*Laryngoscope Investigative Otolaryngology*


# The Effect of Surgeon Experience on Tympanic Membrane Closure

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**Objective:** Review of the English language literature finds little documentation of the relation of otology or otolaryngology outcomes to a surgeon's age, years in practice, or numbers of cases previously performed. Because of one surgeon's adoption of a new tympanoplasty technique for uncomplicated tympanic membrane perforations, our institution was situated to report an example of a surgical learning curve with its outcome. Experience versus outcome is worth establishing objectively because these relationships reflect on training and certification.

**Design:** This retrospective review of the medical records tallied preoperative risk factors and perforation sizes for four consecutive 100-blocks of double-layer tympanoplasties.

**Setting:** An otology specialty care facility in Addis Ababa, Ethiopia.

**Participants:** Participants were 359 patients with tympanic membrane perforations without ossicular discontinuity or erosion who underwent 400 primary simple tympanoplasties.

**Intervention:** A double-layer tympanoplasty was performed in each operation using an endaural approach.

**Outcome Measures:** The outcomes were closure of the perforation and change in hearing.

**Results:** There were no statistically significant differences between the four 100-block case cohorts in preoperative risk factors and perforation sizes. Preoperative, postoperative, and change of hearing were also the same between the four groups; and statistically there was no significant difference between the four 100-block cohorts. Perforation closure for each successive 100-block increased from 74% to 98%. The closure rates of the second, third, and fourth 100-block were each statistically significantly different from the first 100-block, but not from each other.

**Conclusion:** This simple study demonstrates the surgical learning curve with increased surgeon experience, and is one of very few such documentations. With each additional 100 cases, the outcomes improved, and sheds light on the numbers of cases necessary for competency.

**Key Words:** Myringoplasty, tympanoplasty, eardrum perforation, tympanic membrane rupture, surgical education, graduate medical education.

**Level of Evidence:** 3

## INTRODUCTION

Practice reportedly makes perfect. Perhaps this applies to surgical practice; however, documentation of the effect of experience on surgical outcomes is sparse. In otolaryngology, since training, certification, and ultimately competency are tied to surgical experience, some documentation of the learning curve would be useful. Our institutions' review of the English language literature could find little documentation of the relation of otology or otolaryngology outcomes to a surgeon's age, years in practice, or numbers of cases previously performed. A recently published review of the United States and European literature also could find little objective information.[1] Available are reports of fewer complications or rejections of dental implants placed by more experienced surgeons.[2,3] Primary tonsillectomy bleeding appears to occur at the same rates independent of experience, but post-tonsillectomy bleeding is decreased with experience.[4] After thyroid surgery, the complication rates of permanent laryngeal nerve paralysis and hypoparathyroidism were lowest in surgeons who were over 35, but under 50 years of age.[5] In addition, outcomes after surgery for primary hyperparathyroidism were improved if an experienced surgeon was either performing the surgery or directly supervising a trainee.[6]

The study presented here documents improvement of closure rates for tympanic membrane perforations and focuses on an operation, which was a technique new to the surgeon. The closure rates reflect the effects as the surgeon's experience with the new technique increased. Specifically, closure rates of four consecutive batches of 100 patients, undergoing the same operative technique by a single surgeon for primary tympanoplasty, without ossiculoplasty clearly show improvement in outcomes with experience. This type of information is useful as surgical training and certification become more evidence-based.

## MATERIALS AND METHODS

This retrospective review of the medical records was evaluated by the OtoRino ENT Ethics Review Committee in Addis Ababa, Ethiopia, which found no indication of possible injury to patients or ethical violation and gave approval for this study to



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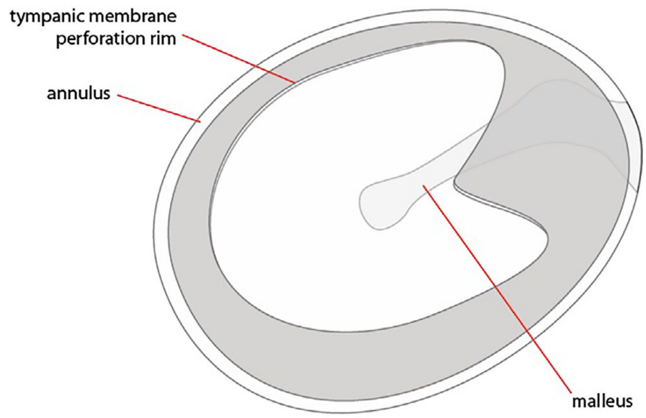


Fig. 1. Tympanic membrane remnant with exposed manubrium.

proceed. In addition, this study was performed consistent with the standards of the Declaration of Helsinki and involved minimal risk to the participants.

### *Study Design*

Retrospective review of the medical record was used to address the question of the effect of the surgeon's level of experience on tympanoplasty success. No other source of information was used for this study.

### *Subjects—Inclusion/Exclusion*

Patients with tympanic membrane perforations without ossicular chain erosion were selected. Children and adults were operated on and only those patients found to have a tympanic membrane with intact ossicular chain were included in this report. None of these patients had previous tumors, burns, irradiation, cleft palate, or craniofacial anomalies. All ears were dry at the time of operation. Tympanic membrane integrity was determined with successive generations of Zeiss office microscopes and by tympanometry.

### *Surgeon Background*

The single surgeon for this patient series completed his medical degree and otolaryngology training at the University of Leipzig in Leipzig, Germany from 1982 to 1988, and subsequently practiced there until 1999. He established a general otolaryngology practice in Addis Ababa, Ethiopia in 1999 and adopted the double-layer technique in 2012 after dissatisfaction with closure rates for single-layer closures. Therefore, the cases in this study document the learning curve of a new technique in a relatively experienced surgeon.

### *Double-Layer Tympanoplasty Operative Technique*

All patients were operated by a single experienced otologist. All operations were transmeatal. Most were performed under local anesthesia with sedation, the only exceptions being due to patient's ability to remain calm throughout the procedure. In subtotal perforations, the tympanic membrane perforation edge was freshened with a sickle knife or sharp needle. In larger perforations, the mucosal layer of the tympanic membrane remnant was rasped away from the medial surface with a sickle knife. The tympanomeatal flap was elevated superiorly and the epithelial layer of the tympanic membrane remnant was elevated off of the fibrous layer of the tympanic membrane and the malleus with the graft (Figs. 1 and 2). If needed the tympanic membrane was sharply cut off of the manubrium, and if a better view of the ossicles was needed, the scutum was curetted with chorda preservation. The ossicular chain was inspected and freed of any granulation tissue present. Any disruption of the ossicular chain disqualified the patient/operation from inclusion in this study.

Graft materials were the same for all patients: a double-layered graft of tragal perichondrium plus tragal perichondrial flap with a cartilage island still attached. In all operations, the grafts were placed over the manubrium and under the fibrous layer of the remnant of the tympanic membrane (Figs. 1 and 2). The cartilage graft was laid laterally upon the malleus handle without a groove cut for the handle. The tympanomeatal flap was returned to position (Fig. 3). Figure 4 shows the orientation of the double-layer grafts. The double-layer grafts were used because of documented increased success with perforation closure over single-layer closure.[7]

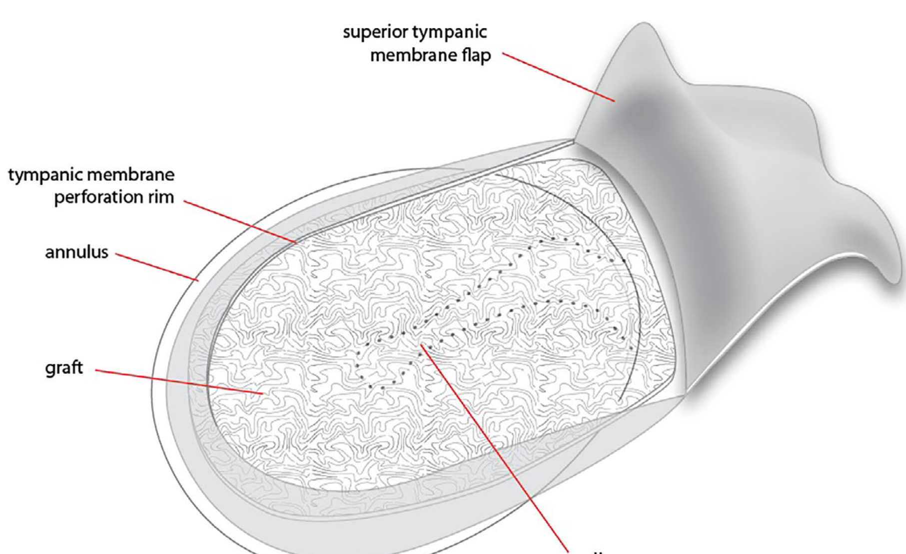


Fig. 2. Superior tympanomeatal flap raised with the graft layers in place, under the fibrous layer of the tympanic membrane remnant, and over the manubrium.

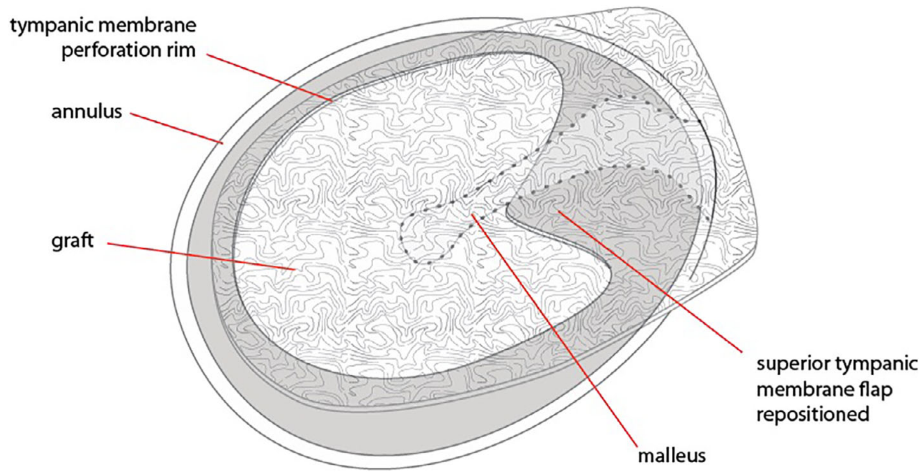


Fig. 3. Superior tympanomeatal flap returned to native position, lateral to the graft layers.

The tympanic membrane perforation size and the middle ear pathology were recorded.

All the recorrection operations were done with concha butterfly composite graft as inlay tympanic membrane graft.

## *Outcomes Measures*

The major outcome of interest was failure of the tympanic membrane to close, or the presence of reperforation on follow-up, was the sole outcome reported for this study. Nonclosure of the perforation was established by the office microscope and tympanometry shape and volume.

Changes in hearing were also noted, to establish whether hearing was positively or adversely affected by experience. Audiometry was performed by audiometry technicians without formal training—there are no formal audiometry or audiology programs in Ethiopia as of 2019. Testing was in a dedicated room with padding on the walls, using Maico ST 32 audiometer, an Amplivox 270 audiometer, a GSI 39 audiotympanometer, and an Otowave 202 tympanometer. Pure tone thresholds for air and bone (masked) were obtained. Word recognition testing materials were not available in Ethiopia until late 2017[8] and therefore no Word Recognition Scores were obtained. Audiology outcome was recorded as the "change in extended pure tone average (PTA) (ePTA) of the air bone gaps (ABG)" which is the change (improvement) in the air bone gap in dB averaged over 500 Hz, 1 kHz, 2 kHz, and 4 kHz (ePTA).[9] This parameter of reporting is in accordance with the previous recommendation of AAO-HNS Committee on Hearing and Equilibrium as described in 1995.[10]

Gurgel et al notes that many countries do not use word recognition testing, and therefore there is no data for one axis of the audiogram's scatterplot.[11] In the cases of changes in conductive hearing loss, Gurgel et al advise the use of the change in PTA ABG model as described by the AAO-HNS Committee on Hearing and Equilibrium.[9] Therefore, change in the ePTA of the ABG represented as a "box-and-whiskers" graph[12] (Fig. 5) in the "Results" section.

## *Statistical Analyses Employed*

The 400 operations were grouped by consecutive blocks of 100, and the outcomes for each of the four 100-blocks were compared. The SPSS software package version 21 was used to analyze the data. Specific tests used where appropriate were Pearson's two-tailed $\chi^2$ test, and the likelihood ratio ($\chi^2$) test, the paired-samples $t$ test, the analysis of variance (ANOVA), and the mid-$P$ exact test. All statistical analyses were performed by a professor of statistics and public health who is also one of the coauthors.

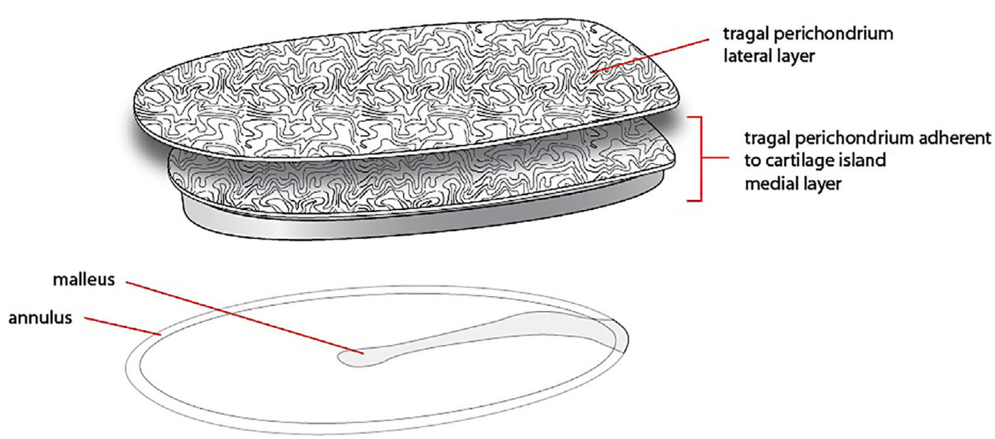


Fig. 4. Orientation of the double-layer grafts. The tragal perichondrium/cartilage island is oriented with the cartilage medial and the perichondrium lateral. The second layer of tragal perichondrium is then positioned laterally.

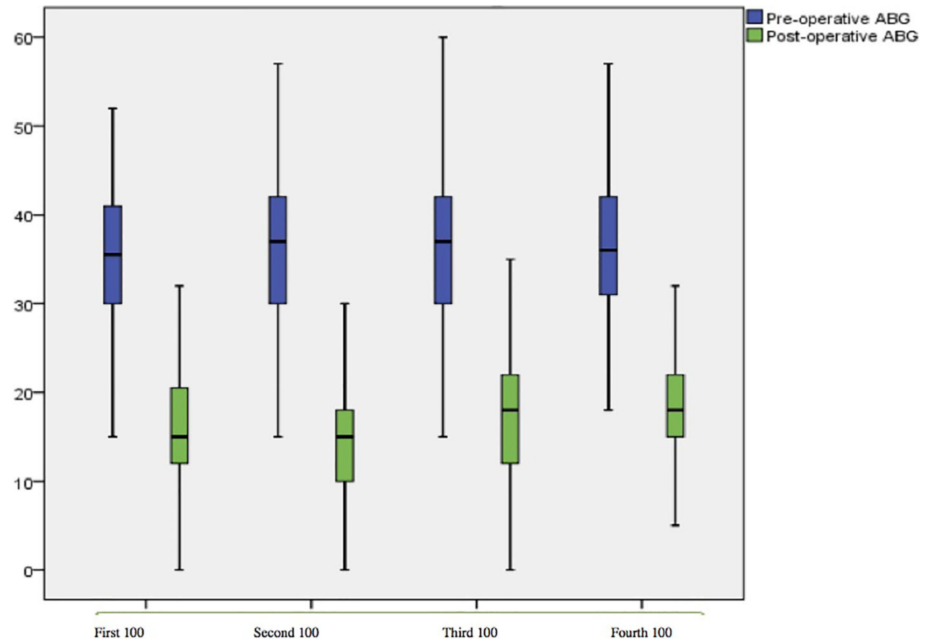


Fig. 5. "Box-and-whiskers" graph[12] of the extended PTA of the changes in ABG for each 100-block of operations. Represented is the average, range, and standard deviations. ABG = air bone gaps, PTA = pure tone average.

## RESULTS

### *Subjects Tally*

Subjects were 359 patients who underwent 400 operations using the double-layer technique from March 6, 2012 through August 28, 2018. Ages were from 4 to 58 years, the average age was 25.2 years (SD = 10.3). There were 246 females and 154 males. Three hundred eighty-one (95%) were performed under local anesthesia with sedation and 19 (5%) were performed under general anesthesia.

### *Preoperative Risk Factor Distribution*

Table I shows the distribution of risk factors for nonclosure between each 100 block of cases. Risk factors recorded were granulation tissue/infection, tympanosclerosis, adhesions/scar, cholesteatoma, mucoid secretion, and malleopexy. Statistical analysis of the distribution of risk factors using Pearson's $\chi^2$ test ($P$ = .694) and the likelihood ratio ($P$ = .565) showed no statistically significant difference among the four 100-block cohorts.

The preoperative perforation sizes as distributed among the four 100-block groups are presented in Table II. Pearson's $\chi^2$ test ($P$ = .013) and the likelihood ratio ($P$ = .011) found no statistically significant difference in the distribution of preoperative perforation sizes among the four 100-block cohorts.

### *Outcomes With Statistical Analysis*

Mean follow-up times for the first 100-block were 8.87 months (SD = 4.8), for the second 100-block 7 months (SD = 3.8), the third 6 months (SD = 2.9), and the last of 6.28 months (SD = 1.88). For all 400 operations, the mean checkup follow-up times were 7.27 months (SD = 3.6).

TABLE I.
Distribution of preoperative risk factors for the 400 double-layer tympanoplasties performed from March 6, 2012 through August 28, 2018.

| Middle Ear Pathology | First 100 Operations Number/% | Second 100 Operations Number/% | Third 100 Operations Number/% | Fourth 100 Operations Number/% | Total |
|---|---|---|---|---|---|
| None | 46 | 46 | 51 | 51 | 194 |
| Granulation tissue/infection | 34 | 29 | 28 | 24 | 115 |
| Tympanosclerosis | 8 | 13 | 13 | 15 | 49 |
| Scar/adhesion | 6 | 6 | 6 | 5 | 23 |
| Cholesteatoma matrix | 1 | 3 | 1 | 3 | 8 |
| Mucoid secretion | 4 | 2 | 0 | 0 | 6 |
| Malleopexy | 1 | 1 | 1 | 2 | 5 |
| Total | 100 | 100 | 100 | 100 | 400 |

Risk factors for failure to close were size of perforation, as well as granulation tissue/infection, tympanosclerosis, adhesions/scar, cholesteatoma, mucoid secretion, and malleopexy. Pearson's $\chi^2$ ($P$ = .694) and likelihood ratio ($P$ = .565) tests showed no statistically significant difference between the four 100-block groups.

TABLE II.
Distribution of preoperative perforation sizes by 100-block of consecutive operations.

| Perforation Size Number and % of Perforation Size | First 100-Block of Cases | Second 100- Block of Cases | Third 100- Block of Cases | Fourth 100- Block of Cases | Totals of Each Perforation Size |
|---|---|---|---|---|---|
| <30% | 11 | 12 | 12 | 24 | 59 = 100% of <30% |
| | 11/59 = 19% | 10/59 = 20% | 12/59 = 20% | 23/59 = 41% | |
| 30%–60% | 33 | 43 | 44 | 45 | 165 = 100% of 30%–60% |
| | 33/165 = 20% | 43/165 = 26% | 44/165 = 27% | 45/165 = 27% | |
| >60% | 56 | 45 | 44 | 31 | 176 = 100% of >60% |
| | 56/176 = 32% | 45/176 = 26% | 44/176 = 25% | 31/176 = 18% | |
| Total cases | 100 | 100 | 100 | 100 | 400 |

Pearson's $\chi^2$ test ($P$ = .013) and the likelihood ratio ($P$ = .011) found no statistically significant difference in the distribution of preoperative perforation sizes among the four 100-block cohorts.

Table III shows the closure rates. Each 100-block of cases followed the previous block without time interval delay between blocks. The first 100-block extended over 32 months, while the next three were over a year's duration. This reflects the surgeon's migration into the new technique as it became apparent that the success rates were better than other techniques.

The closure rates for each of the successive four blocks of 100 operations were 74%, 94%, 97%, and 98%. Statistical analysis using the mid-$P$ exact test showed the differences between the first 100 operations' outcomes and any of the subsequent 100-blocks were statistically significant ($P < .001$). The closure rates continued to improve from the second 100-block to the third 100-block, and from the third 100-block to the fourth 100-block, but not statistically significantly so.

Figure 5 shows the change of the ePTA of the ABG: Each 100-block showed improved hearing from preoperative to postoperative ABG, and these improvements were statistically significant by the paired-samples $t$ test ($P < .001$). As Figure 5 graphically displays, there was no significant difference in preoperative hearing (ANOVA $P$ = .98), postoperative hearing (ANOVA $P$ = .74), or amount of hearing improvement among the four 100-block groups (ANOVA $P$ = .19).

## DISCUSSION

Four hundred consecutive double-layer tympanoplasties without ossiculoplasty for simple perforations without ossicular chain disruption are reported here. These 400 cases date from 2012—when the single experienced surgeon first began to use the double-layer technique—to 2018. Statistical analysis of potentially negative influences on tympanoplasty success (such as preoperative risk factors and preoperative perforation sizes) found that distributions of those were not statistically significantly different between the four 100-block groups. The closure rates increased with each sequential block of 100 cases; however, statistical significance was obtained between the first and second 100-block only. Hearing improvements between postoperative and preoperative levels reached statistical significance for each 100-block, and was not statistically significantly different between the four 100-block groups.

Strengths of this study are the numbers of operations in each block being analyzed and the simplicity of the

TABLE III.
Closure rates of 400 double-layer tympanoplasty operations, by sequential 100-blocks of cases, with statistical comparison between blocks.

| | Initial 100 Cases | Second 100 Cases | Third 100 Cases | Fourth 100 Cases |
|---|---|---|---|---|
| Initial 100 cases 3/6/2012–11/18/2014 (32 months) 26/100 = 74% | | Mid-$P$ exact test $P < .001$ | Mid-$P$ exact test $P < .001$ | Mid-$P$ exact test $P < .001$ |
| Second 100 11/21/2014–12/3/2015 (12 months) 6/100 = 94% | | | Mid-$P$ exact test $P$ = .33 | Mid-$P$ exact test $P$ = .17 |
| Third 100 12/10/2015–3/13/2017 (15 months) 3/100 = 97% | | | | Mid-$P$ exact test $P$ = .68 |
| Last 100 cases 3/14/2017–8/28/2018 (17 months) 2/100 = 98% | | | | |

Mid-$P$ exact test showed significance between the first and second 100-blocks, but the other comparisons did not reach significance.

design. Risk factors were evenly distributed between the four 100-block groups. Also useful for this study is the consistency of technique: Only the double-layer closure operations are analyzed, and these operations are tallied from the very onset of the surgeon's adoption of the technique in 2012. Another advantage is that by chance the follow-up times for each 100-block happened to be equivalent, eliminating a variability often seen in retrospective studies.

Given these strengths, this very basic study appears to show the effect of surgical experience. This study suggests that the more of a type of operation that a single surgeon performs, the better the outcome. This article cannot clarify how many operations of a particular type are optimal for the best outcomes, nor what it is that experience brings to the operating table.

Literature on this topic is surprisingly sparse. Previous papers shed little light on this, except to note that outcomes in hypoparathyroid surgery are the same whether performed by an experienced surgeon or by a trainee who is supervised by an experienced surgeon.[6] This would suggest that a key factor is assessment and adjustment of operative strategy as the operation progresses. This is only speculation, however.

Whatever the intermediary cause of increased surgical success, the study serves to document what we all suspect: that with increased experience are improved outcomes. The hope would be that learning curves for other basic otolaryngologic operations could be similarly documented so that evidence-based minimums could be established for training, certification, and competency. Ultimately, the minimum number of operations performed under supervision and correction by someone who is already proficient would be the gold standard for competency.

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