Monitoring of the quality of side-firing fibers using a special design power meter: Aquarius

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Event: Photonics West '95, 1995, San Jose, CA, United States
Monitoring of the quality of side-firing fibers using a special design power meter
“Aquarius”

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ABSTRACT

The treatment of Benign Prostatic Hyperplasia using the Nd:YAG laser is developing rapidly since the clinical introduction three years ago. In most cases a right angled fiber is used to deliver the laser light laterally towards the abundant prostatic tissue. The characteristics of these fibers differ, with regard to the angle at which the beam exits the fiber and the beam profile, resulting in a specific power density distribution on the tissue. During clinical use the characteristics of a fiber may change due to deterioration of the fiber tip. In this study the behavior of the various devices was monitored before and during clinical use with a special design power meter (Aquarius).

The Aquarius measures the status of a right angled fiber in about fifteen seconds under clinical conditions, i.e., under water and at high input powers (40-80 Watt). In contrast with integrating sphere power meters specifically the primary beam is measured. The degree of deterioration of various fibers was quantified optically and thermally during clinical use.

Devices using a metal mirror transmitted slightly less power than internal refraction based devices (80 versus 90 percent). The transmission of the various devices was not linear with the input power; at higher input powers (>30 Watts) vapor bubbles, that developed at the tip of the device, decreased the transmission. During clinical use there was a large variation in decrease of transmission with regard to the total amount of energy transmitted through the fiber. However, at the end of a procedure the transmission had dropped to under 50 %.

The Aquarius is a powerful tool for evaluation and comparison of different laser prostatectomy devices both for clinical and experimental studies.

1. INTRODUCTION

The treatment of Benign Prostatic Hyperplasia (BPH) using the Nd:YAG laser in combination with a side-firing fiber (VLAP) is developing rapidly. The last years many different fibers have been developed and are presently used. The way these fibers should be used optimal, however, is still being studied [1,2]. One of the major difficulties is the exchangeability of protocols from one fiber to another. In a previous study [3] we showed that the characteristics of these fibers differ, with regard to the angle at which the beam exits the fiber and the beam profile. This results in a specific power density distribution on the prostatic tissue. The therapeutic effect of a laser treatment depends on “laser-related parameters”, such as power density and irradiation time, and patient-related parameters. The characteristics of a side-firing fiber, therefore, influence the clinical result, thus explaining the need for a specific protocol for each fiber. Apart from that, the fiber characteristics may change as well during use. As a result the amount of energy that reaches the tissue, which is responsible for the therapeutic effect, may change and therefore the clinical results may be influenced.

In this study the transmission, defined by the ratio between the power that irradiates the tissue and the power coupled into the fiber, is measured with a special design power meter. The transmission of one fiber was measured during and after use. The effect of water flow (irrigation) on the transmission could be studied as well using the same power meter.

2. MATERIAL AND METHODS

2.1 Side-firing fibers
The fibers for laser treatment of BPH that are studied here are side-firing fibers, i.e., the fibers are designed to deflect the laser light off axis thus enabling irradiation of the prostatic tissue. The fibers can be classified in two groups [3] based on the method that is used to deflect the laser light. These two groups are metal reflection and internal reflection. The following fibers (companies in parenthesis) were studied:

<table>
<thead>
<tr>
<th>Internal reflection</th>
<th>Metal reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD (Laserscope)</td>
<td>Sidefire (Myriadlase)</td>
</tr>
<tr>
<td>Laseguide (Laserperipherals)</td>
<td>Rotalase (Xintec)</td>
</tr>
<tr>
<td>Prolase II (Cytocare)</td>
<td>Urolase (Bard),</td>
</tr>
<tr>
<td>Sidefiber (Ceramoptek)</td>
<td></td>
</tr>
<tr>
<td>Ultraline (Heraeus Lasersonics)</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Side-firing devices that are evaluated in this study, classified regarding the method of deflection.

Only new samples of the devices in table 1 were used. One device, the Prolase II fiber, was studied extensively during and after clinical use, while the total transmitted energy during the procedure was recorded.

2.2 Special design power meter

For a clinical-relevant transmission measurement of a side-firing fiber the conditions should be comparable with the way these fibers are used in clinical practice. The fibers are designed for use under water (particularly in the prostatic urethra) and with relatively high input powers (ranging from 20 to 80 Watt). Therefore a power meter set-up (WRAP, Water-cooled Right-Angled Power meter) is developed as presented in figure 1.

![Figure 1](https://www.spiedigitallibrary.org/conference-proceedings-of-spie)

Figure 1. The power meter set-up “WRAP” for transmission measurement of side-firing fibers (left) and its final version the “Aquarius” (right).

The detector head (power wizard, Synrad) is positioned inside a water-filled container. The fiber is placed in such a way that it emits the laser light perpendicular to the wall of the container and to the surface of the detector head. The distance of the fiber to the detector is about 5 mm. Unlike an integrating sphere power meter only that beam is measured that will cause the clinical effect (the so-called primary or therapeutic beam). Possible secondary beams caused by scattering will not be considered. A water flow can be incorporated along the fiber axis. A pressurized sterile-water bag is then connected to the water flow inlet of the power meter. The flow can be adjusted to a maximum of 3 ml/s. In this way the measured power is a good representation of the power that actually reaches the tissue and that causes the therapeutic effects.
The experimental set-up was used as a blueprint for a commercial version, named Aquarius, that enables side-firing fibers to be measured in a fast and accurate way, so it can be easily incorporated in daily practice.

3. RESULTS

3.1 Transmission measurements

The transmission before use of the eight different side-firing fibers are presented in figure 2. The transmission was calculated relative to that of a bare fiber with the same diameter. Measurements were done at 4 different power settings, viz. 10, 20, 40 and 60 Watt. The Prolase II fiber was not measured at 10 Watt. A water flow was not incorporated.

During the measurements the inter-sample variance increased with increasing input power due to the induction of little vapor bubbles either at the mirror where the laser light is deflected (metal reflection type) or at the place where the laser light exits the device (internal reflection type). Especially the Sidefire and Urolase fiber show this variance, as because of the design vapor bubbles are trapped in front of the mirror.

The transmission of the ProLase II fiber was measured during and after use. In figure 3 the transmission of three samples of the Prolase II fiber during one procedure is presented as a function of the total energy transmitted (horizontal axis). The transmission was measured at 60 Watt as the fibers were clinically used at 60 watt input power. The transmission was calculated in this case relative to that of the fibers before use, i.e. at the beginning of a procedure.
The transmission was measured of 34 ProLase II fibers before and after a clinical procedure. In figure 4 the transmission after the procedure relative to that before the procedure is presented as a function of total transmitted energy during that procedure. The fibers were all new before each procedure.

Figure 3. Prolase II fibers during use.

Figure 4. Prolase II fibers after use compared to before use.
The effect of water flowing along the fiber axis, effectively cooling the fiber tip, was studied for the Prolase II. Figure 5 shows measurements with and without water flow for these fibers at 40 and 60 Watt power setting. The water flow was in all cases adjusted to 3 ml/s.

![Graph showing transmission of five different samples of Prolase II fiber](image)

Figure 5. The effect of water flow on the transmission of five different samples (all used) of the Prolase II at 40 and 60 Watt input power.

A water flow does not influence the transmission of the Prolase II fiber significantly. Therefore, the transmission measured as before, i.e. without water flow, is a good estimation for the transmission as it is in practice, i.e. with water flow. The behavior for the other side-firing fibers is expected to be similar.

4. DISCUSSION

The enormous increase in different side-firing fibers for laser prostatectomy the last years caused confusion. It appeared that the fibers were not compatible, thus the protocol of one fiber could not be used with another fiber. In the past there have been several studies on the efficacy of these different fibers and it has become clear that the best treatment requires different parameters and skills for each fiber separately. When comparing clinical results the amount of energy delivered to the tissue is an important factor. For different samples of one fiber this seems to be constant. However, immediately after the beginning of a laser treatment the transmission and thus the energy delivered to the tissue may change. This makes the transmission behavior of a side-firing fiber important for the therapy. With this study we presented a power meter that is capable of measuring the transmission of a side-firing fiber during use and therefore provides the clinician with important information.

The transmission of the Prolase II fiber decreases with increasing transmitted energy, but it happens rather unpredictable. A measurement after a procedure only does not supply you with a proper insight in the total delivered energy. Measurements taken during a procedure is the best way of dealing with this problem.

The transmission measured with the Aquarius power meter is a relative measurement compared to the transmission of a new device. Some losses in transmission of a device are due to the design of the Aquarius: the water between device and detector head (see figure 1) and the glass window in front of the detector head will respectively absorb and reflect about 10% altogether. This is for all samples of one device the same.
Although the water flow during the application of the Prolase II fiber does not influence the transmission significantly, the water flow causes two important effects. First it cools the tip of the fiber that will burn off without cooling. Second the water flow is indispensable for providing the physician with a proper view during clinical application. The Prolase II fiber is the only fiber that is observed and measured during and after clinical use. The results will possibly be similar for other side-firing fibers but this was not investigated yet. Further the clinical results need to be linked with the transmission results. Besides measurements of the transmission during a clinical procedure as indicator for the status or quality of a prostatectomy device this can be also observed by the absence of tissue effects (e.g. blanching), white flashes seen at the tip or the increase in vapor bubble formation at the tip surface. In all these cases, however, it is the transmission measurement that will confirm these indications.

5. CONCLUSION

The WRAP or Aquarius is a powerful tool for evaluation and comparison of different laser prostatectomy devices both for clinical and experimental studies. The transmission of the Prolase II fiber during clinical use decreases, but not in a controlled way. Therefore, the inclusion of a transmission measurement of a side-firing fiber both for clinical and experimental studies is strongly recommended.

6. REFERENCES