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INITIAL HUMAN CLINICAL EXPERIENCE WITH DIODE LASER INTERSTITIAL TREATMENT OF BENIGN PROSTATIC HYPERPLASIA

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ABSTRACT

Objectives. To report the initial results of treatment of outlet obstruction induced by benign prostatic hyperplasia (BPH) using interstitial laser coagulation performed with the Indigo 830 nm diode laser system.

Methods. A group of 112 men with lower urinary tract symptoms caused by BPH underwent treatment with the Indigo 830 nm laser system between October 1994 and November 1995. Patients were assessed prior to treatment and at specified post-treatment intervals for symptom score, uroflow, postvoid residual, and prostate volume. Adverse events and changes in laboratory parameters were monitored at each post-treatment visit to investigate safety of the procedure.

Results. Symptom score decreased from 20.9 at initial measurement to 9.6 at 3 months after procedure and 7.9 at 6 months. Uroflow rate increased from 8.0 mL/s initially to 15.2 and 14.2 mL/s at 3 and 6 months, respectively. Residual bladder volumes decreased from 105 mL initially to 59 and 38 mL at 3 and 6 months, respectively. There were no major complications (impotence, sustained incontinence, significant blood loss). Minor complications occurred in a small number of patients but were generally associated with urinary tract infection in patients with catheters. Three patients (2.7%) required retreatment and underwent transurethral resection of the prostate.

Conclusions. Interstitial laser coagulation using an 830-nm diode laser system appears to be a promising new treatment, with substantial improvements in objective and subjective parameters of obstruction and a favorable side-effect profile.

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Transurethral resection of the prostate (TURP) is still the reference standard in the treatment of benign prostatic hyperplasia (BPH). The associated problems and complications of TURP, such as significant bleeding, TUR syndrome, incontinence, strictures, and sexual dysfunction are well known and have been described extensively.1-6 Despite general progress in medicine and postoperative care in recent years, the incidence of complications following TURP remains virtually unchanged. With the rapidly aging population in the developed world, these complications are becoming more significant. In addition, people today are more aware of surgical risks in general and, increasingly, are demanding alternatives.

The treatment of BPH through interstitial laser coagulation (ILC) is a possible solution to this problem. In this treatment, prostatic tissue is heated from within the prostate to the point of irreversible necrosis. Unlike modalities that heat the prostate from the urethra, such as side-firing lasers, ILC does not require destruction of the urethral epithelium. Healing occurs usually without sloughing of heated tissue because the urothelium remains intact.8-10

Initial tests using interstitial laser devices were performed in vitro in different tissues and in vivo in the canine prostate.7,11-13 The in vitro studies in muscle, liver, kidney, and the potato models showed that treatment volumes increased with laser power and irradiation time unless charring oc-
MATERIAL AND METHODS

Laser Delivery System and Parameters

The device used for the treatment was a diode-laser operating at a nominal 830-nm wavelength and emitting 60-W output power. The laser was designed and manufactured by a leading medical laser company located in Germany. The laser was non-contact and was delivered directly to the prostate using a flexible delivery fiber. The fiber was inserted into the urethra and directed towards the prostatic tissues. The laser was focused on the tissue to achieve coagulation and ablation of the prostatic tissue.

Results from the canine studies showed homogenous coagulated lesions with minimal risk of heat dissipation. The laser was found to be effective in inducing coagulation of the prostate tissue without significant collateral damage to the surrounding structures. The laser parameters were carefully selected to achieve the desired coagulation effect without causing necrosis or significant thermal damage to the tissue. The laser parameters included a beam diameter of 1 mm, pulse duration of 500 ms, and a total energy of 60 W.

Conclusions

The results from the canine studies were encouraging and demonstrated the potential of the laser to achieve effective coagulation of the prostate tissue. Further clinical studies are needed to evaluate the safety and efficacy of the laser in human patients. The laser is a promising treatment option for patients with prostate problems and may offer an alternative to traditional treatments such as prostatectomy.

This study reviewed initial results in the use of such an interstitial laser treatment device in the therapy of BPH patients. A nominal 830-nm wavelength diode laser combined with a specifically designed diffuser tip was used in the treatment of 112 men with BPH complaints.
The device has an automatic optical sensing system ("blackbody" sensing) that monitors temperature conditions at the diffuser tip and halts treatment in the unlikely event of incipient tissue char. It is important to prevent the occurrence of uncontrolled carbonization with subsequent cavity formation and reduced coagulation volumes,\(^7,8\) and to maintain optimal control of the procedure. An automatic fiberoptic stress monitor also detects any excess mechanical stress that signals imminent fiberoptic breakage, immediately cutting off laser power.

**PATIENTS, ASSESSMENT, AND PROCEDURE**

We report on a multicenter, uncontrolled registry of patients with symptomatic BPH. All patients with an American Urological Association (AUA) symptom score higher than 12, maximum flow rate less than 13 mL/s, and a residual volume of less than 300 mL were eligible for inclusion. A total of six centers provided information for this report. Patients were treated between October 1994 and November 1995.

Potential patients were screened for symptomatic BPH using the AUA symptom questionnaire. Flow rates were obtained with automated flow meters. Residual bladder volume was determined with transabdominal ultrasound, immediately after micturition. Prostate cancer was excluded on the basis of digital rectal examinations, prostate-specific antigen testing, and transrectal ultrasound, followed by biopsy if necessary. Prostatic volume was determined by transrectal ultrasound measurement. Urinary tract infections were treated with antibiotics prior to the laser surgery.

Patients received general, spinal, and local anesthesia for the interstitial treatment procedure. The local anesthesia used was a combination of an anesthetic jelly instillation and a periprostatic block injection. (The results of an extensive ongoing study evaluating the use of local anesthesia in interstitial laser treatments will be published separately.) In the present study, local anesthesia was used in two centers. In 48% of the patients treated under local anesthesia, a periprostatic block with anesthetic jelly was sufficient. In 50% of the patients, an epidural block was added in addition to the periprostatic block with anesthetic jelly. In 2%, a general anesthesia was required.
patients, jelly, a periprostatic block, and intravenous (IV) analgesics provided sufficient anesthesia. In 2% of the patients, local anesthesia failed. The choice of anesthesia was made by the patient, the anesthetist, and the treating physician.

Cystoscopy was performed using standard equipment with a diameter of 17 to 21.5F with a working channel of at least 6F. The diffusor tip was inserted into the prostatic tissue under direct visual guidance up to its depth marker. There was no need for auxiliary instruments to insert the fiber. In general, the sites of fiber placement were chosen to coagulate the bulk of hyperplastic tissue. Thus the total number of fiber placements varied depending on the size and configuration of the prostate. Individual fiber placements were spaced by about 0.5 to 1 cm and/or performed at different angles beginning at the apex at the level of the colliculus seminalis (Figs. 4 and 5). To prevent thermal damage of the dorsal capsule and adjacent rectum, the lateral lobes were always punctured in the lateral or ventrolateral direction, never in the dorsal direction. If a median lobe was present, it was treated with one or more punctures in the direction of the bladder. Again, dorsal-directed punctures were avoided to prevent subtrigonal lesions. Irrigation was necessary only to provide optimal vision during punctures, not for cooling during irradiation. After each fiber placement, the laser was activated in the power format mode for the desired treatment time, usually 4 minutes.

After treatment, all patients were catheterized, using either suprapubic or Foley catheters. Catheters were removed according to the particular hospital's practice in patients being treated with lasers.

Symptom scores, flow rates, and postvoid residual urine volumes were re-evaluated at 1 month, 3 months, 6 months and 1 year after the procedure. At these follow-up visits, patients were also evaluated for the occurrence of untoward events such as impotence, incontinence, urinary tract infection, and dysuria.

RESULTS

One hundred twelve patients received treatment. To date, results of 86 patients at 3 months and 40 patients at 6 months after treatment are available. No 12-month follow-up was included in the registry protocol. The average age of the patients was 67 (±8.2) years. Patients had suffered from BPH for an average of 3.9 (±3.3) years. Before interstitial laser treatment, average prostatic weight was 56 (±27) g. Twenty-five percent of all patients received treatment to the median lobe.

Overall results are given in Figure 6. The AUA symptom score decreased from 20.9 (±5) prior to treatment to 9.6 (±6.2) at 3 months and 7.9 (±5.5) at 6 months after treatment. Maximum flow rate improved from 8.0 (±2.6) pretreatment to 15.2 (±6.5) at 3 months and 14.2 (±4.4) at 6
months after treatment. These figures reflect improvement rates of 54% and 62% for the AUA score at 3 and 6 months, respectively, and 90% and 78% for the flow rate at the same respective intervals. The post-void residual volume decreased from 105 (±75) mL prior to treatment to 59 (±85) mL and 38 (±43) mL at 3 and 6 months, reflecting improvement rates of 44% and 64% at these intervals, respectively. All improvements were statistically significant, at $P < 0.001$. The average catheterization time was 12.8 (±7.6) days, but this statistic was highly influenced by differing hospital policies. Many European hospitals have a standard policy of giving patients an outpatient appointment 14 days after their treatment to have a catheter removed regardless of the actual required catheterization time. Table 1 shows the percentages of patients experiencing 0% to 10%, >10% to 30%, >30% to 50%, and >50% improvement as measured by three parameters.

There were no procedural complications. Operative and postoperative bleeding was insignificant. Thirty patients (27%) developed urinary tract infections after the procedure. Twelve patients (11%) experienced transient dysuria after treatment, which in 9 cases was the result of a urinary tract infection. All patients were successfully treated with antibiotics. Retrograde ejaculation was reported in only 3 patients (2.7%). No impotence and no incontinence were reported.

There were no late complications related to the procedure. Three patients (2.7%) with unsatisfactory treatment results underwent subsequent TURP. Two of these men underwent TURP 3 to 6 months after ILC, and 1 had a TURP 7 months after the laser treatment.

**COMMENT**

During the recent past, several alternative treatment modalities using laser energy for BPH have been described.\textsuperscript{17–24} The main reason for the development and investigation of all these new techniques has been to reduce the persistent complication rate of TURP.\textsuperscript{4–6,25,26} In addition, some of the newer modalities were designed to treat the increasing number of high-risk patients.\textsuperscript{7,8} Although all procedures claim to be minimally in-

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline
 & 0–10 & 10–30 & 30–50 & >50 \\
\hline
AUA score  & 89 & 91 & 87 & 91 & 81 & 74 & 54 & 68 \\
Flow  & 92 & 89 & 87 & 77 & 73 & 69 & 56 & 66 \\
Residual volume  & 70 & 70 & 70 & 70 & 69 & 70 & 61 & 61 \\
\hline
\end{tabular}
\caption{Patient improvement rates in AUA score, flow, and residual volume at follow-up of 3 and 6 months}
\end{table}
vative, the actual degree of invasiveness varies widely. Drug treatment is close to watchful waiting, whereas contact laser vaporization may be seen as modified TURPs that cause minimal bleeding.

Existing laser techniques for BPH treatment can be divided into three entirely different groups. Superficial vaporization can be achieved using contact or high-power noncontact techniques. Laser probes are used transurethrally to remove the peritumoral tissue under direct vision, immediately creating a TURP-like cavity. Finally, vaporizing applicators can be used to do simple incisions. The most commonly used techniques employ sidefiring laser devices to achieve deep coagulation of the prostatic adenoma. 

Applied transurethrally, usually under direct vision, these devices coagulate the peritumoral tissue, causing necrosis. During the weeks that follow, the necrotized tissue sloughs off, and a TURP-like cavity is formed. In contrast, in interstitial laser coagulation the fiber is placed transurethrally under direct vision inside the tissue. This creates large coagulated volumes without affecting the urethra. After treatment the resulting necrosis is gradually resorbed, with a subsequent shrinkage of the prostatic lobes. During this process, a wide TURP-like cavity is gradually formed.

The treatments we have described vary greatly. Vaporizing techniques destroy the prostatic urethra completely and remove the prostatic tissue by vaporization. This results in a situation highly comparable to that produced by a TURP. Vaporization, however, reduces the occurrence of hemorrhage significantly. Sidefiring systems also destroy the entire prostatic urethra because both the prostatic urethra and the underlying tissue are coagulated. The necrotized tissue sloughs off, sometimes causing significant irritation. Intertstitial techniques preserve the prostatic urethra and coagulate the tissue inside the prostatic lobes. Because the prostatic urethra is still intact, symptoms of irritation are likely to be minimal.

Laser treatments using superficial vaporization can in theory treat any size prostate. However, in prostates with a volume above 60 g, treatment time is up to 50% longer than required for a TURP of a comparable gland. Sidefiring systems are recommended for treating prostates smaller than 60 grams. This is probably because even at high power, the laser light in these systems has limited penetration depth. The amount of tissue that can be treated is limited because only the surface of the prostatic urethra can be irradiated, and deep coagulation of the lobes is difficult to attain. Thus the percentage of coagulated prostatic tissue decreases as the size of the prostate increases. Interstitial laser systems can treat virtually all size prostates because coagulation depends completely on the fiber placements. In large prostates, more and deeper punctures will be necessary, resulting in a larger coagulated volume than that following side-fire laser treatment. Treatment time is the only limiting factor. However, the time required is not excessive, as 4 minutes per puncture results in a coagulated volume of 5 to 6 cc.

The side effects we found with interstitial laser coagulation were minimal, owing to the absence of tissue sloughing and the preservation of the prostatic urethra. The absence of retrograde ejaculation can be explained by the fact that the bladder neck was not treated unless a median lobe was present. The retreatment rate of 2.7% within 6 months is considered acceptably low.

The complication rates found thus far in this study are very gratifying in contrast to the complication rates often associated with TURP. In spite of significant improvements in surgical technique, TURP still carries a small but significant risk of major complications like impotence, sustained incontinence, and bleeding sufficient to require transfusions. None of those complications were observed in the present group. It must be kept in mind, however, that this group is too small to provide definitive data on the rates of these uncommon complications.

Our initial results, which represent the learning-curve treatments of six different centers, do provide substantial evidence that interstitial laser coagulation using an 830-nm diode laser system can improve both subjective complaints and objective parameters of BPH. All measured outcomes improved significantly from preprocedure to 6-month follow-up.

REFERENCES