CO2 Laser Myringoplasty Using a Handheld Fiber

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ABSTRACT

We performed laser myringoplasty to treat retraction pockets of the tympanic membrane using a handheld CO2 laser. Similar laser myringotomy techniques have been described with both the line of site CO2 and KTP lasers. We report the efficacy of the handheld CO2 laser for treatment of retraction pockets. 22 patients representing a total of 29 ears were treated using this technique.

Handheld CO2 laser myringoplasty produces hearing improvement. The laser fiber allows for controlled delivery of energy to the TM with improved accuracy. Ears with effusions experience the greatest hearing improvement. Patients with membrane adherence not amenable to valsalva may be at risk for suboptimal hearing results.

INTRODUCTION

Tympanic membrane (TM) atelectasis is a defect in the architectural integrity of the tympanic membrane. It is believed to be caused by the persistent negative pressure within the middle ear synonymous with Eustachian tube dysfunction (ETD). The persistent forces result in loss of the organized collagenous framework of the TM, with collapse of the drum into the middle ear space. This results in a contracted middle ear volume. In addition, the retracted portion of the membrane may progress to involve the ossicles or promontory and may become adherent to the underlying structures and lead to acquired cholesteatoma.

The various treatments for TM atelectasis are aimed at treating the underlying ETD or restoring the TM membrane to a normal state. Medical options for treatment are aimed at removing the underlying ETD and include decongestants, steroids, valsalva, politerization, and balloon inflation. Surgical options include laser Eustachian tuboplasty, tympanotomy with ventilation tube placement, tympanoplasty, and tympanoplasty with mastoidectomy. Recently laser technology has been used to exploit the tissue interaction with coherent incident energy.

Several authors have utilized laser technology in the treatment of TM retraction pockets. Laser energy is absorbed by its chromophor either introduced or naturally present within the membrane resulting in contraction and strengthening of the TM structure. These confocal effects produce a stronger TM and reduce the surface area per volume, reducing the forces that cause further membrane deformation. Various laser wavelengths have been tried. The KTP laser technology can be delivered through a fiber optic system allowing precise placement of the beam; however, the energy is not easily absorbed by the tissue, and its visible light wavelength often requires the application of dye to the TM. This results in poorly controlled and unpredictable energy absorption. KTP produces its effect by contraction scarring of the TM through stimulation of fibroblasts. In contrast, the energy produced by the CO2 laser targets the deformed collagen of the middle layer and restores it to its native configuration. This improves membrane strength and reduces membrane surface area.

While CO2 laser use in otologic surgery was limited to "line-of-sight" delivery system, recent advances in thin film technologies have lead to the development flexible fiber through which surgeons may direct CO2 laser energy towards zones of affected membrane with greater precision. In this study we will show preliminary results using the CO2 for treatment of TM retraction pockets and show that laser myringoplasty is an effective and reliable method producing rapid hearing improvement. We will also address factors that may influence hearing improvement.

METHODS

22 patients, 29 ears total with TM atelectasis were selected to undergo laser myringoplasty. Preoperative audiograms were performed on all patients. All procedures were performed in the operating room under general anesthesia. The area of atelectasis was examined using the operating microscope. First, and effort was made to elevate the membrane adherent to any portions of the middle ear space. In most cases, anesthetic gases served to "balloon" out the retraction pocket. If this did not occur, an attempt was made to release the adherent portion through injection of saline into the middle ear space under pressure (hydrodissection) to release the adherent portion. If unsuccessful, a small myringotomy was made adjacent to the pocket and the TM was mechanically elevated off of the ossicles. CO2 laser energy was then delivered at 2 watts per 100 millisecond pulse to the TM. A myringotomy tube was then placed. Postoperative audiograms were performed at 4 weeks. Information regarding hearing results and adverse events were recorded via review of the clinic encounter notes.

RESULTS

Laser myringoplasty was performed on 22 patients. 12 of the patients were male and 10 were female. The patients ages ranged from 5 to 74 years of age with a mean age of 39 years of age. Audiograms were performed on average three weeks after surgery. Air-bone gaps were calculated for pure tones at 0.5, 1, 2 and 3 kHz. All patients had pre- and post-operative audiograms available for review. The average preoperative ABG for the 29 ears was 13.0dB. The average postoperative ABG was 8.2dB. (P=0.02) The 22 ears with no effusion experienced an ABG closure from 14.7dB to 13.6dB. The four ears that did release had an ABG closure from 15.3dB to 7.4dB. Six of the nine ears requiring mechanical release experienced little to no improvement in hearing, and two of these experienced a decline in hearing.

Of all the patients, six patients experienced a decline in hearing. Two of these patients had unsuccessful mechanical elevation at the time of the procedure. One of these showed improvement at one month, but at eight months postop he was found to have a perforation and requiring tympanoplasty and subsequent revision. The other was found to have dense adherence to the ossicles and the PE tube was placed at the myringotomy defect over the incus. One patient in which mechanical elevation was successfully developed an attic cholesteatoma requiring tympanoplasty with mastoidectomy where it was found his incus and malleus were fused. In addition, a patient who underwent bilateral laser myringoplasty experienced no hearing improvement and was suspected to have otosclerosis. In the remainder, no specific causative factors could be found.

CONCLUSIONS

Laser Myringoplasty is a successful minimally invasive treatment for tympanic membrane atelectasis that permits improved access to all areas of the ear drum due to the handheld design. The CO2 Fiber allows precision coagulation of tissue, limiting thermal damage to unaffected areas of the tympanic membrane. It also permits control of the amount of energy dispersed to the tissue. Visible light lasers require the use of dyes which is cumbersome and results in unpredictable energy dispersal. We showed that ears with effusions experienced the greatest improvement. That the effusion and non-effusion groups showed that laser myringoplasty independently produces immediate hearing improvement. The extent of membrane adherence also should be considered. Significant differences were seen between those ears that were and were not successfully elevated. This may be attributable to several factors. During mechanical elevation, a small myringotomy is made in very weak membrane. This not only increases the risks for significant perforation (as is reported here), but also necessitates the placement of the pressure equalization tube in a suboptimal position, e.g., directly over the incus. The data presented suggest that unsuccessful elevation with valsalva in the clinic may portend a lower probability for hearing improvement with laser myringoplasty and may place them at higher risk for hearing decline.

REFERENCES


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