Use of Lasers in Otosclerosis Surgery

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KEYWORDS

• Laser • Stapedotomy • Otosclerosis • Hearing loss

KEY POINTS

- Lasers were initially used for otosclerosis surgery starting in the late 1970s and quickly became popular as a no-touch alternative to conventional instrumentation.
- Technological advances in laser types and delivery systems have proliferated, and a preference for handheld delivery systems seems to have emerged.
- Currently, it is not possible to demonstrate a clear advantage among the various available laser systems; however, there is some evidence that suggests using a laser could lead to better surgical outcomes.

Video content accompanies this article at http://www.oto.theclinics.com.

INTRODUCTION

The introduction of an operating microscope and a powered drill by William House clearly revolutionized otology and neurotology, empowering and inspiring surgeons to perfect techniques that had previously been impossible or simply too dangerous. Arguably, the invention and application of the laser (light amplification by stimulated emission of radiation) was the third major revolution of twentieth century otology.

THE INVENTION OF THE LASER

In 1958, Arthur Schawlow and Charles Townes applied for a patent for the laser[1] as a modification of an earlier technology, the maser, which used stimulated emissions of microwave radiation. By adapting the principles of the maser to instead use light, of shorter wavelength than microwave radiation, their device acquired properties that were extremely useful for industry and medicine alike.

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The first working laser was built by Theodore Maiman at Hughes Research Laboratories. On May 16, 1960, he was able to demonstrate the linear transmission of a beam of light that had a severely restricted spectrum of wavelength. Maiman built on the invention of Schawlow and Townes, introducing a method to pump energy into a ruby rod with mirrored ends to excite the medium into higher energy states. The energy emitted by the transitions between these states was the source of delivery of extremely high-power densities. Investigators had to wait until later that year before they could enjoy the sight of a thin beam of red light, the first manufactured light to display the characteristics that define laser radiation: monochromaticity, directionality, coherence, and brightness.[2]

HISTORICAL ASPECTS OF STAPES SURGERY

Occurring nearly contemporaneously with the invention of laser technology, the advent of the era of otologic microsurgery was underway. John J. Shea had applied microsurgical techniques to the otosclerotic human stapes and, in 1956, he demonstrated it could be safely removed and replaced with a Teflon prosthetic stapes, thus providing an effective alternative to the fenestration operations promoted by Julius Lempert and others.[3] Although both the invention of laser and the development of modern stapes surgery can be dated to within 2 years, it took 2 decades of refinements before these innovations were combined.

Rodney C. Perkins[4] performed the first laser stapedotomy operation on August 8, 1978. In 1980, he published a report of the first 11 subjects whom he treated with what he called an argon laser microscope, which was built in collaboration with Jack Urban, among others. During the years when stapedectomy was the dominant approach to otosclerosis surgery, there had been no real impetus to investigate instruments other than picks and/or drills. In the 1960s, Plester[5] advocated partial stapedectomy (small fenestra), the removal of the posterior one-third of the footplate, and Shea and colleagues[6] developed a Teflon piston to replace Shea's original replacement prosthesis, which looked very much like an actual stapes. In the 1970s, Fisch,[7] among others, favored minimalist approaches based on histopathologic studies that noted adhesions between the otosclerotic foci and the underlying saccular membrane near the anterior footplate. It was suspected that removal of the entire footplate could fistulize the endolymphatic space and lead to deafening as potassium-rich endolymph poured into the perilymphatic space. These developments enhanced the popularity of piston prostheses over fat-wire because the former were more easily accommodated by the increasingly smaller openings. As small-fenestra approaches gained currency and as the adverse effects of mechanical trauma associated with removal or drilling of the footplate were recognized, the obvious advantages of laser became manifest: it is an instrument that can precisely apply energy to vaporize the posterior crus, transect the stapedius tendon, and create a stapedotomy. These properties further inspired or enabled innovative refinements of work around the footplate, such as the technique of stapedotomy minus prosthesis (STAMP).[8]

LASER TECHNICAL CONSIDERATIONS

Lasers made an attractive alternative or supplement to the existing mechanical technology of drills and microperforation because of the potential to avoid trauma to the inner ear and thus to reduce the incidence of postoperative hearing loss or dizziness. Risk of complications, such as floating footplate, could also be minimized if a no-touch modality could be substituted. It was acknowledged, however, that the nature of laser energy could have undesirable thermal and acoustic effects. The effects of