KBB Uygulamaları 2015;3(3):97-104
doi: 10.5606/kbbu.2015.26818

Original Article / *Original Article*

Middle ear pathologic findings in exploratory tympanotomy and their audiologic effects

Keşif timpanotomide orta kulak patolojik bulguları ve odyolojik etkileri

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ABSTRACT

Objectives: This study aims to investigate the frequency of ossicular fixation or discontinuity, applied surgical procedures and prosthesis sizes, and their audiologic effects.

Patients and Methods: This retrospective study included 95 patients (21 males, 74 females; mean age 37 years; range 11 to 67 years) with conductive hearing loss operated for exploration of etiology between June 2001 and May 2015. Patients were examined preoperatively with microscope and pneumootoscopy to determine ossicles and tympanic membrane mobility, and degree of their hearing loss was identified by audiometry. Patients were evaluated for ossicular fixation, dislocation, malformation, and other pathologic processes intraoperatively.

Results: In terms of middle ear pathologies, 63.1% of patients had normal ossicular chain, 29.4% had ossicular discontinuity, 55.7% had otosclerotic stapes fixation 35.7% had sclerosis and hyaline, 27.3% had mucosal bridge, 4.2% had anterior malleolar ligament calcifications, 4.2% had facial nerve dislocation, 4.2% had previous ossiculoplasty, 2.1% had perilymph fistula, 1.05% had cholesteatoma and middle ear hemangioma. Rate of intraoperative complications was 29.4% including 16.8% for tympanic membrane tearing, 11.5% for chorda tympani severed, and 1.05% for drug allergy. Preoperative pure tone average revealed an air conduction of 59 dB, bone conduction of 23 dB, and air-bone gap of 36 dB.

Conclusion: Our study findings showed no correlation between hearing loss levels, tympanogram types, and types of middle ear pathology. Causes of hearing loss were otosclerosis and ossicular discontinuity. Reasons for ossicular dysfunctions such as fixation or discontinuity may be detected intraoperatively in most patients.

Keywords: Hearing loss; middle ear; otosclerosis; tympanotomy.

ÖZ

Amaç: Bu çalışmada ossiküler fiksasyon veya devamsızlığın sıklığı, uygulanan cerrahi işlemler ve protez boyutları ile bunların odyolojik etkileri araştırıldı.

Hastalar ve Yöntemler: Bu retrospektif çalışmaya kondüktif işitme kaybı olan ve etyolojinin keşfi için Haziran 2001-Mayıs 2015 tarihleri arasında ameliyat edilen 95 hasta (21 erkek, 74 kadın; ort. yaş 37 yıl; dağılım 11-67 yıl) dahil edildi. Hastalar ameliyat öncesinde ossiküllerin ve timpanik membran mobilitesinin tespit edilmesi için mikroskop ve pnömatik otoskop ile incelendi; işitme kayıplarının derecesi odyometri ile tanımlandı. Hastalar ameliyat sırasında ossiküler fiksasyon, dislokasyon, malformasyon ve diğer patolojik süreçler açısından değerlendirildi.

Bulgular: Orta kulak patolojileri bakımından hastaların %63.1'inde normal ossiküler zincir, %29.4'ünde ossiküler devamsızlık, %55.7'sinde otosklerotik stapes fiksasyonu, %35.7'sinde skleroz ve hiyalin, %27.3'ünde mukozal köprü, %4.2'sinde anterior malleolar ligament kalsifikasyonları, %4.2'sinde fasiyal sinir dislokasyonu, %4.2'sinde ossiküloplasti geçmişi, %2.1'inde perilenf fistülü, %1.05'inde kolesteatom ve orta kulak hemanjiomu vardı. Ameliyat sırası komplikasyonların oranı %29.4 idi ve bunların %16.8'i timpanik membran yırtılmasını, %11.5'i korda timpani kopmasını ve %1.05'i ilaç alerjisini içeriyordu. Ameliyat öncesi saf ton ortalaması 59 dB hava kondüksiyonu, 23 dB kemik kondüksiyonu ve 36 dB hava-kemik aralığı gösterdi.

Sonuç: Çalışmamızın bulgularında işitme kaybı düzeyleri, timpanogram tipleri ve orta kulak patolojisi tipleri arasında ilişki görülmedi. İşitme kaybının nedenleri otoskleroz ve ossiküler devamsızlık idi. Çoğu hastada fiksasyon veya devamsızlık gibi ossiküler disfonksiyon nedenleri ancak ameliyat sırasında tespit edilebilir.

Anahtar sözcükler: İşitme kaybı; orta kulak; otoskleroz; timpanotomi.

Received: July 11, 2015 *Accepted:* August 20, 2015

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Conductive hearing loss is a common problem that is usually associated with stapes or other bone fixation or dislocation.[1] Determination of ossicular fixation and discontinuity can be achieved perioperatively in most patients so that appropriate recommendations can be made. Despite recent technological advances it is not always possible to determine disorders and pathologies of the sound conduction system. Available investigations to establish the cause of unexplained conductive hearing loss include computed tomography (CT), tympanometry, laser vibrometry and serological testing. None of these techniques has sufficient sensitivity and specificity to allow a confident diagnosis to be made in all cases.[2,3] The otologist frequently has recourse to exploratory tympanotomy (ET) in order to establish a diagnosis and to allow for surgical treatment, but there is scarce data on ET in literature.

Conductive hearing loss with an intact tympanic membrane is not necessarily otosclerosis. Ossicular fixation or discontinuity are also common middle ear causes of hearing loss. Chronic inflammation in the middle ear has been proposed to be one cause of ankylosis by leading to degeneration of the ligaments, with calcification and ossification resulting in bony fixation of the ossicles.[4] Tympanosclerosis was found to be the second common cause of ossicular fixation, especially that of the incus and malleus.[5] Trauma may lead to fixation by callus formation in the epitympanum. Previous middle ear surgery may also lead to fixation if small pieces of bone or dust are left behind. It is essential to have an idea of the possible existing pathology behind the tympanic membrane to plan therapy and enable an informed preoperative discussion with the patient. Determination of the reasons for ossicular dysfunction like fixation or discontinuity can be achieved perioperatively in most patients so that correct counseling can occur.

Correction of conductive hearing loss requires middle ear exploration. At the time of surgery, the mobility of the entire ossicular chain can be determined. Ossicular fixation should be considered in patients with persistent conductive hearing loss. When fixation or dislocations of the ossicles are found, treatment options exist. A common technique involves removal of the incus and head of the malleus and reconstruction with an incus interposition or a partial ossicular prosthesis and/or stapedotomy.[6] These corrections may be achieved using a variety of reconstruction materials, including homograft ossicles, cortical bone, cartilage, and partial and total ossicular reconstruction prosthesis.[7] Clearance of pathologic process as hyaline, bridge or a mass blocking ossicular mobility in the middle ear is enough in some cases.

In addition ET is advised when sudden unilateral hearing loses occur It is useful for these patients if a perilymph fistula is determined and obliterated or covered with fascia within the first seven days.[8-10]

In this study, we aimed to investigate the distribution of the middle ear pathologies leading to hearing loss and to examine surgical and prosthetic types used for the treatment of these pathologies.

PATIENTS AND METHODS

We analyzed data for 95 patients (21 males, 74 females; mean age 37 years; range 11 to 67 years) who had unknown causes of hearing loss, on whom exploratory tympanotomy was carried out consecutively at the Dr. Lütfi Kırdar Kartal Education and Research Hospital Ear Nose and Throat Clinic. Demographic data and operative findings were recorded at the time of surgery; information on patients who underwent surgery for conductive hearing loss by different surgeons in was sought in the original database. In all cases, the information available in the database was supplemented by consulting the operation notes. Data were transferred to a Microsoft Excel file and the operative findings were coded to allow data analysis.

Each patient underwent preoperative evaluation that included a detailed history and physical examination with audiologic evaluation. Pure-tone averages (PTAs) were recorded and reported at 0.25, 0.5, 1, 2, 4 and 8 kHz. Average air-bone gaps (ABGs) were also determined for the same frequencies. Hearing results were reported in accordance with the 1995 guidelines of the Committee on Hearing and Equilibrium for both preoperative and postoperative results.[11]

All patients had hearing loss and were investigated and treated by exploratory tympanotomy. All operations were conducted under general anesthesia with additional anesthesia using a standard four-quadrant canal injection with 1% lidocaine with 1:100,000 epinephrine. The surgical approaches used were transcanal in 50 cases (52.6%), endaural in 38 cases (40%), retroauricular in four cases (4.2%), transcanal + endaural in two cases (2.1%), retroauricular + endaural in one case (1.05%).

RESULTS

All 95 patients had hearing loss and the status of their ossicular chain was not known preoperatively; none had an obvious tympanic membrane perforation or history of active chronic infection. Three patients underwent bilateral surgery. Three were found to have otosclerosis.

Table 1
Operative findings

Findings	n	%	Mean hearing levels AC (dB)	Mean hearing levels BC (dB)
Intact ossicular chain	60	63.1	60	23
Ossicular discontinuity	35	36.9	60	24
Otosclerotic stapes	53	55.7	60	23
With sclerosis and hyaline	34	35.7	59	21
With bridge	26	27.3	61.3	24.6
Anterior malleolar ligament calcification	4	4.2	53	20
Thickened tympanic membrane	10	10.5	50	5
Facial nerve dislocation	4	4.2	61.6	23.7
Previous ossiculoplasty	4	4.2	47.1	17
Perilymph fistula	2	2.1	75.8	7.5
Cholesteatoma	1	1.05	60	15
Otitis media with effusion	1	1.05	50	37.5
Middle ear hemangioma	1	1.05	20	12

n: Numbers of the ears; AC: Air conduction of hearing levels; BC: Bone conduction of hearing levels; dB: Decibel.

The preoperative PTA air conduction (AC) average was 59 dB, the bone conduction (BC) average was 23 dB and average ABG was 36 dB (range, 11 to 85 dB). The tympanic membrane (TM) was normal in 60 patients (63.1%), atrophic in 17 (17.8%), had retractions in 11 (11.5%), and had occult perforations in five (5.2%) (Table 1).

There were little differences in tympanometric measurements between type of tympanograms and mean hearing loss. For instance patients with type A tympanograms had mean (AC/BC) hearing levels of 59/20 dB, those with type AS, 63/27 dB; type C, 57/16 dB; and type B, 57/16 dB.

Ossicular chain evaluation showed 60 patients (63.1%) had ossicular continuity. The most common findings were ossicular chain fixation due to otosclerosis, 53 (55.7%); ossicular chain sclerosis and hyaline, 34 (35.7%); mucosal bridge, 26 (27.3%); dislocations, 28 (29.4%) and anterior malleolar ligament calcifications, 4 (4.2%). (Percentages of ET findings and mean audiologic effects are shown in Table 2).

Fifty-two (57.3%) patients underwent stapedotomy due to otosclerosis of the stapes fixation, one otosclerotic stapes recover mobility again while their cruras breaking the remaining 39 patients (41%) were treated for malleus/incus fixation, dislocation, and other reasons (Table 3).

Table 2
Operative findings according to type and localization of causes of ossicular dysfunction or discontinuity

Causes	Malleus				Incus				Stapes			
	n	%	AC	BC	n	%	AC	BC	n	%	AC	BC
Eroded	3	3.1	67.2	29.1	9	9.4	63	20	8	8.4	67	26
Absent	2	2.1	71.2	24.3	5	5.2	66	23	7	7.3	66	22
Surrounded with bridge	10	10.5	62.8	24.2	9	9.4	57	17	13	13.6	60	22
Surrounded with hyaline	6	6.3	61	22.6	9	9.4	60	19	9	9.4	55	16
Dislocated	–	–	–	–	7	7.3	54	20	2	2.1	75	43
Anterior malleolar ligament calcification	4	4.2	55	20	–		–	–	–		–	–
Otosclerosis	–		–	–	–		–	–	53	55.7	60	23
Fractured stapes arch	–		–	–	–		–	–	5	5.2	65	26

AC: Air conduction of hearing levels; BC: Bone conduction of hearing levels.

Table 3
Causes of ossicular fixation

Causes	n	%	Mean hearing levels AC (dB)	BC (dB)
Otosclerosis	53	55.7	60	23
Pure stapes fixation	35	36.8	58	23
Stapes fixation with other pathologies mixed	54	60.6	59	22.8
Tympanosclerosis	34	35.7	59	21
Stapes involvement	9	10.1	66.5	31.3
Incus involvement	11	12.3	55.5	17.4
Malleus involvement	6	6.7	57	22

AC: Air conduction of hearing levels; BC: Bone conduction of hearing levels; dB: Decibel.

These procedures included hyaline and mucosal bridge excisions without a prosthesis in 34 (35.7%); ossicular chain repair using total ossicular prosthesis (TORP) in two patients (2.1%); partial ossicular prosthesis (PORP), bone cement, cartilage graft, hemangioma excision, mucosal adhesion repair with silastic shield placement in one patient (1.05%) and fascial coverage of perilymph fistulas in two patients (2.1%). Four patients had a previous ossiculoplasty reoperated for prosthesis displacement or dysfunctions.

Piston prosthesis were applied in 55 patients (57.8%): 0.6 mm diameter, 5 mm length in 28 patients (29.4%), 0.6x4.5 mm in 19 patients (20%), 0.4x4 mm in five patients (5.2%), 0.6x6 mm one patient (1.05%), 0.6x7 mm in one patient (1.05%), and 0.8x8.1 mm in one patient (1.05%).

There were 28 (29.4%) complications: 15 (16.9%) tympanic membranes torn, 10 (11.2%) chorda tympanis were severed, one (1.1%) drug allergy requiring a tympanoplasty in another operation. These complications occurred most likely due to the presence of extremely atrophic or sclerotic membranes.

There were no apparent differences in mean AC/BC hearing levels with differences in stapes movement: fixed stapes, 58/22 dB; mobile, 60/23 dB; minimal mobility, 59/24 dB. However when stapes were absent the AC/BC hearing loss was higher (69/22 dB) (Figure 1).

DISCUSSION

Preoperative investigations such as otoscopy, audiometry, tympanometry and high resolution CT scanning are helpful but cannot provide a reliable diagnosis for patients with a conductive hearing loss.[2,12] A pathological diagnosis of otosclerosis can sometimes be made on CT imaging.[12] Shin et al.[13] found that while CT scanning diagnosed 91.3% of cases of otosclerosis, the accuracy was 57% for other minor malformations. Techniques such as laser Doppler vibrometry[11] and wideband energy reflectance[14] may be of use but their accuracy has yet to be proven in large clinical studies. Decreased anti-measles serum immunoglobulin G may be diagnostic for otosclerosis but does not exclude stapes fixation of other causes.[15] Although mean compliance as measured by tympanometry is lower in ears with otosclerosis, the overlap with the normal population is such that this parameter is not useful in the diagnosis of a conductive hearing loss with a normal tympanic membrane.[3] We found that there were no obvious differences in mean hearing losses related to type of tympanogram in patients who underwent ET.

If cochlear involvement is not present, otosclerosis is limited to maximal conductive loss of 50 to 65 dB

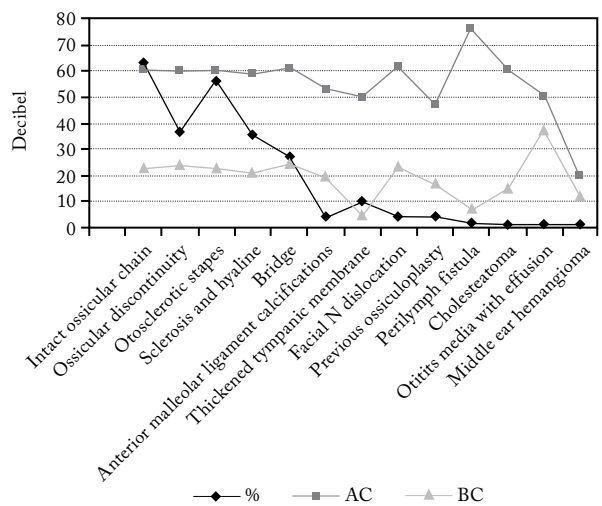

Figure 1. The relations of middle ear pathologies and mean hearing levels. AC: Mean Air conduction hearing levels; BC: Mean bone conduction hearing levels.

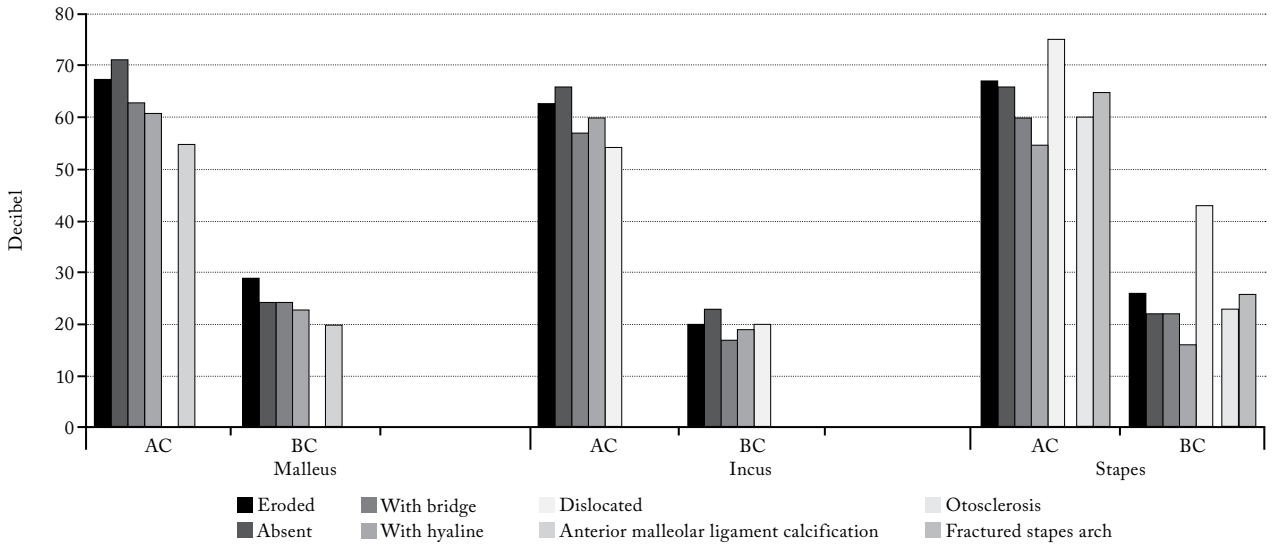

Figure 2. Ossicular chain pathologies, distributions and their effects on hearing parameters. AC: Mean air conduction hearing levels; BC: Mean bone conduction hearing levels.

across all frequencies. Pure-tone audiometry usually demonstrates low-frequency conductive hearing loss. High frequency losses begin to manifest with gradual ABG widening if cochlear involvement is present, a mixed hearing loss appears, with high frequencies more affected. In severe cases, tinnitus may interfere with pure-tone audiometry. Otosclerotic ears had mean PTA AC/BC of 60/23 dB in this study group; similar patterns were seen in previous studies.

Another unsuspected cause of persistent conductive hearing loss after stapes surgery might be dehiscence of the superior semicircular canal.[13] A condition which was not recognized at the time they underwent surgery, although it has long been recognized that patients with a conductive hearing loss may have no abnormality on ET.[8] None of our patients had superior semicircular canal dehiscence.

The pathogenesis of ossicular fixation is not completely understood. It may be caused by tympanosclerosis, chronic infection, trauma, otosclerosis, Paget disease, or may be congenital or idiopathic. For these reasons, surgeons visualize the contents of the middle-ear space. Exploratory tympanotomy is still required to establish a final diagnosis. In a series by Katzke and Plester,[16] tympanosclerosis was found to be the most common cause of malleolar fixation and idiopathy was the

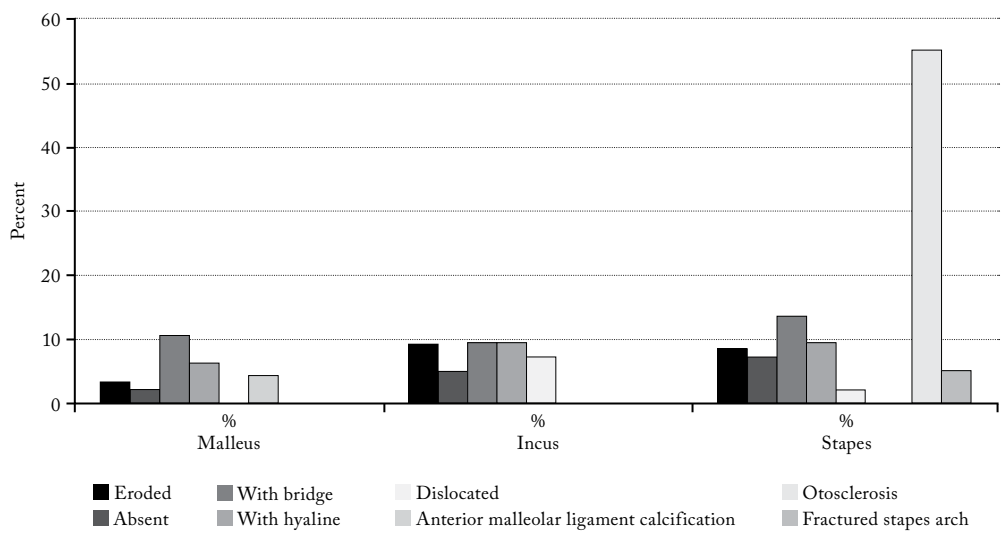

Figure 3. Distributions of middle ear pathologies among ossicles.

second most common cause. Chronic inflammation in the middle ear has been proposed to be one cause of ankylosis by leading to degeneration of the ligaments, with calcification and ossification resulting in bony fixation of the ossicles.[17] Erosion and the ultimate loss of these bones are often caused by chronic middle ear disease.[18] In the presence of tympanosclerosis, the incus was the most affected ossicle in our study, but hearing loss was deeper when the affected ossicle was the stapes. Hyaline and sclerosis affected the incus and malleus with the same proportion, 10% of cases for both ossicles, the malleus was affected rarely. Nevertheless, otosclerosis was still the most common pathology in the middle ear of patients who underwent ossiculoplasty previously. Pure stapes fixation without other associated pathologies of the middle ear cavity was seen at a ratio of 35%. Fractured stapes arch was seen in nearly 5%, possibly a result of previous trauma.

In this study, ETs were most often applied in women (77.9%) compared to men (22.1%). Patients ages ranged from 11 to 67 years old. Pure tone AC/BC hearing loss levels averaged 59/23 dB with 36 dB gaps preoperatively. Mean pure tone AC/BC hearing loss levels in otosclerotic ears were 60/23 dB, and in tympanosclerotic ears, 60/22 dB. These values were not far enough from each other for differential diagnosis. The highest levels of hearing loss were found when malleus and stapes had erosion and absences. When the tympanosclerotic process affect the stapes (10.1%), the highest pure tone AC/BC hearing loses levels existed at 66.5/31.3 dB. Pure stapes otosclerosis without any other middle ear pathology was found in 36.8% and their PTA AC/BC was 58/23 dB. Hearing loss levels were almost the same whatever the middle ear pathology was. Our cases showed mean 59-23 dB hearing levels. Two exceptions exist-- perilymph fistula in which air-bone gap was higher (75-7dB), and hemangioma in which hearing was not affected much (20-12 dB) due to the small size of the tumor. Hearing loss was biggest if the cause was absence of one or more ossicle(s) (Figure 2).

The tympanomeatal flap and similar approaches have been used for this surgery. Lempert in 1946 described an inferiorly based tympanomeatal flap and Shea, writing on the development of stapedectomy, described the posteriorly based flap in use today.[1,5] Seidman and Babu[19] used the transmeatal approach for their cases. Their cases had preoperative hearing loss gaps of 18-51 dB averaging 33 dB. We used a transmeatal approach in 52.6%, endaural in 40%, retroauricular in 4.2%, combined transmeatal and endaural approach in 2.1%, and combined retroauricular and endaural approach in 1.05%.

Paparella and Koutroupas[11] found the most common diagnosis to be otosclerosis in 79.7%, followed by congenital fixation of the stapes in 10.6%, and he also found 20% of case had sensory neural hearing loss, 29.7 % of case had normal tympanic membrane. He could not find the reason for sensorineural hearing loss in three cases. Twelve percent underwent stapedectomy and 37.3% had a history of acute otitis media.[5] Robertson and Mills[1] found otosclerosis most often in 48.2% and ossicular discontinuity in 30.3% on ET. Seidman and Babu[19] found otosclerosis most often in 94.5% and incudo-malleolar fixation in 5.5%. The malleolar fixation in nearly 4.1% was due to anterior malleolar ligament calcification. Preoperative PTA was 51 dB (36-78 dB) with gap of 33 dB (18-51 dB). Two complications occurred in those operations (Figure 3).[19]

The incidence of incus and malleus ankylosis due to congenital anomalies was 0.4-1.6%.[20] Fixation of the malleus and incus is an uncommon cause of conductive hearing loss and can be caused by infection, trauma, or previous surgery, or it can be idiopathic.[21] We observed sensorineural hearing loss due to perilymph fistulas in only two patients. Four patients had a history of stapedectomy. Anterior malleolar ligament calcification was found in 4.2%, incus fixation in 10.9%, malleus fixation in 7.3% in our study group. Our cases that underwent ET had normal tympanic membrane (TM) in 62.1%, atrophic TM in 17.8%, retractions in 12.6%, and occult perforation in 6.3%.

Perioperative middle ear findings showed that otosclerosis was also the most common diagnosis in 55.7% of our series. Ossicular continuity was seen in 63.1%, discontinuity in 36.9%, tympanosclerotic blockade in 35.7%, and cholesteatoma in 1.05%. Ossicular discontinuity (36.9%) was higher in our study than in Paparella's, but similar to Robertson's study.[1,5] Our ET findings showed 2/3 cases had an intact ossicular chain while 1/3 had discontinuity in at least one point of the ossicular chain.

A previous study on ears with chronic otitis media found tympanosclerosis in 28.7% and cholesteatoma in 11%.[22] It appears that a tympanosclerotic process is seen in higher rates in tympanic membranes with hearing loss.

The most common ossicular defect is loss of the incudal long process; the second most common defect is combined loss of the incudal long process and the stapes superstructure. Austin has reported that loss of the incudal long process alone represents 59% of all ossicular defects; the combined loss of the incudal long process and the stapes superstructure accounts for another 23%.[4] The most common form of ossicular

chain lesion after head injury is separation of the incudostapedial joint, with fractures of the malleus, incus, or stapes being described as uncommon.[5-10,12]

When we classified ossicular chain pathologies, the stapes was the ossicle most affected by mucosal bridges and pathologic changes. The incus and malleus were affected in only 10% of cases. Erosion was seen mostly in incus, less often in stapes, and at least in the malleus. Absence of the ossicles was most frequently seen in stapes than in incus and at least in malleus again. The incus pathologies we found on ET were erosion in 9.4%, absence in 5.2%, luxation in 7.3%, and fractured stapes arches in five patients (5.2%) -- possibly due to trauma. It has been recognized that pathological changes due to chronic otitis media can occur behind a normal tympanic membrane.[23] It is possible to encounter cholesteatomas, sequelae of chronic otitis media or other pathologies in ET.[1] Indeed, we found a cholesteatoma and middle ear hemangioma in our series.

Conventional teaching suggests that the surgeon should remove the incus and place a partial ossicular reconstruction prosthesis.[24] In patients with hearing losses who underwent ET, 57.3% were treated with stapedotomy, 3.1% had total ossicular prostheses and partial ossicular prostheses replacement, and 41% were treated without using prosthesis. Stapedotomy prosthesis sizes most often used were 0.6 mm in diameter and 5 mm length in 52.7%, 0.6x4.5 in 34.5%, 0.6x4 mm in 9%, longer size prosthesis were rarely used as 6,7,8 mm lenght in 2% of patients.

The complication rate was 29.4 to 16.9% TM tearing, 11.2% chorda tympani severed, and 1.05% allergy to tamponate saturated with pomad.

Conclusions

Despite current advances in imaging and audiometry, it is still necessary to directly visualize the middle-ear space to establish a diagnosis and to institute treatment. A better understanding of the common findings of exploratory tympanotomy would enable an informed preoperative discussion with the patient. The sequelae of chronic otitis media, hemangioma, perilymph fistula and cholesteatoma may be encountered behind a normal tympanic membrane. More importantly, the process of sclerosis and their effects on hearing function should be carefully examined.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

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