Indications for surgery in stapes mobilization and tympanoplasty

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Since the development of the Lempert1 one-stage fenestration operation in 1938, surgery of the ear has undergone a revolutionary change. This operation held the spotlight in otology because, for the first time, a dependable procedure was available which gave predictable improvement in hearing that could be maintained continuously.

Interest shifted to the procedure of Rosen2 in 1952, when he revised the mobilization operation, adding simplicity, direct approach, and lessened disability. The mobilization operation also offered a theoretic advantage of 25 decibels of additional hearing since it did not disrupt the ossicular chain. The stapes mobilization operation, however, has not proved to be as simple, dependable, or predictable as was hoped, and its theoretic advantage could be achieved in less than 10 per cent of operated cases.

In spite of varied and rapidly changing technics, in which interest changed from transcral application of force, to chisels applied to the stapes footplate (Derlacki, Shambaugh, and Harrison3), and finally to stapes extraction with application of a vein graft to the fenestrated oval window and a prosthetic stapes (Shea4) of polyethylene or stainless steel to energize the fenestra, results in mobilization are still somewhat inconsistent and undependable.

To overcome these disadvantages and preserve the dependability and predictability of the fenestration operation, Réudi5 developed a transmeatal fenestration with incudopexy. This has been modified by Shambaugh6,7 as the myringo-malleo-labyrinthotomy. The attic and antrum are opened as in the classic fenestration operation and an oval-shaped fenestra is made in the horizontal semicircular canal. This is covered by a vein graft. The incus is removed and a cup-shaped excavation made in the head of the malleus to accommodate a polyethylene columella, which directly energizes the new fenestra by transmitting energy from the large tympanic membrane.

The complexity of methods which has evolved from the stapes mobilization and fenestration operations is made even greater by the development of methods to reconstruct the middle ear hearing mechanism which has been destroyed by suppurative disease or surgery. Wullstein,8 in 1953, first used the term “tympanoplasty” to describe these procedures which now are largely replacing the classic radical mastoidectomy. Consequently, since all of these procedures are in a state of development and refinement, it is important that they be correlated.

Determination of operability

Until recently the otolaryngologist lacked the advantage of the ophthalmologist who could see into the eye as far as the ending of the optic nerve. The otologist has been limited to otoscopic inspection of the tympanic membrane. However, with the surgical microscope the otologic surgeon can see into the middle ear: see, palpate, and dislodge otosclerotic changes about the stapedial footplate, and even peer into the endolymphatic labyrinth itself through a fenestra he has constructed.

At the very onset, in order to avoid disappointment to himself and his patient, he must from his otologic and audiologic examination decide when
he should advise a stapes mobilization as a primary procedure, and when he must undertake the more formidable but more dependable and predictable fenestration operation. The patient must be told of his chances of success with each, but the otologist alone should make the choice, bearing in mind that if he fails he may not have a second chance.

The success of mobilization operation is dependent on several unknown anatomic and pathologic variables which cannot be anticipated until they are revealed by the surgical microscope at operation. Farrior has classified these variables as to stapes operability as follows:

**Anatomic Variables**

A. Depth of the Footplate of Stapes
1. Superficial
2. Moderately superficial
3. Moderately deep
4. Deep

B. Angulation of Crura
1. Upright
2. Downward tilt (free)
3. Downward tilt (fixed)
4. Upward tilt

C. Strength of Crura
1. Weak crura
2. Medium crura
3. Strong crura
4. Atrophic crura

**Pathologic Variables**

A. Location of Otosclerosis
1. Type of otosclerosis
   a. Circumscribed
   b. Diffuse
2. Footplate otosclerosis
   a. None
   b. Anterior footplate
   c. Posterior footplate
   d. Superior marginal
   e. Inferior marginal
   f. 1/4 Footplate involved
   g. 2/4 Footplate involved
   h. 3/4 Footplate involved
   i. Complete footplate
   j. Complete footplate
3. Crural otosclerosis
   a. None
   b. Anterior crus
   c. Posterior crus
   d. Bicrural anterior & posterior crus
   e. Apical
   f. Cervical
4. Bound window otosclerosis
   a. No otosclerosis
   b. Marginal without closure
   c. Partial closure
   d. Complete closure

B. Character of Otosclerosis
1. Thickness of otosclerosis of stapes and oval window
   a. Very thin
   b. Thin
   c. Moderately thick
   d. Thick

C. Miscellaneous Pathology

D. Pathological Combinations

It can readily be seen that of the two basic types of otosclerosis, circumscribed and diffuse, circumscribed responds best to mobilization treatment. Thick diffuse, otosclerosis reacts unfavorably to mobilization, and when otosclerosis thickens to obliterate the annulus or oval window, as Farrior points out, "There is no need to jeopardize inner ear function with excessive footplate surgery when the existing pathology is beyond the limits of stapes surgery, present or future."

The surgical limitations of stapes mobilization must be recognized by the surgeon. If the inner ear is damaged by mobilization through careless footplate surgery, the ear is permanently damaged or completely deafened, and there can be no hope of improvement through secondary fenestration.

**Selection of patients for fenestration or mobilization surgery**

Mobilization may be attempted in any case of otosclerosis suitable for fenestration and may be applied to some cases which are no longer suitable for fenestration. Surgical indications for fenestration, therefore, form the basis for decisions.

Cases suitable for fenestration may be classified into ideal cases (Type A); suitable, but not ideal cases (Type B); and borderline cases (Type C).7

**Type A (ideal cases)**

- The stapes is firmly fixed and cochlear function is normal. The following tests and audiologic findings are noted:
  1. C 32 and C 64 forks are not heard by air.
  2. Rinne's test is negative for C 256, C 512, and C 1024.
  3. The air conduction audiogram is flat or rises slightly in high frequencies, and shows a loss of 45 to 60 decibels in the speech frequencies C 500, C 1000, and C 2000.
4. The bone conduction audiogram will be within 5 decibels of the normal 0 line for speech frequencies C 500, C 1000, and C 2000, after correcting for the Carhart\(^{10}\) notch. This correction is achieved by adding 5 decibels to the bone curve at C 500, 10 decibels at C 1000, and 15 decibels at C 2000, and 5 decibels at C 4000.

5. There is an adequate air-bone gap of 35 to 50 decibels.

**Type B (not ideal, but still suitable)** — The stapes is fixed and cochlear function normal for two of the three speech frequencies. The following tests and audiologic findings are noted:

1. C 32 and C 64 tuning forks are not heard by air.
2. Rinne's test is negative for C 256, C 512, and C 1024 forks.
3. The air conduction audiogram shows moderate depression for high frequency tones. The loss by air is 45 to 70 decibels in the speech frequencies C 500, C 1000, and C 2000, but the loss is greater for C 2000.
4. The bone conduction curve is within 5 decibels of the normal 0 after correction of the Carhart notch in the lower of the two speech frequencies, C 500 and C 1000, but there is a greater loss in the higher frequency C 2000.
5. There is an adequate air-bone gap of 35 to 50 decibels.

**Type C (borderline cases)** — The stapes is firmly fixed with considerable cochlear degeneration and loss of cochlear reserve. The following tests and audiologic findings are noted:

1. C 32 and C 64 forks are not heard by air.
2. Rinne's test is negative for the C 512, C 1024, and C 2048 forks.
3. The air conduction audiogram shows a sloping curve with a 75 to 90 decibel loss for the speech frequencies C 500, C 1000, and C 2000.
4. The bone conduction curve shows a loss of more than 10 decibels for two higher speech frequencies when corrected by the Carhart notch, C 1000 and C 2000.
5. There is an adequate air-bone gap of 35 to 50 decibels.

All cases selected for either mobilization or fenestration must have an intact tympanic membrane, a functioning eustachian tube, and an external canal and middle ear free from active or recent infection.

While mobilization may be advised as the preliminary procedure in all suitable cases for fenestration surgery, it must be remembered that it is speculative and unpredictable, and hence the fenestration operation is advised for cases of bilateral otosclerosis of Types A and B. In Type C cases, the mobilization operation is advised as the primary procedure.

Stapedectomy with polyethylene prosthesis is now being used as the primary procedure in all three types of cases with predictable and dependable results, equal or superior to those previously obtained with fenestration operations.\(^{11,12}\)

**Selection of patients for tympanoplasty**

The five types of tympanoplasty, as classified by Wullstein,\(^8\) are as follows:

**Type I (myringoplasty, myringopexy)** — Findings are as follows:

1. Ossicular chain intact and functioning
2. Central perforation tympanic membrane
3. Middle ear and mastoid free from active disease
4. Eustachian tube must be functional
5. Prosthesis (patch) over perforation improves hearing to serviceable level
6. Sound probe test (Zöllner\(^{13}\)) positive; hearing better on ossicular chain than at promontory.

Hearing can be expected to improve to approximately the same level as indicated by patch test. Attic and antrum must be inspected through control holes to discover and remove cholesteatoma and other destructive disease.

**Type II (tympano incudoplasty, tympano incudopexy)** — Findings are as follows:

1. Partial destruction of malleus
2. Incus and stapes mobile and functional
3. Central perforation tympanic membrane
4. Middle ear and mastoid free from active disease
5. Patch test positive for serviceable improvement
6. Eustachian tube must be functional
7. Sound probe test (Zöllner) positive.

Hearing is improved on ossicular chain rather than at promontory. Serviceable hearing improvement can be expected approximately equal to that produced by the prosthesis or patch test. The epitympanum and mastoid antrum must be investigated for cholesteatoma.

**Type III (tympano stapedioplasty, tympano stapediopexy)** — Findings are as follows:

1. Stapes intact and mobile
2. Malleus and incus destroyed or unusable
3. Large complete destruction of tympanic membrane
4. Sound probe test on stapes head are positive
5. Eustachian tube must be functional
6. The epitympanum and mastoid antrum must be free from active disease. The mastoid antrum and epitympanum must be completely explored.

Skin graft must produce a shallow middle ear in direct continuity with the mobile stapes head, giving a columella effect.

**Type IV (hypotympanoplasty, small middle ear, Kleine Pauke)** — Findings are as follows:

1. The ossicles and tympanic membrane are destroyed
2. The stapes crura are gone but a mobile footplate remains
3. The middle ear, mastoid, and epitympanum must be free of active disease.
1. The eustachian tube must be functional.
A small middle ear is made to sound-protect the round window. The resultant small middle ear must have free air communication between the functional eustachian tube and the round window. The oval window is not covered by the graft.

Type V (small middle ear, Kleine Pauke, with fenestration of horizontal semicircular canal) • Findings are as follows:
1. The ossicles and membrane tympani are completely destroyed and the stapedial footplate is fixed
2. The eustachian tube is functional
3. The middle ear and mastoid are free of active disease
4. Sound probe tests are negative but a satisfactory air-bone gap of 35 to 50 decibels exists.

The round window is sound-protected by skin graft, forming a small middle ear in direct air communication with functional round window. The fenestra nov-ovalis (fenestration of horizontal semicircular canal) replaces the fixed stapes footplate and restores acoustic transmission in endolymph.

All tympanoplastic procedures must be considered unpredictable and speculative at this stage of development. The frequency of finding cholesteatoma or hidden granulomata in what seemed to be an inactive ear, and the failure of a flap or skin graft, make this type of operation one of unpredictable disappointment and failure or unexpected and rewarding success. The experience of the surgeon and his ingenuity to solve the micromechanical problems encountered spell the difference between brilliant success and dismal failure.

The use of vein grafts to repair defects in the tympanic membrane, combined with prostheses (polyethylene and stainless steel), have expanded the indications and improved the results in all five types of tympanoplasty.

Special problems

The problem of dealing with the actively suppurating ear in chronic suppurative otitis media and mastoiditis takes on new meaning since the added responsibility of preservation and improvement of hearing has been given to the surgeon. Never is radical mastoidectomy indicated in the benign type of chronic suppurative otitis media, acute suppurative otitis media, secretory otitis, or even tuberculous otitis. The Bondy or Heath modified radical mastoidectomy can often be employed to deal with this situation.

In chronic destructive otitis media and mastoiditis with chronic osteitis or cholesteatoma, the classic radical mastoidectomy is indicated but with the modification that the middle ear must be left in such a condition that a Type IV or V tympanoplasty can be done. There should never be any compromise between infection and hearing. Infection should always be eliminated first. Just as the cancer surgeon must remove all cancer cells, primary and secondary, if he is to save the patient, the otologic surgeon must remove all of the infection if he is to save the hearing. Reconstruction must always occur in an inactive ear. Infection will destroy the results of the most carefully conceived procedure.

Summary

1. Surgical indications for reconstructive middle ear operations have been evaluated, and the limitations of direct mobilization of the stapes in otosclerosis discussed.

2. Fenestration of the horizontal semicircular canal has been shown to be the most predictable and dependable surgical procedure for otosclerosis, but it has the disadvantage of leaving an operative cavity and failing to recover about 22 decibels of hearing because of loss of sound pressure transformation.

3. Stapedectomy with polyethylene prosthesis is presently advised as the primary operation in all three types of otosclerosis, with results equal or superior to the fenestration operation but overcoming its two disadvantages.

4. The surgical requirements and indications for tympanoplasty have been outlined. The results of tympanoplasty, while still unpredictable and speculative, are greatly improved by the surgical elimination of all diseased tissue in the middle ear and mastoid and the use of vein grafts and prostheses to repair defects in the sound pressure transformer mechanism. When the sound pressure mechanism is absent or destroyed, hearing can still be improved by sound protecting the round window to create a phase difference (small middle ear).