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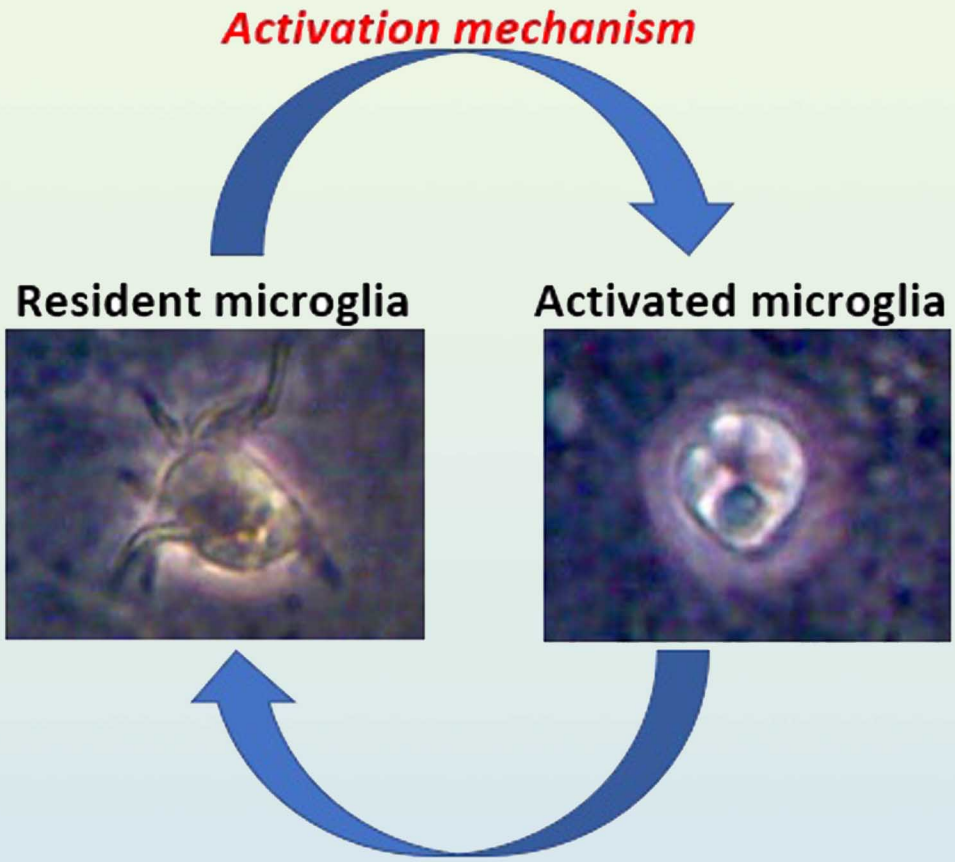


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## [ CONTENTS ]

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**AIM AND SCOPES**
Journal of Cellular Neuroscience and Oxidative Stress is an online journal that publishes original research articles, reviews and short reviews on the molecular basis of biophysical, physiological and pharmacological processes that regulate cellular function, and the control or alteration of these processes by the action of receptors, neurotransmitters, second messengers, cation, anions, drugs or disease.

Areas of particular interest are four topics. They are;

**A- Ion Channels** ($Na^+$- $K^+$ Channels, $Cl^-$ channels, $Ca^{2+}$ channels, ADP-Ribose and metabolism of $NAD^+$, Patch-Clamp applications)

**B- Oxidative Stress** (Antioxidant vitamins, antioxidant enzymes, metabolism of nitric oxide, oxidative stress, biophysics, biochemistry and physiology of free oxygen radicals)

**C- Interaction Between Oxidative Stress and Ion Channels in Neuroscience**
(Effects of the oxidative stress on the activation of the voltage sensitive cation channels, effect of ADP-Ribose and $NAD^+$ on activation of the cation channels which are sensitive to voltage, effect of the oxidative stress on activation of the TRP channels in neurodegenerative diseases such Parkinson's and Alzheimer's diseases)

**D- Gene and Oxidative Stress**
(Gene abnormalities. Interaction between gene and free radicals. Gene anomalies and iron. Role of radiation and cancer on gene polymorphism)

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**RESEARCH ARTICLE**

**J Cell Neurosci Oxid Stress 2019;11(2): 825-834.**

# The epidemiology of tympanosclerosis in chronic otitis media patients in the Kars region of Turkey: The role of computerized temporal tomography in diagnosis of tympanosclerosis

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**Abstract**

The aim of this study was to evaluate tympanosclerosis patients operated with tympanoplasty in terms of patient profile, clinical characteristics, diagnostic role of preoperative computed tomography (CT) and postoperative graft and hearing outcome. The patients operated with tympanoplasty due to tympanosclerosis were included in this study. Data on patient demographics, type of otitis media, preoperative findings, characteristics of tympanosclerosis, preoperative temporal bone CT findings and preoperative and post-operative audiological assessment were recorded in each patient. Postoperative hearing outcome (pure tone averages, air-bone gap) and graft survival rates were also recorded.

Most of patients with operated tympanosclerosis were females (75.9%) and in the 41-60-year (37.0%) age group. CSOM (81.5%) was the most common diagnosis. Tympanosclerosis was open type in 94.0% and located in posterioinferior tympanic membrane in 35.2% of patients and in epitympanum of middle ear in 53.7% of patients with involvement of malleus and incus in most of cases. Loss of mastoid air and volume (94.4%) and high-density areas in middle ear and around ossicles (88.9%) were the leading findings on pre-operative temporal bone CT. Overall graft survival rate was 75.5%, and higher with cartilage than temporal fascia grafts. A significant improvement was noted in pure tone average and air-bone gap. Preoperative temporal bone CT findings seem to offer a potential pre-surgical guide for surgeons operating tympanosclerosis. Tympanoplasty was associated with favorable graft outcome, particularly for cartilage rather than temporal fascia grafts and improved postoperative hearing outcome in terms of pure tone averages and air-bone gap, regardless of the graft type.

**Keywords:** Chronic otitis media, tympanic perforation, tympanoplasty, temporal fascia, graft survival.

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**List of Abbreviations;**

**CSOM,** chronic suppurative otitis media; **CT,** computed tomography; **OME,** otitis media with effusion; **PTA,** pure tone audiometry; **ROM,** recurrent otitis media

## Introduction

Tympanosclerosis is described as an irreversible, though not immutable end result of any unresolved specific or nonspecific inflammatory disease of the middle ear, characterized by anatomical distortion resulting in functional impairment that is hearing loss of the conductive type (Pal et al. 2005). Being more likely in cases with ossicular chain involvement, tympanosclerosis often results in distortion of sound transfer mechanism and thus leads to conductive hearing loss, depending on size and site of tympanosclerotic plaques (Asiri et al. 1999; Aslan et al. 2010).

Tympanosclerosis is a common sequela of chronic suppurative otitis media (CSOM), otitis media with effusion (OME) and recurrent otitis media (ROM) or treatments such as ventilation tube insertion or myringotomy (Asiri et al. 1999; Aslan et al. 2010). However, etiology and pathogenesis of tympanosclerosis remains unclarified alongside the ongoing controversy regarding the role of surgical treatment and the choice of an optimal tympanoplasty approach in the management of hearing loss (Asiri et al. 1999; Aslan et al. 2010). In addition, estimating real incidence of tympanosclerosis is considered challenging due to discordance between clinical histological and surgical diagnosis methods (Aslan et al. 2010).

This retrospective study was designed to evaluate tympanic membrane and tympanic cavity tympanosclerosis patients operated with tympanoplasty in terms of patient profile, clinical characteristics, diagnostic role of preoperative computed tomography (CT) and postoperative graft success and hearing outcomes.

## Materials and Methods

### Study population

A total of 54 otitis media patients operated with tympanoplasty due to tympanosclerosis (myringosclerosis plus intratympanic tympanosclerosis) were included in this retrospective study conducted between December 2011 and May 2013. The study was conducted in full accordance with local Good Clinical Practice guideline and current legislations, while the permission was obtained from our institutional ethics committee for the use of patient data for publication purposes.

### Study parameters

Data on patient demographics (age, gender), type of otitis media (CSOM, ROM, OME), preoperative otomicroscopy findings, type of tympanoplasty, characteristics of tympanosclerosis (unilateral vs. bilateral, open vs. closed type, localization of tympanosclerotic plaques in the tympanic membrane and middle ear), accompanying symptoms, preoperative temporal bone CT findings and preoperative and post-operative audiological assessment were recorded in each patient. Tympanosclerotic plaques intraoperatively excised from the tympanic membrane and/or the tympanic cavity were analyzed for pathological findings. Preoperative CT scans of the temporal bones were evaluated by the same radiologist experienced on head and neck radiology who was blinded to the clinical and operative findings. Postoperative hearing outcome (pure tone averages, air- bone gap) and graft survival rates were also recorded.

### Preoperative otomicroscopy

Following the evaluation of the pinna for any lesions or signs of infection such as cellulitis, perichondritis, or discharge at the meatus, otomicroscopy was performed. The external auditory canal was evaluated for cerumen impaction, discharge, or canal skin infection or lesions. The tympanic membrane was then evaluated for a perforation or retraction including the extent and location. Presence of cholesteatoma, continuity of the lateral attic wall, presence of tympanosclerosis, status of the annulus and ossicles, and segmental middle ear aeration were all evaluated.

### Tympanoplasty

In all patients with presence and mobility of all three ossicles, type 1 tympanoplasty was performed under general anesthesia via harvesting graft tissue from the areolar tissue layer above the temporalis fascia via a post-auricular or endaural incision. This was followed by the elevation of the tympanomeatal flap to gain access to the tympanic cavity. Following a thorough elimination of inflamed and infected tissue in the tympanic cavity, graft tissue is placed on the undersurface of tympanomeatal flap to reconstruct the tympanic membrane. In case of recognition of ossicular chain defects during surgery, then a concomitant

Table 1. Demographic and clinical and operative characteristics

| | | | |
|---|---|---|---|
| **Patient demographics** | | **Tympanosclerosis characteristics, n(%)** | |
| **Age (year), mean(SD, min-max)** | 34.0(15.4,10-66) | **Side of tympanosclerosis** | |
| **Age groups, n(%)** | | Right | 15(27.8) |
| ≤20 year | 14(25.9) | Left | 13(24.1) |
| 21-40 year | 19(35.2) | Bilateral | 26(48.1) |
| 41-60 year | 20(37.0) | **Type of tympanosclerosis** | |
| >60 year | 1(1.9) | Open (perforated membrane) | 51(94.4) |
| **Gender, n(%)** | | Closed (intact membrane) | 3(5.6) |
| Female | 41(75.9) | **Localization of tympanosclerotic plaques** | |
| Male | 13(24.1) | **Tympanic membrane** | |
| **Type of otitis media, n(%)** | | Posterioinferior | 19(35.2) |
| CSOM | 44(81.5) | Anteriosuperior | 10(18.5) |
| ROM | 7(13.0) | Anterioinferior | 6(11.1) |
| OME | 3(5.6) | Posterior | 4(7.4) |
| **Tympanoplasty characteristics, n(%)** | | Circular | 3(5.6) |
| **Type of tympanoplasty** | | All quadrants | 3(5.6) |
| Type 1 | 28(51.9) | Total perforated | 3(5.6) |
| Type 2 | 22(40.7) | Anterior | 2(3.7) |
| Type 3 | 3(5.6) | Posteriosuperior | 2(3.7) |
| Type 4 | 1(1.8) | Inferior | 1(1.9) |
| **Technique** | | Superior | 1(1.9) |
| Post-auricular approach | 51(94.4) | **Middle ear** | |
| Endaural approach | 3(5.6) | Epitympanum | 29(53.7) |
| **Operated ear** | | Mezotympanum | 11(20.4) |
| Right | 28(51.9) | Hypotympanum | 2(3.7) |
| Left | 26(48.1) | mucosa+ epitympanum | 9(16.7) |
| **Graft type**[a] | | mucosa+mezotympanum | 3(5.6) |
| Temporal fascia | 41(77.3) | **Accompanying symptoms** | |
| Cartilage | 12(22.7) | Hearing loss total | 54(100.0) |
| **Preoperative temporal bone CT findings, n(%)** | | conductive | 51(94.4) |
| Loss of mastoid air and volume | 51(94.4) | mixed | 3(5.6) |
| high density areas in middle ear and around ossicles | 48(88.9) | Tinnitus | 15(27.8) |
| ossicle chain defect | 12(70.5) | Otalgia | 14(25.9) |
| thickened tympanic membrane | 46(85.2) | Vertigo | 12(22.2) |
| | | Otorrhea | 2(3.7) |
| **Preoperative otomicroscopy findings, n(%)** | | | |
| **Tympanic membrane status** | | **Middle ear mucosa** | |
| Pars tensa perforation | 44(89.8) | Sclerotic-dry | 50(92.6) |
| Pars tensa+ pars flexia perforation | 4(7.4) | Discharge | 4(7.4) |
| Total perforation | 3(5.6) | Polyp | 2(3.7) |
| Intact status | 3(5.6) | Granulation | 4(7.4) |
| Atrophy | 7(13.0) | Hypertrophy | 2(3.7) |
| Retraction | 4(7.4) | Cholesteatoma | 3(5.6) |
| Hypertrophy | 1(1.9) | | |
| **Involved ossicles** | | | |
| Malleus+incus | 18(33.3) | | |
| Malleus (isolated) | 16(29.6) | | |
| Incus+stapes | 9(16.7) | | |
| Malleus+incus+stapes | 7(13.0) | | |
| Incus (isolated) | 4(7.4) | | |

[a] includes 2 patients with closed tympanosclerosis due to intraoperative perforation during plaque removal

ossiculoplasty was applied. Finally, the middle ear and external ear canals are packed with sponge gel (GelFoam; Pfizer, Michigan, USA). All patients received broad spectrum antibiotic treatment for 1 week. In patients with ongoing otorrhea, middle ear mucosal edema and active infection findings, medical treatment was initiated to maintain dryness of the perforated ear for at least for 3 months before the surgery.

**Audiological assessment**

All patients underwent pure tone audiometry (PTA) analysis to evaluate their pre- and post- operative hearing status. The mean hearing level and air-bone gap of each patient were measured by averaging their hearing thresholds at 500, 1000, 2000, and 4000 Hz. PTA was obtained using an ascending-descending method in 5 dB steps. Threshold was defined as the lowest decibel hearing level at which responses occur in at least one-half of a series of ascending trials.

**Statistical analysis**

Statistical analysis was made using IBM SPSS Statistics for Windows, Version 18.0 (SPSS; IBM Corp., New York, USA). Chi-square ($\chi 2$) test was used for the comparison of categorical data, while Student's t-test was used for the parametric variables. Data were expressed as “mean ± standard deviation (SD)”, and percent (%) where appropriate. $p<0.05$ was considered statistically significant.

**Results**

**Demographic and clinical characteristic**

Overall 113 operations for otitis media were performed in our clinic between Dec 2011 and May 2013, while 54 of 113 operations were due to tympanosclerosis. This indicates 47.8% prevalence of tympanosclerosis among indications for middle ear surgery.

Most of patients with operated tympanosclerosis were females (75.9%) and in the 21-40-year (35.2%) and 41-60-year (37.0%) age groups (Table 1).

CSOM (81.5%) was the most common diagnosis, while type 1 (51.9%) and type 2 (40.7%) tympanoplasty with post-auricular approach (94.4%) and use of temporal fascia graft (77.3%) were the most commonly performed surgical operations (Table 1).

Tympanosclerosis was bilateral in 48.1% of patients, open type in 94.0%, located in posterioinferior tympanic membrane in 35.2% of patients and in epitympanum of middle ear in 53.7% of patients. Accompanying symptoms included hearing loss in all patients (conductive type in 94.4%), as followed by tinnitus in 27.8% and otalgia in 25.9% of patients (Table 1).

Pars tensa perforation was the leading type of tympanic membrane perforation (89.8%) with intact tympanic membrane only in 5.6% of patients, while middle ear mucosa was sclerotic- dry in 92.6% of patients (Table 1).

Malleus was the most commonly involved ossicle either isolated (29.6%) or with incus (33.3%) (Table 1). Manubrium mallei in 19 out of 41 cases with malleus involvement, incus body in 18 out of 40 cases with incus involvement and stapes head in 10 out of 16 cases with stapes involvement were the most common locations for tympanosclerotic plaques.

Loss of mastoid air and volume (94.4%) and high-density areas in middle ear and around ossicles (88.9%) were the leading findings on pre-operative temporal bone CT, which confirmed the clinical and/or surgical diagnosis of tympanosclerosis (Table 1).

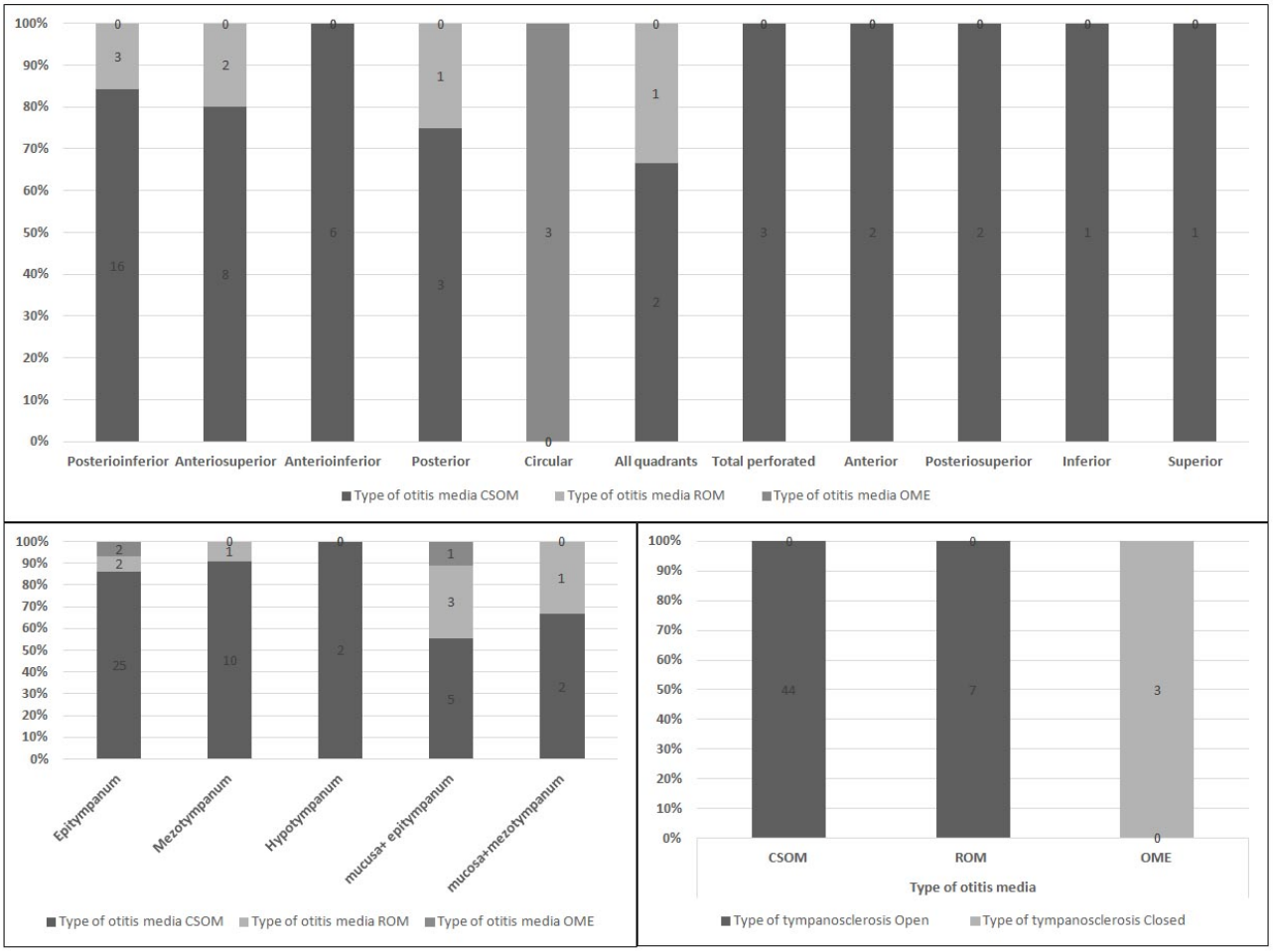
**Tympanosclerosis characteristics according to type of otitis media**

OME was the diagnosis in all (n=3) closed type tympanosclerosis cases, whereas CSOM and ROM were the underlying diagnosis in 86.3% and 13.7% of open type tympanosclerosis cases, respectively (p=0.000) (Figure 1).

For tympanosclerosis plaques, the most common tympanic membrane locations were posterioinferior and anteriosuperior locations in patients with CSOM (24 out of 44) and ROM (5 out of 7), whereas all tympanosclerosis cases (n=3) in patients with OME showed circular location in the tympanic membrane ($p<0.05$) (Figure 1).

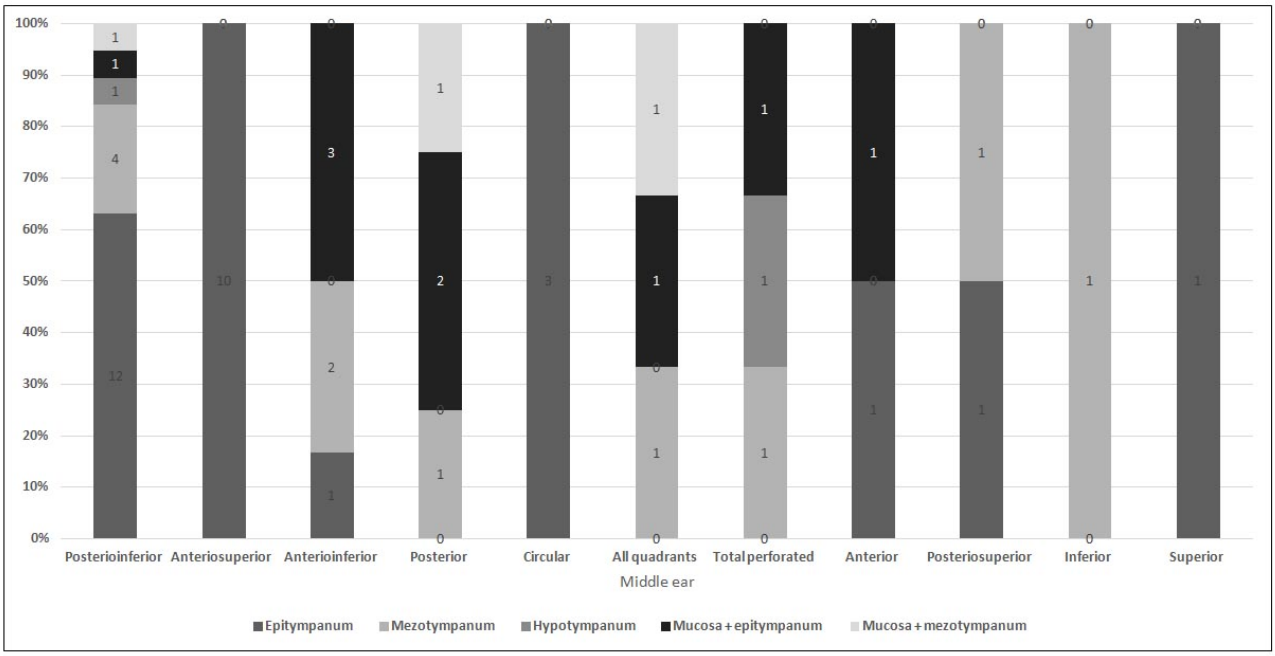
The most common middle ear locations for tympanosclerosis plaques were epitympanum and mezotympanum in patients with CSOM (35 out of 44), epitympanum and mucosa + epitympanum in patients with ROM (5 out of 7) or OME (3 out of 3) ($p<0.000$) (Figure 1).

**Figure 1**. Tympanosclerosis characteristics according to type of otitis media




(CSOM: Chronic suppurative otitis media; ROM:Recurrent otitis media; OME: Otitis media with effusion)

**Figure 2**. Relation between middle ear and tympanic membrane localizations of tympanosclerotic plaque



**Relation between middle ear and tympanic membrane localizations of tympanosclerotic plaque**

Middle ear epitympanum localizations (22 of 29) were more likely to be accompanied with posterioinferior (n=12) and anteriosuperior (n=10) tympanic membrane localizations, while middle ear mucosal localization (n=12) was more likely to be accompanied with anterioinferior (n=3) and posterior (n=3) tympanic membrane localizations ($p<0.05$) (Figure 2).

**Postoperative graft status and hearing outcome**

Overall graft survival rate was 75.5%, while graft success was more likely with use of cartilage than temporal fascia grafts (100.0% vs. 68.3%) (Table 2).

A significant improvement was noted in pure tone average from 52.8(13.3) dB in the preoperative period to 31.5(11.1) dB postoperatively (p=0.000). Air-bone gap was significantly improved from preoperative levels of 32.0(90.0) to 17.6(7.6) postoperatively (p=0.000) along with increase in the percentage of patients with <20 dB air-bone gap from 5.6% to 64.8% after the operation ($p<0.05$) (Table 2).

**Discussion**

Our findings in a retrospective cohort of patients operated with tympanoplasty due to tympanosclerosis revealed predominance of females and middle-aged adults in the study population alongside CSOM as the most common underlying diagnosis. Tympanosclerosis was open type with pars tensa perforations and conductive type hearing loss in majority of cases, while malleus and incus were the most commonly involved ossicles. Posterioinferior tympanic membrane and epitympanum of middle ear were the two most common locations for tympanosclerosis plaques. OME was associated with closed type of tympanosclerosis and circular location of tympanosclerosis plaques in the tympanic membrane. Preoperative temporal bone CT confirmed the clinical and surgical diagnosis of tympanosclerosis in majority of patients. Type 1 and type 2 tympanoplasty were the most common operations, while postoperative hearing outcome and graft success were favorable.

Tympanosclerosis is a sequal of the acute and/or chronic middle ear diseases. Beside this, ventilation tube insertion may be a reason of myringosclerosis. In recent years, oxidative stress was considered as an important point for development of the tympanosclerosis (Karlidag et al. 2004; Kucuktag et al. 2014). Karlıdağ et al. demonstrated higher oxidant and lower antioxidant enzyme levels in the sclerotic specimens of the middle ear (Karlidag et al. 2004). Mattsson et al. showed that hyperoxic condition may lead to tympanosclerosis after experimental trauma of the middle ear. In addition to this, nitric oxide which is a radical molecule may induce the production of the ectopic bone formation like tympanosclerosis in the middle ear (Mattsson et al. 1997; Forseni et al. 2001). Our findings indicate 47.8% prevalence of tympanosclerosis among indications for middle ear surgeries performed in our clinic within the study period.

**Table 2**. Postoperative graft status and hearing outcome

| **Graft outcome** | **Total** | **Temporal fascia** | **Cartilage** |
|---|---|---|---|
| Success | 40(75.5) | 28(68.3) | 12(100.0) |
| Failure | 13(24.5) | 13(31.7) | 0(0.0) |
| **Hearing outcome** | **Preoperative** | **Postoperative** | **p value** |
| Pure tone average (dB), mean(SD) | 52.8(13.3) | 31.5(11.1) | <0.001 |
| Air bone gap (dB), mean(SD) | 32.0(9.0) | 17.6(7.6) | <0.001 |
| <20 dB | 3(5.6) | 35(64.8) | |
| 20-45 dB | 42(77.8) | 19(35.2) | <0.05 |
| >45 dB | 9(16.7) | 0(0.0) | |

This seems notable given that patients in our cohort had tympanosclerosis involving not only the tympanic membrane but also other middle ear structures, despite lesser likelihood of combined involvement of tympanic membrane and middle ear (20%) than isolated tympanic membrane (50%) or middle ear (30%) involvement reported in patients with tympanosclerosis (Asiri et al. 1999).

Past studies revealed a wide range (3.0% to 63%) for prevalence of tympanosclerosis among patients operated with chronic otitis media (Asiri et al. 1999; Wu et al. 2006; Ho et al. 2010), depending the history of ear disease, use of ventilation tube and individual, environmental, genetic and familial risk factors for sclerosis development (Wu et al. 2006). In different studies, the incidence of tympanosclerosis was reported to be 7%–33% and the frequency of myringosclerosis 24%–52% in patients with chronic otitis media (Ağrı et al. 2018). Hence, high prevalence of tympanosclerosis in our series seems to be associated with insidious and progressive course of tympanosclerosis with average 25-year duration of ear disease and higher rate of patients aged 41-60 vs. ≤20 years in our cohort.

Higher prevalence of CSOM than ROM and OEM as underlying diagnosis of tympanosclerosis in our patients support the variation in tympanosclerosis rates depending on the type of otitis media reported in a study and association of COM with higher likelihood of tympanosclerosis development (Magliocca et al. 2018). Notably, while tympanosclerosis is considered to be a frequent sequela of ventilation tube insertion treatment in patients with ROM and OME (Kalcioglu et al.2003), previous history of ventilation tube insertion or paracentesis was evident only in 6 patients (11.1%) in our cohort.

Our findings support the consideration of tympanosclerosis as a middle-age disease with a higher prevalence in females (Mutlu et al. 2015; Aslan et al. 2010). In addition, our findings are also consistent with more common manifestation of open type tympanosclerosis with perforated tympanic membrane mostly located in the pars tensa , as well as bilateral ear involvement (range from 40% to 60%) indicating the likelihood of a systemic response to promote development of tympanosclerosis (Gibb et al. 1994; Bayazit et al. 2004; Aslan et al. 2010).

Our findings are in line with data from past studies on the middle ear structures most affected by tympanosclerosis, including epitympanum and mezotympanum with malleus, incus and incudo-malleolar joint in the attic as the most common locations for tympanosclerotic plaques in the middle ear (Ho et al. 2010; Magliocca et al. 2018).

While isolated stapes involvement was reported to range from 22% to 50% in tympanosclerosis patients (Giddings et al. 1992; Garov et al. 2017), none of patients in our cohort had isolated stapes involvement, while stapes in combination with other ossicles was involved in 29.6% of cases.

Rates for middle ear mucosal involvement (22.2%) in our cohort seems also to be within the range (12% to 21%) of mucosal plaques reported in patients with tympanosclerosis (Asiri et al. 1999; Wu et al. 2006). Identification of sclerotic-dry middle ear mucosa in 92.6% of our patients support that dry middle ear mucosa to accompany 80-90% of tympanosclerosis cases while cholesteatoma accompanied 5.6% of tympanosclerosis cases in our cohort, supporting the incidental and occasional comorbidity of tympanosclerosis with cholesteatoma in the range of 4% to 6% reported in the past studies (Asiri et al. 1999; Ho et al. 2010; Tos et al.1990).

Given that hearing loss was evident in all of our patients, regardless of the tympanic membrane or tympanic cavity involvement, our findings support the likelihood of conductive hearing loss also in myringosclerosis cases along with lack of association between the severity of hearing loss and the site of tympanosclerosis in the ossicle chain (Forseni et al. 2001).

Notably, pure tone average of 52.8 dB and air-bone gap of 32 dB in the preoperative period in our cohort supports the increased likelihood of more severe hearing loss (>40 dB air-bone gap and pure tone average) in patients with tympanosclerosis affecting both the tympanic membrane and the middle ear than those with tympanosclerosis confined only to the tympanic membrane (Tos et al. 1990; Asiri et al. 1999; Beyazıd et al. 2004).

Type 1 and type 2 tympanoplasty were the leading types of surgery in our cohort, supporting the use of type 1 tympanoplasty in all of myringosclerosis cases and higher rate of type1 and type 2 tympanoplasty in

cases with myringosclerosis plus intratympanic tympanosclerosis (Gurr et al. 2008). Our findings indicate favorable surgical outcome in patients with tympanosclerosis involving myringosclerosis as well as ossicle chain in the attic with surgical resection and the individual tympanic membrane and the ossicular chain reconstructions, supporting the good results after surgical treatment of tympanosclerosis regardless location and the extent of the process affecting the middle ear (Gurr et al. 2008).

Overall graft success rate (75.4%) in our cohort was also within the range reported in previous studies among tympanoplasty-treated patients with tympanosclerosis (Glasscock et al. 1982; Milewski et al. 1993). Although use of temporalis fascia in initial tympanoplasties has been associated with high success rates ranging from 93% to 97%, postoperative outcome is considered unpredictable due to structural composition of fascia temporalis involving irregular elastic fibers and fiber connective tissue (Cabra et al. 2010; Jalali et al. 2017). Given the increased likelihood of decreased blood supply to grafts in patients with tympanosclerosis, use of cartilage grafts with diffusion-based nutrition has been suggested to provide better and more predictable postoperative outcome in tympanosclerosis this patient (Dornhoffer et al. 2003). Accordingly, our findings revealed 100% graft success with use cartilage grafts as compared with 68.4% success rates with temporal fascia grafts in tympanoplasty for tympanosclerosis. This seems consistent with high success rates reported with cartilage tympanoplasty, as compared with success rates with temporal fascia grafts (Dornhoffer et al. 2000).

In addition, while hearing outcome after cartilage grafts has been considered to be poorer than temporal fascia grafts, hearing outcome was favorable with significantly improved air-bone gap after operation (from 32.0 to 17.6 dB, <20 dB in 64.8%) as well as improved pure tone average (from 52.8(13.3) to 31.5(11.1) dB) in our cohort, regardless of the graft type. Similarly, past studies revealed 13.5 to 20 dB gain in air-bone gap in patients with tympanosclerosis and fixation of ossicles (Stankovic 2009). This seems notable given the association of 10 dB and 30 dB gains after timpano-ossiculoplasty with 39% and 100% subjective gain, respectively (Yuen et al. 2000).

Preoperative temporal bone CT findings on loss of mastoid air and volume and high-density areas in middle ear and around ossicles are consistent with findings associated with tympanosclerosis in the past studies, while confirmed the clinical and surgical diagnosis of tympanosclerosis in at least 88.9% of patients (Swartz et al. 1983, Walshe et al. 2002). This seems to support the high sensitivity of high-resolution CT in identification of soft and fibrous tissues located in middle ear and /or mastoid region and thus tympanosclerotic plaques leading to preoperative diagnosis of tympanosclerosis with 97-100% accuracy (Walshe et al. 2002). Incus lenticular process was considered to be the most common site for ossicle destruction in patients with tympanosclerosis (Dornelles et al. 2007). However, visualization of the regions with more extensive destruction such as manubrium mallei, incus lenticular process and stapes is considered to be difficult with temporal bone CT as compared with easier evaluation available for malleus and incus bodies (Dornelles et al. 2007). Nonetheless, ossicle destruction, involving incus lenticular process, was evident in 17 patients in our cohort, while preoperative temporal bone CT confirmed the ossicle chain defect in 12 out of 17 patients (70.5%), supporting the 50% to 92.0% sensitivity of preoperative temporal bone CT in detection of ossicle chain defects in patients with tympanosclerosis (Swartz et al. 1983; Boyraz et al. 2009).

Our findings indicate feasibility and accuracy of preoperative temporal bone CT in diagnosis and location of tympanosclerosis prior to operation as a potential preoperative guide to limit complications related to tympanosclerosis surgery. Moreover, given that preoperative temporal bone CT revealed bilateral tympanosclerosis in 26 cases, our findings seem also emphasize superiority of radiological evaluation in detection of tympanosclerosis in the less symptomatic ear accompanied with no further diagnostic workup neither clinically or surgically. Moreover, preoperative temporal bone CT may also reveal data on ossicle chain defects prior to surgery and enable the diagnosis of tympanosclerosis in cases with challenging preoperative clinical examination due to presence of polyp or granulation tissue or suspected cholesteatoma.

In conclusion, our findings in a retrospective cohort of patients with tympanosclerosis revealed

predominance of open type tympanosclerosis accompanied with pars tensa type of tympanic membrane perforations and conductive type hearing loss in majority of cases, and posterioinferior tympanic membrane and epitympanum of middle ear as the two most common locations for tympanosclerosis plaques. On the basis of confirming the clinical and surgical diagnosis of tympanosclerosis in majority of patients, preoperative temporal bone CT findings offer a potential pre-surgical guide for surgeons operating tympanosclerosis. Tympanoplasty was associated with favorable graft outcome, particularly for cartilage rather than temporal fascia grafts and improved postoperative hearing outcome in terms of pure tone averages and air-bone gap, regardless of the graft type.

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