Use of Laser-based Technology in Otology Surgery

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The surgical techniques and prostheses used in stapes surgery have continued to evolve since Shea’s revival of stapes surgery in the 1950s. Shea’s original technique involved the complete removal of the stapes footplate, followed by oval window coverage with a vein graft and placement of a prosthesis to bridge the gap between the incus and the oval window.

Currently, the procedure of choice for most patients undergoing stapes surgery is small fenestra stapedotomy. The fenestra in the footplate was originally created using a handheld or an electric microdrill. However, on August 8, 1978, Dr. Perkins utilized an Argon laser attached to a modified Zeiss operating microscope, in order to create a fenestra in the footplate of a patient undergoing stapes surgery. The preliminary results of this first patient and the results of 10 other patients were presented at the Western Section of the Triological Society in 1979 (1). As a result of this initial report by Dr. Perkins, a variety of lasers have been utilized to facilitate various aspects of stapes surgery, including fenestra creation. Among those lasers, the use of carbon dioxide (CO2) laser became common practice in this delicate procedure. The microsurgical precision of the CO2 laser makes it an ideal tool for safe and effective treatment for the sensitive auditory structures. Studies have shown that physicians can attain comparable and often superior outcomes using CO2 laser for ear surgery compared with other lasers and treatment modalities (2,3). In this review, we will present the unique features of lasers in general and CO2 laser in particular, and discuss the potential applications and advantages when using CO2 laser in otology, specifically in stapes surgery.

Lasers and acoustic effects

In general, lasers have the ability to cut and coagulate with great precision without generating mechanical pressure or movement. This makes them particularly useful for several applications in stapes surgery such as: separating the stapedius tendon, dividing the stapes crura and fenestrating the footplate. Since the use of laser does not generate mechanical pressure or movement on the footplate, the laser minimizes the risk of the surgeon creating a floating footplate or traumatizing structures within the inner ear. In addition, the laser has the ability to fenestrate a mobile footplate, should this situation occur. Although the laser itself does not generate mechanical energy, the vaporization of tissue can generate a slight “popping” sound. However, this sound is much less than the sound generated when using a microdrill. In a study by Kamalski and his colleagues, the sound effects generated by the microdrill and various laser types were compared.

The results showed that the microdrill reached a maximum of 95 ± 7 dB, compared with 49 ± 8 dB for the KTP laser and 68 ± 4 dB for the CO2 laser (4). Despite these findings, there are currently no studies that clearly demonstrate a statistically significant difference in hearing results when comparing stapedotomies using a microdrill versus using a laser (3). However, the laser has proven itself to be a very useful tool in stapes surgery.

Typically during surgery, with both the visible and non-visible spectrum lasers, an overlapping rosette pattern is created on the footplate that will accommodate the selected piston. The surgeon should allow 2 or 3 seconds to lapse between laser pulses to allow the perilymph to cool. It is better to create a slightly larger fenestra than a slightly smaller one, as friction between the prosthesis and the bone edges of the fenestra can adversely impact the result. An oval window rasp or similar instrument can be used to ensure that the fenestra is in the appropriate diameter.

Using CO2 laser – new solutions in surgical delivery system

In the past, using the CO2 laser required a microscope-attached laser delivery system with a direct line of sight from the microscope towards the footplate. Recently, a handheld flexible CO2 delivery systems with an aiming beam have been introduced. One such device is the Lumenis OtoLase™ delivery system. This system was specifically designed for enhanced precision and ease of use in middle ear surgery, and is a combination of reusable fiber and handpieces with different single-use tips. The two different single-use tips were designed to accommodate variations in surgeons’ preferences and facilitate access to structures within the middle ear. The operational design of OtoLase™ allows great precision and excellent visualization, enabling the surgeon to remove undesired tissue layer-by-layer and enhance clinical outcomes of delicate ear procedures. Furthermore, the air flow system eliminates the laser plume and facilitates visualization, and the aiming beam ensures target accuracy.
We have used the OtoLase™ system for a variety of middle ear conditions, ranging from otosclerosis to chronic otitis media. Two illustrative cases are detailed herein.

The first case was a 43-year old female with left-sided otosclerosis, where we utilized the Lumenis OtoLase™ CO₂ Fiber Delivery System with AcuPulse DUO CO₂ laser system on the Stapedius tendon and the posterior crus, and to thin the footplate prior to the fenestration. The surgery went without any complications, and at the end of the procedure the patient had a positive Rinne and could hear whispered speech. The use of the OtoLase™ CO₂ Fiber during the procedure is depicted in Figures 1-3.

In the second case, we have treated a 19-year old patient with a cholesteatoma limited to the left middle ear space. Again, we have used the Lumenis OtoLase™ System to facilitate the removal of the cholesteatoma from the stapedius tendon and to remove middle ear adhesions. A post auricular approach was utilized and there was a complete removal of the cholesteatoma. In this case, the OtoLase™ system proved to be very useful in removing cholesteatoma that was very adherent to the stapedius tendon and the stapes footplate. No mechanical force was imparted to the stapes footplate, minimizing the likelihood of displacing the footplate out of the vestibule (5,6). The use of the OtoLase™ CO₂ Fiber during this procedure is depicted in Figures 4-6.

Clinical experience with the OtoLase™ CO₂ laser delivery system
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Clinical experience with the OtoLase™ CO₂ laser delivery system

During the two procedures, we have used different laser settings. Since the laser settings can be easily modified during the operation, the surgeon can control the speed of the laser, as well as the required precision for different otology applications. Finally, one can also change the tissue effect by altering the distance of the tip from the tissue. The typical laser settings are presented in Table 1.

Table 1: CO₂ laser settings for different parts of the 2 procedures

<table>
<thead>
<tr>
<th>Case 1 - Stapedotomy</th>
<th>Case 2 - Cholesteatoma</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power mode (W)</strong></td>
<td><strong>Power mode (W)</strong></td>
</tr>
<tr>
<td>Stapedius tendon</td>
<td>Cholesteatoma removal</td>
</tr>
<tr>
<td>Continuous, 2 W</td>
<td>Continuous, 1 W</td>
</tr>
<tr>
<td>Posterior and anterior crura</td>
<td>Single, 0.2 sec</td>
</tr>
<tr>
<td>Continuous</td>
<td>Single, 0.1 sec</td>
</tr>
<tr>
<td>Stapes footplate</td>
<td>Adhesion removal</td>
</tr>
<tr>
<td>Continuous, 1 W</td>
<td>Continuous, 2 W</td>
</tr>
<tr>
<td></td>
<td>Single, 0.2 sec</td>
</tr>
<tr>
<td></td>
<td>Single, 0.1 sec</td>
</tr>
</tbody>
</table>

Conclusions

In summary, we have presented our preliminary experience using the OtoLase CO₂ laser. The laser was used specifically for stapes surgery and Cholesteatoma removal. During our preliminary experience with the new OtoLase Fiber Delivery System by Lumenis, the fiber proved particularly useful in removing cholesteatoma that was very adherent to the footplate. It also proved useful in lasing the stapedius tendon, vaporizing the crura and thinning the footplate. Overall, the 2 cases confirmed the potential benefits of a fiberoptic CO₂ laser with an integrated aiming beam.
References


Risk Information

CO₂ lasers (10.6 µm wavelength) are intended solely for use by trained physicians. Incorrect treatment settings or misuse of the technology can present risk of serious injury to patient and operating personnel. The use of Lumenis CO₂ laser is contraindicated where a clinical procedure is limited by anesthesia requirements, site access, or other general operative considerations. Risks may include excessive thermal injury and infection. Read and understand the CO₂ systems and accessories operator manuals for a complete list of intended use, contraindications and risks.