A Study of the edge

Of

Tympanic Membrane Perforations

by

MAHMOUD MOHAMED ABD EL KHALECK

M. B. B .Ch

THESIS

SUBMITTED IN PARTIAL FULFILMENT FOR

MASTER DEGREE OF

EAR . NOSE and THROAT

FACULTY OF MEDICINE

EIN SHAMS UNIVERSITY

1981

ACKNOWLEDGEMENT

No doubt,I am considered lucky to be introduced to the field of otology by Professor Dr. Alaa El Seifi who,if not the best,is one of the best ear surgeons in this world. This chance offered to me by him makes me feel the responsibility put on my shoulders to try to make this work of some value. During my work with this great surgeon I was learnt how to manage things very intellegentlly,how to be precise and accurate and I was learnt that punctuality is the politeness of kings. His sincere and valuable remarks and notes made it possible for this work to come to an end. It is an ever-lasting honour and I shall always be proud of working with this great man.

I am also indebted to Professor Dr.Abd El-Rahim Sarout whose respectable and valuable instructions were agreat forward push for this work.

I would like to thank very much Professor Dr.Ismail Kamel who offered me a great part of his precious time . His professorial instructions and great cooparation helped me very much to finish this work and to provide this thesis with the needed pictures of slides.

Lastly,I would like to thank very much my colleagues and every person who gave me a hand in establishing this work.

Dr. Mahmoud Abd El Khaleck

بسم الله الرحمن الرحيم

CONTENTS

INTRODUCTION & THE AIM

The changes that occur at the edge of tympanic membrane perforations have an important bearing on the reconstruction of these defects. Macroscopically, we may see in traumatic cases rolling in, evertion, laceration, ecchymosis and in pathological cases :- thickening, granulation or keratinization. Changes that appear under light microscopy include: metaplasia, hyperplasia, fibrosis, tympanosclerosis and infiltration by inflammatory cells. But the most important change is migration of the keratinizing epithelium around the edge.

Tympanic membrane perforation is one feature of otitis media, myringitis or trauma. Traumatic perforation may close alone or by using a paper patch, gelfoam or other material as splint after evertion and approximation of the free edges. In pathological perforations, promotion of healing can be induced by cautery destruction of the edge using silver nitrate bead or trichloracetic acid and this can proceed to closure. Surgical repair of the tympanic membrane perforations is effected by any of the different technique of myringoplasty. An important step common to all technique is denudation of the edge of keratinizing epithelium. At the present time surgery is considered the most effective method of closure. Also dealing with the edge is a crucial point. Therefore success of reconstruction depends in part on management of the edge of the defect. Also a proper knowledge of tympanic membrane anatomy, physiology and pathology has contributed much to the success of modern reconstructive middle ear surgery.

This work has been under-taken to study the pathological changes that occur at the edge of drum perforation and how these changes govern the methods of reconstruction and prognosis.

ANATOMY OF THE TYMPANIC MEMBRANE

Some points in tymapanic membrane anatomy have a direct bearing on our study. These points include: dimentions, parts, middle ear compartments in direct relation to the tympanic membrane, blood & nerve supply.

Dimentions :-

Thickness	0.1	mm
Total area	85	sq.mm
Height	10	mm
Width	8	mm
Malleus length	5.5 - 6	mm

Parts discription :-

The tympanic membrane consists of two anatomical segments: membrana tensa inferiorly and small membrana flaccida superi--orly. They are separated from each other by the anterior and posterior malleolar folds. Membrana tensa forms the greater part of the tympanic membrane. It is thickened peripherally into a fibrocartilagenous tympanic annulus which fits into the grooved tympanic sulcus. The tympanic annulus is carried from the anterior & posterior extremities of the notch of Rivinus to the lateral process of the malleus. Membrana tensa is sem-itransparent with a triangular cone of reflected light antero -inferiorly. The point of maximum concavity is called the umbo. The membrana tensa is formed of outer epithelial layer, middle fibrous layer & inner mucosal layer. The handle of the malleus is directed downward & slightly bakward and is firmly attached to the middle fibrous layer of the tympanic membrane. Membrana flaccida forms the smaller part of the tympanic membrane. It is called Shrapnell's membrane. It is attached above to the squama & below to the anterior &posterior malleular folds. It occupies the notch of Rivinus the tympanic annulus & fibrous layer are absent .

Middle ear compartments in direct relation to the tympanic membrane :-

Prussak space is limited laterally by the pars flaccida, superiorly by the lateral malleular ligaments and inferiorly by the lower part of the malleus neck. The anterior and posterior pouches of Von Troltsch are present between the anterior & posterior malleular folds respectivesy and that portion of the tympanic membrane posterior to the handle of the malleus.

Blood supply :-

The inner surface is supplied by branches of:middle meningeal, internal maxillary,stylomastoid and assending pharyngeal arteries. These branches form the peripheral vascular circle. The outer surface is supplied by deep auricular branch of the maxillary artery.

Nerve supply :-

The inner surface is supplied by branches of glossopharyngeal nerve. The outer surface is supplied by branch of trigeminal nerve in the anterior half and by branch of vagus nerve in the posterior half.

HISTOLOGY

Bloam & Fowcett[3] mentioned that the tympanic membrane is composed of :-

A - pars tensa :- It is composed of three layers epidermis, lamina propria and mucosal layer. The external is an epidermal layer which is a thin one (50-60 um) devoid of hairs and other appendages but consisting of the four strata characteristic of skin : stratum corium, stratum granulosum, stratum spinosum and stratum basal. The stratum granulosum contains keratin granules in association with fine cytoplasmic microfilaments attached to desmosomes.

The middle layer is the lamina propria which consists of two subepidermal connective tissue layers: an outer radially arranged collagenous layer, inner circular arranged collagenous layer and submucosal connective tissue layer. The outer radial and inner circular collagenous layers form spider's web arrangement. There is also a thin network of elastic fibers located mainly in the central and peripheral parts of the membrane.

The mucosal or inner layer is only 20-40 microns thick and consists of simple cubical epithelium.

B - The membrana flaccida: has an epidermis which is composed of five to ten layers of desquamating epithelial cells.

It also has a lamina propria which consists of an abundant irregularly arranged collagen and elastic fibres, large numbers of capillaries and myelinated and unmyelinated nerve fibres.

Lastly its mucosal layer is formed mainly of simple squamous cells.

PHYSIOLOGY OF THE MIDDLE EAR AND THE TYMPANIC MEMBRANE

Tympanic membrane perforations interfere with the normal vibration of tympanic membrane, movement of the ossicles, sound transmission mechanism of the middle ear and normal migration of epithelium on the tympanic membrane and external canal. Thus the proper knowledge of middle ear physiology had contributed to the understanding of the pathophysiolgy and of the importance of closure of the defect.

The normal vibration of tympanic membrane :

It was found that the area of maximum displacement is seen near the lower margin. The central part of the membrane vibrates uniformily as a sheet suspended from a curvilinear axis near its upper edge. The vibration of the malleus handle lags behind that of the tympanic membrane. It was also found that at low frequencies all parts of the tympanic membrane contribute in equal degree to the total transformer action of the middle ear and at high frequencies it breaks up into quasi-independent subpatterns and ceases to contribute to displacement of the manubrium. It simply serves as a baffle for the manubrium. The pars flaccida apparently serves simply to provide freedom of motion for the malleus.

The vibration mode of the ossicular chain :

It can be deduced from their dimensions and from the arrangement of their ligamentous support and joints surfaces. The malleus and incus vibrate as a combined unit, rocking on a linear axis which runs from the anterior ligament of the malleus to the attachment of the short process of the incus in the fossa incudis. As regard movement of the stapes, it was found that with sound of moderate intensity a rocking movement occurs about a transverse axis near the posterior end of the annular ligament and with high sound levels the mode of action changes and a side to side rocking movement is seen about an axis running longitudinally through the length of the foot plate. These movements constitute a protective mechanism for minimizing too violent stimulation of the inner ear.

Transformer mechanism of the middle ear:

In the intact middle ear a considerable degree of impedance matching is brought about so that the amplitude is greatly reduced at the oval window as compared with the amplitude at the tympanic membrane and at the same time the force of the vibrations at the oval window is increased. This is brought about by:

1 - The ossicular chain lever ratio:

The malleus and incus jointly act as a levar, pivoting upon the axis of rotation. The malleular arm is longer than the incudal arm in the ratio 1.3 : 1 .

2 - The areal ratio of the tympanic membrane and that of the oval window:

Here there is an hydraulic effect between those two structures which will increase the force of the vibration at oval window.

So the effective area for the tympanic membrane is two thirds of the anatomical area. If the area of the oval window is measured an effective ratio between these two structures of 14 : 1 is obtained. The over-all ratio of middle ear is the product of the ossicular chain lever ratio and the areal ratio between the tympanic membrane and the oval window. This gives an approximate figure of 18:3.

3- The round window :

It is of considerable importance in determining the effectiveness of sound transmission to the inner ear. It has an area of 2 sq.mm, is protected by the overhanging lip of the round window niche, and lies in a horizontal plane at right angles to the oval window. In the normal ear, intact tympanic membrane shields the round window from direct impact of sound. Sound waves normally reach the two windows in different phases and this will tend to enhance sound transmission. However this effect is minimal in the normal ear because of the great effectiveness of the hydraulic and lever mechanism.

In the diseased ear with perforation of tympanic membrane, the effect of sound pressure acting on the round window membrane becomes more important. Thus sound vibrations of low frequency reach the head of the stapes and round window at the same phase. Where at higher frequencies the sound vibrations may meet these structures at opposite phases. It seems quite clear that to achieve optimum sound transmission to the inner ear, the round window membrane must be free to move against an elastic air cushion and that it must be shielded from the direct impact of sound entering the middle ear.

4- The tympanic muscles :

The tympanic muscles restrict the vibrations of the ossicular chain, tense the tympanic membrane and reduce the sensitivity of the ear. The tensor tympanic also draws the malleus slightly superiorly and forward. The stapedius acts for damping of the noise.

5- The size and the site of the defect in the tympanic membrane :

A small hole in the tympanic membrane has no appreciable effect on sound conduction provided that the rest of the conducting apperatus is normal. A larger hole of the membrane causes a diminution of the areal ratio and permits direct access of sound waves to round window. Total loss of pars tensa creats a hearing loss for all frequencies of about 30 DB, this being caused by a loss of the hydraulic mechanism and the cancelling effect of sound waves striking the round window membrane thus a hearing loss will be greater if the perforation is located in the postero-inferior part of the membrana tensa, permitting ready access of sound waves to the round window. In the perforation of the anterior part of the tympanic membrane, the hearing loss is less severe.

The normal epithelial migration on the tympanic membrane:

Alberti [1] noted an average migration rate of 0.07 mm/day and the umbo appeared to be the centre of migration. The author also doubted the existence of any relationship between epidermal migration and the origin of middle ear cholesteatoma because such migration would tend to prevent rather than to cause such an epidermal cyst. Boedts & Kuijpers [5] failed to show the existence of such a rapid epithelial migration in mice, only a very slow movement of labeled cells was observed from the annulus towards the central part of the pars tensa. They showed that the slow migration rate appeared to be mainly confined to the cells of the basal epithelial layer. They also mentioned that the migration of the upper layer of the stratum corneum might represent a physiological mechanism in taking care of the removal of keratin and cerumen from the tympanic membrane. The displacement or extrusion of grommets might be at least partly attributable to this mechanism. The driving force of this cleaning process remains a matter of speculation. However, several mechanisms underlying this migration have been postulated such as vibration of the tympanic membrane or the blood flow in the vessels of the membrane.

Lastly, mal-functions of tympanic membrane and middle ear that occur after inadequate closure of the defect as a result of graft cholesteatoma, lateralized membrane and blunting anterior angle reduce the vibratory surface of the drum and contribute towards a poor hearing result.

HISTOPATHOLOGY

Tympanic membrane perforations are classified according to their site into :

A- Perforations of membrana tensa :

1- Central perforations :-

A perforation of pars tensa regardless of size and site is described as central when a rim of tympanic membrane remains all arround.

2- Marginal perforations :-

When some part of the defect extends to the tympanic annulus.

B- Perforations of membrana flaccida ;

Defect of Schrapnell's membrane is commonly termed attic perforation.

Tympanic membrane perforations heal spontaneously when they are caused by infection or trauma, but permanent perforation may occur when the area of destruction is large or when infection is recurrent or prolonged.

Etiology and pathology of central perforation :

Tawfic [21] mentioned that central perforations of the tympanic membrane may be of traumatic origin, but more often result from an acute suppurative otitis media of necrotic type. The usual type of acute suppurative otits media with a tiny tympanic membrane perforation and with a self limiting course eviding in a restoration of the structures to normal in contrast with the necrotizing form of acute suppurative otitis