

Cochlear Tolerance of Nd:YAG Laser Myringotomy

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Abstract. *Aim: The objective of this study was to assess whether Nd:YAG laser myringotomy has a negative effect on the cochlea. Materials and Methods: Ten adult guinea pigs with a normal Preyer's reflex were treated by myringotomy with an Nd:YAG laser (power output 8-10W) under surgical microscopic guidance. Preoperative and immediately postoperative hearing tests were performed using auditory brainstem response. The cochlear hair cells were investigated by scanning electron microscope (SEM). Results: The mean postoperative hearing threshold of the auditory brainstem response showed an insignificant elevation. SEM findings revealed normal outer and inner hair cells after laser myringotomy. Conclusion: No negative effect of Nd:YAG laser myringotomy on the cochlea was found. From these results, it can be concluded that the Nd:YAG laser is safe and effective for myringotomy.*

Myringotomy with ventilation tube insertion has become the surgical procedure most commonly performed on children for persistent otitis media with effusion (OME), recurrent acute otitis media and in cases of adhesive otitis media to prevent cholesteatoma formation. Conventional myringotomy heals after 1 to 2 days, which is usually too short for there to be a therapeutic effect. Perforations for transtympanic ventilation of the middle ear achieved with a suitable laser system, an adequate mode of application, and appropriate parameters may offer a solution to this important clinical problem.

The use of a laser for performing the myringotomy in patients with OME is a well established and effective procedure, whether associated with the insertion of ventilation tubes or not. The most frequently used laser is

that with carbon dioxide (CO₂). After initial animal experiments in 1977, CO₂ laser myringotomy was clinically introduced by Goode (1). Since then, various study groups have clinically tested different application systems (2-8). The beam of the CO₂ laser is invisible and strongly absorbed by water, thereby quickly dissipating its heat. The neodymium-doped yttrium aluminum garnet (Nd:YAG) laser is also invisible, therefore necessitating an aiming beam. Because of its long absorption path, deep tissue penetration is possible. However, modern contact tips and computerization translate into similar coagulation depth profiles compared with the CO₂ laser (5-6). The low-power (<15 W) setting of an Nd:YAG laser reduces the penetration thereby reducing subsequent tissue damage (9). It is usually used in nasal surgeries (turbinate reduction, endoscopic sino-nasal video-assisted procedures and oral cavity resections) with different fiberoptic cables and parameter schedules. The clinical usefulness of the Nd:YAG laser in myringotomy has been reported in only one study (10).

The aim of this study was to evaluate the tolerability of Nd:YAG laser myringotomy on the cochlea.

Materials and Methods

Animals and Nd:YAG laser myringotomy. Ten male guinea pig (250-300 g) with otoscopically normal findings, particularly unaffected tympanic membranes, were used. Guinea pigs were anesthetized by intraperitoneal injection of ketamine hydrochloride and xylazine hydrochloride.

A laser with a 0.2 mm diameter sapphire tip (Figure 1) whose power was set at between 8 and 10 W was used. In each instance a 1 mm-sized round tympanostomy with clear margins was made without bleeding in the anterior-inferior quadrant of the right tympanic membrane using the Nd:YAG laser (CLS, Surgical laser technologies Co. Pennsylvania, USA) under surgical microscopic guidance. The tympanic membranes of the left side were untreated as a control.

Auditory brainstem response (ABR) recordings. ABRs were recorded under general anesthesia (ketamine 35 mg/kg and xylazine 15 mg/kg intramuscularly) using an evoked potential system (Tucker-Davis

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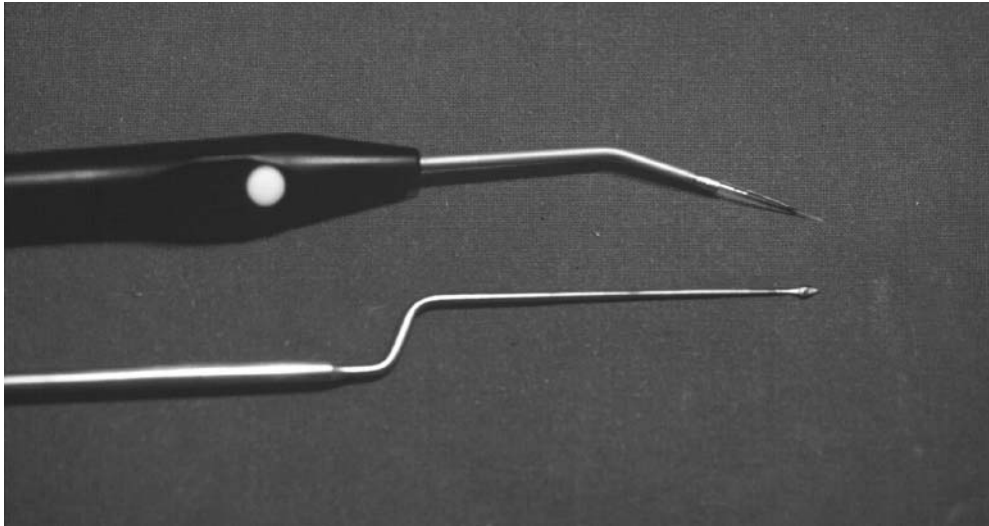


Figure 1. The 0.2 mm sapphire tip of the Nd:YAG laser is similar in diameter to the myringotomy knife.

Technologies, Florida, USA) and a Samsung computer. Stimuli were digitally synthesized using Siggen® software and presented through an inserted earphone (ER-2, Etymotic Research, Inc., IL, USA). Acoustic stimuli consisting of click and 8, 16, and 32 kHz tone bursts were produced. Intensity was expressed in decibels (dB) sound pressure level (SPL) peak equivalent. Animals were presented with a stimulus intensity series which was initiated at 90 dB SPL and reached a minimum of 10 dB SPL. Stimulus intensity was progressively lowered in 10 dB decrements. Each average consisted of 500 stimuli presentations, with a 10 ms analysis time. Electrical activity was recorded *via* a platinum needle electrode inserted into the scalp at the vertex, referenced to another needle electrode in a deep neck muscle. A third needle electrode in the pinna served as a ground. The intensities that appeared to be near threshold were repeated. Threshold was defined as the lowest intensity capable of producing a visually detectable, reproducible ABR response; values were extrapolated to the nearest 5 dB assuming a log-linear fall off with intensity. At threshold, the baseline-to-peak amplitude of the largest ABR component was reduced to <10% of that evoked by the 90 dB stimuli. ABRs were assessed preoperatively and 1 and 14 days after myringotomy.

Scanning electron microscopy (SEM). After the final ABR recordings, the anesthetized animals were perfused intracardially with 4% paraformaldehyde while under general anesthesia. The temporal bones were isolated and the perilymphatic spaces of the cochlear were gently perfused with 2.5% glutaraldehyde in 0.1 M phosphate-buffered solution (PBS) by cochleostomies at the round and oval windows. Bony capsules were removed to expose the organ of Corti after which specimens were post-fixed in 2.5% glutaraldehyde overnight at 4°C. The specimens were washed three times in PBS and then post-fixed in 1% osmium tetroxide for 1 h at 4°C. Organ of Corti specimens were then dehydrated through a graded series of ethanols and critical-point dried using liquid carbon dioxide. Critical-point dried specimens of the organ of Corti were attached to aluminum SEM stubs with aluminum paint and then sputter coated with gold-palladium. The surface of the organs

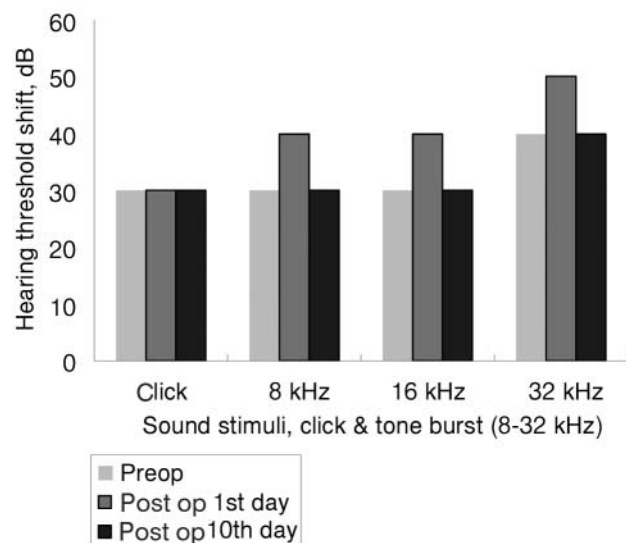


Figure 2. Preoperative and postoperative auditory brainstem response thresholds. No significant differences were found.

of Corti were examined in a JSM6400 JEOL scanning electron microscope (Jeol Ltd. Tokyo, Japan).

Statistical methods. All comparisons of data for statistical significance were performed by ANOVA and Mann-Whitney U-test. The statistical significance was considered if the *p*-value was less than 0.05.

Results

ABR findings. In random guinea pigs exposed to clicks and tone bursts, the ABR threshold range was estimated at

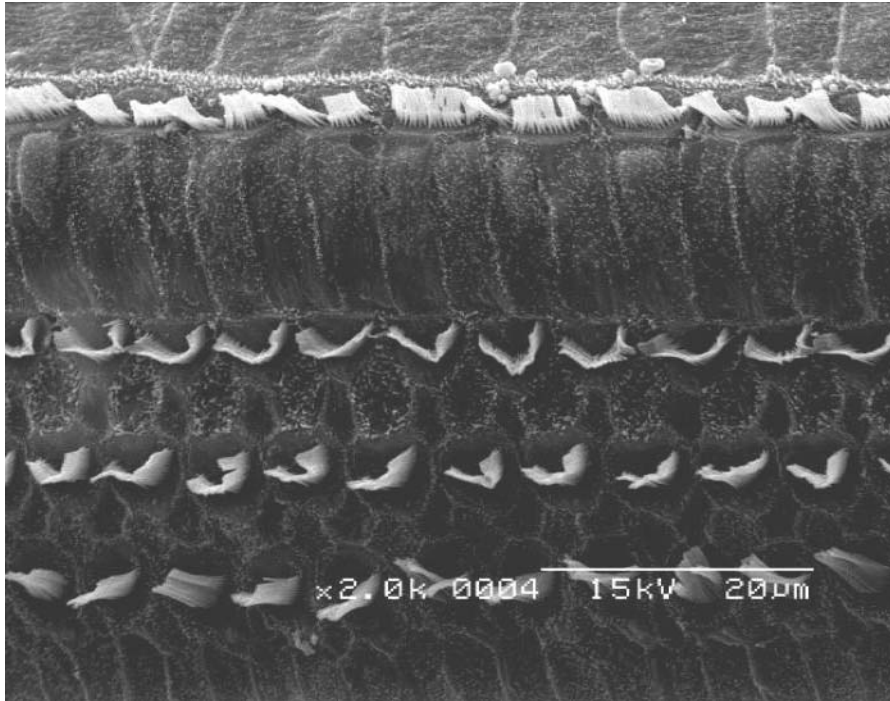


Figure 3. Scanning electron micrograph showing intact outer and inner hair cells after Nd:YAG laser myringotomy.

between 20 and 30 dB SPL before laser myringotomy (starting point, 0 dB). The right sides treated with Nd:YAG laser myringotomy showed insignificant changes in ABR threshold compared to left sides (within 10 dB) 1 to 10 days later (Figure 2). The increased ABR threshold returned to the starting point at day 14 after the closure of the tympanic membrane perforation induced by laser myringotomy.

SEM findings. No alterations of the cochlea were observed. No visible changes of the outer or inner hair cells were found (Figure 3).

Discussion

The use of laser for myringotomy in otitis media with effusion (OME) patients is a well established and effective procedure whether associated with insertion of ventilation tubes (VT) or not. When performed alone, it usually guarantees an average 3-week ventilation of the middle ear (11-13).

The most frequently used laser is that of carbon dioxide (CO₂). The risks of inner ear harm from direct laser radiation are thermal effects (in particular for continuous-wave lasers), acoustic shock and pressure fluctuations of the perilymph (14). However, these risks have been associated with laser application in stapedotomy. The Nd:YAG laser assisted myringotomy does not work directly on the inner ear. In a study by Hukki *et al.* (15), it was found that tissue injury correlated directly with the size of the tip used. The

smallest tip, having a size of 0.2 mm, caused the least tissue damage at all power settings. Tissue damage also increased with time. However, the time required for myringotomy is less than 5 seconds. The contact tips allow much more precise tympanostomy than the noncontact CO₂ laser. The small size of the device used in this study allows portability and easy handling in the operating room.

In this study, a comparison of preoperative with postoperative ABR showed unchanged or slight elevation due to myringotomy-induced perforation. Our data confirm, as reported in another clinical study by Zawislak *et al.* (10), that Nd:YAG laser myringotomy had no negative effects on the cochlea. They also reported that the healing of the tympanic membrane after laser myringotomy was uneventful, with a low percentage of permanent sequelae. Nd:YAG laser-assisted myringotomy can be considered as halfway between simple myringotomy and tympanostomy with insertion of ventilation tubes.

In conclusion, no negative effect of Nd:YAG laser myringotomy on cochlear function was found. From these results, it can be concluded that the Nd:YAG laser is safe and effective for myringotomy.

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