A Case of Otosclerosis Treated with One Shot Laser-Assisted Stapes Surgery

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Otosclerosis is an abnormal bone growth that causes fixation of stapes, leading to hearing loss. Several stapes surgery techniques were introduced, including stapedotomy, partial and total stapedectomy according to the extent of removal of the foot plate. Application of lasers during a stapes surgery minimizes the risk of mechanical force into the inner ear, compared to that of the conventional micro-drill or micro-pick using stapes surgery. The ideal laser technique in stapedotomy should prevent thermal damage into the perilymph. Recently, one shot laser stapedotomy technique has been reported to minimize inner ear damage compared with the multiple shot technique. We experienced one shot laser stapedotomy including resection of stapedius tendon, posterior crusrectomy, and stapedotomy as selection of different power, focus size and achieved satisfactory results without complications.

Key words
Stapes; Lasers; Stapes surgery
INTRODUCTION

Otosclerosis is an abnormal bone growth that causes fixation of stapes, leading to conductive hearing loss, as well as sensorineural hearing loss and mixed hearing loss. Fissula ante fenestram located just before the oval window is the most common site involved with the otosclerotic foci. Other popular localizing regions have also been discovered, such as on the stapes footplate, at the round window, pericochlear region, and the internal auditory canal. Most patients, who have otosclerosis, experience hearing loss by the third decade of life, and about 80% of these patients show bilateral hearing loss. The exact mechanism as to how otosclerosis progress have yet been found; however, puberty, pregnancy, and menopause are thought to play an important role in disease progression.

Since Shea first reported of stapedectomy in 1956, several surgical techniques have been introduced to reduce inner ear damage. From removal of the entire stapes footplate and replacement with a prosthesis, succeeding surgical procedures began to focus on the removal of only one-third of the footplate. However, due to its direct damage to the inner ear, sensorineural hearing loss and vertigo frequently occurred. Palva first introduced laser for perforation of the footplate, and this new technique was able to avoid aforementioned risks. Lesinski and Palmer first proved efficacy, as well as safety of the carbon dioxide (CO2) laser for stapes surgery. Since then, numerous succeeding studies demonstrated that the use of CO2 laser results in better post-operative hearing recovery, along with fewer complications. Fenestration with a single impulse or ‘one shot’ stapedotomy than multiple shot were reported in recent studies. It can minimize thermal damage and make worse bone conduction threshold in high frequency. But there is no applicable standard mode and power for one shot laser stapes surgery. Herein we experienced one shot CO2 laser stapes surgery by applying a different laser power in otosclerosis and report its efficacy.

CASE REPORT

A 23-year old female visited our Otorhinolaryngology-Head and neck surgery department, complaining of progressive hearing loss that started when the patient was a child. Except ear fullness and tinnitus, other otologic symptoms and dizziness were absent. The patient’s older sister had similar progressive hearing loss. Otoscopic examination showed normal tympanic membrane and pure tone audiometry demonstrated conductive hearing loss on both sides. The average of air conduction threshold for frequencies 500 Hz through 4,000 Hz of the right ear was measured to be 55 dB, while the average bone conduction threshold for frequencies 500 Hz through 4,000 Hz was measured to be 25 dB. And average of air and bone conduction threshold for frequencies 500 Hz through 4,000 Hz of the left ear came out to be 49 dB and 19 dB. Increases of air-bone gap (ABG) in low frequencies were demonstrated in both ears (Fig. 1A). Tympanometry showed type A tympanogram. External auditory canal, mastoid air cell, middle ear cavity and inner ear structure showed no significant abnormal findings in temporal bone computed tomography (CT); bony ingrowth was not found around the footplate and other inner ear structures.
With suspicion of otosclerosis, explorative tympanotomy was planned on the right ear due to better functioning of the left ear. Surgery was performed under general anesthesia through endomeatal incision. The meatal skin flap was elevated to expose middle ear cavity and the chorda tympani was preserved. Canalplasty was performed with diamond burr to make better surgical field. The incudostapedial joint was separated with pick and micro-scissors. The stapedius tendon was removed through one shot technique with CO₂ laser power of 10 W, with beam diameter of 0.6 mm in continuous wave mode. Trial shots were performed on wooden tongue depressor to check alignment. Posterior crusectomy was achieved through CO₂ laser and the selected power for the one-shot technique was 15 W, with beam diameter of 0.4 mm in continuous wave mode (Fig. 2A). The anterior crus was fractured on the promontory with a pick. Using a measuring rod, the proper length of a teflon prosthesis was determined; through a special cutting block, the prosthesis was trimmed to be 5.2 mm in length. Stapedotomy was completed through one shot technique with CO₂ laser power of 20 W, with beam diameter of 0.8 mm in continuous wave mode (Fig. 2B). Once the teflon prosthesis is placed into the fenestration of the foot plate, the loop is firmly fixed to the long process of incus using smooth alligator forceps (Fig. 2C). Deep temporalis fascia was harvested from the postero-superior auricular incision, which then was used to seal the remaining stapedotomy opening to prevent leakage of perilymph. Tympanomeatal flap was replaced on the posterior bony external auditory canal, and then packing was done by Gelfoam pledgets soaked in normal saline.

The patient gradually recovered without any complications, and was discharged on postoperative day 2. The follow-up pure tone audiometry was done after 6 weeks. The average of air and bone conduction threshold for frequencies 500 Hz through 4,000 Hz of the right ear are 44 dB and 25 dB (Fig. 1B). The result exhibited improvement in air conduction threshold of right ear.

**DISCUSSION**

Many different laser device was used in stapes surgery. Optimal reference modes and powers for important surgical step in stapes surgery were reviewed (Table 1). In this case, a CO₂ laser system (Xlender-Y; Wontech, Daejeon, South Korea) was used for the operation. Using the micromanipulator, the output of laser was visualized.
With wavelengths lying between 9,600 and 10,600 nm, CO₂ laser is readily absorbed by water; since the 60 percent of human bone are composed of water, such idea suggests minimal penetration depth of the CO₂ laser. Therefore, deep tissues and structures are protected from its effect. In stapes surgery, protection of perilymphatic space during the operation is particularly important. Therefore CO₂ laser is considered the useful device for stapes surgery.

Through multiple overlapping laser usage, the multiple-shot technique in stapes surgery produces an opening on the cochlear just large enough to precisely fit the prosthesis. Jovanovic proposed laser power at 6 W, with pulse duration of 0.05 seconds to be appropriate perforation. On the other hand, Just et al demonstrated disadvantage of such technique through 48 patients with stapes surgery, in which worse bone conduction thresholds at 6 kHz were found after a second-shot of CO₂ laser. The one-shot laser technique in the stapes surgery allows precise perforation of footplate with only one laser application. Jovanovic recommend power settings of 1-20 W, with pulse duration of 0.03-0.05 seconds for the effective one-shot technique. In this case, posterior crusectomy was achieved through CO₂ laser in 15 W, with beam diameter of 0.4 mm in continuous wave mode; furthermore, stapedotomy was completed with CO₂ laser power of 20 W, with beam diameter of 0.8 mm in continuous wave mode. As the results show, patient in this case showed improvement in air conduction threshold level without bone conduction threshold after the surgery.

One of the difficulties we faced during the operation was that certain mode of CO₂ laser only provides limited power and beam diameter. The CW mode enables operator to adjust the beam diameter to precisely deliver the laser power to the spot needed. However on other modes, it was difficult to find the properly focused power and beam diameter in trial shot for stapedotomy. To get a properly focused beam and power on various modes, the operator has to shift the microscope itself before operation to fit precisely to the stapedotomy site.

Many reports demonstrate that one shot laser stapes surgery has advantage in terms of inner ear damage. However, because laser beam is not visible and erroneous shot can induce severe complication in stapes surgery, a trial shot outside of the surgical field is essential routinely at the start of every surgery to check the diameter and power.

Based on this case, application of one-shot laser stapes surgery is to be expected good surgical option for otosclerosis patient.
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