



## INTRAOPERATIVE FINDINGS OF OSSICULAR CHAIN STATUS IN CHRONIC OTITIS MEDIA: OUR EXPERIENCE IN A TERTIARY CARE CENTRE

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### ABSTRACT

**Background:** Chronic otitis media (COM) is a permanent abnormality of the pars tensa (PT) or pars flaccida (PF) which may manifest in the form of atelectasis, perforation, tympanosclerosis, retraction pocket development, cholesteatoma, cholesterol granuloma, ossicular chain disruption etc. It has been further subdivided into active and inactive forms or Safe tubotympanic variety and Unsafe atticointral variety. COM of all types is associated with erosion of the ossicular chain. The incidence and degree of ossicular destruction is much greater in cases of unsafe COM due to the presence of cholesteatoma and/or granulations. The aim of the present study was to correlate the type of COM, the site of perforation/retraction and the type of disease pathology with the pattern and degree of ossicular chain necrosis. **Aims and objectives: AIM OF THE STUDY:** To study the ossicular chain involvement in both safe and unsafe types of COM in patients attending to E.N.T. Department of a tertiary care hospital

#### OBJECTIVES:

1. To study the incidence of ossicular chain pathology in both types of COM.
2. To study the frequency and type of involvement of each ossicle.
3. To compare the ossicular chain involvement in tubotympanic and atticointral variety of Chronic otitis media.

**Methodology:** A prospective study was performed in 90 cases of COM who were subjected to tympanomastoidectomy in tertiary care hospital for a period of 1 year from January 2019 to December 2019. Pre-operative clinical and audiometric findings were compared with per-operative ossicular chain status. **Results:** Ossicular involvement is seen in both types of COM more in unsafe type of COM. Incus is the most commonly affected ossicle while malleus is the least affected ossicle. **Conclusion:** Ossicular chain status should be checked in all patients with COM. So otolaryngologists should be able to address the ossicular chain reconstruction to give the best hearing outcome to the patient.

### KEYWORDS :

#### Introduction

Chronic otitis media (COM) is characterized by a permanent abnormality of the pars tensa (PT) or pars flaccida (PF) which may manifest in the form of atelectasis, perforation, tympanosclerosis, retraction pocket development, ossicular chain disruption, cholesterol granuloma etc<sup>1</sup>. It has been further subdivided into active and inactive forms or safe/tubotympanic and unsafe/atticoantral variety. COM of all types is associated with erosion of the ossicular chain<sup>2</sup>. The incidence and degree of ossicular chain destruction is much greater in cases of unsafe COM due to the presence of cholesteatoma and/or granulations<sup>3</sup>. The proposed mechanism for erosion of ossicular chain is chronic middle ear inflammation as a result of over production of cytokines—TNF alpha, interleukin-2, fibroblast growth factor and platelet derived growth factor which promote hypervascularisation, osteoclast activation and bone resorption causing ossicular damage. TNF-alpha promotes granulation tissue formation by producing hypervascularity. COM is thus an inflammatory process with a defective wound healing mechanism<sup>4</sup>. COM when interrupt the ossicular chain result in mild to severe hearing loss. Complete ossicular chain disruption can result in a 60 dB hearing loss that affects normal conversation<sup>5,6</sup>. Bone erosion may occur in COM even without cholesteatoma, it is more frequent when the keratinizing epithelium is present<sup>7</sup>. Prevalence of ossicular chain disease (in India) in rural population is 46/1000 whereas in urban population it is 16/1000. Incidence of ossicular disease is 9.2 per 100000 in adults whereas it is 3 per 100000 in children<sup>8</sup>. Operative intervention is frequently

needed in both types of COM to eradicate middle ear disease process and to reconstruct ossicular chain integrity. Prior clinical and audiometric evaluations can give us idea about ossicular chain involvements and thus proper reconstruction planning can be adopted.

We present here the intra-operative ossicular chain status of 90 cases of COM who underwent surgery, at our institution over a 1 year period from January 2019 to December 2019, to establish association between pre operative clinical and audiological findings with intraoperative ossicular disease findings so that a proper understanding of the entire scenario can be achieved.

#### AIMS AND OBJECTIVES

##### AIM OF THE STUDY:

To study the ossicular chain involvement in both safe and unsafe types of COM in patients attending to E.N.T. Department of a Tertiary care Hospital.

##### OBJECTIVES:

1. To study the incidence of ossicular chain pathology in COM.
2. To study the frequency and type of involvement of each ossicle.
3. To compare the ossicular chain involvement in safe/tubotympanic type and unsafe/atticoantral type COM

#### MATERIALS AND METHODS

This prospective study has been conducted over a period of 1 year (from January 2019 to December 2019). in the

Department of ENT and Head and Neck Surgery, in a Tertiary care centre, India. Total patients studied during the period were 90.

**Inclusion Criteria:**

1. Cases of chronic otitis media (safe and unsafe) requiring surgery and with pure conductive hearing loss.
2. Patients of 10 to 70 years of age.
3. Patient willing for surgery offered to him or her.
4. Patient giving consent for the study upon him or her.
5. Patient willing to come for regular follow up and obey the medical advice.

**Exclusion Criteria:**

1. Patients with mixed hearing loss.
2. Chronic otitis media with complications like facial nerve palsy, labyrinthitis, intracranial complications etc.
3. Revision cases.
4. Patient not giving consent for study upon him.
5. Patients not willing for surgery

The selected patients were subjected to a detailed history and complete ENT examination. The ears were examined by otoscopy initially and subsequently by otoendoscopy and examination under microscope (EUM) to establish a preoperative diagnosis of mucosal or squamosal disease. All patients underwent a preoperative pure tone audiometry to find out the hearing status and obtain documentary evidence for the same and X-ray mastoid (Schuller's view) to assess the pathology and surgical anatomy of the mastoid to determine operative planning. Eustachian tubes function test and culture and sensitivity test of collected pus as per requirement were done. All patients were sent to pre-anaesthetic checkup and proper preoperative preparation done. Patients with dry perforations in TMs which were dry since more than 6 months with normal Eustachian tube function were offered only tympanoplasty despite the status of mastoid air cell system on X-ray. In patients with safe type of CSOM with intermittently or continuously discharging ears despite medical treatment we choose proper antibiotics by culture and sensitivity test and preferred to do cortical mastoidectomy and tympanoplasty as one-stage procedure. In cases, patients with cholesteatoma where eradication of the disease was not possible, we preferred modified radical mastoidectomy with or without tympanoplasty. All the patients were evaluated under microscope during surgery. Ossicular mobility and round window reflex was checked. Intra-operative middle ear findings including ossicular chain status, erosion of the individual ossicles, and continuity of the malleo-incudal and incudo-stapedial joint were noted. The ossicular chain status in mucosal and squamosal variety was compared statistically. Chi square test was applied and p value less than 0.05 was taken significant.

**OBSERVATIONS AND RESULTS**

A total of 90 cases were selected for this study and divided into 'safe/Tubotympanic' and 'unsafe/Atticoantral' variety of COM based on the history and clinical findings. There were 58 patients of safe com and 32 patients of unsafe com preoperatively but intraoperatively 4 patients of safe type were found to be unsafe. The ossicular chain status in safe and unsafe ear was compared statistically. So the number of cases with safe COM was 54 (60%) and that with unsafe COM was 36 (40%). The patients were aged between 10 and 70 years.

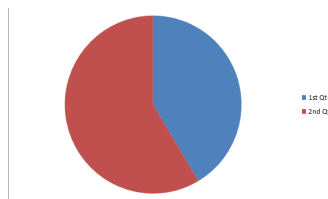
**Table 1(Age Distribution)**

Age group of the patients	No of patients in age group	Percentage %
11-20	11	12.22
21-30	11	12.22

31-40	8	8.89
41-50	17	18.89
51-60	26	28.89
61-70	17	18.89

In this study, among the age range of 11-20 and 21-30 years, each group contained 11 patients (12.22%). among 31-40 years age there were 8 patients (8.89%). 17 patients each (18.89%) were in age groups of 41-50 and 61-70 years. Among 51-60 years of age group there were 26(28.89%) patients.

**Table 2(Sex Distribution of patients)**



Females = 32

Males = 58

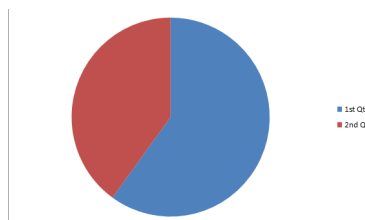
In the study population, 58 patients were males (64.44%) and 32 patients were females (35.56%).

**Table 3 ( Socio economic Status of the Patient)**

Socioeconomic Groups	No of patients	Percentage(%)
Lower class	40	44.44
Lower middle Class	30	33.33
Middle class	16	17.78
Upper middle Class	3	3.33
Upper class	1	1.11

It has been seen that 44.44% of patients belonged to lower class and 33.33% of patients belonged to Lower middle class. 17.78% of study population were among the middle class group. Only 1 patient belonged to Upper class.

**Table 4 (Types of COM patients found preoperatively by Clinical and Audiometric Assessment)**



Safe com = 54

Unsafe com = 36

Based on the intra-operative findings, the patients were reclassified into those with safe COM, 54 (60.00%) cases, and those with unsafe COM, 36 (40.00%) cases.

**Table 5(Clinical features in study patients of COM)**

Clinical features	No of patients	Percentage
Ear discharge	90	100
Decreased hearing	89	98.89
Tinnitus	31	34.44
Earache	13	14.44
Giddiness	15	16.66
Facial weakness	1	1.11

Ear discharge is the most common finding among all study population. (100%). 98.89% patients had decreased hearing as per pure tone audiometry. 31 patients (34.44%) had associated tinnitus. 14.44% patients had earache (mainly seen amongst

unsafe variety of com patients), 16.66% patients had giddiness and only 1 patient of unsafe variety had facial weakness.

**Table 6(Intra operative Status of malleus)**

Malleus	COM (%) n=90	Safe (%) n=54	Unsafe (%) n=36
Intact	72 (80)	53(98.15)	19 (52.78)
HOM Necrosed	11 (12.22)	1 (1.85)	10 (27.78)
Head Necrosed	4 (4.44)	-	4 (11.11)
Handle + Head Necrosed	1 (1.11)	-	1 (2.78)
Absent	2(2.22)	-	2(5.56)
<b>Total:</b>	<b>90 (100.00)</b>	<b>54 (100.00)</b>	<b>36(100.00)</b>

**Status of Malleus in COM:**

The malleus was found to be the most resistant ossicle to erosion in COM. It was found intact in 72 (80%), eroded in 16 (17.78%) and absent in 2 (2.22%) of the cases. In safe COM, 53(98.15%) of the cases had an intact malleus while in 1 (1.85%) cases the tip of handle of malleus was found necrosed. In unsafe COM, the malleus was found intact in 19 (52.78%), necrosed in 15 (16.67%) and absent in 2 (5.56%) cases.

**Table 7(Intraoperative Status of Incus)**

Incus	COM (%) n=90	Safe (%) n=54	Unsafe (%) n=36
Intact	55 (61.11)	50 (92.59)	5(13.89)
Absent	16 (17.78)	1 (1.85)	15 (41.67)
Long + Lenticular Process Necrosed	14 (15.33)	1 (1.85)	13 (36.11)
Lenticular Process Necrosed	3 (3.33)	2 (3.70)	1 (2.78)
Short Process Necrosed	1 (1.11)	-	1 (2.78)
Body + Long Process Necrosed	1 (1.11)	-	1 (2.78)
Body + Lenticular Process Necrosed	-	-	-
Long + Short Process Necrosed	-	-	-
<b>Total:</b>	<b>90 (100.00)</b>	<b>54 (100.00)</b>	<b>36 (100.00)</b>

**Status of Incus in COM:**

Incus was the ossicle most commonly found eroded in our study. We found the incus intact in 55 (61.11%), eroded in 19 (21.11%) and absent in 16 (17.78%) cases. The most commonly necrosed parts of the incus were the lenticular process and the long process. In safe COM, the incus was found intact in 50 (92.59%), eroded in 3 (5.55%) and absent in 1 (1.85%) cases. Lenticular process was the most commonly necrosed part of the incus.

**Table 8 (Status of MALEOINCUDAL JOINT and INCUDOSTAPEDIAL JOINT in Safe and Unsafe variety of COM)**

Joint status	Safe COM (n=54)	Percentage %	Unsafe variety of COM(N=36)	Percentage %
MI joint intact	53	98.15	14	38.89
MI joint discontinuous	1	1.85	22	61.11
IS joint Intact	50	92.59	5	13.89
IS joint discontinuous	4	7.41	31	86.11

Ossicular chain has been found intact (M+I+S) in 58 cases(64.44%).In safe com,53 cases had intact MI joint(98.15) and 50 cases( 92.59%) had intact IS joint.MI joint was found discontinuous in only 1 case among 54 study patients (1.85%) whereas IS joint was found discontinuous in 4 cases(7.41%).

In unsafe COM, MI joint is found intact in 38.89% cases and discontinuous in 61.11% cases.IS joint is found intact in 5 cases(19.89%) and discontinuous in 31(86.11%) cases among unsafe variety COM patients.

**Table 9(Intra op Status of stapes)**

Stapes	COM (%) n=90	Safe (%) n=54	Unsafe (%) n=36
Intact	71(78.89)	53(98.14)	18(50.00)
SuprastructureNecrosed	19(21.11)	1(1.85)	18(50.00)
<b>Total:</b>	<b>90(100.00)</b>	<b>54(100.0)</b>	<b>36(100.00)</b>

**Status of stapes in COM:**

Stapes was found intact in 71 (78.89%) cases while in 19 (21.11%), the superstructure of stapes was found eroded by the disease. In safe COM, 53 (98.14%) of the cases had an intact stapes and only 1 (1.85%) case had erosion of the superstructure. In unsafe COM, 18 (50.00%) cases had an intact stapes and 18 (50.00%) showed erosion of the superstructure of stapes.

**Table 10(Preoperative Pure tone audiometry finding of degree of hearing loss and associated ossicular erosion in Safe variety of com) n = 54**

Degree of hearing loss in safe com	Ossicular erosion present in	Percentage
Mild(33)	3	9.09
Moderate (14)	5	35.71
Moderately severe (5)	1	20
Severe (1)	1	100
Profound (1)	1	100
<b>Total 54</b>	<b>11</b>	

In this study it is found that 11 patients(20.37%) patients had ossicular erosion among safe com patients. Patients with severe and profound hearing loss had ossicular erosion in all cases.5 patients (35.71%) had ossicular erosion in moderate degree hearing loss patients.

**Table 11(Preoperative pure tone audiometry finding of degree of hearing loss and associated ossicular erosion in Unsafe variety of com) n=36**

Degree of hearing loss in Unsafe com	Ossicular erosion present in	Percentage
Mild(8)	8	100
Moderate ( 16)	16	100
Moderately severe (6)	6	100
Severe (4)	4	100
Profound (2)	2	100
<b>Total(36)</b>		

In unsafe variety of com patients, all the patients had ossicular erosion (either malleus, incus, stapes or combined).

**Table 12 (Ossicular status and associated clinical features)**

Clinical features	Ossicular erosion present(27)	Ossicular erosion absent(63)	P value (Significant at less than 0.05)
Tinnitus	7	20	0.12(NS)
Giddiness	3	9	0.19(NS)

Earache	5	9	0.35
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So it is seen that ossicular involvement has no significant association with clinical features of com like tinnitus, giddiness and earache. Null hypothesis is true.

**Table 13(Associated Middle ear Pathologies)**

Middle ear pathology	Safe variety of COM (n=54)	Unsafe variety of COM (n =36)	Total
Cholesteatoma	0	26	26
Granulation tissue	10	7	17
Tympanosclerotic patch	5	5	10

In this study, Cholesteatoma is found associated with 26 out of 36 unsafe variety of COM but not with any case of safe variety of COM. 10 Out of 54 patients had granulation tissue among safe variety of COM whereas 7 out of 36 patients had granulation tissue among unsafe variety. There were 5 cases each with tympanosclerotic patch among both types of COM.

**Table 14 (Associated Middle ear pathologies found in both types of COM with ossicular status)**

Middle ear pathology	Safe variety of COM			Unsafe Variety of COM		
	Ossicles intact	Ossicles eroded	P value (Significant at <0.05)	Ossicles intact	Ossicles eroded	P value (Significant at <0.05)
Cholesteatoma	0	0	-	0	26	-
Granulation tissue	4	6	0.37(NS)	1	6	0.007(S)
Tympanosclerotic patch	0	5	-	2	3	0.5(NS)

In this study, it has been found that all patients with cholesteatoma had ossicular erosion among unsafe variety of COM. Also associated granulation tissue with unsafe variety had significant relation with ossicular erosion. In case of safe variety, it is found that Tympanosclerotic patch is associated with ossicular erosion in all cases.

**Discussion**

In our study we have taken total 90 patients of COM for assessment of intra-operative ossicular status. The cases were divided into safe com (60%) and unsafe com (40%). Majority of the patients belonged to age group 51 to 60 years (28.89%). Ear discharge was seen in all patients and diminished hearing in 98.89% followed by tinnitus and giddiness. Among the ossicles, Malleus was found to be the most resistant one and seen eroded in 17.78% of which handle of malleus eroded only in 12.22%, head necrosed in 4.44% and handle and head necrosed in 1.11% and absent in 2.22% of the cases in com patients but intact in 80% of the patients. In unsafe COM, malleus was intact in 52.78% of the patients and head of malleus eroded in 27.78%, head and handle erosion in 2.78% and absent in 2.56% of the patients. These findings were consistent with study by Udaipurwala et al<sup>8</sup>. Another study by Sade et al<sup>5</sup> shows malleus eroded in 26% of the patients which is similar to our study. Incus was found to be intact in 92.59% of the patients of safe COM and 13.89% patients of unsafe COM. Incus found eroded in 86.11% of the patients most common was long and lenticular process eroded in 41.67% of the patients. Stapes was found to be eroded in 50% of the patients in unsafe com and 1.85% of safe com. Thus we see that incus is the most commonly eroded and absent ossicle in COM. Study by Mathuret al<sup>10</sup> found eroded

incus in 22% of the cases and another study by Quarranta et al<sup>11</sup> showed eroded incus in 27% of the cases.

I.H. Udaipurwala et al included 145 study subjects and showed erosion of incus in 41% patients and long process of incus is the most common involved with extensive cholesteatoma in 30 cases. In our case also incus was the most commonly involved ossicle with long and lenticular process involved in 41.67% of the patients. In the study by Udaipurwala et al, he has not mentioned about lenticular process as may be he has included lenticular process within the long process. In our study cholesteatoma was seen in 26 patients of unsafe COM. In a study by George G Brownie et al, he found erosion in the incus long process, stapes crura, body of incus, handle of malleus in frequency among the patients of unsafe COM. Srestha et al<sup>6</sup> shows that malleus was intact in 76% of the cases, incus eroded in 56% patients and absent in 24% of the cases of unsafe COM. In our study we have seen malleus intact in 80%, absent incus in 41.67% of the patients and long and lenticular process eroded in 36.11% of the patients. Stapes was eroded in 50% of the cases of unsafe COM. Study by Motwani et al<sup>13</sup> reported stapes necrosis in 30% of the cases of unsafe COM. Kurien et al<sup>14</sup> showed incus erosion in 65.3%, malleus in 22.5% and stapes in 63.3% but footplate not involved. In our study incus seen to be eroded in 86.11%, malleus in 47.22% and stapes in 50% of the patients.

In our study incudo-stapedial joint was eroded in 86.11% and incudomalleolar joint was involved in 61.11% of the patients of unsafe COM. Saurab Varshney et al<sup>15</sup> showed that Ossicular erosion are more common in squamosal disease compared to mucosal variety. Rout MR et al<sup>16</sup> found 74 out of 200 patients of safe type of COM had some amount of ossicular involvement. Ossicular chain is mostly eroded in unsafe type COM mainly because of the long standing inflammatory process, cholesteatoma and their vicinity to the ossicles. Incus mainly lenticular process erosion seems to be due to tenuous blood supply, bone marrow quite noticeable. In safe COM, posterior perforations expose the incus to the external environment which may lead to further erosion of the incus. Malleus erosion in safe COM seen mainly in subtotal perforations as scanty blood supply leads to handle of malleus erosion. Stapes erosion was seen at a higher number than the number cited by various other studies because of the fact that may be these patients were referred to us at a much later stage as we are in a tertiary care centre. As more extensive cholesteatoma in unsafe COM had more erosion of stapes. In this study we found that 11 patients (20.37%) patients had ossicular erosion among safe COM patients but in unsafe variety of COM patients, all the patients had ossicular erosion (either malleus, incus, stapes or combined). In our study we have seen that all patients with cholesteatoma had ossicular erosion. Ossicular erosion with presence of granulation tissue was found to be statistically significant. A study by j. Karja it was shown that 75% ossicular erosion in cholesteatomatous disease.

Patients with safe COM had mild type of hearing loss pre-operatively mainly followed by moderate and moderately severe type of hearing loss. But patients with unsafe type of COM majority of the patients had moderate type of hearing loss followed by mild, moderately severe and severe type of hearing loss. In this study it is found that patients with extensive ossicular involvement can give rise to severe or profound hearing loss in both types of COM but more chance of progression to such degree of hearing loss is seen with squamosal variety (6 out of 34 patients) rather than with mucosal variety (2 out of 54 patients). Yingxi Liu<sup>17</sup> et al his study that in middle ear extensive disease where ossicles are involved and completely disrupted can give rise to defective sound conduction leading to severe and profound hearing loss. Finally it is also in our study that there was no significant

association of ossicular chain erosion with clinical features like tinnitus, giddiness or earache.

### Conclusion

Thus in our study we have seen that ossicular erosion was more common with unsafe type of COM than safe type and the most common ossicle to be eroded was incus. The most common necrosed part was also that of the long and lenticular process of incus. But malleus was found to be the most resistant one. Extensive Ossicular erosion is also associated with moderate to moderately severe type of hearing loss in both types of COM. So we should always assess the ossicular chain so that we as otorhinolaryngologists can aim for restoration of the hearing mechanism as early as possible. Thus knowledge of these informations preoperatively can influence surgical decision making and preparedness regarding ossiculoplasty and patient consent.

### REFERENCES

1. Gopen Q. Pathology and clinical course of the inflammatory diseases of the middle ear. In: Gulya AJ, Minor LB, Poe DS, editors. 6th ed. USA Shelton: Connecticut: Peoples Medical Publishing House; 2010. pp. 425-36.
2. Mills RP. Management of chronic suppurative otitis media. In: Booth JB, Kerr AG, 6th ed, editors. Scott-Brown's Otolaryngology . Vol 3. London: Reed Educational and Professional Publishing limited; 1997. p. 1.
3. Proctor B. The development of middle ear spaces and their surgical significance. *J Laryngol Otol.* 1964;78:631-48
4. Deka RC. Newer concepts of pathogenesis of middle ear cholesteatoma. *Indian J Otol.* 1998;4(2):55-57.
5. Sade J, Berco E, Buyanover D, Brown M. Ossicular damage in chronic middle ear inflammation. *Acta Otolaryngol.* 1981;92:273-283.
6. Shreshtha S, Sinha BK. Hearing results after myringoplasty. *Kathmandu Univ Med J.* 2006;4(4):455-4599. Singh RK, Safaya A. Middle ear hearing restoration using autologous cartilage graft in canal wall down mastoidectomy. *Indian J Otol.* 2005;11:10-14.
7. Thomsen J, Bretlau P, Jorgensen MB. Bone resorption in chronic otitis media. The role of cholesteatoma, a must or an adjunct? *Clin Otolaryngol.* 1981;6:179-186.
8. Kemppainen HO, Puhakka JH, Laippala PJ, Sipila MM, Manninen MP, Karna PH. Epidemiology and etiology of middle ear cholesteatoma. *Acta Otolaryngol* 1999;119:568-72.
9. Udaipurwala IH, Iqbal K, Saqulain G, Jalisi M. Pathological profile in chronic suppurative otitis media- the regional experience. *J Park Med Assoc.* 1994;44(10):235-237.
10. Mathur NN, Kakar P, Sing T, Sawhney KL. Ossicular pathology in unsafe chronic suppurative otitis media. *Indian Journal of Otolaryngol* 1991;43:9-12.
11. Quaranta A, Bartoli R, Lozupon E, Resta L, Luranto S. Cholesteatoma in children. Histopathologic findings in middle ear ossicles. *J Otolaryngol Relat Spec* 1995;57:296-8.
12. George G, Brownie, Saamil N, Merchant Gerord Kelly et al chronic suppurative otitis media chapter 237c Scott-Browns otorhinolaryngology. *Head, Neck surgery Vol 3 7th edition Page 3399-3409.*
13. Motwani G, Batra K, Dravid CS. Hydroxylapatite versus Teflon ossicular prosthesis: our experience. *Indian J Otol.* 2005;11:11-20.
14. Kurien M, Job A, Mathew. Orogenic intracranial abscess: concurrent craniotomy and mastoidectomy: changing trends in a developing country. *Arch Otolaryngol Head Neck Surg* 1998;124:1356-66.
15. Sourab S, Nangia A, Bist SS et al. Ossicular chain status in chronic suppurative otitis media in adult. *Indian J otolaryngol Head & Neck surgery* 2010;62(4):421-426 published online 02011. doi;10.1007/s12070-010-0116-3
16. Rout MR, Das P, Mohanty D, Rao V, Susritha K, Jyothi BE. Ossicular chain defects in safe type of chronic suppurative otitis media. *Indian Journal of Otolaryngol.* 2014 Jul 1;20(3):102.
17. Numerical analysis of ossicular chain lesion of human ear by: Yingxiliu. Shenug Li, Xiuzhen Sun. *Acta Mechanica Sinica*, doi;10.1007/s10409-008-0206-6