Effect of Laser Insult on Devices Used to Prevent Stone Retropulsion During Ureteroscopic Lithotripsy

Kaveh Vejdani, M.D., Brian H. Eisner, M.D., Witsanu Pengune, M.D., and Marshall L. Stoller, M.D.

Abstract

Purpose: To examine laser damage to three commercially available devices used to prevent stone retropulsion during ureteroscopic lithotripsy.

Methods: Two experiments were performed with 5 Accordion (Percsys, Palo Alto, CA), Stone Cone (Boston Scientific, Natick, MA), and NTrap (Cook Urological, Bloomington, IN) devices each. All devices were of 7-mm outer diameter. The holmium:YAG laser was set at 8 W. Experiment 1 was performed in an acrylic tube of 10-mm inner diameter in a saline water bath. The laser was fired against the antiretropulsion element of each device until the device could not be opened or closed. Experiment 2 was performed in a saline water bath; the laser was fired against the carrying catheter of each device until it was severed.

Results: For Experiment 1, the mean number of laser firings against the antiretropulsion element until device failure was 2 for the NTrap, and 28.6 for the Stone Cone. The Accordion was operable after 100 laser firings. The Accordion was more laser-resistant than either device (P < 0.001, P < 0.001, respectively), and the Stone Cone was more laser-resistant than the NTrap (P < 0.001). In Experiment 2, mean time to break the carrying catheter was 13.6 seconds for the NTrap, 17.4 seconds for the Stone Cone, and 6.6 seconds for the Accordion. The Stone Cone and NTrap carrying catheters were more laser-resistant than the Accordion (P = 0.007, P = 0.03, respectively) and there was no statistical difference between the Stone Cone and NTrap.

Conclusions: The antiretropulsion element of the Accordion was most laser-resistant, and both the Accordion and Stone Cone antiretropulsion elements were more laser-resistant than the NTrap. The carrying catheters of the Stone Cone and NTrap had similar laser resistance, and both were more laser-resistant than the Accordion. Urologists should be mindful of structural characteristics when using these devices.

Introduction

Laser lithotripsy is the modality of choice at many centers in North America for treatment of obstructing ureteral stones. The holmium:YAG laser is able to fragment stones of all compositions, with excellent results and minimal damage to the urothelium. During ureteroscopic laser lithotripsy, stones or stone fragments may migrate to the upper ureter or kidney (i.e., stone retropulsion). This can lead to increased operative times, increased cost due to use of additional equipment (e.g., change from semirigid to flexible ureteroscope), and secondary procedures to treat clinically significant fragments that have migrated to the kidney.

To prevent stone retropulsion, there are several commercially available devices, including the Accordion (Percsys, Palo Alto, CA), the Stone Cone (Boston Scientific, Natick, MA), and the NTrap (Cook Urological, Bloomington, IN). The Accordion consists of a two-part nylon and stainless steel guidewire 2.9 Fr in diameter, with a short length of polyurethane film attached to both wire sections. When engaged, the film occlusion element forms a bottle-brush-like barrier within the lumen of the ureter. The Stone Cone is a 3.0-Fr-diameter Teflon carrying catheter within which resides a nitinol wire. When advanced out of the carrying catheter, the nitinol wire assumes a spiral cone shape to occlude the lumen of the ureter. The Stone Cone and NTrap carrying catheters were more laser-resistant than the Accordion (P = 0.007, P = 0.03, respectively) and there was no statistical difference between the Stone Cone and NTrap. These devices are designed to be positioned immediately proximal to the stone and serve as a backstop to prevent retropulsion as the stone is fragmented. As such, it is possi-
ble for the laser to inadvertently contact these devices for several seconds during ureteroscopic laser lithotripsy. Laser damage could lead to the inability to close the device and difficulties with device extraction. The purpose of the current study was to quantify the amount of laser damage necessary to damage the antiretropulsion element and outer carrying catheter of each of these devices.

Materials and Methods

For the following 2 experiments, a holmium:YAG laser was used with a 365-μm fiber at settings of 1 J and 8 Hz (8 W). All antiretropulsion devices were 7 mm in maximal diameter when deployed. All statistical comparisons were performed using the Student's t-test.

Experiment 1

Five (5) of the following trials were performed with each device in an acrylic tube of 10-mm inner diameter in a saline water bath: A single point on the antiretropulsion element of each device was targeted. The laser was fired one time, and then the device was opened and closed. The laser was fired a second time and the device was opened and closed. This was repeated until the device could no longer be opened and closed. The points targeted were as follows: the outer coil of the Stone Cone (Fig. 2), the outer rim of the basket of the NTrap, and the portion of the Accordion film closest to the laser.

Experiment 2

Five (5) of the following trials were performed with each device in a saline water bath: A single point on the outer carrying catheter of each device was targeted. The laser was fired continuously against the target until the carrying catheter was severed and the inner core was visible. Timing was

FIG. 1. Three antiretropulsion devices in deployed position (left to right: Accordion, Stone Cone, NTrap).

FIG. 2. Experimental setup showing Stone Cone.

FIG. 3. NTrap unable to be fully closed after laser damage.

FIG. 4. Laser damage to film of Accordion. This damage did not prevent the device from being opened and closed.
performed with a stopwatch and times were rounded to the nearest second (Fig. 2).

Results

Experiment 1

Mean number of laser contacts until the device could not be opened and closed was 2 for the NTrap (standard deviation = 1.4), and 28.6 for the Stone Cone (standard deviation = 6.73). A damaged NTrap that was unable to be fully retracted is shown in Figure 3. The Accordion was able to be opened and closed after 100 contacts for all 5 trials and the experiment was terminated at this time. The laser did cause visible holes in the film of the Accordion (Fig. 4) but did not change the ability to open and close the device. The laser resistance of the Accordion was significantly greater than the Stone Cone and NTrap (*P* < 0.001, *P* < 0.001, respectively) and the laser resistance of the Stone Cone was significantly greater than that of the NTrap (*P* < 0.001).

Experiment 2

Mean time to breakage of the carrying catheter was 13.6 seconds for the NTrap (standard deviation = 4.9), 17.4 seconds for the Stone Cone (standard deviation = 5.9), and 6.6 seconds for the Accordion (standard deviation = 2.9). The Stone Cone and NTrap carrying catheters were more laser-resistant than the Accordion (*P* = 0.007, *P* = 0.03, respectively), and there was no statistical difference between the Stone Cone and NTrap.

Discussion

During ureteroscopic laser lithotripsy, with limited working space within the lumen of the ureter, it is possible to inadvertently contact various instruments and tools with the laser. While the great majority of these contacts are inconsequential, laser contact times of as little as 1–4 seconds have been reported for the breakage of nitinol baskets, 20–40 seconds for breakage of Terumo guidewires, and 55 seconds for standard Teflon-coated guidewires. The U.S. Food and Drug Administration’s Manufacturer and User Facility Device Experience (MAUDE) database contains reports of antiretropulsion device damage following laser contact. Laser fragmentation of these devices can lead to inability to properly close the device (and thus, difficulty with device extraction), and inadvertently retained fragments of these devices could serve as a nidus for stone formation. Therefore, a precautionary statement to the physician about the potential for damage to the antiretropulsion component from laser insult is present in the instructions for use of all three antiretropulsion devices. Our study sought to quantify the amount of laser contact required to damage these devices. Holmium:YAG laser settings of 1 J, 8 Hz for a total power of 8 W were chosen because these are clinically relevant and commonly used settings for ureteroscopic laser lithotripsy.

In the current study, the ability of the Accordion to open and close was unchanged after 100 contacts between the laser and the antiretropulsion element, and this was significantly more resistant than the antiretropulsion elements of the Stone Cone and the NTrap. The Stone Cone, while less robust than the Accordion and more robust than the NTrap, required a mean of 28 firings (minimum of 21, maximum of 39) with the laser to lose its functionality. Finally, the NTrap required a mean of 2 laser firings (minimum of 1, maximum of 4) to fracture the basket, rendering the device unable to be opened or closed. In fact, 3 of the 5 NTrap devices tested fractured after only 1 contact with the laser. Therefore, the Accordion is nearly impossible to render inoperable. The Stone Cone was rendered inoperable in this *ex vivo* experiment, but it seems unlikely that one would contact the coils in the exact same spot 21–39 times during one ureteroscopic procedure. On the other hand, the NTrap was far more easily fractured at what we consider a clinically possible scenario: 1–4 contacts with the laser.

Regarding the outer carrying catheter of these devices, both the Stone Cone and NTrap were significantly more laser-resistant than the Accordion. The carrying catheter portion of the device is less accessible than the antiretropulsion element during routine laser during lithotripsy, but damage is still possible.

Conclusions

The antiretropulsion element of the NTrap was more easily fractured than that of the Stone Cone, while the Accordion withstood 100 firings of the laser and was still operable. The carrying catheter of the Accordion was more easily fractured than the Stone Cone and NTrap. Risk of laser damage should be considered when choosing the appropriate antiretropulsion device.

Disclosure Statement

The authors state that no competing financial interests exist.

References


Address reprint requests to: Marshall Stoller
Department of Urology, UCSF
400 Parnassus Avenue, Suite A-610
San Francisco, CA 94143
E-mail: mstoller@urology.ucsf.edu

Abbreviations Used

None