High-Powered Holmium-Laser Ablation: Comparison of Setting Effectiveness Using Tissue-Surrogate Model

RAMSAY L. KUO, M.D.,1 RYAN F. PATERSON, M.D.,2 TIBÉRIO M. SIQUEIRA, JR., M.D.,3 SAMUEL C. KIM, M.D.,3 and JAMES E. LINGEMAN, M.D.3

ABSTRACT

Background and Purpose: The 100-W holmium laser, in conjunction with a sidefiring 550-μm fiber, can ablate prostate glands as large as 40 g to relieve lower urinary-tract symptoms. We evaluated the effect of various setting combinations on ablation efficiency using beef kidney as a tissue-surrogate model.

Materials and Methods: Beef kidney specimens (mean weight 44.8 ± 3.1 g) were secured in a cylinder, which was submerged in a water-filled tank through which a 27F resectoscope and 550-μm sidefiring fiber were positioned. Four energy/frequency combinations were tested, with each used to treat 10 kidney specimens. The difference between the mean pretreatment and post-treatment weights of each treatment group were compared statistically with Student’s t-test.

Results: The largest mean weight difference after treatment (8.94 ± 2.38 g) was achieved using 3.2 J and 25 Hz. This mass reduction was significantly greater than that of all other combinations except 2.5 J and 40 Hz.

Conclusions: Use of the 3.2 J and 25 Hz setting combination resulted in the greatest amount of ablation in this tissue-surrogate model, suggesting that maximal energy settings may provide an advantage in tissue vaporization using the 100-W holmium laser. Clinical assessment must be performed to substantiate these findings.

INTRODUCTION

AFTER FAILING A TRIAL OF MEDICAL THERAPY, patients with lower urinary-tract obstruction from benign prostatic hyperplasia (BPH) typically proceed to surgical intervention for relief from their symptoms. For smaller prostates (<40 g), many effective minimally invasive procedures have been developed as alternatives to transurethral resection of the prostate (TURP). These procedures include microwave thermotherapy, transurethral needle ablation, interstitial laser coagulation, and water-induced thermotherapy. More recently, ablation with new-generation holmium and KTP lasers has become an accepted method of treating BPH, providing significant improvements in voiding parameters with minimal associated morbidity.1 Although the KTP laser (532 nm) can be used to vaporize prostate tissue,2 the Ho:YAG laser remains the only multipurpose urologic laser capable of both effective tissue ablation or cutting as well as the fragmentation of all types of urinary calculi.

Despite longer operating times than are required for TURP, previous investigators have reported holmium ablation outcomes equivalent to those of TURP.1 The laser settings used in these initial series ranged from 2.4 to 2.6 J and 25 to 30 Hz, as the maximal power output of previous holmium units was 60 to 80 W.3

With the advent of the 100-W holmium laser, a broader range of energy and frequency settings have become available for soft-tissue applications. Settings of 2 J and 50 Hz are currently used for holmium-laser enucleation of the prostate (HoLEP), switching to 2.5 J and 40 Hz for spot coagulation.4 However, the most efficient energy and frequency setting combinations for ablation have not been well defined for the 100-W unit. We evaluated the ablation efficiency of various setting combinations using beef kidney as a tissue surrogate.

1Department of Urology, Thomas Jefferson University, Jefferson Medical College, Philadelphia, Pennsylvania.
2Department of Surgery, Division of Urology, University of British Columbia, Vancouver, British Columbia, Canada.
3Methodist Hospital Institute for Kidney Stone Disease and Indiana University School of Medicine, Indianapolis, Indiana.
MATERIALS AND METHODS

Beef kidneys were manually sectioned to approximately equal portions by weight. Portions of adjoining fibrous collecting-system tissue were carefully removed to provide mainly corticomedullary tissue for use in this experiment. The mean pretreatment mass of the specimens was $44.8 \pm 3.1$ g.

Each kidney specimen was secured within a cylinder so that it would remain stationary during treatment (Fig. 1). The cylinder was then placed in a tank filled with tap water. An access port at the end of the tank allowed insertion of a 27F resectoscope. A Duotome 550-µm sidefiring laser fiber (Lumenis, Santa Clara, CA) was inserted through the resectoscope working channel. Tap-water irrigant was utilized throughout the test sessions.

Four energy/frequency setting combinations were tested: 1.5 J and 50 Hz, 2.0 J and 50 Hz, 2.5 J and 40 Hz, and 3.2 J and 25 Hz. We chose these combinations to evaluate the effect of typical HoLEP settings on ablation efficiency, as well as to utilize the maximal energy and frequency settings available with a 100-W holmium laser.

Ten kidney specimens underwent ablation with each setting combination. Each specimen was treated for 5 minutes by rotating the tip of the fiber over the surface of the kidney in a sequential fashion to allow tissue vaporization (Fig. 2). To ensure technique consistency, a single operator (RLK) performed all ablations. After ablation, the kidney specimens were removed from the testing apparatus, blot dried, and reweighed to determine the change in mass. A representative postablation specimen is shown in Figure 3. Results are presented as the mean ± SD, with the mass differences from each group of treated specimens compared using Student’s $t$-test.

RESULTS

The mean weight differences achieved using the four energy/frequency setting combinations are summarized in Table 1. The 3.2 J/25 Hz combination produced the greatest overall mean change in mass ($-8.9 \pm 2.4$ g). This mass loss was sig-

<table>
<thead>
<tr>
<th>Setting Combination</th>
<th>Mean Difference (g ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 J/50 Hz</td>
<td>5.9 ± 1.5</td>
</tr>
<tr>
<td>2.0 J/50 Hz</td>
<td>5.6 ± 3.3</td>
</tr>
<tr>
<td>2.5 J/40 Hz</td>
<td>7.1 ± 2.7</td>
</tr>
<tr>
<td>3.2 J/25 Hz</td>
<td>8.9 ± 2.4*</td>
</tr>
</tbody>
</table>

* $P < 0.05$ compared with all other setting combinations except 2.5 J/40 Hz.
nificantly higher ($P < 0.05$) than that produced by either 1.5 J/50 Hz or 2 J/50 Hz.

**DISCUSSION**

Holmium ablation of the prostate was initially employed along with the neodymium (Nd:YAG) laser to facilitate coagulation during the treatment of obstructive glands. The hemostatic effect of the holmium laser was soon noted to be sufficient on its own, allowing elimination of the Nd:YAG component. As experience with holmium ablation expanded, it became apparent that the main disadvantage of the procedure was its inefficiency in treating larger prostates. This led to the development of the HoLEP technique, which has been used to treat even the largest glands with good outcomes and minimal morbidity. For smaller glands <40 g, however, holmium laser ablation remains an attractive option for a number of reasons. First, the procedure itself is simple to learn and apply. Importantly, the penetration depth of the holmium wavelength is minimal (0.4 mm), such that significant postoperative irritative voiding symptoms are rare. Outcomes from holmium ablation of prostates have been shown to be durable as well as favorable. Lastly, ablation can serve as a foundation for progression to the more advanced HoLEP procedure when a 550-μm end-firing fiber is employed. For example, use of the end-firing fiber in patients with a large median lobe can provide experience in creating the lateral grooves, followed by enucleation of the median lobe and then ablation of the lateral lobes with the side-firing fiber. In addition, an end-firing fiber can be used to tailor the channel created by the ablation process by eliminating any protruding strands of prostate tissue. To strip these portions of tissue away from the prostatic capsule, the surgeon utilizes the same rotational motions employed during HoLEP.

Although ablation times have been reported to be longer than the time needed for TURP, it should be noted that these results were produced by 60- to 80-W holmium lasers. The ablation efficiencies of various setting combinations of the 100-W holmium unit have not been reported previously.

Using beef kidney as a tissue surrogate for the prostate, we found that settings of 3.2 J and 25 Hz produced the highest average mass loss. The trend to greater mass loss when utilizing higher energy levels suggests that energy, as opposed to frequency, may have a greater impact on soft-tissue ablation efficiency. It is possible that ablation efficiency will be improved with the wider range of settings available with this new laser unit, resulting in a reduction in operating times from those of prior series. Further clinical experience with high-powered holmium ablation of the prostate will be required to substantiate these findings.

**REFERENCES**


Address reprint requests to:
Ramsay L. Kuo, M.D.
Dept. of Urology, Suite 1112
Thomas Jefferson University
1025 Walnut St.
Philadelphia, PA 19107

E-mail: ramsay.kuo@jefferson.edu