

A Personal History of Stapedectomy

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"There is nothing new under the sun." Ecclesiastes 1:9

The first attempts to mobilize and remove the stapes to improve hearing in the last quarter of the 19th century failed because these operations were ahead of their time. The conditions were not right for such delicate microsurgery. After many attempts, mostly failures, and some serious complications and deaths, in 1900, these operations were condemned by Adam Politzer (1) and Friedrich Siebenmann (2) and were no longer performed. The first otologist to mobilize and remove the stapes, Professor Johannes Kessel of Jena (3), was censured for unscrupulousness. Embittered and discouraged, he retired from research and practice (4).

The fenestration era, from 1910–1960, saw the introduction and refinement of a difficult and unsatisfactory operation, advanced by a technical master, Julius Lempert of New York City, and his pupils, George Shambaugh, Jr., of Chicago and Howard House of Los Angeles. However, even before the second stapedectomy era began, the fenestration operation had begun to lose its appeal.

The second stapes surgery era, from 1952–present, began with the accidental and originally unrecognized mobilization of the stapes by Samuel Rosen. Others began to mobilize the stapes, cut across the footplate and anterior crus (5), and performed other procedures, again with limited success. In 1956, I resurrected the stapedectomy operation (6) and made it safe and successful by covering the oval window with a living membrane and reconstructing the sound-conducting mechanism of the middle ear with a biocompatible Teflon (Du Pont Pharmaceuticals, Wilmington, DE) implant prosthesis.

Most important of all, no matter how effective the stapedectomy operation is, the hearing of a patient with otosclerosis is a wasting asset, deteriorating more rapidly than in patients without otosclerosis. As sensorineural hearing loss begins, over time, some patients with an initially successful stapedectomy operation lose hearing and need to wear a hearing aid.

The great number of stapedectomy operations being done began to decline about 1964, so that now primary stapedectomy rarely is performed. Evidence is increasing that the stimulus to the otosclerosis focus in the human temporal bone is the measles virus, which only infects humans and a few higher primates. With the near-universal vaccination of children against measles in developed countries, this should greatly reduce hearing loss from otosclerosis in the future.

THE FIRST STAPES SURGERY ERA (1876–1900)

To appreciate how this first stapes surgery era could have come before its time, you must realize the limited and confused knowledge these pioneers had of the physiology and pathology of the ear. There was no accurate way to measure hearing loss or to examine the ear adequately before, during, and after operation. The diseases of the ear, especially chronic otitis media, suppurative and nonsuppurative, and otosclerosis, were not well understood. X-rays had not been discovered. Otology was a specialty of medicine that attracted charlatans (7).

There were advances in knowledge, but not everyone, like those in the second stapes surgery era, acted with full awareness of these advances. In 1703, the great Italian physician anatomist, Antonio Maria Valsalva (8) of Bologna, after discovering stapes fixation in a patient with a progressive hearing loss, defined this cause of hearing loss (probably otosclerosis) as "dry catarrh of the middle ear." Beginning in the 1850s, the great German pathologist Rudolph Virchow (9) introduced cellular pathology and encouraged the microscopic examination of disease. In 1853, Joseph Toynbee (10) of London, who dissected 1,659 temporal bones, described ankylosis of the stapes footplate in 39 patients, most of whom were hard of hearing. In 1861, Prosper Meniere (11), in Paris, presented the case report of a young woman with attacks of vertigo and fullness, tinnitus, and hearing loss. After her death, he observed changes in her membranous labyrinth he correctly believed to be the cause of her illness, to which disease his name is forever attached. In 1868, Hermann Ludwig von Helmholtz (12) of Berlin,

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one of the greatest scientists of the 19th century, described the function of the eardrum and ossicles in the amplification of sound and its transmission to the inner ear fluids. In 1893, Adam Politzer (13), Professor of Otology at the Ear Clinic of the University of Vienna, described the clinical picture and gross and microscopic pathology of otosclerosis, clarifying that it was a "dystrophy of the temporal bone" and not caused by infection or "dry catarrh" of the middle ear as was commonly believed at the time. These observations were quickly confirmed by Bezold and Siebenmann (14). Anton von Trötsch (15) first used the name "otosclerosis" to describe the hearing loss associated with fixation of the stapes, but Siebenmann (16) correctly called it "otospongiosis" in the German literature. Despite this large and growing body of knowledge, because of the lack of accurate testing of hearing, the improvement in hearing claimed by some patients clearly was exaggerated. When the drum was incised and middle ear fluid removed by Astley Cooper (17) in 1801 and when the drum, incus, and malleus were removed, the hearing improvement claimed by some of these patients confused these pioneers as to the necessity of these parts of the middle ear and the value of the operations they were performing. The knowledge of ear disease of these pioneers largely was from surgical experimentation and clinical observation, unconfirmed by histologic examination or laboratory tests.

One of the first otologists to use animal experimentation to gain information to guide treatment was the dominant figure of this first era, Professor Johannes Kessel of Jena (Fig. 1). He suspected, like many of his time, that the conductive hearing loss of dry and suppurative otitis media was caused by increased pressure in the inner ear



FIG. 1. Photograph of Professor Johannes Kessel of Jena.

fluids. To test this theory, he removed the columella (stapes) from two pigeons, in which clear fluid continued to be drained from the ears for 8 days, until a membrane formed to seal the oval window and the drainage stopped. He did observe that while their ears were draining perilymph, neither pigeon lost hearing or balance, and from these experiments, he concluded the stapes could be removed without harm in humans to improve the hearing of patients with various causes of conductive hearing loss (18). In 1876, Kessel mobilized the stapes in a young woman with inactive chronic suppurative otitis media with no drum, malleus, and incus. There was some immediate hearing gain. Subsequently, Kessel removed the stapes in humans, with, according to him, "some improvement in hearing and no serious complications." (3).

Europe, at the time before the turn of the century, was a relatively small harmonious medical community, and news of such an advance spread quickly. Adam Politzer had a series of temporal bone sections in a display to show the histologic and gross appearance of otosclerosis, which he brought to the Centennial Celebration of the Declaration of Independence in Philadelphia in 1876, as well as to Washington, DC; Boston; New York City; and other large cities in Europe (19).

The first mobilization of the stapes and stapedectomy operations by Kessel in 1876 was soon followed by Camille Miot in France, who, in a series of 5 publications, reported 200 mobilizations of the stapes operations and contributed greatly to the technique of operation, with strict antiseptics according to the newly explained principles of Lister (20). Later reports came from Hermann Schwartze (21) in Germany in 1885, August Lucae (22) in Germany in 1885, Emile Boucheron (23) in France in 1888, Claude Pottier (24) in France in 1889, and Giuseppe Feraci (25) in Italy in 1899.

It was at this time that the otologists in the two American schools of otology, New York City and Boston, began to perform these operations and provide reports. Samuel Sexton (26), at the Manhattan Ear, Nose and Throat Hospital in New York City, reported his results in 1889 on removal of the incus, malleus, and stapes for otosclerosis and nonsuppurative otitis media to the Section of Otology of the British Medical Society meeting, Leeds, England. He was the author of the major textbook of otology in English at the time, *The Ear and Its Diseases*, in which mobilization of the stapes and stapedectomy occupied only two pages (27). H. A. Alderton (28) of Brooklyn, New York, in 1898 reported the lack of hearing gain in a young girl in whom he performed stapes footplate trephination after failure to mobilize or remove the stapes. This was a last desperate attempt to make stapes surgery work, exactly what Rosen (29) did at the beginning of the second stapes surgery era in 210 patients to try to make mobilization of the stapes more successful. These trephining of the footplate operations, leaving the oval window open, draining perilymph into the middle ear, offering no reported loss of hearing and balance and no serious complication, are only part of the reason I so vigorously oppose the myth of spontaneous perilymph fistula (30).

The Boston story begins with Clarence John Blake, MD, 1843–1919, Harvard College and Harvard Medical School graduate, who trained in Vienna under the great Adam Politzer from 1865–1868. He returned to Boston to begin the practice of otology and was appointed Aural Surgeon on the Staff of the newly opened Massachusetts Charitable Eye and Ear Infirmary, November 1, 1870. He rose to be Chief of the Aural Service, and on May 25, 1888, Blake was appointed Professor of Otology and Head of the Department of Otology at Harvard Medical School, in which capacity he served until 1915. In addition to his pioneering work in mobilization of stapes and stapedectomy and his support and encouragement of Frederick L. Jack, Blake worked with Alexander Graham Bell, making recordings of the human voice, especially the vowels, the work of which was used by Bell to help assert his claim for patents for invention of the telephone.

The next player in this story is Frederick Lafayette Jack, MD, 1861–1951 (Fig. 2), also a Harvard College and Harvard Medical School graduate, a very proper Bostonian who was appointed Aural Extern, November 6, 1883, until December 1, 1887, at which time he became Assistant Aural Surgeon, then Aural Surgeon in 1896, and Chief of Aural Service from 1912–1918. In 1888 at the age of 27, he took a leave of absence and studied in Vienna and other European centers for 6 months. He remained on the consulting staff until his death at age 90 in 1951. When Clarence Blake became Chief of the Aural Clinic of the Massachusetts Charitable Eye and Ear Infirmary for the spring term of 1888, it was his intention to “avail himself of the clinical material afforded by the Aural Clinic” to perform stapedectomy, “but for the temporary loss of the use of his right hand because of an accident,” these operations were performed by his Assistant Aural Surgeon, Frederick L. Jack, MD. Jack performed the stapedectomy operations according to the technique of Kessel, and these and some similar operations he performed were reported by Blake (31) to the American Otological Society in 1892. At the same meeting, Jack reported on his experience with the stapedectomy operation in an article entitled, “Remarkable Improvement in Hearing by Removal of the Stapes” (32). After this report, Jack (33,34) made subsequent reports in 1893 of 32 patients and in 1894 of 70 patients, but because of the bad results in patients with otitis media insidiosa (otosclerosis), he advised those attending his presentation in 1894 to “mobilize the stapes rather than remove it.”

Operations on the middle ear for hearing loss or aural discharge or both generally were performed with the patient under local anesthesia, achieved by insufflating 10% cocaine solution into the middle ear through a silver Eustachian tube catheter. The operation was performed through a hand-held ear speculum, with or without a hand-held lens for magnification, with a head mirror and lantern for illumination, because the electric light did not come into general use until the turn of the century. An inverted V incision was made in the drum, posterior to the malleus, and the bleeding controlled with pledgets of cot-

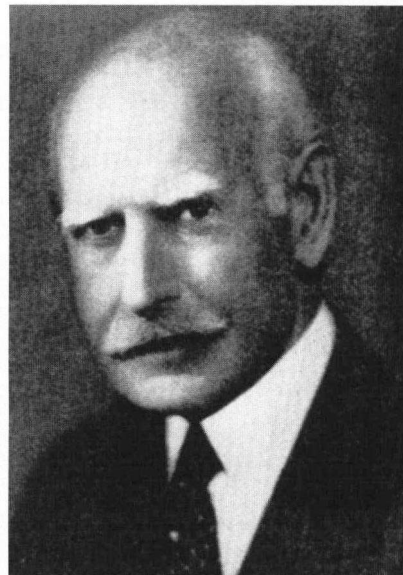


FIG. 2. Photograph of Frederick L. Jack, MD.

ton soaked in cocaine solution. The incus was extracted and the stapes mobilized or extracted as was possible. No attempt was made to seal the oval window. Strangely enough, no particular harm came to the patient other than dizziness for a day or 2. One patient reported by Jack had profuse drainage of clear fluid from the ear after extraction of the stapes, probably caused by a large cochlear aqueduct or internal auditory meatus. Although no mention was made in these presentations about meningitis and other septic complications of stapedectomy operations, these certainly must have occurred and accounted, in part, for the decline in interest in the stapedectomy, mobilization of stapes, and other operations on the middle ear for hearing loss before the turn of the century.

However, 10 years after his original report, in 1902, Jack made a final follow-up report on a patient, a young girl of 20, from whom he had removed the stapes from one ear and 2 months later from the other ear, entitled, “Supplementary Report on a Case of Double Stapedectomy Operated Upon Ten Years Ago” (35). In this girl, who probably had chronic adhesive otitis rather than otosclerosis, and after removal of the stapes, the drums became adherent to the margins of the oval window. She had maintained a good hearing improvement in both ears 10 years later.

Despite all this initial enthusiasm for stapes surgery, the inevitable happened, meningitis and death, as reported by Politzer (36) in 1899 to the Sixth International Congress of Otology in London. In 1900, Politzer, Siebenmann, and other leading otologists summarily denounced stapes surgery for otosclerosis as “useless, often mutilating, and dangerous.” Siebenmann summed up the official position, concluding, “The question of surgical therapy for otosclerosis was interred with great pomp at the 1894 International Conference in Rome. There is no reason to revive it.” (37). Support for the new condem-

nation echoed throughout the otologic community. Even Ricardo Botey, whose animal studies in 1890 inspired Jack and others, condemned the operation. In 1900, he wrote, "Since the lesion (in otosclerosis) is a trophoneurotic one, involving the entire (inner) ear, surgical treatment of this disease is the wrong method. Extraction of the stapes, in spite of the great hope raised, is a bad operation, its results (in otosclerosis) practically nil." (38).

The father of stapes surgery, Johannes Kessel, had fallen into disrepute. In 1900, he was publicly censured for unscrupulousness. Embittered and discouraged, he retired from all scientific work. By 1901, he officially was remembered only for the resection of the drum, membrane, malleus, and incus for suppuration. Stapedectomy had become anathema. Jahn (37), reporting on "Stapes Surgery in the Nineteenth Century," wrote, "It remained for the otologists of another generation, Rosen and Shea, and their students, to reapply the surgeon's skills to the stapes."

While interest in stapes surgery stopped, no more articles were published about it, and little mention was made of it in the textbooks of the time, some surgeons continued to perform the operation. According to the late A. C. Furstenberg, Department of Ear, Nose and Throat of the University of Michigan, "when Norton Canfield returned to our department from traveling in Germany in 1905, he began to do stapes surgery and continued until 1915." Doctor Furstenberg began to do mobilization of the stapes in 1918 and had some good, but more bad, results with perforation of the drum, infection, and postoperative vertigo (39). For these reasons, he stopped performing these operations. I expect many surgeons, all over the world, did not stop stapes surgery completely in 1900, but over time after many bad results, they did stop, and operations on the stapes just slowly faded away.

THE FENESTRATION ERA (1910-1960)

The fenestration era began as conditions began to improve for otologic microsurgery. The pathology of otosclerosis was better understood after the article and traveling exhibition of Politzer and those by Siebenmann and Bezold. Temporal bone pathology laboratories were being established in otologic centers in the United States and Europe. The electric audiometer did not appear until the late 1920s, and hearing testing improved. The various forms of conductive and sensorineural hearing loss were being better recognized, and the treatment of each codified. Most of all, anesthesia, antiseptics, and patient care were advanced by the establishment of special hospitals and medical school departments for the training of otologists and the care of patients with ear disease. Gunnar Holmgren of Sweden introduced the operating loupe, Samuel Sexton of New York introduced the electric head lamp, and Carl-Olof Nylén, working with Holmgren, developed the binocular operating microscope. And so from the beginning of this century, otologists turned from attempting to reopen the oval window by mobilizing or removing the stapes to creating another passageway for sound into the inner ear. In 1897, Passow (40) first postu-

lated that perhaps it would be better to detour around the obstruction in the oval window rather than to mobilize or extract the stapes. He reported an operation in which he used a drill to create a fenestra in the promontory near the oval window, which he covered with mucous membrane from the middle ear with temporary improvement in hearing. Floderus (41) in 1899 proposed that the obstruction to the passage of sound could be bypassed by making an opening into the bony labyrinth and covering it with a skin graft. In 1900, Sir Charles Ballance (42) operated on a patient in whom, during the course of exploring the ear for deafness and vertigo, he found a fistula in the posterior part of the promontory and adjacent semicircular canal. He covered this fistula with a skin graft exposed to the ear canal, and when the wound had healed, he was pleasantly surprised to find that the patient heard much better with that ear. Ballance (42) repeated this operation several times but without success, possibly because the wound of entry closed, and so the incoming sound waves could not directly fall on the fistula covered with a thin layer of skin in the vestibular part of the labyrinth, and the fistula must have closed. In 1910, Robert Bárány of Vienna and Uppsala (43) created an opening in the posterior canal in a patient with otosclerosis, with an immediate hearing gain, but the opening closed, and the hearing gain was lost. Holmgren (44) reported in 1923 that he accidentally pulverized the stapes footplate in a patient with otosclerosis with temporary hearing gain.

George J. Jenkins, at the XVIIth International Congress of Medicine in London in 1913, first suggested making an opening in the bony lateral semicircular canal for the treatment of hearing loss of otosclerosis. He had already made such an opening for the relief of vertigo, which he named "fenestration" (45). After opening the lateral canal, Jenkins left it uncovered, and the postaural incision was closed. Hearing improvement lasted only a few days. He opened the lateral canal in another patient, turned a skin flap down from the ear canal, and then covered all the raw surfaces with skin grafts, but the hearing gain lasted <2 days. Gunnar Holmgren in Stockholm continued this "closed" fenestration of the superior and later the lateral semicircular canal of Jenkins, but he covered the fenestra with mucoperiosteum and closed the postaural incision. In some of his patients, Holmgren kept the fenestra open, and there was a permanent hearing improvement (46). In 1924, Maurice Sourdille visited Holmgren and observed one closed fenestration operation. He returned to his home in Nantes, France, and made something reasonable of the fenestration of the lateral semicircular canal by his three-stage "tympanolabyrinthopexy" open operation. For the first time, the opening in the lateral semicircular canal was exteriorized, by being covered with a flap of ear canal skin, so the sound could enter the perilymph space directly without the obstruction of the eardrum and bony canal wall. Despite this improvement, the fenestration operation still lost the 20- to 25-dB gain added by the drum and ossicular chain, but this three-stage open operation of Sourdille was a big improvement over the closed fenestration operation of Jenkins and Holmgren.

Sourdille (47) came to New York City in 1937 to present his three-stage open fenestration operation to the Section of Otolaryngology of the New York Academy of Medicine where he was well received. Julius Lempert (48), who had just published his landmark report on the endaural approach to the mastoid for chronic otitis media, heard the lecture with great interest, took copious notes, and by the next year, 1938, published his one-stage, endaural fenestration of the lateral semicircular canal operation (49). This operation, performed with the electric drill rather than the hammer and chisel, greatly improved on the three-stage postaural operation of Sourdille, because it was all done at once, with less insult to the inner ear, and offered better hearing results. George E. Shambaugh, Jr. (50), the first pupil of Lempert, published his results with the one-stage fenestration operation, and soon others came from all over the world to learn from the "master," Julius Lempert, and his pupils, George Shambaugh and Howard House. The results with the Lempert modification of the fenestration operation were better, with a lasting hearing gain to the 20- to 25-dB level in approximately half, in expert hands, and poor results in the hands of the less expert, who quickly gave up or lost out to those who were more expert.

I never went to learn the fenestration operation from Julius Lempert, never fell under his spell as everyone else who met him did, so I had no emotional attachment to the fenestration operation or to him. When Rosen resurrected mobilization of the stapes, I was free to pursue this new development and stapedectomy, which the "loyal disciples" of Lempert were not.

In January 1953, I went to Los Angeles to learn the fenestration operation and the practice of otology from Howard House. One night while practicing the fenestration operation on cadavers at the morgue of the Los Angeles County Hospital, we read about Rosen's accidental and unappreciated mobilization of the stapes (51). One of us would read while the other dissected. We were both impressed with the potential of such a simple and apparently effective operation. With this publication, the fenestration era was ending, and the second stapes surgery era was beginning.

In 1962, after I resurrected the stapedectomy operation and it gained worldwide acceptance, it was arranged by my former Chief at the Massachusetts Eye and Ear Infirmary, Phillip Meltzer, who worked with Lempert, for me to come to New York City to meet Lempert. During the meeting, a quiet supper at the home of Tom Rambo who worked with Lempert, it was arranged that Lempert was to ask me to teach him the stapedectomy operation. I sat next to Lempert, and we talked all evening about everything but otologic surgery. Lempert just could not bring himself to ask me to spend the week at his Endaural Hospital to teach him the stapedectomy operation, so I went home to Memphis the next day. Lempert never learned the stapedectomy operation and lost everything as the fenestration operation gave way to stapedectomy. He had been advised by Georg von Békésy, who won a Nobel Prize in medicine for his discoveries on the transformer action of the cochlea in hearing, Glen Weaver, and Merle

Lawrence that if perilymph was lost during stapedectomy, the hearing would get worse (52). Lempert, the most original otologic surgeon of his time, wanted to believe to lose perilymph would damage the hearing and stapedectomy would not work. I had no such misconception. Lempert's beloved only child, Misha, had died years before of leukemia at age 11, and his wife Flo, a Radio City Music Hall Rockette dancer, had died. He ended his life alone and feeble-minded in a nursing home in 1968, with his regrets about what had happened to the fenestration operation. The technical master of the fenestration era had suffered much the same fate as the father of the first stapes surgery era, Johannes Kessel.

THE SECOND STAPES SURGERY ERA (1952-PRESENT)

When I returned to Memphis from Los Angeles after studying at Howard House, I began to do the fenestration operation with reasonable success, but I soon realized even the good results hardly were worth the great effort, and I began to search for a better and more direct way to improve hearing in otosclerosis.

To his credit, Rosen was curious and had asked the right questions. Why did some of the fenestration patients not get a good hearing gain? Could it be the stapes was not fixed? To test his theory, Rosen explored the middle ear in five patients using Lempert's (53) newly introduced transcanal approach to the middle ear for promontory sympathectomy. On April 3, 1952, when Rosen pushed backward on the neck of the stapes to test whether it was fixed, the stapes came loose, and to his amazement, the patient began to hear. The patient must have had a fibrous, not bony, fixation of the stapes, which occurs in approximately 1% of patients, and for which even now, mobilization of the stapes is the operation of choice. Rosen published the results of this study in an article entitled, "Palpation of Stapes for Fixation: Preliminary Procedure to Determine Fenestration Suitability in Otosclerosis," in December 1952 in the *Archives of Otolaryngology* (51) and included this one patient with improved hearing, without realizing the enormous implications of the hearing gain achieved, along with four others. However, Rosen, inspired by this one patient with hearing gain after palpation of the stapes, researched the literature and realized what he had done and quickly began to do mobilization of the stapes on other patients with good results. In November 1953, Rosen published a series of five patients, with improved hearing in each, in the *New York State Journal of Medicine* (54) without mentioning the previous publications on mobilization of the stapes and stapedectomy by Kessel, Miot, Boucheron, Sexton, Blake, and Jack, with which he must have been familiar by the time of this publication.

Like Lempert, Rosen now was overwhelmed by patients wanting the new simple and better mobilization of the stapes operation and otologists anxious to learn how to do it. In the fall of 1953, I too went to learn from Rosen, and seeing my interest in the procedure, he suggested I go to

Vienna to practice the technique of mobilization of the stapes on the abundant cadaveric material available there. After an introduction by Franz Altmann, a former member of the faculty of the Department of Otolaryngology in Vienna in January 1954, I went to study at the First Ear Clinic, made famous by Adam Politzer, now under Professor Otto Novotny, who assigned Kurt Burian (Fig. 3) to be my teacher. There I observed fenestration operations each day, and, after paying 1 shilling each (16 cents) for fresh cut temporal bones, I dissected the bones each evening, practicing the incision, exposure, and mobilization of the stapes technique. I spent nights and weekends studying in the medical library, which was damaged during World War II but still was able to supply me with all the articles of the pioneers of the first era of stapes surgery for which I paid \$1 each to be translated into English. The article that interested me the most was the last one by Jack, published in 1902, "Supplementary Report on a Case of Double Stapedectomy Operated Upon Ten Years Ago" (35) of the young girl from whom the stapes bones had been removed from both ears, 2 months apart, for nonsuppurative otitis media. After the operation, her drums had become adherent to the margins of the oval windows so that sound was conducted into the inner ear directly. This one case report made me realize that what was needed to make stapedectomy safe and successful was to do what had happened spontaneously in this girl: seal the oval window with a tissue membrane and get sound into the inner ear fluids directly. It became obvious to me that even in that preantibiotic first stapes surgery era, removal of the stapes was not necessarily fatal to the hearing or the patient, as generally was believed, if the oval window was sealed after the stapes was removed. This article is so important, I shall reproduce it in its entirety:

Supplementary Report on a Case of Double Stapedectomy Operated Upon Ten Years Ago by Frederick L. Jack, M.D., Boston

The case is one of a number reported at the meeting of this society, July 20, 1892. It is an interesting one not only on account of the effect of the operation on the hear-

ing, but because it is probably the only instance of a person without a stapes in either ear.

The patient is a girl 20 years old. The impairment of hearing was the result of a chronic non-suppurative inflammation in both middle ears. The left was the worse and the first one operated upon. The improvement in the hearing was so great that two months later, at her request, the right stapes was also removed.

At the time of my original report it was suggested that probably time would diminish the improvement in hearing if it did not destroy it altogether. On the contrary ten years have elapsed without apparent diminution.

During this time the case has been under observation, and was last seen in May 1902. General conversation, also hearing for all ordinary sounds has been good, whereas previous to the operation it had been bad. The drums have remained healed. The portion covering the seat of operation is somewhat sunken, forming a movable membrane over the oval window. There are no signs of increased changes in the middle ear. This case in the light of our present knowledge is unique.

I take this opportunity to state conclusions based on the past ten years of investigation.

1. Removal of the stapes does not destroy hearing but sometimes improves it. The contrary statements found in most textbooks up to the time of my paper were incorrect.
2. The operation upon the profoundly deaf is not advisable. This opinion is based upon 70 cases. In this class of cases as a rule the bone cannot be removed and if it were the chances are that no improvement will follow, as the sound perceiving apparatus has undergone irremediable changes.
3. Removal of the stapes as a perfectly justifiable procedure in certain cases of distressing vertigo (Meniere's disease) after all other means have failed.
4. Operation upon cases of moderate deafness may give brilliant results but is attended with some risk to the hearing.

DISCUSSION

DR. JOHNSON: I would like to know how many operations for removal of the stapes the doctor has done in the last year.

DR. JACK: None.

I too graduated from Harvard Medical School in 1947, took my training at the Massachusetts Eye and Ear Infirmary and, after military service during the Korean War in 1954, went to study in Vienna and other continental cities. In Vienna, at the First Ear Clinic of Professor Otto Novotny, between assisting in the operating room with the classical fenestration and other otologic operations and dissecting in the laboratory, I read all the old literature on mobilization of stapes and stapedectomy in English, German, French, and Italian. One snowy Sunday night, I came across this last publication by Jack in 1902, a 10-year follow-up double stapedectomy. When I read it,



FIG. 3. Photograph of my instructor in Vienna, Kurt Burian.

I remembered having met Jack at a Wednesday staff meeting when I was a Resident at the Massachusetts Eye and Ear Infirmary in 1949 and when he was 88 years old and retired for many years. Although Jack said nothing at the meeting, I did remember how bright and alert he was, attentive to every word of the meeting, which caused me to give special significance to this one case report by Jack of a successful double stapedectomy from so long before.

When I returned to Memphis, I continued to do the mobilization of stapes operation, with the refinements that were coming along, including anterior crurotomy suggested by E. P. Fowler, Jr. (5). Further research of the literature, which was not as easy to do then as it is now with the National Library of Medicine database, showed me that both Terence Cawthorne (55) in London and Gino Cornelli (56) in Milan, Italy, unknown to each other, during World War II had removed the stapes and attempted to drop the drum down onto the oval window without success. After trying this on the cadaver and in several patients without success, I realized that as a practical matter, it could not be done, just as Cawthorne and Cornelli had found before me. I then turned my research toward sealing the oval window with a tissue membrane and reconstructing the sound-conducting mechanism of the middle ear with a prosthesis. By the summer of 1955, I had completed my research, and on September 14, 1955, I did my first briefly successful operation. I removed the stapes, covered the oval window with a thin slice of subcutaneous connective tissue, taken well below the dermal layer, and inserted a narrow rod of homograft cortical bone (Campbell Orthopedic Clinic Bone Bank, Memphis, TN) as a prosthesis between the incus and the oval window. The immediate result was good, hearing gain and no vertigo, but the hearing gain was soon lost as adhesions formed around the homograft bone graft and the patient began to reject it. I had to remove the bone graft, now buried in adhesions, and fit the patient with a hearing aid. I realized at once that what I needed was a biocompatible material, made into a prosthesis, that could be attached to the lower end of the incus and rest on the center of the tissue graft covering the oval window. At this time, I read about the newly discovered material Teflon (Dupont, Wilmington, DE) and learned from an orthopedic surgeon colleague that it was being used in a total hip joint prosthesis being made in Memphis by the Richards Manufacturing Company. I presented my problem to the newly hired engineer at the Richards Manufacturing Company, Harry Treace, lent him my binocular loupe and several stapes bones, and told him what I needed. Two days later, he gave me a Teflon replica of the stapes with an opening above the head of the stapes into which the incus could be inserted at operation and the footplate resting on the covered oval window. The first patient was carefully selected, a 54-year-old woman with severe hearing loss in one ear and much better hearing in the other. On May 1, 1956, I removed her stapes with no difficulty and covered the oval window with a vein graft from the back of the patient's hand. I then inserted the end of the incus into the hole in the head of the Teflon replica of the stapes (Fig. 4). The footplate came to rest on the oval win-

dow, covered with vein graft. The patient was able to hear very well at once on the operating table, for she was under local anesthesia. I looked up at the clock. It was 1:00 PM. My pulse was racing and so was the patient's. The rest is history. I knew at once this was the long-sought answer to the hearing loss of otosclerosis. The patient was unsteady after operation and could hear much better. She was lost to follow-up 3 years later but at that time still was hearing much better, with complete closure of the preoperative air-bone gap (Fig. 5). Harry Treace and I became good friends, and, during the next 35 years, developed prostheses, instruments, and procedures that advanced the new specialty of microsurgical otology (Fig. 6).

Howard House allowed me to present this first stapedectomy and reconstruction of the sound-conducting mechanism of the middle ear as the last speaker at the First Symposium on Mobilization of the Stapes at the Annual Meeting of the Triological Society in Montreal on May 17, 1956 (6). There was an immediate request by many members of the audience to reply to my presentation, but time had expired, and the meeting ended with no remarks by anyone about my presentation. I realized the implications of what I had said, which is that stapedectomy would be the new operation of choice for otosclerosis rather than mobilization of the stapes or fenestration of the lateral semicircular canal. To my surprise, no one was willing at that time to accept what I had proposed and was very anxious to get up and condemn it. In retrospect, I realize now I was too young, too brash, and too much a threat to the leaders of the fenestration and mobilization establishments who still were battling it out for acceptance.

I continued to try to do mobilization or anterior crurotomy when possible and stapedectomy with reconstruction of the sound-conducting mechanism of the middle ear when not. I began to do partial anterior stapedectomy, covered the oval window with vein graft, and interposed the posterior crus and attached a piece of footplate (57). I demonstrated this technique of stapedectomy to Michel Portmann in Bordeaux when I visited him in August 1957 (Fig. 7). He, Jack Hough, and others adopted stapedec-

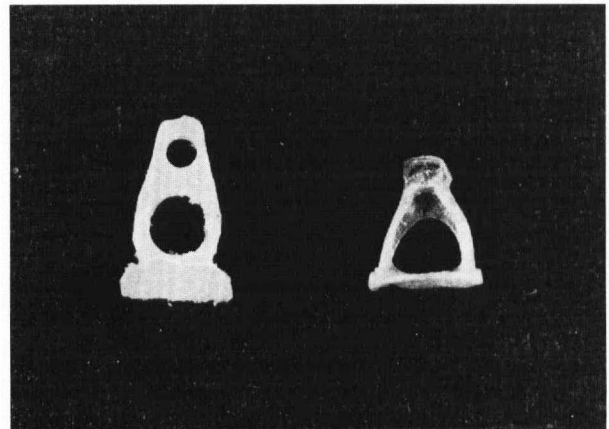


FIG. 4. Photograph of the first Teflon (Dupont, Wilmington, DE) replica of the stapes prosthesis and human stapes bone.

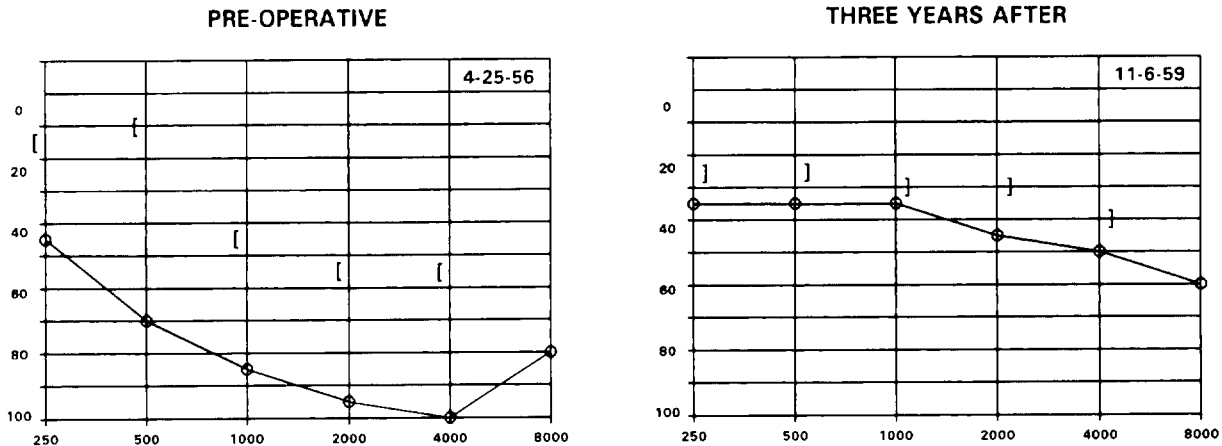


FIG. 5. Preoperative hearing test of first stapedectomy and 3 years' postoperative.

tomy with posterior crus interposition as their preferred technique for many years. In 1958, I began using a pointed polyethylene tube to reconstruct the sound-conducting mechanism of the middle ear. I presented this variation on the total stapedectomy operation to the French Society of Otolaryngology in Paris in the fall of 1958 (58). I read the article in French at the Sorbonne, the University of Paris, where my father had studied after World War I, which was a great thrill for me. In May 1958 at the Annual Meeting of the Triological Society in San Francisco during the Second Symposium on Mobilization of the Stapes, I presented my results in 89 patients with stapedectomy with vein graft and polyethylene tubing with good hearing improvement in 50%. At the same symposium, Harold Schuknecht presented his equally good results with 50 patients using stainless-steel wire on a piece of fractured footplate to reconstruct the sound-conducting mechanism of the middle ear (59). After this meeting, I visited Los Angeles and demonstrated stapedectomy to Howard House, and most otologic surgeons gradually began to do stapedectomy and stopped doing fenestration of the lateral semicircular canal and mobilization of the stapes. In 1962, I began using an all-Teflon piston prosthesis on the vein graft (60), and in 1964, I began using a Teflon cup piston prosthesis with platinum loops to hold the incus down onto the cup in the head of the prosthesis (61). In 1993, I began using an argon laser (HGM Compac Argon Plus Laser, Eoloo AA, HGM, Salt Lake City, UT) with a hand-held fiber-optic microtip to cut across the arch of the stapes and the footplate. In my opinion, this low-energy argon laser, with hand-held fiber-optic microtip, is the greatest technical advance in stapedectomy surgery.

This argon laser, advanced audiology, operating microscope, and intravenous anesthesia cause me to reflect on how far we have come in this second era of stapes surgery in the technical improvements. The stapedectomy operation has now received universal, worldwide acceptance, with the obvious variations in the details of technique from surgeon to surgeon. All now generally

agree on the indications for operation: a conductive hearing loss of 30 dB or more with absent stapedial reflexes and a shallow, type A impedance audiogram, reasonable speech comprehension, and a dry healthy ear canal and drum. Most operations are done with the patient under local anesthesia, although those of us at the Shea Clinic and the Causse Clinic in France use intravenous general anesthesia. Most surgeons are now using a laser to remove all or part of the stapes. Most are using a Teflon or stainless steel piston prosthesis with interposed vein, fascia, or other connective tissue. Most are making a small opening in the stapes footplate, removing half or less, rather than removing all or most of it. I still give sodium fluoride (Florical; Mericon Industries, Peoria, IL, U.S.A.), 6.8 mg twice a day, to those patients with extensive otosclerosis at operation or rapidly progressive hearing loss or both. I consider a speculum holder attached to the operating table, to operate with both hands, a living oval window seal, not Gelfoam (Upjohn Company, Kalamazoo, MI, U.S.A.) or blood clot, and a piston prosthesis, not wire, as the three indispensable ingredients necessary to perform the stapedectomy operation properly.

What is strange and sad is that now there is so much agreement about how to perform stapedectomy and the results are so uniformly good, the great backlog of patients have been operated on, and the patients coming for operation now are mostly those who have been operated on before or those with newly developed otosclerosis of recent origin. Furthermore, recent ultrastructural and immunohistochemical studies of the temporal bones of patients with otosclerosis show what look like measles virus and antigens in the cells of the otosclerotic focus (62). There is good epidemiologic evidence that the measles virus, when it infects the patient, stimulates the latent focus of otosclerosis in the temporal bone and causes the hearing loss of otosclerosis. If this is true, and the evidence so far is very compelling, then with the near-universal administration of the measles virus to children in the developed world, there will be less hearing loss from otosclerosis.

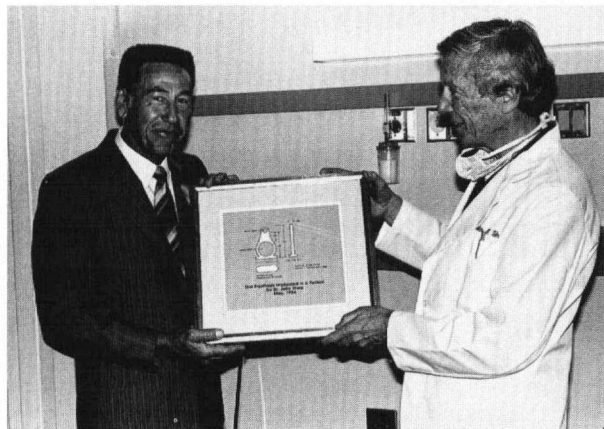


FIG. 6. Photograph of Harry Treace and John J. Shea, Jr., MD, with drawing of the first Teflon™ prosthesis.



FIG. 7. Photograph of Michel Portmann and John J. Shea, Jr., MD, Bordeaux, France, 1957.

When I was reporting my first successful stapedectomy, Agnar Hall and Curt Rytzner in Gothenburg, Sweden, in 1956 were removing the stapes and incus and interposing the incus onto the open oval window for otosclerosis with limited success (63). Hans Heermann (64) of Essen, Germany, who died in 1995 at age 96, removed the footplate of the stapes in patients with otosclerosis through an endaural approach and covered the oval window with a Sourdille skin flap and free skin grafts. He reported this operation in Germany in 1955 and again at the Sixth International Congress of Otolaryngology in Washington, DC, in 1957. I remember him explaining the operation to me at that meeting. Although his results are not reported in his publication, Heermann told me these patients did hear better, but when stapedectomy and reconstruction of the sound-conducting mechanism of the middle ear with a prosthesis began, he did not continue to do this operation.

At the First Symposium on Mobilization of the Stapes, Tom Rambo presented a technique he was testing in animals and humans at the New York University–Bellevue Medical Center to remove the incus, malleus, and stapes and drop the drum onto the margins of the oval window, with good hearing improvement. He predicted that putting sound through the oval window would be the operation of the future rather than fenestration of the lateral semicircular canal (6).

No history of stapedectomy would be complete without mentioning all those who contributed to its improvement after it was first introduced. To name a few, Harold Schuknecht introduced the wire prosthesis on a depressed, fractured piece of footplate at the Second Symposium on Mobilization of the Stapes (59), Michel Portmann and Jack Hough promoted the partial stapedectomy with posterior crus and interposed vein graft, and Howard House promoted the Gelfoam wire prosthesis. The great contribution of Jean René Causse and his son, Jean-Bernard Causse, in the use of sodium fluoride to prevent the sensorineural hearing loss of otosclerosis, and many other refinements in the operation should be

mentioned. Those who have contributed are too numerous to mention, but Ned Fowler, Terry Cawthorne, Dietrich Plester, George Shambaugh, Jr., and J. Brown Farrior also must be given recognition.

Although I believe my Teflon replica of the stapes was the first successful biocompatible implant prosthesis, both Zöllner (65) and Wullstein (66) tried to reconstruct the sound-conducting mechanism of the middle ear in tympanoplasty operations in the early 1950s with a non-biocompatible implant prosthesis, which was rejected by the body, so they stopped using these materials (67).

I have recently published my “Forty Years of Stapes Surgery” (68), which will, I expect, be my last report of my results with stapedectomy.

SUMMARY AND CONCLUSIONS

Aristotle has said the essential ingredient of tragedy is first hubris. Fame leads to the hubris that offends the gods, who send great punishment. This is so true in the history of stapedectomy.

The three distinct eras of surgery for otosclerosis teach us a lot about what happens in science and in life. The first stapes era began in Europe, ahead of its time, and in those halcyon days before the turn of the century, the Belle Epoch, proceeded, uncorrected to its tragic extreme, and then was stopped suddenly, quite rightly, by the establishment.

The fenestration era proceeded to an extreme, when its technical master Julius Lempert would allow no criticism or improvement in “his” one-stage endaural technique, however good, nor would he accept the new mobilization and stapedectomy operations, and he and it ended badly. The fact that Jenkins and Holmgren would make an opening in the lateral semicircular canal and then close it in the epitympanum, not open to the ear canal, to expect to improve hearing is amazing. Until Sourdille went to Stockholm and saw one closed fenestration operation performed by Holmgren and devised his “open to the ear canal technique,” the closed fenes-

tration operation was not reasonable. Then Sourdille came to New York City, and Lempert heard him speak and read and reread his publication and greatly improved on his operation. It was Lempert's one-stage endaural open operation that gave the fenestration operation the worldwide acceptance it gained.

The second stapedectomy era began before the fenestration era ended with the accidental and originally unrecognized mobilization of the stapes by Rosen and my resurrection of stapedectomy. I realized in reading the literature of the past that stapedectomy was not necessarily fatal to the ear or the patient as was generally believed, and what was needed was to seal the oval window with a living elastic membrane and reconstruct the sound-conducting mechanism of the middle ear with a biocompatible implant prosthesis to make it successful. But for me, in 1955–1956, the "Zeitgeist" was finally right. I realized the stapes could be removed and covered the oval window with a vein graft, and Harry Treace made me a biocompatible implant prosthesis out of the newly discovered Teflon. For a new technology to be accepted, it must be much better than what it replaces, and stapedectomy was much better than fenestration. In the new microsurgical era of otology that began, improvements in the stapedectomy operation came from everywhere and were readily accepted. Stapedectomy has now become so successful, like many treatments in medicine, the problem has now largely disappeared. If the measles virus is the cause of the growth of the otosclerotic focus, as it seems to be, then vaccination against measles eventually will eliminate the hearing loss of otosclerosis completely.

What the history of stapedectomy reveals is the truth of the quotation from Ecclesiastes, "There is nothing new under the sun." Progress is only made when the Zeitgeist is right, by someone who puts together the truths of the past with the new discoveries of the present.

REFERENCES

1. Politzer A. Geschichte der otosclerose. In: *Geschichte der Ohrenheilkunde*. Stuttgart: Enke Verlag, v. 2. 1913:171–5.
2. Siebenmann F. Sur le traitement chirurgical de la sclerose otique. *Congr Inter Med Sec Otol* 1900;13:170.
3. Kessel J. Über das mobilisieren des steigbügels durch ausschneiden des trommelfells, hammers und ambosses bei undurchgängigkeit der tube. *Arch Ohrenh* 1878;13:69–88.
4. Heermann H. Johannes Kessel and the history of endaural surgery. *Arch Otolaryngol* 1969;90:652–7.
5. Bask M, Fowler EP Jr. Anatomical factors in stapes-mobilization operations. *AMA Arch Otolaryngol* 1956;63:589–97.
6. Meltzer PE, Lindsay JR, Goodhill V, et al. Symposium. The operation for the mobilization of the stapes in otosclerotic deafness. *Laryngoscope* 1956;66:729–84.
7. Kerr AG. Controversies in otology. *J Laryngol Otol* 1987;101:983–92.
8. Valsalva AM. *The human ear (Latin)*. Bononiae: C. Pisarri, 1704.
9. Virchow R. *Handbuch der speciellen pathologie und therapie*, 1854.
10. Toynbee J. *Descriptive catalogue of preparations illustrative of diseases of the ear*. London, 1857.
11. Meniere P. Mémoire sur des lésions de l'oreille interne donnant lieu à des symptômes de congestion cérébrale apoplectiforme. *Gaz Méd Paris* 1861;16:597–601.
12. Helmholtz HLF von. Die mechanik der gehörknöchelchen und des trommelfells. *Pflügers Arch ges Physiol* 1868;1:1–60.
13. Politzer A. Ueber primäre erkrankung der knöchernen labyrinthkapsel. *Ztschr Ohrenh* 1893-94;25:309–27.
14. Bezold F, Siebenmann F. *Text-book of otology for physicians and students in 32 lectures*, Lecture XXVI, 1894. Holinger J (trans). Chicago: E.H. Colegrove Co., 1908.
15. Tröltzsch AF von. *Lehrbuch der Ohrenheilkunde*, 7. Aufl. Leipzig: Vogel, 1881.
16. Siebenmann F. Demonstration mikroskopischer und makroskopischer präparate von otospongiosa progressiva. *Int Otol Congr* 1912;9:207.
17. Cooper A. Further observations on the effects which take place from the destruction of the membrana tympani of the ear; with an account of an operation for the removal of a particular species of deafness. *Philos Trans R Soc Lond B Biol Sci* 1801;91:435–50.
18. Kessel J. Ueber die durchschneidung des steigbügelmuskels beim menschen und über die extraction des steigbügels, respektive der Columella bei Thieren *Arch Ohrenh* 1876;11:199–217.
19. Stool SE, Kemper MJ, Kemper B. Adam Politzer, otology and the centennial exhibition of 1876. *Laryngoscope* 1975;85:1898–904.
20. Miot C. De la mobilisation de l'étrier. *Rev Laryngol Otol Rhinol* 1890;10:113–30.
21. Schwartze HHR. *Lehrbuch der chirurgischen krankheiten des ohres*. Stuttgart: Enke, 1885.
22. Lucae A. Ueber operative entfernung des trommelfells und der beiden grösseren gehörknöchelchen bei sklerose der paukenschleimhaut. *Arch Ohrenh* 1885;22:233–42.
23. Boucheron E. La mobilisation de l'étrier et son procede operatoire. *Union Med Paris* 1888;46:412–3.
24. Pottier A. *Du traitement de la surdité consécutive à l'otite moyenne purulente*. Paris: Ollier-Henry, 1889:59.
25. Feraci G. Importanza acustica e funzionale della mobilizzazione della staffa; risultati di una nuova serie di operazioni. *Arch Ital Otol Rhinol Laryngol* 1899;9:209–21.
26. Sexton S. Operation for deafness and tinnitus, due to immobilization of the ossicles, and for otorrhea. *Br Med J* January 11, 1890;1:69–70.
27. Sexton S. Operation for deafness and tinnitus, due to immobilization of the ossicles, and for otorrhea. In: *The Ear and its diseases*. New York: Wood & Co., 1888.
28. Alderton HA. Trephining of the stapedia footplate for otitis media sclerosa. *Trans Am Otol Soc* 1898;3:60–3.
29. Rosen S. New middle ear mechanisms for normal hearing. *AMA Arch Otolaryngol* 1958;67:428–34.
30. Shea JJ. Myth of spontaneous perilymph fistula. *Otolaryngol Head Neck Surg* 1992;107:613–6.
31. Blake CJ. Middle ear operations. *Trans Am Otol Soc* 1892;5:306–24.
32. Jack FL. Remarkable improvement in hearing by removal of the stapes. *Trans Am Otol Soc* 1892/93;5:284–305.
33. Jack FL. Further observations on removal of the stapes. *Trans Am Otol Soc* 1893;5:474–87.
34. Jack FL. Remarks on stapedectomy. *Trans Am Otol Soc* 1894;6:102–6.
35. Jack FL. Supplementary report on a case of double stapedectomy operated upon ten years ago. *Trans Am Otol Soc* 1902;8:99–100.
36. Politzer A. Ueber extraction des steigbügels mit demonstration histologischer präparate. Presented at the 6th International Otiologic Congress, London, 1899. *Arch Ohrenh* 1899;47:223.
37. Jahn AF. Stapes surgery in the nineteenth century. *Am J Otol* 1981;3:74–7.
38. Botey R. Le traitement chirurgical de la sclerose otique. *Annales des maladies de l'oreille* 1900;26:129–40.
39. House HP. Personal experiences with stapes mobilization. *Trans Pacific Coast Oto-Ophthalmol Soc* 1956;229–51.
40. Passow A. Cited in Panse R. Discussion, Die operative Behandlung hochgradiger Schwerhörigkeit. *Verhandl Deutsch Otol Gesselsch* 1897;6:141–5.
41. Floderus B. Bidrag till stigbygelankylosens operativa radikalbehandling. *Nord Med Ark* 1899;32:1–17.
42. Ballance CA. *Essays on the surgery of the temporal bone*. v. 2. London: MacMillan, 1919:327–8.
43. Bárány R. Die indikationen zur labyrinthoperation. *Acta Otolaryngol (Stockh)* 1924;6:260–88.

44. Holmgren G. Some experiences in the surgery of otosclerosis. *Acta Otolaryngol* 1923;5:460-6.
45. Jenkins GJ. Otosclerosis: certain clinical features and experimental operative procedures. *Trans XVIIth Inter Congr Med London* 1913; 16:609-18.
46. Holmgren G. The surgery of otosclerosis. *Ann Otol Rhinol Laryngol* 1937;46:3-12.
47. Sourdille M. New technique in the surgical treatment of severe and progressive deafness from otosclerosis. *Bull New York Acad Med* 1937;13:673.
48. Lempert J. Complete apicectomy (mastoidotympanoapicectomy) *Arch Otolaryngol* 1937;25:144-77.
49. Lempert J. Improvement of hearing in cases of otosclerosis: a new one stage surgical technic. *Arch Otolaryngol* 1938;28: 42-97.
50. Shambaugh GE, Jr. Fenestration operation for otosclerosis. *Acta Otolaryngol Suppl (Stockh)* 1949;79:1-101.
51. Rosen S. Palpation of stapes for fixation: preliminary procedure to determine fenestration suitability in otosclerosis. *AMA Arch Otolaryngol* 1952;56:610-5.
52. Lawrence M. Otologic research and the Zeitgeist. *Ear Hear* 1983; 4:73-8.
53. Lempert J. Tympanosympathectomy: a surgical technic for the relief of tinnitus aurium. *Arch Otolaryngol* 1946;43:199-212.
54. Rosen S. Mobilization of the stapes to restore hearing in otosclerosis. *New York State J Med* 1953;53:2650-3.
55. Cawthorne T. *Proc R Soc Med* 1947;6:320.
56. Cornelli G. Tecnica e risultati dell' apertura del vestibolo laberintico attraverso una finestra oval nella terapia dell' otosclerosi. *Revista L'Ospedale Maggiore* 1949;37:2.
57. Shea JJ Jr. Fenestration of the oval window. *Ann Otol Rhinol Laryngol* 1958;67:932-51.
58. Shea JJ. Fenestration de la fenêtre ovale. *Communication au 56e Congrès Français d'Oto-Rhino-Laryngologie* 1958:1-4.
59. Symposium. Stapes mobilization two years later. *Laryngoscope* 1958;68:1403-41.
60. Shea JJ, Sanabria F, Smyth GDL. Teflon piston operation for otosclerosis. *Arch Otolaryngol* 1962;76:516-21.
61. Shea JJ. Management of the stapes footplate with special reference to otosclerosis. *J Laryngol Otol* 1982;96:383-403.
62. McKenna MJ, Kristiansen AG, Haines J. Polymerase chain reaction amplification of a measles virus sequence from human temporal bone sections with active otosclerosis. *Am J Otol* 1996;17:827-30.
63. Hall A, Rytzner C. Stapedectomy and autotransplantation of ossicles. *Acta Otolaryngol* 1957;47:318-24.
64. Heermann H. Über ausmeisselung der steigbügelplatte. *Sechster Internationaler Kongress für Otolaryngologie* 1957:248-9.
65. Zöllner F. Plastische eingriffe an den labyrinthfenestern. *Arch Ohren Nasen Kehlkopf* 1952;161:414.
66. Wullstein H. The restoration of the function of the middle ear in chronic otitis media. *Ann Otol Rhinol Laryngol* 1956;65:1020-41.
67. Harrison WH, Shambaugh GE Jr, Kaplan J, et al. Prosthetics in the middle ear: preliminary report on the use of prosthetics to reestablish continuity of the sound pressure transformer of the middle ear. *AMA Arch Otolaryngol* 1959;69:661-6.
68. Shea JJ. Forty years of stapes surgery. *Am J Otol* 1998;19:1.