The Stapes Prosthesis

Past, Present, and Future

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KEYWORDS

• Stapes • Prosthesis • Stapedectomy • Stapedotomy • Otosclerosis

KEY POINTS

- In 1956, Shea and Treace made a stapes prosthesis using a Teflon piston and vein graft over the oval window after stapedectomy for otosclerosis, as an alternative to fenestration.
- Further iterations of stapes prostheses followed, by Shea, House, Robinson, McGee, Schuknecht, and many others.
- A wide array of biomaterial availability influenced stapes surgery techniques, especially methods for incus attachment.
- Stapes prosthesis has many shapes and sizes; titanium, nitinol, and Teflon are popular materials. There are also powered implant options.
- Excellent results can be achieved with prostheses designed to rest on tissue grafts in stapedectomy techniques or pass through the footplate in stapedotomy techniques.

NASCENCE OF STAPES SURGERY

Although Valsava first described stapes ankylosis leading to hearing loss in 1703 and Meniere described mobilization of the stapes with a gold rod in 1842, stapes surgery is regarded to have begun in 1876 when Kessel developed the removal of the stapes after mobilization to address hearing loss. Hearing improvement with mobilization alone was fleeting; however, with stapedectomy, results were more durable and the practice spread through Europe and even to the United States. Unfortunately, without antibiotics, hearing loss and lethal intracranial complications led to the condemnation of stapes surgery in 1899 by Politzer, Siebenmann, and Moure at the International Otology Congress in London.[1,2] There was a shift to fenestration techniques from 1900s until the 1950s. Rosen rediscovered stapes mobilization in 1952, and notably in 1956 Shea revisited stapes surgery using a carved Teflon (DuPont, Wilmington,

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Delaware) stapes prosthesis (Fig. 1B) made by Treace with a vein graft over the oval window after stapedectomy to restore hearing in the setting of otosclerosis.

NATURAL OR NO MATERIALS

Although utilization of a prosthesis to replace the stapes is the most common technique, some surgeons developed stapes surgeries that did not require the implantation of foreign material. Partial footplate removal developed by Plester and then fenestration of the footplate was advanced by Shea, Marquet, and Martin. In the late 1950s. Portman, Hough, Juers, and others advanced a posterior crus interposition stapedioplasty with anterior curotomy and partial stapedectomy.[3] In those techniques, the anterior crurotomy freed the stapes superstructure from the anterior otosclerosis fixation and the remaining posterior crus provided ossicular connection to the partial footplate removal, which had been sealed with a vein graft. More recently, Silverstein described laser stapedotomy minus prosthesis (STAMP) in cases of minimal otosclerosis with transection of the blue footplate and anterior crurectomy to mobilize the stapes with preservation of the stapedial tendon.[4,5]

EARLY PROSTHESES

The basic physical requirement of a stapes prosthesis is to achieve a secure connection between the mobile incus and the sealed perilymph in the oval window. More than 100 other stapes prostheses have been developed since Shea and Treace's original carved Teflon stapes replica (see Fig. 1B). The evolution of Shea's personal stapedectomy technique over time provides a window to the confluence of changing concepts of the physical requirements of stapes prostheses as well as the changes in biomaterial availability and surgical equipment capabilities. Shea himself started to use a pointed polyethylene tube strut in 1958 (Fig. 1C) and then a Teflon piston prosthesis in 1962, followed by a Teflon cup prosthesis in 1964; then he added microsurgical laser techniques in 1993.

House popularized a stainless steel wire-loop prosthesis (Fig. 1D) that could be crimped onto the long process of the incus in 1960. This crimp-on prosthesis type used in a total stapedectomy technique has provided excellent long-term results, including paired comparisons in patients undergoing total stapedectomy on one

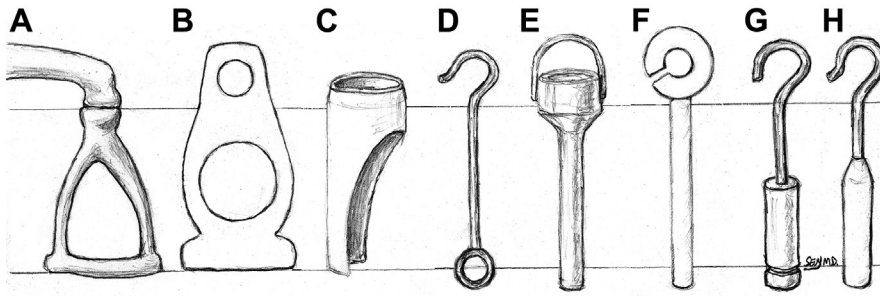

Fig. 1. Early and representative stapes prostheses. (*A*) Human stapes and incus long process; (*B*) first stapes prosthesis, Shea and Treace, carved Teflon fluoroplastic; (*C*) Shea strut, polyethylene; (*D*) House wire loop, stainless steel; (*E*) Robinson bucket handle, titanium; (*F*) fluoroplastic loop; (*G*) platinum wire hook, stainless steel piston; and (*H*) nitinol wire hook and fluoroplastic piston. (*Courtesy of* Alexander Sevy, MD, Louisiana State University School of Medicine, New Orleans, LA.)

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