote recalcification and a return to mature lamellar bone. A significant beneficial effect was not observed, and overdosage of sodium fluoride may cause toxic side effects, such as gastric irritation with fatal consequences (Morrison, 1971).

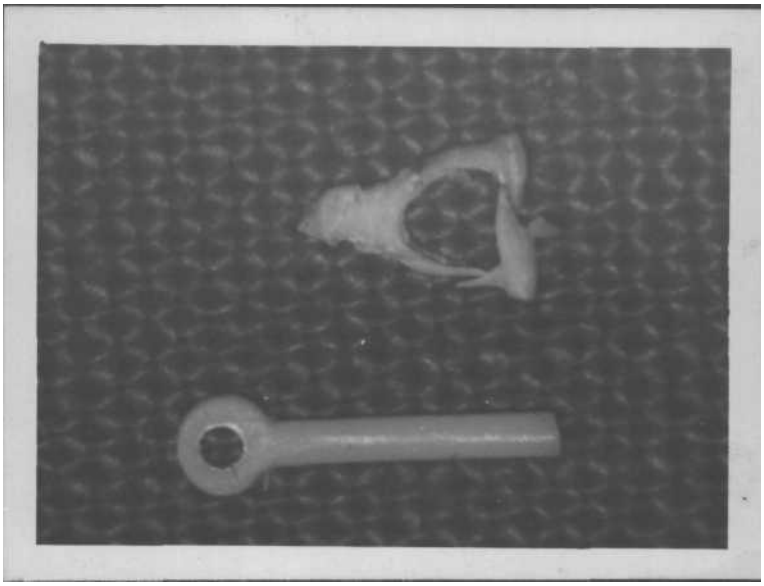
Hearing aid gives excellent results in almost all patients with deafness, whether stapedial, cochlear or combined. Hearing aids should be advised when surgery is awaited, refused or contra-indicated. The use of hearing aid does not prevent the natural progression of deafness; in more severe deafness the amplification required can lead to acoustic trauma; and natural hearing can't be given.

Therefore, surgical approach is the one generally followed by surgeons to restore the hearing function. There are three major surgical procedures for otosclerosis, viz., stapes mobilization, stapedectomy and fenestration.

Stapes mobilization was first employed by Kessel in 1878. Rosen in 1953, however, gained recognition for introducing the mobilization operation for otosclerosis in modern days.(Lindsay, 1973).

Passow in 1897 reported the first operation (fenestration) for otosclerosis in which the fixed stapes was bypassed by drilling a hole into the promontory (Lindsay, 1973). Lempert in 1938 popularized one stage fenestration operation, designed to by-pass the footplate obstruction by creating a new window in the lateral canal allowing sound waves to enter the cochlea via the canal and vestibule.

Blake and Faracl(1899) described stapedectomy without stapes replacement. Partial stapedectomy (with polythene tube from incus to fractured footplate) was described by House in 1959 and Hall in 1958. Finally the whole stapes was removed by Shea in 1958 and replaced by an oval window graft and polythene strut (Morrison, 1971). Since he was not fully satisfied with polythene strut and vein graft, he came forward with his



Teflon piston and Stapes (Which was removed during Stapedectomy) teflon piston technique in 1962 (Dayal, 1970). The technique has not yet stabilized to a point at which a 'standard' operation exists. The basis of the procedure is to create a patent window, seal it with a membrane of either natural or artificial material and to provide a connection between the incus and the neo-membrane cover of the oval window. The oval window is covered with vein, mucous membrane, connective tissue, fat, Gelfoam or collagen membrane; and sound transmission is re-established with a stapes crus, polyethylene or Teflon tubing, a Teflon or stainless steel piston, stainless steel or tantalum wire, a platinum prosthesis or a stapes carved from the patient's mastoid cortex. There are variations in this procedure (Ballenger, 1969).

Stapedectomy results and complications:

Complications may be either immediate or delayed. Some of the early complications are: distortion or loss of taste due to stretching or sectioning of the chorda tympani; perforation of the tympanic membrane which will usually heal spontaneously when it is small; otitis media, a rare complication; facial palsy; persistent vertigo, which may be due to too long or too short a prosthesis; high-frequency hearing loss; fluctuating sensori-neural hearing loss (Ballantyne, 1976); labyrinthine hydrops; perilymph flooding and reparative granuloma (Morrison, 1971).

Some of the delayed complications are: perilymph fistula; cochlear otosclerosis (Morrison, 1971); delayed conductive hearing loss due either to slipping of the prosthesis or to necrosis of the incus.

When stapedectomy has been remarkably successful, in some instances there is full recovery of hearing with total closure of the air-bone gap (Rosenberg, 1959; Ballenger, 1969; Prescod, 1978). The percentage closure is calculated on the basis of comparison between pre- and post-operative air-conduction levels with respect to pre-operative bone-conduction level. The formula is:

$$\frac{\text{Pre-op.AC} - \text{Post-op.AC}}{\text{Pre-op.Ac} - \text{Pre-op. Bc}} \text{ or } \frac{\text{AC gain}}{\text{A-B gap}} = \text{\% improvement}$$

(Goodhill et al.,1971)

monour and Goodhill (1963) studied the audiometric results of 75 patients undergoing stapedectomy in which the polyethylene-perichondrium prosthetic assembly was used. The group as a whole had an average loss (500 - 2000Hz.) of 52.2dB by air-conduction and 17.8dB by bone-conduction. The results of the 6-month post-operative tests showed that the group as a whole achieved almost complete closure of the air-bone gap (within 2dB of the pre-operative bone-conduction mean score).

Robinson (1965) utilized a machined stainless steel prosthesis with a vein graft, and the post-operative audiometric findings 6 months after surgery showed a 96.5% success rate using closure of the air-bone gap to within 10dB as the criteria for success. Another 1.9% were partially successful, obtained a closure of the air-bone gap to within 20dB. 1.6% were failures who maintained more than a 20dB air-bone gap. In a recent study (1967), out of 1336 cases, only 7 had a 10dB bone conduction loss.

In order to find out the change in the slope of the air-conduction curve, Hardick et al.,(1969) have suggested a formula, which is as follows:

$$\text{Slope in dB/octave} = \frac{(HL_{1Kc/s} - HL_{0.5Kc/s}) + (HL_{2Kc/s} - HL_{1Kc/s})}{2}$$

Change in slope would be indicated by the difference between pre-operative and post-operative values and direction of the difference.

Studies have shown that typical Carhart notch, found in bone conduction thresholds, disappeared following stapedectomy (Carhart, 1950; Wood, 1950; Causse et al, 1975; Kacker, 1978; Prescod, 1978). The explanation for this disappearance is the involuntary transformation of absolute bone conduction to relative bone conduction after the release of the stapedo-vestibular otosclerotic block (Causse et al., 1975).

Post-operative speech audiometry:

Comparisons by pare tone testing are not qualitative unless they are validated by equal results in speech tests. The usual question is how well the patient hears and understands speech. The great damage to the cochlea is reflected in the area of speech discrimination.

Post-operative speech discrimination results are found to be variable in stapedectomized patients. Sheehy (1962) reports about improvement in discrimination which may be due to improved hearing thresholds. He states, "although the discrimination may not actually improve, the patients ability to use the discrimination he possesses is certainly enhanced." (Sheehy, 1964)

Rosenberg(1959) has reported a case in which successful stapes mobilization surgery on an ear with mixed deafness resulted in a marked loss in speech discrimination. Even though there was complete closure of the air-bone gap, there was high frequency nerve loss and resultant difficulty in discriminating consonants.

Honour and Goodhill (1963) reported the post-operative results of 75 patients who underwent stapedectomy in which the polyethylene-perichondrium prosthetic assembly was used. The results of the 6-month post-operative tests showed that the mean PB score decreased from 87.5% to 83.8%. Patients belonging to the age group of more than 61 years showed slightly more decrease in PB scores following surgery. The investigators report that their data were obtained under clinical rather than research conditions. Speech discrimination score was obtained by using PB 50 lists administered by monitored live voice at plus 35dBSL.

Oppenheimer et al.'s (1963) study quoted by Cody et al.,(1967) reports that 15% have a loss of speech discrimination following stapedectomy.

Guilford(1964) found that, for 3 groups of stape-dectomized patients (the grouping based on the type of prosthesis used), discrimination losses greater than 10% at the four-month postoperative test occurred in from 1.6% to 3.7% of the patients (Owens et al., 1972).

Cody et al., (1965) reported that a speech discrimination loss of 10% or more was found in 38 of 489 ears (7.8%) 6 months post-stapedectomy, and in 20 of 178 ears (11.2%) from 6-36 months post-stapedectomy (Owens et al., 1972).

Robinson (1967) utilized a machined stainless steel stapes prosthesis with a vein graft for stapedectomy surgery. In an earlier study (1965), postoperative audiometric results 6 months after surgery showed a discrimination loss of more,than 10% in 0.5% of the cases. In Robinson's recent study (1967), only one patient had a total discrimination loss postoperatively and two had a partial discrimination loss postoperatively. Out of 1336 cases, only 7 had maintained their discrimination level.

Ginsberg (1968) studied the postoperative results in a group of patients who underwent stapedectomy in which the wire-fat technique was used, and a similar group of patients who underwent an identical operation except for the substitution of a wire-absorbable gelatin sponge technique. The data supported the view that cochlear distress following total stapedectomy with a fat wire prosthesis was less than the cochlear distress following total stapedectomy with an absorbable gelatin sponge-wire prosthesis. Postoperative speech scores were depressed more with the absorbable gelatin sponge-wire technique than with the fat-wire technique.

Hardick et al., (1969) presented data to evaluate the assertion that the removal of an air-bone gap due to otosclerosis, in patients who exhibited an underlying high frequency sensorineural hearing loss, might result in a substantial loss of speech discrimination. No systematic relationship was found between loss of discrimination and tilting the air-conduction thresholds through the surgical process of removing the air-bone gap.

Hough (1969) has reported postoperative audiometric findings in 200 ears for which partial stapedectomy was done. None of the 200 ears had lost 50% or more of discrimination either immediately postoperatively or in the subsequent five to seven years. None had lost 20% of speech discrimination during the first 6 months post-operatively, and none of the ears had lost even 10% of speech discrimination at the time of the 6-month post-operative test. 5-7years later, 2% had demonstrated a drop in discrimination of 20% and a long-term loss of speech discrimination of 10% or more was seen in 3% of the ears. These tests were done using standardized tape and recorded speech under sound-proof conditions.

Kos (1969) reported the audiometric findings of 117 stapedectomized patients, where the vein plug prosthesis technique was used. Mean speech discrimination preoperatively was 95.2%. At one year postoperative, it had dropped a little bit, 94.5; and in 6 years, 92.3; an overall drop of about 3%.

McGee (1969) reported the long-term follow-up studies on 200 patients who had stapedectomy surgery for otosclerosis in late 1959 and early 1960 utilizing the fat-wire prosthesis. The 6—year speech discrimination scores were compared to the preoperative tests. At 6 years, 3.8% of the patients continued to show a gain in their speech discrimination threshold over their preoperative score, while 79% of the patients at 6 years showed a speech discrimination within 10% of their preoperative score. A significant loss of discrimination of 11% to 20% had occurred in 10.5%; 2.9% had a loss of 21% to 30%; and 3.8% over 30% loss of discrimination after 6 years.

Owens et al,(1972) aimed to study the effects of stapedectomy on speech discrimination when successful air-bone closure had been achieved and to observe the facotrs that seem to be involved when reduction in speech discrimination occurred. In a series of 312 patients with otosclerosis whose stapedectomies had been successful in terms of air-bone closure, no systematic differences had appeared between pre-operative and 4-month postoperative speech discrimination scores on W-22 word lists (presented by monitored live voice). A high-risk group was identified, namely, patients 60 years of age or older, with preoperative bone-conduction averages of 25dB or greater, and any one of four pre-operative bone-conduction configurations described as 'flat then falling', 'gradually falling', falling than flat', and 'sharply falling', in the 500 to 2000Hz range. Within such a high-risk group, it was estimated that permanent reduction in speech discrimination following stapedectomy would be experienced by four of any ten patients 70 years or above, and two of any 10 patients from 60 -70 years of age.

Sooy et al., (1973) undertook a study to determine the stability of hearing in patients over an eight-year period following a wire-vein graft stapedectomy procedure for otosclerosis. They compared the 4-month and 8-year postoperative hearing test results for a population of 76 patients who had undergone stapedectomy. A slight decrement of 2.8 percentage points in mean speech discrimination score was shown over the 8-year period, while no change had occurred in mean speech reception threshold.

Contradictory findings have been reported by Robinson (1970). He noted that many stapedectomized patients appeared to have a higher postoperative discrimination score than the preoperative score. This was attributed to the fact that the AC loss was so severe that sufficient amplification was not possible to obtain a true measure of cochlear function. By using the BC vibrator and the audiometer microphone with live voice, it was possible to elicit a much higher discrimination score preoperatively. These high BC scores correlated very closely with the final postoperative AC discrimination score (Robinson, 1973).

Robinson (1977) reported that majority (75%) showed a drop in AC speech discrimination scores by at least 10%, 7 days postoperatively. However, when the same patients were tested by the BC speech discrimination method, 80% had maintained their speech discrimination level at the preoperative level.

Thus majority of studies indicated that there was a marked reduction in the postoperative speech discrimination score, though there was improvement in post-operative pure tone audiogram in most of the cases.

Factors affecting speech discrimination scores:

Health and Bartlett (1961) have shown that difficulty of speech discrimination and intelligibility tests varies for different talkers - both on individual item and overall test list.

The work of Brandy (1966) showed that re-utterances of a given list of words even by the same talker results in significant differences in listener performance.

Kreul et al.,(1969) have indicated that in speech discrimination and intelligibility test development, selection of the talker, his specific set of utterances, the carrier phrase, and the deliberately introduced distortion will all interact to determine level of test difficulty.

Majority of research describing variables influencing speech-sound discrimination has been concerned with the type of materials chosen as stimulus items (Travis and Raaus, 1931; Mase, 1946; Templin, 1957; Perozzi, 1969).

Schwartz et al, (1974) have reviewed the literature regarding the variables influencing performance on speech-sound discrimination tests and have quoted the following variables: the type of materials selected as stimulus items; the context in which the stimulus items are presented; the type of response required of the listener; the presence of background noise; and the inclusion of a training session to familiarize the listener with either the task involved or the meanings of the stimulus items.

Reduction in speech discrimination score postoperatively may also be due to: postoperative high frequency hearing loss, which may be due to revision stapes operations (Sheehy et al. 1962; Shambaugh, 1963; Shea, 1963; Cody et al., 1967; Cody, 1971); or type of prosthesis used (Guilford, 1964; Antoli-Candela, 1969; Kos, 1969; Sooy etal., 1973) or labyrinthine infection (Cody et al., 1967).

Keeping in mind all the factors which affect speech discrimination performance, the present study was undertaken to find out speech discrimination scores of the stapedectomized cases one-week and 3-months postoperatively, and to compare them with preoperative speech discrimination scores.

CHAPTER III

METHODOLOGY

The methodology of the present study comprised of the following steps:

1. Selection of subjects.
2. To obtain pre-operative and one-week post-operative audiometric findings from A.I.I.S.H. case records.
3. To obtain a post-operative otologie history and subjective impression of the post-operative hearing status by using a questionnaire.
4. To obtain three-month post-operative pure tone audiogram, speech discrimination scores and impedance audiometric findings.

Subjects:

Criteria for selection of subjects for the present study were:

1. Subjects should have been surgically confirmed otosclerotics.
2. A pre-operative pure tone audiometry, speech aadiometry, impedance audiometry and the same evaluations one-week postoperatively must have been done (adequate masking should have been used whenever necessary).

3. Speech discrimination testing must have been done utilizing "the common speech discrimination test for Indians" which was developed and standardized by Maya Devi (1974)

4. The pure tone audiogram must show a conductive hearing loss or mixed hearing loss consisting of a sensorineural component not more than 30 dB in any bone conduction test frequencies.

5. The preoperative and postoperative speech discrimination test must have been done by using monitored live voice.

6. The pre-operative and post-operative speech discrimination test must have been administered at constant sensation levels unless prevented by the output limits of the audiometer.

7. The surgical procedure adopted should be stapedectomy, wherein teflon plston(and gel-foam) was used as prosthesis.

8. The residence of the subjects should have been at Mysore or any nearby place, so as to utilize their visits to the clinic for the purpose of study, postoperative evaluations and advice.

Depending on all the above mentioned criteria, twenty subjects were selected for the study. Out of them, 13 were females and 7 were males, with an age range of 20-58 years (Mean age: 34.65). Amongat the 20 subjects, 11 were operated in the rig-ht ear, and 9 in the left ear.

All the subjects were called for a 3-month postoperative evaluation. Prior to the post-operative audiometric evaluations, all the subjects underwent regular otoscopic examination.

Postoperative history:

Taking into account the etiologie factors which could affect the postoperative hearing, a questionnaire was constructed which is shown in Appendix 1. The questionnaire also included some items which were used to collect the subjective opinion of the hearing status of the subjects in different physical conditions postoperatively.

Responses for the questionnaire was collected from all the subjects before carrying out the 3-month postoperative audiometric evaluations.

Equirment and test enviroment:

A calibrated (ANSI 1969) dual channel diagnostic audiometer (Madsen OB 70) with TDH-39 earphones and

MX-41/AR ear cushions was used to obtain pure tone thresholds and speech discrimination scores of the subjects. Talk-back system was used to record the response of the subjects during speech audiometry.

An electroacoustic Impedance bridge (Madsen ZO 72) with Telex 1470 earphone and MX-41/AB ear cushion calibrated to ANSI 1969 was used to record the tympanometry, static compliance and stapedius reflex thresholds of the subjects.

The calibration of the instruments (Madsen ZO 72) and Madsen OB 70) was maintained by periodical check up by using a standard variable cavity(Madsen ZO 70), a 2 cc coupler; an artificial ear (B & K type 4152); an artifical mastoid (B & K type 4930) ; a condenser microphone (B & K type 4145); and a SPL meter (B & K type 2203) with octave filter set (B & K type 1613). Subjective calibration was done everyday.

The hearing thresholds and speech discrimination scores of the subjects were determined in the sound treated room (double room situation) of All Indian Institute of Speech and Hearing, Mysore, and the Impedance audiometry was performed in a fairly quiet room. The noise levels in these rooms at various octave bands are given in Appendix 2 and 3.

Test procedure:

(1) Measurement of pure tone threshold:

Pure tone thresholds were found out for all the subjects at 250 Hz, 500 Hz, 1 KHz, 2 KHz, 4 KHz, 6 KHz and 8 KHz, while tone was presented through ear phones, and the thresholds were established for 250 Hz, 500 Hz, 1 KHz, 2 KHz and 4 KHz when the tone was presented through the bone vibrator. Hughson Westlake (1944) ascending procedure waa used to establish the pure tone thresholds. The following verbal instruction was given to every subject:

"You are going to hear a series of musical tones, first in one ear and then in the other. When you hear a tone, no matter how high or low in pitch and no matter how loud or soft, please signal that you have heard it. Raise your index finger when you first hear the tone and keep it as long as you hear it. Put down the finger quickly when the tone goes away. Remeber to signal every time you hear a tone. Are there any questions?" (Martin 1975).

Both air conduction and bone conduction thresholds obtained at the aforesaid frequencies were recorded on the Audiogram sheet. Pure tone average (PTA) of 500 Hz, 1 KHz and 2 KHz was estimated for every subject from the obtained air conduction thresholds.

Speech reception thresholds were obtained for all the subjects in order to validate the pure tone thresholds. Standard procedures were used for this purpose. Pure tone averages for all the subjects were in agreement with SRT by ±7 dB.

Measurement of speech discrimination:

Since all the subjects were Kannada speakers, and there is no standardized speech discrimination test material in Kannada, "A common speech discrimination test for Indians" which was developed and standardized by Maya Devi (1974) was used as the test material for the present study. List of speech material used for speech discrimination testing is shown in Appendix 4.

The tester was a Final M.Se. female student who used monitored live voice. The tester stationed herself directly in front of the microphone and spoke directly into the diaphragm from a distance of six to twelve inches. The last word of the carrier phrase peaked at zero of the VU meter. The test stimuli were uttered with the same monotonous stress. Sufficient time was allowed between each presentations to allow the patient to respond.

For testing the subjects, the following instructions were given:

'Now you are going to hear in your operated ear (which was specified) some speech sounds like Ka, Ma, etc. They are preceded by a Kannada phrase 'i:ga i annu he:li. You need not repeat the phrase again, but you have to repeat the syllables which you hear in the end."

These instructions were translated into Kannada. The purpose of the carrier phrase was (1) to alert the attention of the patient to ligten to the test items, and (2) to Monitor the live voice through the VU meter of the audiometer.

A talk back system was used to note the verbal responses of the patient.

The test was administered at 40 dBSL (re:PTA) as standardized and recommended by Maya Devi(1974).

Speech discrimination score was obtained by converting the number of items repeated correctly into percentage.

Impedance audiometric measures

Following a period of five minutes rest after speech audiometry, the impedance test battery was administered to all the subjects. Tympanometry, static compliance and reflexometry (when the probe ear was the operated ear) were done following standard proceedures as given in Madsen ZO 72 Manual.

CHAPTER IV
RESULTS AND DISCUSSION

The obtained data about the prepperative, one-week postoperative and 3-month postoperative audiometric results and the subjective opinion of the subjects about the change in speech discrimination ability postoperatively, were subjected to statistical analysis.

Table 1 shows the speech discrimination scores obtained preoperatively, one-week and 3-month postoperatively, and their mean and standard deviation values.

The three sets of scores were compared with each other in order to observe if there were any significant differences between the discrimination scores obtained preoperatively and, one-week and 3-months postoperatively.

When the preoperative and one-week postoperative discrimination scores were compared, the obtained 't' value (1.69) was not significant at the 0.05 level of confidence. This indicated that there was no significant difference between the speech discrimination scores obtained preoperatively and one-week postoperatively. Since the average preoperative discrimination score was by itself within the normal range (i.e., 80-100%), a significant difference might not have been observed.

When the preoperative and 3-months postoperative

Table 1:- showing the pre-operative, 1-week and 3-month postoperative speech discrimination scores.

Sl. No.	Ear operated	Pre-op. speech discmn. scores (in %)	1-week postop. speech dismn. scores(in %)	3-month postop. speech dismn. scores(in %)
1	R	80	80	80
2	L	100	100	100
3	R	85	85	90
4	L	70	80	90
5	L	100	100	100
6	L	80	80	85
7	R	70	80	85
8	L	75	80	80
9	R	90	90	85
10	R	95	100	100
11	R	95	90	90
12	L	100	100	100
13	R	85	85	85
14	L	95	95	95
15	R	90	95	100
16	L	90	95	100
17	R	100	100	100
18	L	95	95	95
19	R	100	95	95
20	R	90	90	95
	Mean	89.25	90.75	92.50
	S.D.	9.65	7.63	6.98

discrimination scores were compared, the obtained 't' value (2.23) was significant at the 0.05 level of significance. This indicates that there was a significant difference between the speech discrimination scores obtained preoperatively and 3-months postoperatively, which also indicates that there was slight improvement in the DS which was significant.

This finding agrees with Robinson's (1970) observation. He has noted that many patients appeared to have a higher postoperative discrimination than the preoperative score. He has attributed this improvement to the fact that the preoperative air-conduction loss which was severe. Due to this, sufficient amplification was not possible to obtain a true measure of cochlear function. Whereas postoperatively, the air-bone gap was closed, and hence sufficient amplification was possible to obtain the true measure. The explanation appears to hold good for the present finding also.

Sheehy (1964) also noted an objective improvement in thresholds, and in discrimination, in a 4-raonth post operative study with far advanced otosclerotics.

Contradictory findings have been reported by Moncur and Goodhill (1963), Owens et al, (1972)and Sooy et al, (1973).

Owens et al, (1972), in a 4-month post-stapedectomy study, did not find systematic differences between pre-operative and postoperative speech discrimination scores. This difference in findings may be due to either or both of the following factors: (1) In Owens' study, both the preoperative and 4-month postoperative data were not obtained in research conditions; whereas in the present study, only the 3-month postoperative data was obtained in research conditions; (2) Owens et al, have used CID W-22 word lists, where in the present study, lists of monosyllables from 'The common speech discrimination test for Indians' (Maya Devi, 1974) was used, to find out the discrimination scores.

Honour and Goodhill (1963), in a 6-month postoperative study, noted that the mean PB score decreased from 87.5% to 83.8%. The investigators have not reported about the statistical significance of this reduction in postoperative scores. Apart from that, their data were obtained under clinical rather than research conditions, and they used PB 50 lists which was not used in the present study.

In a 8-year post-stapedectomy study, Sooy et al, (9173) noted a statistically significant decrement of 2.8percentage points. The investigators have not mentioned the age range of the subjects. The decrement in 8-year postoperative score might be due to the addition of sensori neural component due to aging process (i.e., presbycusis).

When the discrimination scores obtained one-week and 3-month postoperatively were compared, the obtained 't' value (2.33) was significant at the 0.05 level of significance. This indicated that there was a significant difference between the speech discrimination scores obtained one-week and 3-month postoperatively.

Table 2(a) shows the 'objective findings' and the subjective opinion of the patients about the change in speech discrimination ability, one-week and 3-month postoperatively.

In order to make a convenient comparison between the subjective opinion and the objectively obtained postoperative discrimination scores, a suitable criterion was adopted to convert the numerical change in scores into 'objective findings' (improvement, no change, or reduction). An improvement in the postoperative discrimination score of 10% or more, was considered as 'better'; a reduction of 10% or more was considered as 'worse'; and a change of less than 10% was considered as 'unchanged'.

The subjective opinion of the subjects about the change in speech discrimination ability one-week and 3-month postoperatively, was obtained in comparison with the preoperative ones.

According to the subjective opinion about the

Table 2(a):- showing the objective findings and the subjective opinion of the patients about the change in speech discrimination ability one-week and 3-month postoperatively.

Sl. No.	Objective findings		Subjective findings	
	After 1-week	After 3-montha	After 1-week	After 3-months
1	U	U	B	U
2	U	U	B	B
3	U	U	B	B
4	B	B	B	B
5	U	U	B	U
6	U	U	B	B
7	B	B	B	B
8	U	U	U	B
9	U	U	B	U
10	U	U	U	B
11	U	U	B	B
12	U	U	B	U
13	U	U	B	B
14	U	U	U	U
15	U	B	B	B
16	U	B	B	U
17	U	U	U	B
18	U	U	B	B
19	U	U	B	B
20	U	U	B	B

'U' denotes unchanged 'B' denotes better discrimination ability, 16 subjects (80%) found it to be better and the remaining 4 subjects (20%) found no change, when one-week postoperative discrimination ability was compared with the preoperative ones. 14 subjects (70) found it to be better and the remaining 6 subjects (30%) found no change when the 3-month post-operative discrimination ability was compared with the preoperative ones.

The objective findings and subjective opinion were compared with each other to observe whether there was any significant relationship between them, following surgery. Ø coefficients were found out for the subjective opinions and the respective objective findings, one-week and 3-months following surgery. Later values were found out (0.58 and 0.05, respectively), which were not found to be significant at the 0.05 level of significance. Thia indicated that there was no significant relationship between the subjective opinion about the change in speech discrimination ability and the change in the objectively obtained speech discrimination scores, one-week and 3-months following stapedectomy.

Since there was no significant relationship between the subjective opinion and the change in objectively obtained speech discrimination scores, one-week and 3-months postoperatively, an effort was made to find out

Table 2(b):- showing the presentation levels(preoperative, one-week and 3-month postoperative) and the subjective opinions about the speech discrimination ability.

Sl. No.	Presentation levels(in dB)			Subjective opinion	
	Preop.	1-week postop.	3-mth postop.	1 wk.post-op.	3-mth postop.
1	120	115	75	B	B
2	90	100	65	B	B
3	100	80	60	B	B
4	120	90	65	B	B
5	100	110	120	B	U
6	95	75	60	B	B
7	115	120	100	B	B
8	120	100	100	U	B
9	100	110	75	B	U
10	95	105	60	U	B
11	100	95	60	B	B
12	120	110	90	B	U
13	120	80	65	B	B
14	105	70	105	U	U
15	105	95	70	B	B
16	95	85	70	B	U
17	120	70	60	U	B
18	90	70	60	B	B
19	120	105	75	B	B
20	90	75	60	B	B

'B' denotes better 'U' denotes unchanged if there was any significant relationship between the change in presentation levels (for the speech discrimination testing) and the subjective opinion. Ø coefficients were found out for the subjective opinions and the respective one-week and 3-month postoperative change in presentation levels (shown in Table 2(b)). The obtained X^2 values (1.25 and 1.68, respectively one-week and 3-month following surgery) were not found to be significant at the 0.05 level of significance. This indicated that there was no significant relationship between the change in presentation levels for the speech discrimination testing and the subjective opinion about the change in speech discrimination ability, following stapedectomy.

Table 3 shows the change in speech discrimination scores when the preoperative, one-week and 3-month post-operative scores were compared. From this table, it is evident that out of 20 ears, 10% (2 ears) of them showed a reduction in discrimination scores, and 60% (12 ears) showed no change, when the preoperative and one-week postoperative scores were compared.

When the pareoperative and 3-month postoperative discrimination scores were compared, 15% (3 ears) showed a reduction in discrimination scores.

When one-week and 3-month postoperative discrimination

Table 3;- showing the change in speech discrimination scores when a comparison was made between the preoperative, 1-week and 3-month postoperative scores.

No.	1-week postop. DS -preop. DS	3-month postop. DS -preop. DS	3-month postop. DS -l-week postop. DS
1	0	0	0
2	0	0	0
3	0	+5	+5
4	10	+20	+10
5	0	0	0
6	0	+5	+5
7	+10	+15	+5
8	+5	+5	0
9	0	+5	-5
10	+5	+5	0
11	-5	-5	0
12	0	0	0
13	0	0	0
14	0	0	0
15	+5	+10	+5
16	+5	+10	+5
17	0	0	0
18	0	0	0
19	-5	-5	0
20	0	+5	+5

scores were compared, 60% (12 ears) showed no change in discrimination and 5% (1 ear) showed a reduction in discrimination score.

On the whole (i.e., without applying any statistical methods), we can say that majority of them showed no change in speech discrimination scores following stapedectomy, which is in agreement with the findings of Owens et al, (1972).

Tables 4(a), 4(b) and 4(c), show the obtained mean and standard deviation values of the preoperative, one-week and 3-month postoperative air conduction thresholds, respectively.

Table 5 shows the preoperative, one-week and 3-month postoperative slopes of the air-conduction thresholds. The slopes were obtained by using the formula (Hardick et al, 1969):

$$\text{AC slope in dB/octave} = \frac{(HL_{1Kc/s} - HL_{.5Kc/s}) + (HL2_{Kc/s} - HL_{1Kc/s})}{2}$$

Change in slope was indicated by the difference between preoperative and, one-week and 3-month post-operative values, and the direction of the difference.

When the preoperative and one-week postoperative air conduction slopes were compared, the obtained change

Table 4(a):- showing the means and standard deviations of the pre-operative air-conduction thresholds.

	250 Hz	500 Hz	1 KHz	2 KHz	4 KHz	6 KHz	8 KHz
Mean	67.5	69.5	68.5	61.25	64.0	67.0	68.5
S.D.	11.67	12.03	16.05	17.31	21.6	23.11	22.09

Table 4(b):- showing the means and standard deviations of the 1-week post-operative air-conduction thresholds.

	250 Hz	500 Hz	1 KHz	2 KHz	4 KHz	6 KHz	8 KHz
Mean	48.5	50.75	55.75	54.0	68.0	74.73	77.75
S.D.	13.05	16.22	16 .30	17 .36	12.09	12.50	18.41

Table 4(c) :- showing the means and standard deviations of the 3-month post-operative air-conduction thresholds

	250 Hz	500 Hz	1 KHz	2KHz	4 KHz	6 KHz	8 KHz
Mean	39.75	38.25	31.5	34.25	45.0	60.0	70.25
S.D.	17.17	21.11	17.97	19.25	20.62	18.10	22.70

Table 5:- showing the preoperative, 1-week and 3-month post-operative slopes of the air conduction thresholds.

Sl. No.	Pre-op. slope (in dB)	l-week poet-op. slope(in dB)	3-month postop. slope (in dB)
1	+10	0	+10
2	- 5	+5	0
3	-7.5	0	-10
4	0	+12.5	-2.5
5	-7.5	+10	-7.5
6	-12.5	-10	-5
7	0	+ 2.5	+2.5
8	0	+ 7.5	0
9	+10	+10	+5
10	-10	0	-2.5
11	-10	+10	+7.5
12	-5	- 2.5	-5
13	-2.5	0	-2.5
14	- 5	+ 2.5	-12.5
15	- 5	-12.5	+5
16	-2.5	0	-12.5
17	-5	0	- 2.5
18	-10	+2.5	- 2.5
19	0	-7.5	- 2.5
20	-7.5	+2.5	- 2.5
Mean	-3.75	+1.63	-2.0

in AC slope was found to vary from -10 to +20dB with a mean of +4.93dB. Out of 20 ears tested, 16 ears (80%) showed a positive change in slope and only one ear (5%) showed no change in slope.

When the preoperative and 3-month postoperative AC slopes were compared, the obtained change in AC slope was found to vary from -10 to +17.5dB, with a mean of +1.75dB. 9 ears (45%) showed a positive change in slope and 5 ears (25%) showed no change in slope.

When one-week and 3-month postoperative AC slopes were compared, the obtained change in AC slope varied from -17.5 to +10dB, with a mean of -4.63dB. 3ears (15%) showed a positive change in slope, 16 ears (80%) showed a negative change in slope and the remaining showed no change in slope.

In order to find out whether there wag any significant relationship between the change in speech discrimination score (both in amount and direction) and change in slope of AC threshold following surgery, comparisons were made between change in discrimination score and change in AC slope preoperatively, one-week and 3-month postoperatively.

A negative, insignificant product moment correlation value was obtained between the change in discrimination score and the change in AC slope following stapedectomy.

Since the correlation value was not significant, the direction (i.e., the negative sign) of correlation will not have any value.

A similar study by Hardick et al (1969) has shown that the correlation between change in AC slope and change in discrimination score was not significant at the 0.05 level of significance, which supports the findings of the present study.

Table 6 shows the preoperative and 3-month post operative impedance audlometric findings. Impedance audiometric evaluations were not done one-week post operatively, since the healing process after surgery might be incomplete. Due to increase of pressure during the evaluation, the healing flap might give way.

From table 6, it is evident that out of the 20 ears tested, 3 ears (15%) did not show A_S type of tympanogram preoperatively. This is in agreement with a recent study by Kulkarni (1977) who has shown that out of 60 surgically confirmed cases of otosclerosis, 16 cases (26.67%) did not show A_S type of tympanogram pre-operatively. This indicates that misdiagnosis of otosclerosis might happen by depending on a single parameter of impedance audiometry.

3-month postoperatively, all the 20 ears showed A type tympanogram, which indicates absence of middle ear

Table 6:- showing preoperative and 3-month post-operative i0mpedance audiometric findings.

Sl. No.	Pre-op. Impedance findings			Poatop. impedance findings		
	Tympano-gram	Static Compliance	Acoustic reflex	Tympano-gram	Static Compliance	Acoustic reflex
1	A_s	0.4	NR	A	0.6	NR
2	A_s	0.6	NR	A	0.6	NR
3	A_s	0.2	NR	A	0.4	NR
4	A_s	0.2	NR	A	0.5	NR
5	A_s	0.2	NR	A	1.0	NR
6	A_s	0.2	NR	A	1.0	NR
7	A_s	0.2	NR	A	0.6	NR
8	A_s	0.2	NR	A	0.6	NR
9	A_s	0.5	NR	A	1.0	NR
10	A_s	0.3	NR	A	0.4	NR
11	A_s	0.2	NR	A	0.8	NR
12	A_s	0.2	NR	A	1.0	NR
13	A_s	0.2	NR	A	0.8	NR
14	A_s	0.2	NR	A	0.8	NR
15	A_s	0.2	NR	A	1.0	NR
16	A	0.3	NR	A	0.8	NR
17	A	0.3	NR	A	0.7	NR
18	A_s	0.2	NR	A	0.6	NR
19	A_s	0.1	NR	A	0.4	NR
20	A_s	0.1	NR	A	0.8	NR
Mean		0.25			0.72	
S.D.		0.12			0.21	

pathology. This indicated that there was a significant difference between the preoperative and 3-month postoperative tympanometric results.

The obtained mean (0.25) of the preoperative static compliance scores indicated that the value fell within the stiffness range (i.e., less than 0.3c.c). Postoperative static compliance mean (0.72) indicated that it was within the normal range (i.e., 0.3 to 1.5c.c).

The obtained 't' value (7.67), when the preoperative and 3-month postoperative static compliance values were compared, was significant at both 0.05 and 0.01 levels of significance. This indicated that there was a significant difference between the static compliance values obtained preoperatively and 3-month postoperatively.

Acoustic reflex was absent both preoperatively and 3-month postoperatively, when the stapedial reflex was measured with the operated ear as the probe ear. The preoperative findings agree with the findings of Kulkarni (1977), who has shown absence of stapedial reflex in all his 60 subjects preoperatively.

Absence of stapedial reflex postoperatively was expected, since during surgery, the stapedial tendon was disarticulated in all the 20 ears.

Thus the impedance audiometric findings (except reflexometry) showed a significant difference between preoperative and 3-month postoperative results.

CHAPTER V

SUMMARY AND CONCLUSIONS

Middle ear surgery for otosclerosis has in the past been evaluated primarily in terms of preoperative and postoperative pure tone results. The amount of reduction in the air-bone gap by surgery has been used as an indicator of success. It haa been only in the last few years that speech discrimination scores have been used in the evaluation of stapes surgery, primarily because speech discrimination was thought to be a cochlear function unaltered by the surgical restoration of ossicular chain. However, the recent literature dealing with the effects of stapes surgery on speech discrimination store suggests that in some otosclerotic cases a decrease in discrimination score may occur. From clinical experience it had been observed that majority of patients report "better discrimination" after surgery, which was in contradiction with the available literature.

There was no literature regarding the impedance audiometric findings following stapedectomy.

Hence the present study attempted to find out:
(1) if there was any change in speech discrimination scores one-week and 3-month following stapedectomy;

(2) if there was any relationship between the subjective opinion about the speech discrimination ability and the objectively obtained discrimination scores after surgery; (3) if there was any relationship between the change in AC slope and the change in discrimination score following surgery; and (4) if there was any change in postoperative impedance audiometric findings.

In order to find out these, the study was planned as follows: Preoperative and one-week postoperative audiometrie (pure tone, speech and impedance) findings were collected from the surgically confirmed otosclerotics A.I.I.S.H. case files. Later those 20 subjects were called for a 3-month postoperative re-evaluation, when the postoperative otologic history and the subjective opinion about the change in speech discrimination ability were collected by using a questionnaire. The subjects then underwent pure tone, speech and impedance audiometric evaluations.

Significant difference between the means, Ø coefficient and X^2 , and product moment correlation were used to analyze the obtained preoperative, one-weak and 3-month postoperative data.

The results of the study were:

(1) There was no significant difference between

the speech discrimination scorea obtained preoperatively and one-week postoperatively.

(2) There was a significant difference between the speech discrimination scores obtained preoperatively and 3-month postoperatively.

(3) There was a significant difference between the speech discrimination scores obtained one-week and 3-month postoperatively.

(4) There was no significant relationship between the subjective opinion of the subjects about the change in speech discrimination ability and the change in the objectively obtained discrimination scores, one-week and 3-months poatoperatively.

(5) There was no significant relationship between the change in speech discrimination acore(both in amount and direction) and the change in AC slope, following stapadectomy.

(6) There was a significant difference between preoperative and 3-month postoperative impedance audiometric results(except reflexometry).

The following conclusions were drawn:

(1) The change in speech discrimination scores, observed one-week postoperatively, is not significant;

whereas there is a significant improvement in speech discrimination acores 3-month poatoperatively (even when the 3-month and one-week postoperative data were compared).

(2) The relationship, between the subjective opinion about the change in apeech discrimination ability and the change in the objectively obtained speech discrimination score upto 3-month following sur-gery, is not significant.

(3) The relationship between the change in AC slope and the change in speech discrimination scores (both in amount and direction), following stapedectoay, is not significant.

(4) 3-month postoperatively, the impedance audio-aetric results (except reflexometry) will be within the normal range.

Limitations:

(1) The testers in the 3 different conditions (i.e., preoperative, one-week and 3-months postopera-tive) were different.

(2) A control group for speech discrimination testing could not be used due to lack of time.

(3) Cases in whom the severed stapedial tendon

was placed on the teflon prosthesis, and cases with advanced otosclerosis were not included for the study.

(4) English PB word lists which have been standardized for Indians could not be used for the study becauae of diveraity of the languages of the subjects.

Implications:

(1) The study emphasizes the importance of speech discrimination testing for the stapedectomized patients, in order to find out cochlear reserve and the improvement or reduction of hearing in practical situation.

(2) The study also indicatea the importance of impedance audiometry for the 3-month postoperative otosclerotics in order to find out the middle ear integrity after stapedectomy.

Recommendations for further research:

The present study provides scope for further research in the same area; such as,

(1) To select a larger sample of stapedectomized cases and find out whether there is any difference between preoperative and postoperative discrimination scores.

(2) The same subjects may be called for a

6-month and l-year postoperative follow up and the change in speech discrimination scores can be found out.

(3) To find out whether there is any difference between preoperative and post operative discrimination scores in cases with far advanced otosclerosis.

(4) The reflexometry can be studied in those cases where the severed stapedial tendon end has been placed on the teflon prosthesis.

APPENDICES

Instruments used for calibration

A F analyzer B & K Type 2107:

Type 2107 ia an alternating current operated audio-frequency analyzer of the constant percentage band width type.

It has been deaigned especially as a narrow band sound and vibration analyzer, but may be used for any kind of frequency analysis and distinction measurement within the specified frequency range.

This instrument is used with artificial ear type 4152 and artificial mastoid type, 4130 for air-conduction end bone-conduction calibration.

Artificial ear type 4152:

Artificial ear type 4152 ia designed to enable acoustical measurements on ear-phones to be carried out under well-defined acoustical conditions (ISO apecifica-tions). It consista basically of a replaceable acousti-cal coupler and 2 sockets for the mounting of a condenser microphone cartridge type 4132 and a cathode follower amplifier type 2163, connected to the Audio-frequency analyzer 2107.

A spring arrangement is provided to fulfil cer-tain standard requirements regarding the force applied to the object under meaaurement. To enable acousical tests, to be made on head phones used in audiometers, a 6 cm cube acoustical coupler is provided in this type.

The artificial ear satisfies the ISO specifications (ISO/TC 43)%

Artificial Mastoid type 4930:

Artificial Mastoid Type 4930 was used to measure objectively for the calibration of bone vibrators. This artificial mastoid could present to the bone vibrator exactly the same mechanical impedence as human mastoid. All preliminary adjustments such as, static load and the calibration for the impedance head art made periodically before bone-conduction calibration.

SPL meter 2203:

The precision sound level meter type 2203 and octave filter set type 1613.

The Precision Sound Level Meter type 2203 is a highly accurate instrument designed for outdoor use as well as for precise laboratory measurements. It covers the I.E.C. Publication 123, draft specifications regarding the sound pressure level meters.

The SPL meter is provided with octave filter network type 1613. The unit contains 11 band pass filters for octave analysis. The SPL meter was calibrated prior to noise measurements using Piston phone type 4220.

The above 2 instruments are used in connection with the noise measurements in the test room.

APPENDIX 1

A PROFORMA FOR POST-OPERATIVE HISTORY OF STAPEDECTOMIZED PATIENTS

1. How is your hearing now?

   Better, Unchanged, Worst

2. (a) Did you consult any doctor for your problem after the operation?

   (b) If yes, what for?

3. (a) Did you have any of the following infectious diseases after the operation?

   (i) Mumps
   (ii) Measles
   (iii) Chicken pox
   (iv) Typhoid
   (v) Malaria
   (vi) Flu
   (vii) Any others

   (b) Did you have pain in the operated ear after the operation (Not soon after the operation)

   (c) Did you have discharge in the operated ear after the operation?

4. (a) Did you have head injury after the operation?

   (b) Did you meet with any accidents? If yes where were you injured?

5. (c) Have you taken any drugs like streptomycin, quinine Kanamycin, neomycin after the operation? If yes,

   What for? What drug?
   What was the dosage?
   For how many days did you take it?

6. Were you exposed to gun fire or any other loud noise after the operation?

7. Did you undergo operation again in the operated ear?

8. **Hearing sensitivity after operation**

1. Did you find any difference in hearing,

   (a) Soon after operation - Better, Unchanged, Worse

   (b) later - Better, Unchanged, Worse

2. Do your relatives or friends say that your hearing has improved after operation?

3. Do you find it difficult to understand speech clearly in the following situations:

   (a) Conversation
   (b) Radio-talks
   (c) Over the telephone
   (b) Movie
   (d) Conversation in noisy environments.

APPENDIX 2

Sound pressure levels in the sound treated room at various frequencies

	Max. allowable noise levels in dB SPL re:0.0002 dyne/cm^2	SPL value in the test room in dB re:0.0002 dyne/cm^2
C Scale	30	33
Octave bands:		
75 - 150 Hz	31	18
150 - 300 Hz	25	17
300 - 600 Hz	26	15
600 - 1200 Hz	30	9
1200 - 2400 Hz	38	11
2400 - 4800 Hz	51	10.5
4800 - 9600 Hz	51	10

APPENDIX 3

Sound pressure levels in the test room where impendance audiometry was performed

	SPL values in the test room in dB re: 0.0002 dyne/c2e
A scale	42
B scale	44
C scale	49
Linear	54
Octave bands:	
75 - 150 Hz	48
150 - 300 Hz	44
300 - 600 Hz	39
600 - 1200 Hz	38
1200 - 2400 HZ	35
2400 - 4800 Hz	32
4800 - 9600 Hz	30

The SPL values given above are the average SPL values measured on 5 different days, thrice a day.

APPENDIX 4

List of Monosyllables

List 1	List 2
ಮ	ಚ
ತ	ದ
ನ	ಣ
ಚ	ಕ
ದ	ಬ
ಟ	ರ
ರ	ಗ
ಣ	ಪ
ಪ	ಮ
ವ	ವ
ನ	ಚ
ಜ	ತ
ಕ	ನ
ಡ	ಹ
ಬ	ಯ
ಹ	ನ
ಗ	ಟ
ಚ	ಶ
ಯ	ಜ
ಶ	ಲ

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