INTRODUCTION
The term tympanoplasty was first coined in 1953 by Wullstein to describe surgical technique of reconstruction of the hearing mechanism of the middle ear that had been destroyed by chronic suppurative otitis media [CSOM] \(^1\). In 1965, the American Academy of Ophthalmology and Otolaryngology Subcommittee on Conservation of Hearing defined tympanoplasty as “a procedure to eradicate disease in the middle ear and to reconstruct the hearing mechanism with or without tympanic membrane grafting” \(^2\). Myringoplasty (tympanoplasty type I) is usually the treatment of choice for perforations of tympanic membrane in CSOM \(^3\). Transcanal Tympanoplasty Type I [TET 1] is more advantageous than post-aural approach because of lower operative time and minimal tissue injury \(^4,5\). For decades the use of endoscopes in ear surgery was primarily for anatomical studies of the middle ear and use was limited to simple observations of tympanic cavity through perforations and an adjunctive method to aid traditional microscopic procedures \(^6,7\). However, in the last two decades it has been used exclusively for otologic surgical procedures which were earlier classically performed by operating microscopes, such as myringoplasties, ossiculoplasties, stapedotomies and cholesteatoma surgeries \(^7,8\). The traditionally difficult areas like sinus tympani, the anterior epitympanic recess etc. are easily visualized by use of endoscopes \(^6,9\). In our study we observe the results of TET 1 of last four years done by a single surgeon who had switched over to the endoscopic technique nine years ago preferentially over the microscopic technique, which he had been practising for 18 years before switching over to endoscope. The aim of study was to evaluate the change of the techniques in doing TET 1 in a single
department of Otorhinolaryngology in Imphal, Manipur, INDIA.

MATERIAL AND METHODS
The results of the Transcanal Endoscopic Tympanoplasty Type I, performed by an experienced surgeon, who has had 18 years of experience of performing Microscopic Tymanoplasty and 5 years of performing Endoscopic otological surgery before this study period; was monitored in the duration of four years from 1st January 2012 to 31st December 2015. Follow up all cases was done for minimum 3 months to 4.5 years. The details of the TET 1 as practiced in the centre of the study is illustrated as below:

Preoperative assessment:
- History of ear discharge and hearing loss was taken to note the duration of the disease and patients giving history of discharge in the last 2 weeks were removed from the study.
- Otoscopic Examination was done to find out the status of discharge and perforation. Tuning fork test was performed to confirm the conductive type of hearing loss.
- Endoscopic assessment: During endoscopic assessment of the ears in minor operation theatre, only patients with Kartush’s Middle Ear Risk Index (MERI) score of 1-3 or Mild Disease score and; Austin/Kartush Score of zero in ossicular status (M+I+S+) was taken and any others were removed from the study. Only central pars tensa perforation and intact ossicular chain were taken for the study. Paper patch test was done to assess the improvement in hearing by patching up the perforation under endoscope by a cigarette-paper. Audiometry was done after the sealing of the perforation by cigarette-paper to see any improvement from the audiometry report taken with the perforation.
- Audometric Assessment: Pure tone audiometry was done to assess the hearing loss. Only pure conductive hearing loss cases were taken for the study.
- Eustachian Tube Function: Normal saline was instilled in the tympanic end of the Eustachian tube with sterile 2 cc disposable syringe, during endoscopic examination and patient was asked to swallow. Reduction in the level, appearance of small air bubbles or disappearance of the instilled saline was taken as sign of patent Eustachian tube.
- Any risk factors like allergic rhinitis, sinusitis, adenoid enlargement, DNS with nasal obstruction, wet ear, fungal infections, granulations and cholesteatoma were excluded from the study.
- High Resolution CT scan were routinely taken for evaluation of the mastoid air cells. Any ear with hazy mastoids were removed from the study.

Anesthesia: All operations were performed under local anaesthesia except children below 10 years of age. Children below 10 years of age and some apprehensive adults need general anaesthesia. But in our study only two children aged 3 plus and 7 plus needed general anaesthesia.

Local Anaesthesia: Before giving local anaesthesia premedication were given. 0.008 mg/Kg body weight of glycopyrolate were given by intravenous injection. Then 0.16 mg/Kg body of promethazine hydrochloride (Phenergan®) and 0.2 mg/Kg body weight of pentazocine (Fortwin®) in a mixture were given by slow intravenous route. After a wait of 10 minutes the ear to be operated was trimmed of excessive hair inside the ear canal and ear canal was packed with cotton impregnated with framycetin skin ointment (Soframycin®), to avoid antiseptic liquids entering the middle ear cavity. The external ear and pinna were then painted with 10% W/V povidone iodine (Betadine®). Then rectified spirit was used to clean the external canal and pinna. A sterile plastic adhesive drape cut with an oval hole measuring 5X7.5 cm in the middle was applied to the operating field and pasted all around keeping only the pinna and external canal exposed. Then routine sterile dressing and draping was done. The external canal was once again cleaned under endoscope and a cotton ball soaked in 4% lignocaine mixed with 1:10000 adrenaline was kept in the middle
ear cavity through the tympanic membrane perforation. 0.4 ml each of a solution of 2% lignocaine mixed with 1:30000 adrenaline was injected at four points at the bony cartilaginous junction of the external canal at 12, 3, 6 and 9 O’clock anatomical positions at the subcutaneous plane. An additional injection of 0.5 ml each of the 2% lignocaine + 1:30000 adrenaline solution as stated above was injected from behind the ear to a plane just deep to the external canal skin at 3, 6 and 12 O’clock anatomical positions to reinforce the earlier infiltration. Then four more subcutaneous injections of 0.5 ml each of 2% lignocaine + 1:30000 adrenaline solution was injected at the following points: two extreme margins, superior and inferior, one each at the anterior surface and posterior surface of Tragus.

**Harvesting of graft:** Tragal perichondrium was used in all cases. A longitudinal incision along the outside margin of the tragus was given deep to the perichondrium. All skin and subcutaneous tissue were dissected away from the tragal cartilage and the whole tragal cartilage was harvested along with the perichondrium. Care should be taken not to injure the tragal perichondrium. The resultant cavity after removal of the tragal cartilage was looked for oozing points and cauterized with bipolar radiofrequency cautery. An incision is given along the posterior border of tragal cartilage to cut through the perichondrium and the perichondrium is peeled off the cartilage without injuring the tragal cartilage. The harvested perichondrium looks like a butterfly and is large enough for TET 1. The cartilage removed is kept soaked in normal saline till the end of the surgery to be put back in place to maintain the shape of tragus.

**Canaloplasty:** Only two cases needed widening of the canal. Incision was made a little proximal to the bony cartilaginous junction from the 1 O’clock anatomical position to 11 O’clock position and tympanomeatal flap was based and reflected superiorly. The protruding canal wall could be easily curetted to remove any constriction.

**Tympanomeatal flap:** All tympanomeatal flaps were based and reflected superiorly.

**Technique of positioning of graft:** All cases were divided into three broad groups according to the size of the perforations.

- **Group 1:** >50%
- **Group 2:** 50-75%
- **Group 3:** >75%

All Group 1 perforations were done TET 1 by Onlay technique, that is, the graft is placed over a supportive bed of fibrous layer of pars tensa. All Group 2 perforations were done by Interlay technique, that is, the graft is placed over the remnant layer of middle ear mucosa, with tragal perichondrium graft hugging the malleus and all Group 3 perforations were done by Underlay technique, that is, the graft is placed below all three layers of the remnant tympanic membrane including fibrous annulus, and the tragal perichondrial graft is put hugging the malleus on both sides.

**Bleeding Control:** Most of the bleeding occurred from the margins of the tympanomeatal flap, more so at 6 and 1 O’clock anatomical positions. All bleeding could be controlled by bipolar radiofrequency cautery. Bleeding was hardly a problem in all surgeries.

**Middle ear absorbable gelatine sponge:** Absorbable gelatine sponge impregnated with 1% ciprofloxacin ear drops was placed in the middle ear cavities in 32 cases [MEG]. The rest of TET 1 were done without putting anything inside the middle ear for support [No-MEG].

**External canal packing:** Pieces of absorbable gelatine sponge impregnated with moxifloxacin ophthalmic ointment were packed over the new tympanic membrane till the bony cartilaginous junction and the rest of the space was filled with moxifloxacin eye ointment pumped into the canal. The tragal cartilage was replaced in its earlier position and skin closed over it by 3 stiches. A cotton ball of about 3-4 cm diameter was impregnated with moxifloxacin eye ointment and snugly packed over the external canal. A
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folded gauze pad of 6-8 layers of 4X4 cm is placed over the cotton ball and adhesive tape applied. No pressure bandage necessary.

Patient is discharged after one to three hours after surgery, if the surgery was undergone under local anaesthesia or was discharged the next morning if the surgery was undergone under general anaesthesia.

**Post-operative care:** Patients were given infusion antibiotics for seven days after surgery. Analgesics were usually needed for 2-3 days immediately after surgery. Stitch removal is done after seven days. The cotton ball and the gauze pad was removed and after cleaning with antiseptic lotion, the old moxifloxacin ointment pack in the canal was usually seen to remain in place and was undisturbed and a folded cotton gauze pad was placed over it and closed with adhesive tape. The final dressing was done under endoscopy on the 30th day after surgery and the new tympanic membrane were already formed by then. The external canal was cleaned and painted with povidone iodine 10% w/v lotion. An audiogram was taken 3 months after surgery.

The percentage of perforation, the type of operative technique in regard to graft placement and middle ear placement of absorbable gelatine sponge, time taken for surgery, pain and dizziness after surgery, pre and post-surgery pure tone audiometry readings with findings of closure of airbone conduction gap and size of residual perforation in graft rejections etc. were recorded.

**RESULTS**

67 TET 1 cases were included in the study. 30 males and 37 females ranging from age 3 to 64 years were included in the study. Operating time was 60 ± 20 minutes with an average of 50 minutes. The magnitude of pain experienced by the patients was rated on a scale of 11 levels from 0 to 10. The Maximum recorded score within the first 24-hours post-operative was 6 and it rapidly subsided in 3-5 days reaching level zero; but most pain were fully controlled by routine analgesics. Very few patients felt a little dizziness on the first 24 hours but no vertigo and nystagmus; and the dizziness could be due to sedatives. 32 cases were given absorbable gelatine sponge inside the middle ear [MEG] for graft support and 35 cases were done without putting anything inside the middle ear [No-MEG].

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<th>Table 2: Classification of groups by size of TM perforation</th>
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<th>Table 3: Comparison of results of TET 1 in MEG and NO-MEG group</th>
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**Figure 1:** Showing pain magnitude plotted in a scale of 11 levels from 0 to 10

**Figure 2:** Air-bone gap closure in all cases at completion of healing after 3 months of surgery.
average value of 6.82 dB whereas it was 14.13 dB in the MEG group. Three groups that were divided according to the size of the tympanic membrane perforation made up of Group 1 – 27, Group 2 – 12 and Group 3 – 28 number of cases. Group 1 cases, in which Onlay TET 1 had been performed, had the best outcome with less than 10 dB in average ABG closure and better generalized patient comfort scores. Group 2 cases, in whom the Interlay TET 1 was performed also had results similar to Group 1. Group 3 cases, in which the Underlay TET 1 were done showed good results with an average 14 dB ABG closure and 2 residual perforations in MEG group. But on the whole the results of the TET 1 was ranging from good to excellent by Kartush’s ABG closure guidelines of reporting. No-MEG group showed all round better results than MEG group.

DISCUSSION
Microscope always remained the mainstay of ontological surgery. Microscope allows a broad and excellent image quality, with good depth perception and stereoscopic visualization, and ability to use both hands. However, there are limitations to the equipment, such as: decrease of brightness proportional to the magnification; limitation of the surgical field-of-view, especially in narrow spaces such as external auditory canal and the middle ear and need of frequent change of positions. Endoscopes provide in-depth images in hidden areas in the middle ear cavity including the anterior and posterior epitympanic spaces, sinus tympani, facial recess and hypotympanum, while maintaining brightness and allowing different visualization angles. Exclusive endoscopic approach during tympanoplasty has been applied to produce the concept of minimally invasive otologic surgery, a great improvement over the microscopic approach. Endoscopic ear surgery first tried in the 1990s, has become popular with anatomic and physiologic concepts. Advantages of endoscopic ear surgery compared to the conventional microscopic surgery include avoiding endaural vertical and mastoidectomies and securing the surgical field in the middle ear surgery. Endoscopically, the typical transcanal approach is possible by elevating a tympanomeatal flap. This avoids unnecessary tissue injury. Disadvantages associated with endoscope involve working with only one hand and absence of stereoscopic view, which many authors consider crucial for otologic surgery. Other criticisms of endoscope use in otologic surgery refer to the delicate nature of the surrounding structures, with potential risk of mechanical and thermal trauma, bleeding problems compromising the surgical field, and the space conflict in the surgical field between optic fibre and the surgical instrument. The learning curve is another determining factor of surgical outcomes with the use of endoscopes. Various studies compared the microscopic myringoplasty and TET 1 with conclusions in favour of the later. The advantages are reduced operating time; reduction in pain, dizziness, nausea and other discomfort in post-operative period; significant hearing improvement and better closure of ABG and better graft success rate. Closure of the tympanic membrane is an important solution to hearing impairment, recurrent discharge, inability to join armed forces, inability to enjoy water sports and swimming in an otherwise healthy individual. TET 1 is a very acceptable procedure because of its quality of being a minimal invasive surgery, a day-care procedure, producing minimal pain and discomfort in post-operative period, no hair-cuts and excellent cosmetic effect, excellent hearing improvement and near 100% graft incorporation rate. The stringent selection process in our study has made these excellent results possible. Tragal perichondrium as a graft material is tough, easily available through an almost invisible scar post-operatively and big enough: average size is of length 2.5 – 3 cm and width 1.5 – 1.75 cm and can be harvested with minimal bleeding along with a cartilage which can be readily used for ossiculoplasty and attic reconstruction.
All the cases reported used tragal perichondrium because of its convenience and suitable mechanical properties. The pre-anaesthetic sedation and the local anaesthetic mixture regime is being developed after titrating its dosage and effect on patients of more than 500 endoscopic ear surgeries. The techniques of placement of graft was developed after an experience of more than 200 tympanoplasties. Onlay placement of graft gives excellent ABG closure and healing, but need a support from the remnant of fibrous layer of pars tensa; hence it is more convenient when some portion of fibrous layer is still attached on either side of the malleus. This is the logic of performing Group 1 cases with this technique. Interlay technique gives excellent healing and is anatomically more rational to preserve the middle ear mucosa layer below the graft after reflecting the pars tensa along with the fibrous annulus. But it is very difficult in near total perforation as in Group 3 to get a sizeable middle ear mucosal layer. Hence Underlay is done in Group 3 cases. The result of ABG closure and graft success were not significantly different in all the three groups.

Placement of absorbable gelatine sponge inside the middle ear is universally practised in tympanoplasty. But the chances of adhesion and longer duration of healing and graft rejection was speculated. To study the possibility of difference in outcome another group was operated without putting anything inside the middle ear cavity. The result was a confirmation of our suspicion. The operating time was shorter by 2-5 minutes in No-MEG group. The graft incorporation success rate in No-MEG was 100% whereas it was only 93.75% in MEG group. The average ABG closure was also 6.82 dB in No-MEG group whereas it was 14.13 dB in MEG group. Thus a significant improvement in outcome of the technique of TET 1 could be achieved by this change. The study of most recent literature shows the graft incorporation rate in TET 1 to be 87.5% in the study of DÜndar et al20, 86.4% by Leandro de BG25, 95.8% by Ozgur Surmelioglu27, 96 % by Ayache et al5, 98% by Tzu-Yen Huang et al28 and 100% by Nayeon Choi et al29. The time has come to work further to popularise and achieve universal recognition for TET 1 as the most accepted technique of treating CSOM cases.

**CONCLUSION**

Transcanal Endoscopic Tympanoplasty Type I is efficient, well-accepted by patients; a minimally invasive surgery with good success rate of graft incorporation for closure of tympanic membrane perforations and recovery of normal hearing thresholds. It can be performed and taught in academic institutions in the residency program in the department of Otorhinolaryngology. It can replace the conventional microscopic surgery in future.

**REFERENCES**

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