Otosclerosis was first discovered by Valsalva in 1704 \cite{1}, and the term was first used by Anton von Troltsch in 1872 to differentiate from tympanosclerosis \cite{2}. Normally, the otic cyst in human remains stationary after full development and contains no visible activated osteoblasts or osteoclasts. In patients with otosclerosis, co-existing re-absorption and osteogenesis can be seen in the bony otic cyst. Otosclerosis is therefore a disease process characterized by this primary osteospongiotic changes in the otic cyst.

A few milestones in the discovery of otosclerosis are worth mentioning, including Valsalva's finding in 1704 that fixation of the stapes impaired hearing, Meniere's report in 1842 that hearing was temporarily improved in a patient when the stapes was moved with a gold needle \cite{4}, the first use of the term of "otosclerosis" by Anton von Troltsch in 1872, Politzer's work in 1893 with temporal bone pathology that showed that this was a primary sclerotic disease in the otic cyst \cite{3}, and the proof by Bezold and Siebenmann in 1894 that osteospongiosis in the labyrinth was the cause of stapes fixation and hearing loss.

Our attempts to treat otosclerosis have been a process of "exploration-failure-re-exploration". In 1876, Kessel concluded that opening the oval window was not necessarily associated with severe damage to the inner ear, based upon his experiments with pigeons \cite{5}. Both Kessel and Jena have been viewed as the founders of stapes surgeries. In 1885, Schwartzé and Lucae started stapes mobilization and stapedectomy procedures. In 1890, Miot reported a series of 126 cases of stapes mobilization procedures, of which 74 showed improved hearing. Boucheron, Pottier, Feraci, Blake, Jack, Sexton, Alderton and others also performed stapedectomy and stapes mobilization procedures in various numbers of patients in the same period of time. This was followed by continuous reports of new techniques. Passov recommended stapes fenestration in 1897 and Floderus proposed vestibular fenestration in 1899 \cite{1}. But because hearing improvement was maintained for only a few days to a few weeks following stapes mobilization and stapedectomy and there were risks of fatal labyrinthitis and intracranial infections, in 1899, Politzer, Siebenmann and Moure declared on the 6th International Otology Conference in London that stapes surgeries were not useful but dangerous and unethical. As a result, treatment for otosclerosis appeared suspended.

However, pioneers never stopped exploring. In 1913, Jenkins proposed fenestration in the horizontal semicircular canal to improve hearing. In the 1920s, head light was adopted in clinical therapies to provide improved illumination in narrow field surgeries \cite{6}. In 1937, Holmgren became the first to use a microscope in lateral semicircular canal fenestration, and building on this, his student, Sourdille, started three-stage tympano-labyrinthotomy and achieved stable hearing improvement in 64% of a series of 109 cases \cite{7}.

In 1938, Lempert simplified and standardized semicircular canal fenestration, making it a one-stage procedure. From that time, treatment of otosclerosis was accepted and adopted across the world and semicircular canal fenestration became the standard treatment for otosclerosis \cite{8}. In China, the late Prof. JIANG made the first diagnosis of a case of otosclerosis in 1950. After careful studies on cadaver specimens, he successfully performed lateral semicircular canal fenestration on a patient from Anhui in July, 1950. Prof. SUN Hongquan successfully completed the procedure on another patient in Shandong
in the same year [9]. At the time, China lagged far behind the west in its health care levels, especially in the field of otology which requires support of comprehensive knowledge and sophisticated equipment. The success by these two Chinese surgeons greatly elevated the level of otologic care in China at the time. Through his continuous efforts to improve surgical techniques, Prof. JIANG later proposed a unique "roof fenestration" technique with minimized post-operative discomforts and re-closure, yielding consistent good outcomes.

In the 1950s, the operative microscope was officially introduced to clinical application, especially in otology. Rosen started to explore stapes mobility before semicircular canal fenestration in 1950 and confirmed the value of stapes mobilization in improving hearing [10]. In 1956, Shea stated that the stapes could be replaced. He worked with Treace, an engineer, to develop the first Teflon stapes prosthesis. On May 1, 1956, Shea removed the stapes from a female patient and successfully replaced it with custom-made stapes prosthesis to reconstruct the osicular chain followed by sealing the oval window with a piece of venous wall graft [11, 12]. His success has been the foundation of modern treatment for otosclerosis. All stapes surgery techniques since then have been variations based upon Shea’s technique. In China, LI Baoshi and JIANG Sichang also started to perform stapes mobilization surgeries in 1956 [9].

In 1957, Portmann, Claverie and Zangemeister proposed preservation of the stapes supra structure for the advantages of not needing an artificial prosthesis and natural incudostapedial connection. In 1960, Schuknhecht and Oleksiuk invented a "wire-fat"prosthesis prepared during surgery, which was later widely adopted until even today [13]. In the same year, Zoller reported using cortical bone in the place of stapes in reconstructing hearing, which is still used by some surgeons today. In the 1960s, Plester recommended resection of the posterior or 1/3 of the stapes—a real stapedotomy technique [13]. All these were closely watched in China by Prof. JIANG and his team. They were clear about their direction when seeing the success of stapedectomy. After working hard on animal experiments, cadaver dissection and manufacturing custom-made inner ear surgical instruments, Drs. JIANG Sichang and TIEN Zhongrui successfully conducted stapedectomy on a patient with otosclerosis on January 13, 1962. Subsequently, ZHOU Lude from the Peking Union Medical College Hospital was also successful in conducting stapedectomy for otosclerosis. In the following 18 months, Prof. JIANG and his team completed 24 stapedectomy procedures for patients with otosclerosis, with preservation of the stapes supra structure in most of these cases. In this series, a stainless steel wire was used to connect the incus and stapes only when the stapes supra structure could not be saved or the crus was too short. All but one case in this series gained excellent hearing improvement after surgery, marking the beginning of a time of stapedectomy in China. In the early days of stapedectomy by Prof. JIANG and his group, venous valve and fascia grafts were used to seal the oval window, which was later replaced by fat graft. Research and clinical observation by Prof. LI Qi showed that fat graft provided best results. In reconstructing the ossicular chain, Prof. YANG Weiyen and the team at the Department of Otolaryngology Head and Neck Surgery, PLA General Hospital, experimented with stapes crus, ear canal cortical bone graft, cartilage graft and stainless steel wire as the prosthesis. In the 1980s, the group used custom made Teflon-titanium wire prosthesis as the reconstruction prosthesis [14]. The surgical technique has evolved from total stapedectomy to preservation of the supra structure and incudostapedial joint, to preservation of stapedius tendon ("physiological stapedectomy"), to lately partial footplate resection or even footplate fenestration, with continuously improving treatment outcomes and decreasing complications. Up to 2004, the PLA General Hospital Department of Otolaryngology has successfully completed about 4000 cases of stapes procedures.

In 1962, Shea, Marquet and Martin proposed drilling a small hole in the center of the footplate, i.e. the platinitomy [15], and in 1969, Schuknecht and Applebaum extensively used the Teflon piston-minimal plastinitomy technique [16], which helped minimize disturbance to the vestibule and greatly increased procedure safety. The marketing of various types of prosthesis to be used with this technique since then has also improved the ease of its use and helped produce consistent hearing outcomes.

In 1980, Perkins first applied argon laser in stapes surgeries, becoming the pioneer in application of laser in stapes procedures [16]. Since then, KTP, CO2 and Er: YAG lasers have all been tried in stapes surgeries. Prof. WANG Zhengmin reported a series of 44 cases of stapes surgeries in 1997, in which CO2 laser was used, showing the safety and reliability of the technique. His report was the first on application of laser in assisting stapes surgeries in China, which continues to be used at the Eye, Ear, Nose and Throat Hospital, Shanghai Fudan University, providing excellent outcomes [20]. At this time, Research and clinical experiences seem to indicate that stapedotomy with "one-shot" technique using CO2 laser (with scanner) may be the most appropriate and safest procedure for otosclerosis [21-23].

To summarize, understanding otosclerosis has been a long and arduous process. Each step on the way (success or failure) has served as the foundation to the next step of exploration and trial. Thanks to the unwavering efforts by the generations before us, surgical treatment of
otosclerosis has been the most successful example of management of conductive hearing loss. And the hard work and contributions from outstanding ear surgeons in China have left clear marks on the path that has led otology in China to meet the trend in the world.

References


(Received August 29, 2012)