Outline

- Define terms
- History
- Anatomy and Embryology
- Physiology of sound transmission
- Etiology
- Preoperative evaluation
- Techniques
- Tympanoplasty in children
- Complications
- Results
Introduction

- **Myringoplasty** - reconstruction of a perforation of the tympanic membrane (TM)
  - Assumes – normal middle ear (ME) mucosa and ossicles
  - TM is not elevated from its sulcus

- **Tympanoplasty** – reconstruction of the TM
  - Also includes addressing middle ear pathology
    - Cholesteatoma, adhesions
    - Ossicular chain problems
    - Usually involves elevating the TM from its sulcus
Introduction

- Tympanoplasty is sub-classified based on
  - Medial or lateral grafting
  - Associated type of ossicular chain reconstruction (OCR)
History

- **1640 – Banzer**
  - First attempt at repair of a TM perforation
  - Used pigs bladder as a lateral graft
- **1853 – Toynbee**
  - Placed a rubber disk attached to a silver wire over the TM
  - Reported significant hearing improvement
- **1863 – Yearsley**
  - Placed a cotton ball over a perforation
- **1877 – Blake**
  - Paper patch
History

- 1876 – Roosa
  - Treated TM perf. with chemical cautery
- 1878 – Berthold
  - Coined the term myringoplasty
  - Placed cork plaster against TM to remove epithelium
  - Applied a FTSG
History

- **1950s – Wullstein and Zollner**
  - STSG over de-epithelialized TM
- **1956 - Wullstein**
  - Described five types of tympanoplasty
- **1957 – first medial graft performed by Shea with vein graft**
- **1961 – Storrs**
  - Introduced the use of temporalis fascia grafting
  - Medial grafting
- **1961 and 1967 – House, Glasscock and Sheehy**
  - Developed and refined techniques for lateral grafting
Anatomy and Embryology of the Tympanic Membrane
Embryology

tympanic cavity and auditory tube

tympanic membrane
auricle
intratonsillar cleft
palatine tonsil
former site of cervical sinus
ultimobranchial body

C

thymus
thyroid

superior parathyroid
inferior parathyroid

external acoustic meatus
foramen cecum

lymphoid tissue

skin of neck

tongue
Embryology

- 4th week of gestation
- TM develops from three sources
  - Ectoderm – 1st branchial groove
  - Endoderm – 1st branchial pouch
  - Mesoderm – 1st and 2nd branchial arches
Embryology
Anatomy

- TM is oval in shape
  - 8 mm X 10 mm
  - 55 degrees to the floor of the meatus
  - Near circumferential fibro-cartilaginous thickening
    - Annular ligament or annulus
  - 3 layers – 130 microns thick
    - Outer epithelial – keratinizing squamous
    - Middle fibrous – superficial radial, deep circular
    - Inner – mucosa
  - Epithelial migratory pattern
    - Centrifugal growth for the umbo outward
Anatomy
Anatomy

Membrana tympani (Pars flaccida)

Plica mallearis anterior

Chorda tympani

Prominencia mallearis

Plica mallearis posterior

Chorda tympani

Crus longum incudis

Stapes

Eminentia pyramidalis, M. stapedius

Membrana tympani (Pars tensa)
Anatomy

- **Blood supply**
  - Inner surface
    - Ant. Tymp a.
  - Outer surface
    - Deep auricular a.
Blood Supply
Physiology of the TM

- **Middle ear**
  - Transforms air waves to fluid waves
  - Two mechanisms
    - Area affect of TM
      - TM area:foot plate area – 17:1
    - Lever action of the ossicles
    - 1.3:1 malleus to incus ratio
    - 22:1 combined transformer ratio of middle ear
    - Translates to 25 dB
Physiology of hearing with TM perforations

- Effects on hearing
  - Decreased transformer ratio
  - Round window stimulation causes inner ear fluid waves that cancel out those at the oval window
  - Sound pressure entering the perforation acts on the medial surface of the TM against that on the lateral surface
Etiology of TM perforations

- **Infection – most common cause**
  - Bacteria
  - Mycobacterium
  - Viruses

- **Trauma**
  - Penetrating trauma
    - Self induced with cue tip most common penetrating cause
  - Blunt
    - Temporal bone fractures
    - Longitudinal fractures more common than transverse fractures
    - Slap injury
Etiology of TM perforations

- **Trauma**
  - **Thermal**
    - Welders and steelworkers
    - Lightning
  - **Barotrauma**
    - Cadaver studies – 14-33 lbs/in²
    - Keller (1958) – 195-199 dB sound pressure
- **Iatrogenic**
  - Retained ventilation tube
    - Nicoles et al. – 40% incidence of perforation with retained tubes
      > 36 months vs. 19% < 36 months
Etiology of TM perforations

- Traumatic TM perforations
  - 1992 – Kristensen
    - 80% heal spontaneously
    - Thermal injuries 40% heal spontaneously
  - Other negative factors
    - Age > 30 years
    - Large kidney bean shaped central perforations
    - Posterosuperior perforations
    - Infection
Preoperative Evaluation

- History
  - Hearing loss
  - Tinnitus
  - Vertigo
  - Otalgia
  - Otorrhea
  - Facial paralysis
  - Prior otologic procedures
  - Medical history – DM, heart, lung, kidney, liver
Preoperative Evaluation

- Physical exam – complete H/N exam
  - Facial nerve
  - External ear
  - Tullio’s Phenomenon
- Otomicroscopy
  - Ear canal
  - TM
    - Perforation – location, size
    - Retraction pockets, granulation tissue
    - Status of middle ear through perforation
- Audiometry – preferable with a dry ear
  - Air and bone lines, acoustic reflexes
- Tympanometry
- +/- CT temporal bone
Indications for Surgery

- Conductive hearing loss due to TM perforation or ossicular dysfunction
- Chronic or recurrent otitis media secondary to contamination
- Progressive hearing loss due to chronic middle ear pathology
- Perforation or hearing loss persistent > 3 months due to trauma, infection, or surgery
- Inability to bathe or participate in water sports safely
Goals of Surgery

- Establish an intact TM
- Eradicate middle ear disease and create an air-containing middle ear space
- Restore hearing by building a secure connection between the ear drum and the cochlea
Techniques

- Overlay technique (lateral grafting)
- Underlay technique (medial grafting)
Lateral Grafting
Postauricular incision
Harvest of temporalis Fascia Graft
Elevation of the vascular strip
Lateral Grafting
Removal of canal and TM skin
Drilling the anterior canal bulge
Ensure complete removal of TM epithelium
Shaping the fascia graft
Replacing the canal skin
Medial Grafting
Medial Graft Position
Debride the edges of the perforations

- **Purpose**
  - Separates the continuity of the inner mucosa with the outer epithelium
  - Disrupts the fistulous tract
Elevation of the tympanomeatal flap

- Inspect the undersurface of the TM for squam
- Inspect the middle ear
  - Ossicles
    - Erosion
    - mobility
  - Round window reflex
  - Eustachian tube
Pack middle ear with gelfoam
Placing medial fascia graft
Replacing the tympanomeatal flap
## Medial vs. Lateral Graft Tympanoplasty

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td><strong>Overlay grafting</strong></td>
<td><strong>Requires precision</strong></td>
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<tr>
<td>• Excellent exposure</td>
<td>• Longer healing time (months vs. weeks)</td>
</tr>
<tr>
<td>• High graft take rate</td>
<td>• Possibility of blunting, lateralization, or epithelial pearls</td>
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<tr>
<td>• Applicable to all cases</td>
<td></td>
</tr>
<tr>
<td><strong>Underlay grafting</strong></td>
<td><strong>Limited visualization</strong></td>
</tr>
<tr>
<td>• Less blunting or lateralization</td>
<td>• Large, anterior perforation less suitable</td>
</tr>
<tr>
<td>• High graft take rate</td>
<td>• Difficult with small external auditory canal</td>
</tr>
<tr>
<td>• Simpler technique</td>
<td></td>
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</tbody>
</table>
Blunting of Annulus
Blunting at Annulus
Classification of Tympanoplasty

- **Wullstein (1956)**
  - Type I tympanoplasty
    - TM is grafted to an intact ossicular chain
  - Type II tympanoplasty
    - Malleus is partially eroded
    - TM +/- malleus remnant is grafted to the incus
  - Type III tympanoplasty
    - Malleus and incus are eroded
    - TM is grafted to the stapes suprastructure
Wullstein classification continued…

- Type IV tympanoplasty
  - Stapes suprastructure is eroded but foot plate is mobile
  - TM is grafted to a mobile foot plate

- Type V Tympanoplasty
  - TM is grafted to a fenestration in the horizontal semicircular canal

- Classification does not take into account middle ear pathology
Type III tympanoplasty
TORP using cartilage stiffener
Type IV Tympanopasty
Belluci

- Proposed a dual classification
- Added status of middle ear
  - Group I – Dry ear
  - Group II – Occasional drainage
  - Group III – Persistent drainage with mastoiditis
  - Group IV – Persistent drainage and nasopharyngeal malformation (cleft palate and choanal atresia)
Classification of Tympanoplasty

- **Austin’s classification**
  - Describes the residual ossicular remnants
    - (M+/I+/S+) – intact ossicular chain
    - (M+/S+) or (M+/S-) – good prognosis
    - (M-/S+) or (M-/S+) – poor prognosis

- M – malleus
- S – stapes
- I – incus
Postoperative Care

- Day surgery
- Mastoid dressing removed postop day one
- Incisions cleaned bid with H2O2 and topical abx
- Patient instructions
  - Avoid nose blowing
  - Sneeze with mouth open
  - Avoid heavy lifting (>10 lbs) or straining
  - Dry ear precautions
- One week staples or steri-strips are removed and ear drops are started
- Three weeks, gelfoam is removed from the EAC
- 2-3 months, postop audiogram is performed
Graft Materials

- **FTSG, STSG**
  - Initial good results
  - Subsequent desquamation and infection with high delayed failure rate

- **Canal skin**
  - Similar to STSG

- **Vein grafts (Shea)**
  - Atrophy
Graft Materials

- **Temporalsis fascia**
  - Hermann (1960) and Storrs (1961)
  - Large quantity
  - No separate incision
  - Sturdy
  - Low metabolic rate

- **Homograft TM**
  - Excellent success similar to fascia
  - Theoretic risk of infectious disease transmission (prions, HIV)
  - Availability
Cartilage Tympanoplasty

- 1958 – Jansen
  - First used cartilage in the middle ear
- 1963 – Salen and Jansen
  - First reported use of cartilage for reconstruction of the TM
- Excellent for prevention of recurrent retraction pockets
  - Most successful when placed posteriosuperiorly and pars flaccida (Poe and Gadre, 1994)
- Recommended by Vrabec (2002) to be placed over TORP or PORP to prevent extrusion
Cartilage Tympanoplasty

- Results
  - Gerber (2000) and Dornhoffer (1997)
    - Hearing results comparable to temporalis fascia and perichondrium even with complete TM reconstruction with cartilage
Cartilage Tympanoplasty
Cartilage Tympanoplasty

[Diagram showing labeled parts: Malleus, Flap, Fascial graft]
Cartilage Tympanoplasty
Cartilage Tympanoplasty
Tympanoplasty in Children

- Controversial
- Considered less successful than adults
  - Higher incidence of ETD and otitis media
- Wide range of success rates
  - 35% to 93%
- Tos and Lau (1989)
  - Found comparable success rates compared to adults for all ages in children (92%)
  - Helps to lessen progression of ossicular pathology
Tympanoplasty in Children

- Manning
  - 78% success

- Deskin and Vrabec (1999)
  - Meta-analysis of all common variables assoc. w/ success
  - Found only advancing age was statistically associated with improved outcomes.
Complications

- **Infection**
  - Poor aseptic technique
  - Prior contamination
  - Graft failure is associated with postop infection

- **Graft failure**
  - Infection
  - Inadequate packing (anterior mesotympanum)
  - Inadequate overlay of graft with TM remnant (underlay)
Complications

- Chondritis
- Injury to the chorda tympani nerve
- SNHL and vertigo
  - Excessive manipulation of the ossicles
- Increased conductive hearing loss
  - Unrecognized eroded ISJ
  - Blunting
    - Thick graft extending onto the anterior canal wall in lateral grafting
    - Lateralization of the TM from the malleus handle
- External auditory canal stenosis
  - Lateral grafting
Results – *closure of perforations*

- **1992 – Smyth (Toynbee Memorial Lecture)**
  - Stated that most series report 90% success
    - Majority of studies have only one year f/u
    - Most do not report atelectatic pockets

- **Halik and Smyth**
  - 60% success in revision cases
  - Found improved results in patients with dry ears
  - Similar success with temporalis fascia versus homograft
  - Worse results with anterior perforations
    - Recommend using fascia
      - Anterior TM is less vascular
      - Fascia less susceptible to anoxia and is less antigenic than homograft
Results – hearing

- **Albu et al.**
  - Three most important prognostic indicators
    - Status of the middle is the most important predictive factor
    - Presence of the handle of the malleus
    - Perforations > 50%

- **Halik and Smyth**
  - 80% success rate closing ABG to within 10 dB at 5 years
Results – overlay grafting

- Sheehy and Anderson (1980)
  - Compared 472 overlay
    - 97% success with fascia grafts
    - 84% success with canal skin
    - 1.3% complication rate
      - Anterior blunting
      - Lateralization
    - 80% had ABG within 10 dB
Results – overlay vs. underlay

- Doyle et al. (1972)
  - Compared 52 overlay to 79 underlay at a teaching institution
    - Overlay
      - 36% re-perforation
      - 27% with hearing improvement (15db ABG or better)
    - Underlay
      - 14% re-perforation
      - 62% hearing improvement
  - > complication rate with overlay group
Results – overlay vs. underlay

- Doyle et al. (1972)
  - Conclusions
    - In experienced hands either technique can be equally successful
    - Residents and otolaryngologist of limited experience
      - Medial grafting gives better healing and fewer complications
  - All cases utilized endaural approach with is more technically demanding
Results – overlay vs. underlay

- Rizer (1997)
  - Compared 551 underlay to 158 overlay
    - Closure in 88.8% of underlay versus 95.6% of overlay
    - Closure of ABG to 10 dB or less in 84.9% of underlay vs. 80.4% of overlay
    - Similar complication rates
Results – overlay vs. underlay

- **Rizer (1997)**
  - Both groups – no relationship in re-perforation with:
    - Age of patient
    - Perforation size or location
    - Middle ear status
    - Presence of cholesteatoma
Conclusion

- Tympanoplasty has a high rate of success in closing tympanic membrane perforations and improving hearing.
- Patients should be chosen carefully based on the indications discussed and attempts at attaining a dry ear prior to surgery should be made.
- Patients should be thoroughly counseled preoperatively about the expectations and goals of the surgery.
- Tympanoplasty in the pediatric age group is controversial.
- Both underlay and overlay techniques for grafting are effective, however, the surgeon should do what he/she is most experienced and successful with.