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VARIATION IN OUTPUT POWER OF LASER PROSTATECTOMY FIBERS: A NEED FOR POWER MEASUREMENTS

CHRISTIAAN F. P. VAN SWOL, ED TE SLAA, RUDOLF M. VERDAASDONK, JEAN J. M. C. H. DE LA ROSETTE, AND TOM A. BOON

ABSTRACT

Objectives. The aim of this study was the assessment of the quality of side-firing fibers that are being used for laser prostatectomy, either by a laser light transmission measurement or by visual inspection.

Methods. A power meter (Aquarius) was developed to measure the actual power transmitted through a sidefiring fiber and delivered to the prostatic tissue. The power measurements were performed under clinical conditions, that is, under water and at relatively high input power. Furthermore, a protocol was developed for visual inspection of the fibers. Eight types of side-firing fibers were measured before use. Before and after a procedure, three fiber types were measured: ProLase II (28 samples), UltraLine (23 samples), and UroLase (44 samples). All these fibers were used in standard treatment protocols.

Results. At 60 W the transmission of new fibers (not used) ranged between 49% and 83% when compared to a bare fiber. After use, a large variation was found in transmitted power between different samples of one device. A correlation with total transmitted power was not present. At higher power input, vapor bubbles are generated at the tip of the fibers. Depending on the fiber design, these bubbles have a major impact on the transmission. Only for the UroLase fiber was there a significant correlation between visual inspection and the transmission of used samples at 10, 20, and 40 W.

Conclusions. The transmission strongly varies between fibers and between different samples of one fiber during clinical use. Moreover, the transmission does not correlate with visual inspection. A power measurement during a clinical treatment will contribute to a more controlled procedure and to a better comparison

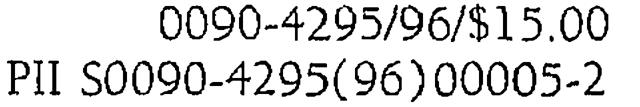
The possible use of the neodymium:yttrium-**L** aluminum-garnet laser as a minimal invasive treatment of benign prostatic hyperplasia was already reported in 1988.^{1,2} The inability, however, to direct the laser light to the prostatic tissue resulted in an ineffective laser treatment. In 1990 the first canine experiments were performed using a side-firing fiber that could be inserted through a cystoscope³ or that was incorporated in a transurethral ultrasound device.⁴ In both cases the laser light was directed almost perpendicular to the pro-

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static tissue. These initial experiments were soon followed by other canine and later by human studies^{5,6} to find the optimal laser prostate treatment that is to compete with the gold standard, transurethral resection of the prostate. Until now, however, there is no consensus regarding treatment strategy for laser prostatectomy. To achieve such consensus, two questions need to be answered: How can we most effectively apply laser energy to the prostate? Does the delivered energy depend on the type of device and does the energy delivery change with time?

The success of a laser prostatectomy can be defined as the relief of symptoms, caused by obstructive prostatic tissue, by the application of laser energy with minimal complications. Removal of abundant tissue is possibly the key mechanism. In the case of laser irradiation, tissue removal can be obtained in two different ways: indirectly by heating of the tissue to a maximum of 100°C, thus

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causing the coagulated tissue to slough after the procedure, or instantaneously by vaporizing the tissue while temperatures rise over 300°C. Either way depends on the power density at the tissue surface in combination with the irradiation time.⁷ The power density is the result of power output of the laser source and the transmission of the fiber, and the irradiated surface area (spot size), defined by the characteristics of the side-firing fiber that is used and its distance to the tissue.⁸ This implies that, although using the same laser source and the same power settings, each type of fiber may deliver a different amount of energy to the tissue. Consequently, the results of different laser prostatectomy studies may not be comparable.

Presently, more than 15 different side-firing fibers are commercially available. All are designed to deflect the laser light laterally, thus directing it to the prostatic tissue. In a previous study,⁹ we showed that the method used to deflect the laser light highly influences the power density on the prostatic tissue. Two types of side-firing fibers can be distinguished, depending on the deflection method that is used: metal reflector and total internal reflector. During a laser procedure, changes in fiber characteristics may occur, due to deterioration of parts of the fiber that transmit or reflect the laser light. Both transmission and beam characteristics may change, thus influencing the tissue effects and the clinical outcome in the long term. Therefore, clinical and experimental studies are difficult to compare with respect to (ideal) power settings, since the total amount of energy irradiating the tissue can only be estimated within limits. Apart from laser-related parameters, the tissue composition and the blood perfusion also play an important role in laser-tissue interaction. Blood vessels will cool the tissue surface efficiently and prevent heat deposition in deeper tissue layers.^{10,11} Characterization of prostatic tissue prior to treatment may result in a better understanding of the clinical results. In this study a method will be presented to measure the transmission of a side-firing fiber under controlled conditions similar to clinical settings. Consequently, the power that actually reaches the tissues, and thus is responsible for the tissue effects, can be determined. The measurements were done before and after clinical procedures, to monitor the behavior of side-firing fibers during use.

guide (Laser Peripherals), ProLase II (Cytocare), SideFiber (Ceramoptec), and UltraLine (Heræus Lasersonics). Before and after clinical application, the transmission of three types of fibers was measured: ProLase II (28 samples), UltraLine (23), and UroLase (44).

TRANSMISSION MEASUREMENTS

The transmission measurement in the experimental setting should be performed under conditions approaching those of the actual (clinical) laser treatment. Because the medium surrounding the device influences the way the laser light travels to the tissue, the measurement should take place under water. A measurement should include only that beam that contributes to the clinical effect. The transmission may be dependent on the power input, so a measurement needs to be performed with a power input similar to the clinical power setting. Figure 1A is a schematic illustration of a side-firing fiber inserted in the prostatic urethra during treatment. In Figure 1B the power meter setup is shown schematically, and in Figure 1C a photograph of the final version of the power meter, named "Aquarius," is shown.¹² The detector head (power wizard, Synrad) is positioned behind a glass window at the outside of a water-filled container. A side-firing fiber is positioned through the fiber support in front of the window (detector). Through the use of this support, all fibers are positioned at the same distance (5 mm) to the detector. By repositioning the detector head (into another slot), the meter can be used to measure end-firing fibers as well (for reference). Parameters like distance of fiber to detector remain unchanged. It is possible to incorporate a water flush parallel with the fiber (through the support). The flow could be adjusted to a maximum of 3.0 mL/s. For each fiber sample, the measurements were repeated five times.

VISUAL INSPECTION

The simplest way of assessing the status of a side-firing fiber during clinical use is by direct visual inspection, as it can be done with minimal interruption of the procedure. It is discussed whether any visual objective characteristics of a used fiber correlate to its loss in transmission of laser light. Therefore, the same fibers for which the transmission was measured during clinical use were inspected visually. To obtain an objective measure, a classification scheme was designed. All fibers were scored in a range from 1 to 5, where 5 is a totally damaged fiber and 1 an undamaged fiber.¹³ As an example, the different grades of deterioration for the UroLase fiber are presented in Figure 2. The fibers were evaluated by two independent observers (EtS, JdlR). The sum of the obtained scores resulted in a scale from 2 to 10.

RESULTS

NEW FIBERS

The measurements were performed at input powers of 10, 20, 40, and 60 W, using the Aquarius power meter described before. Three new fiber samples were measured for each type. The transmission was calculated relative to the transmission of an end-firing fiber with the same diameter as each side-firing fiber. The results of these transmission measurements are presented in Figure 3. The SideFire device has the lowest transmission at 60 W, especially when compared to its transmission at lower input power. This may be caused by the presence of vapor bubbles (caused by heating of the device) near the reflecting mirror that

MATERIAL AND METHODS

Prior to clinical use, transmission measurements were performed on various samples of eight types of side-firing fibers. Three were metal reflectors: RotaLase (Xintec), SideFire (Myriadlase), and UroLase (Bard). Five were total internal reflectors: Angled Delivery Device (ADD; Laserscope), Lase-

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MEASUREMENTS DURING AND AFTER CLINICAL USE Three different fibers, the UroLase, UltraLine, and ProLase II, were measured during and after clinical use and their transmission was compared type of fiber was applied at its own clinical protocol. The ProLase II was used at 40 W either fixed or moved over the tissue (the "painting" method).¹⁴ An average energy of 35,000 J was unsethod).¹⁴ An average energy of 35,000 J was transmitted through the 28 samples. The UltraLine was used at 60 W while painting over the tissue.¹⁵ At average a total of 51,000 J was transmitted through the 23 samples. The UroLase was used at 40 W at several fixed clock positions, depending on prostate volume.¹⁵ The average amount of en-

ergy transmused through the 44 Urolase fibers

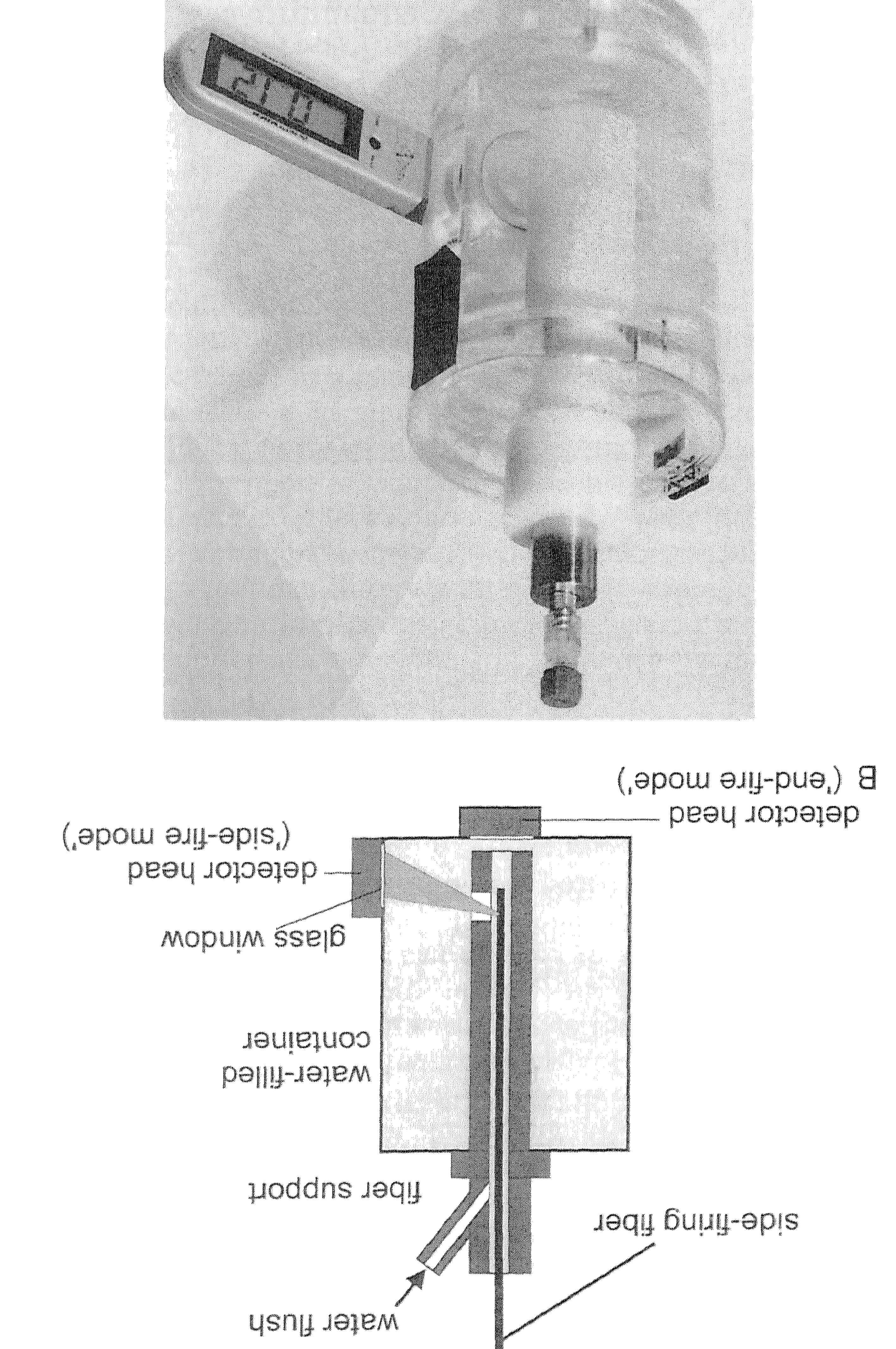
FIGURE 1. A side-firing fiber in the prostatic (pr) urethra during laser light irradiation (A) and the same sidesetup (B); the final version of the setup, the Aquarius power meter (C).

spreads the beam over a larger area than the detector area. The measurements at 60 W of the did show a large variation, probably for the same teason. Nevertheless, it is very likely that vapor

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FIGURE 3. Results of the transmission measurements

bubbles are also generated with the other devices (internal reflectors) but, due to their shape, these bubbles do not stay in the laser light path.



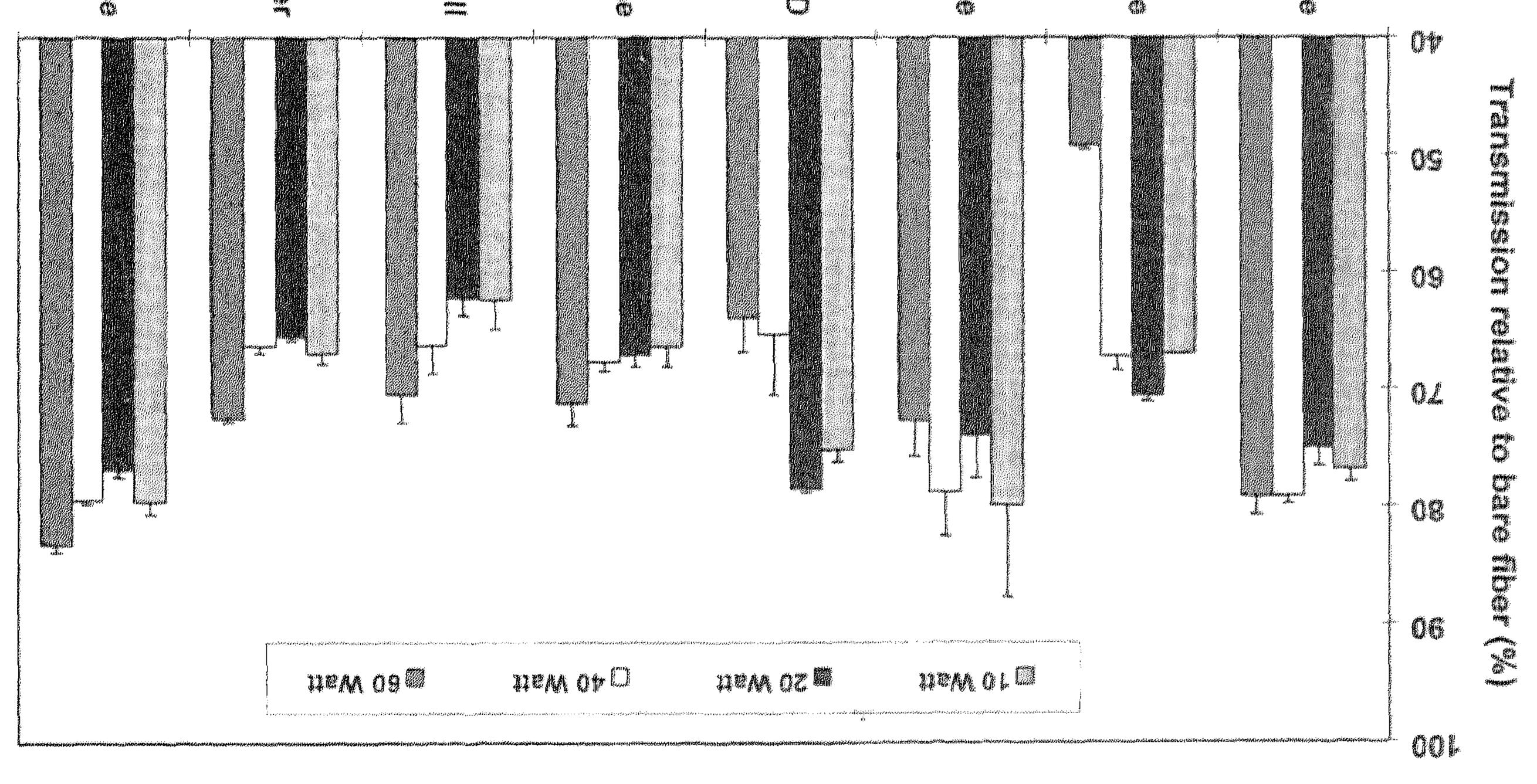
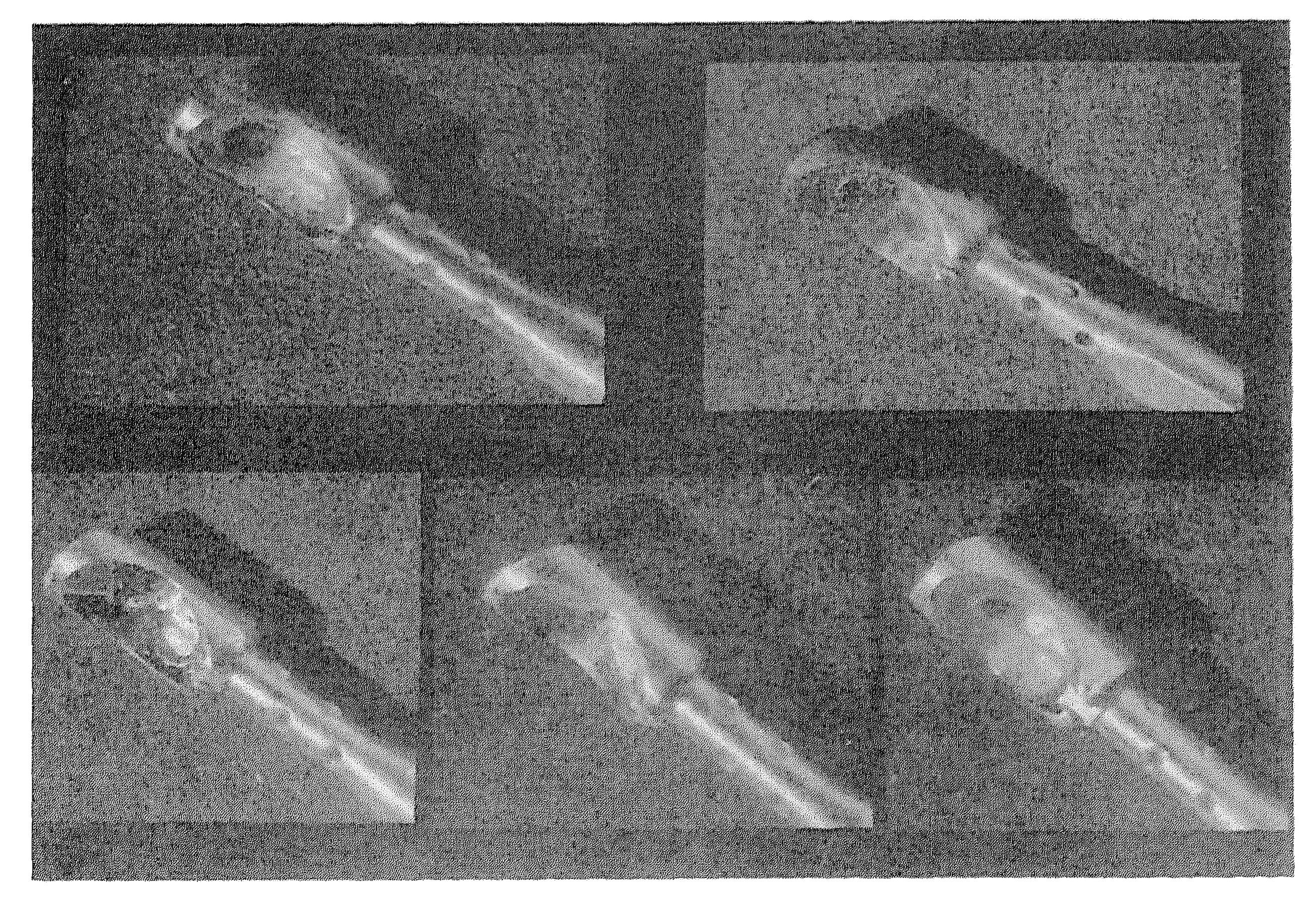
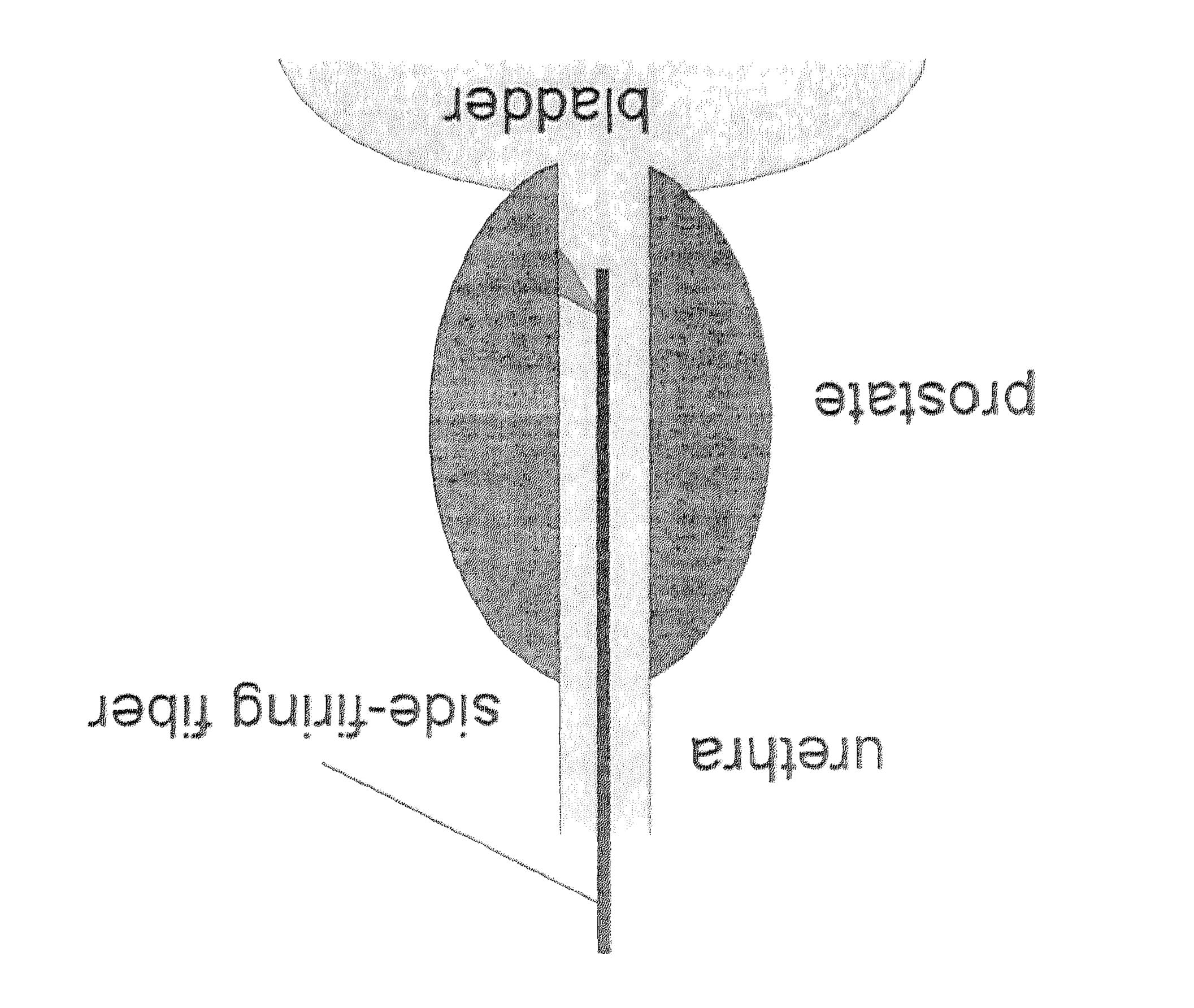


FIGURE 2. Visual aspects of the laser fiber. Example of vight to left and top to bottom to the bottom left corner with score J (undamaged), then





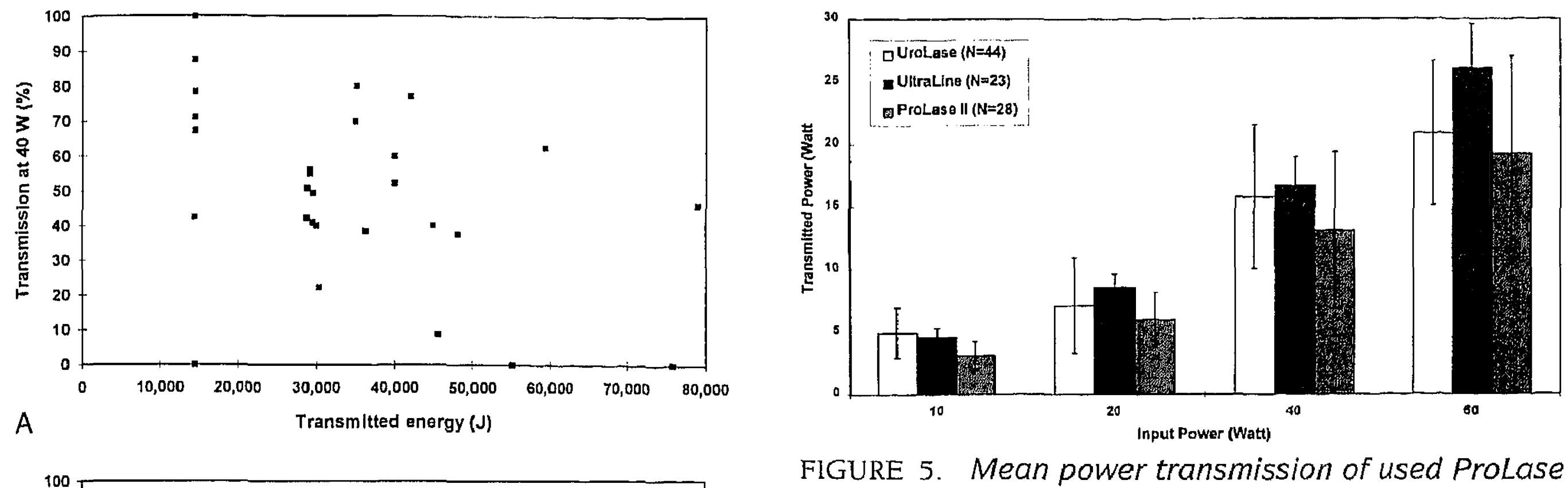
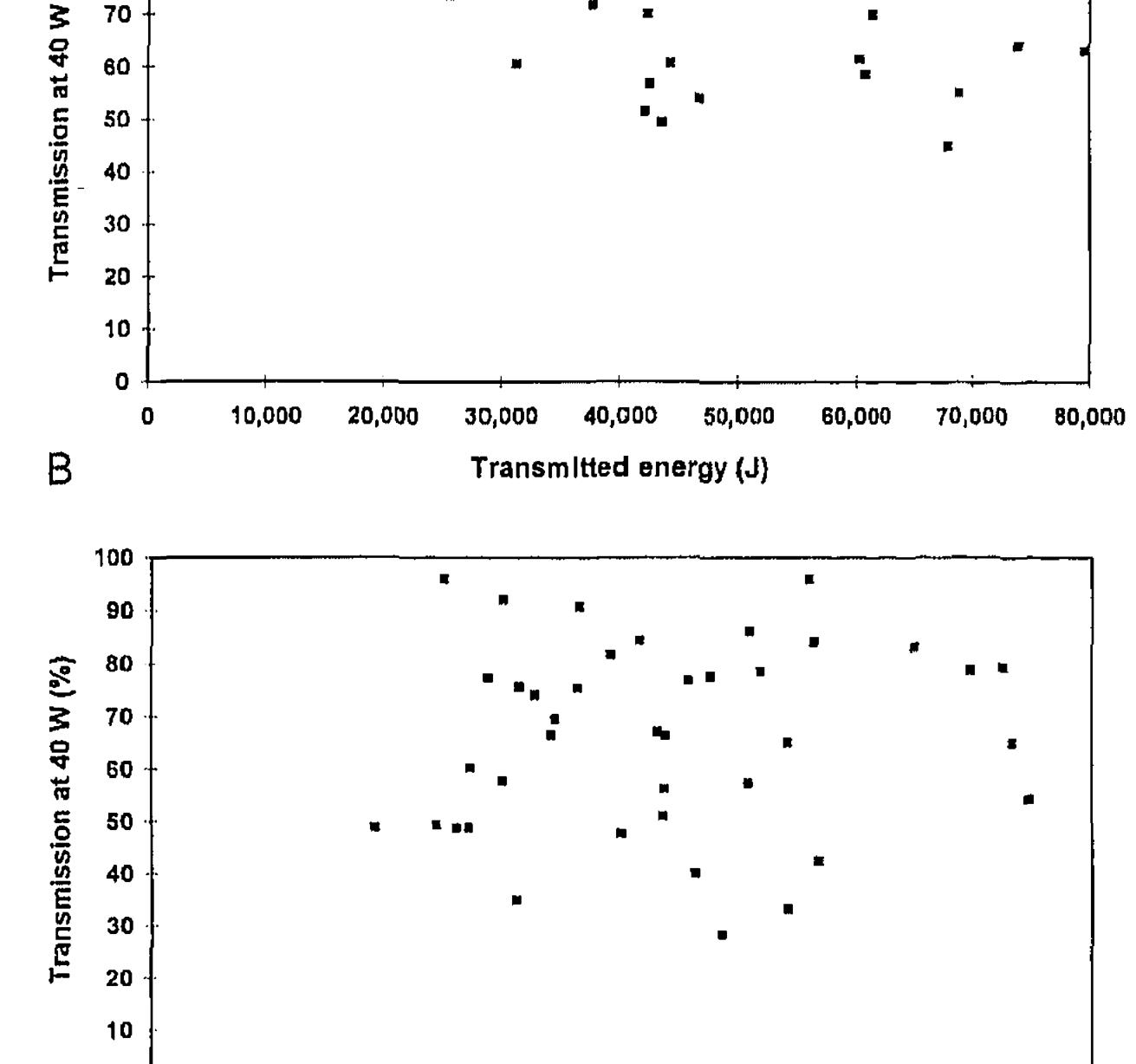


FIGURE 5. Mean power transmission of used ProLase II, UltraLine, and UroLase fibers at 10, 20, 40, and 60 W input power (bars indicate standard deviation).



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(%)

for enhanced cooling of the fiber tip. The transmission was calculated for five used samples of the ProLase II, UltraLine, and UroLase, again at 10, 20, 40, and 60 W. Only at high-power input (40 and 60 W) did the transmission increase slightly compared to the no-flush situation, as less vapor bubbles are generated at the tip. Therefore, for further experiments, the transmission measured without flush was considered similar to the situation with flush.

VISUAL INSPECTION

The ProLase II, UltraLine, and UroLase fibers were all inspected visually. The scored values (in a scale from 2 to 10) were correlated with the transmission measurements reported before. The fibers were grouped in two categories based on this visual aspect score: medium (score from 2 to 5) and high (score from 6 to 10) decay. In Figure 6 the transmission at different input powers is presented for these two categories for each of the three fibers. Figure 6 reveals a gross relationship between the visual aspect and the transmission for the ProLase II and the UroLase fibers. For each individual sample, the correlation between the visual aspect and the transmission increased with decreasing input power. A significant statistical level could be reached only for the UroLase fiber at 10, 20, and 40 W input power (t test, two-tailed, P < 0.01). Therefore, when using 40 or 60 W for a clinical treatment, visual inspection does not give sufficient information on the transmission or quality of the side-firing fibers discussed here.

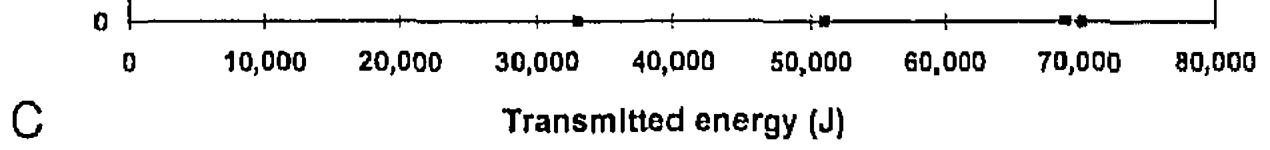
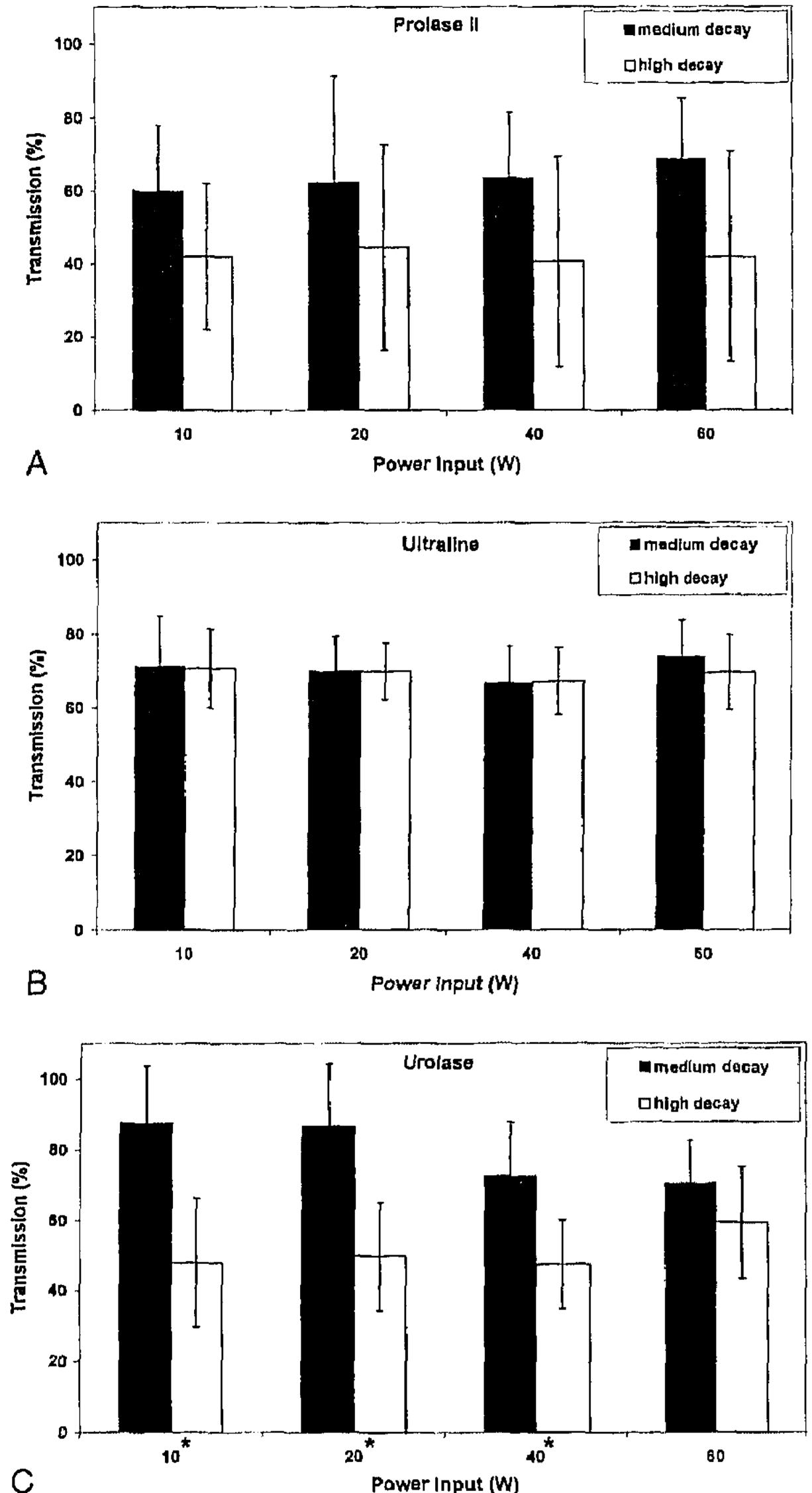


FIGURE 4. Scatter plot of the percentage transmission relative to a new fiber at 40 W of all 28 used ProLase II (A), 23 used UltraLine (B), and 44 used UroLase fibers (C) as a function of energy transmitted.

was 44,000 J. The measurements were performed at 10, 20, 40, and 60 W. As an example, the transmission at 40 W of all used ProLase II, UltraLine, and UroLase fibers is presented as a function of energy transmitted in a scatter plot in Figure 4. The mean values and standard deviations of the transmission of the three different fiber types are presented in Figure 5. The differences in efficiency of laser light transmission are only significant between the UltraLine and the ProLase II at 10, 20, 30, and 40 W, between the UroLase and the ProLase II at 10 W, and the UroLase and UltraLine at 60 W (t test, two-tailed, P < 0.01). A water flush was incorporated in the measuring device with a flow rate of 3 mL/s parallel with a used side-firing fiber. The water is used normally



Since the clinical introduction of laser prostatectomy, many side-firing fiber devices have been developed for this procedure. The results that are reported in the literature using these devices are promising regarding both objective and subjective



not only between the new devices, but also after use between different samples of one device. In general, the transmission decreased with increasing total transmitted energy. However, the correlation was poor. This suggests that transmission should be considered for a proper evaluation study of a device. The inclusion of a transmission measurement during a clinical procedure, as the change in transmission is unpredictable, would be the preferred situation.

Contamination of the reflecting (gold mirror) or transmitting (glass capillary) parts of the fiber tip will lead to absorption of laser light. As a result, the temperature at the contaminated place will rise easily over the boiling temperature of water, thus creating vapor bubbles. Of course, this happens both in clinical application and inside the power meter. The bubbles will (back) scatter the light, thus influencing the transmission. As bubbles are formed as a result of light absorption, it is impossible to determine the independent effect of absorption or scattering on the transmission of laser light. In the case of the UroLase fibers at 10, 20, and 40 W, there was a significant relationship between visual inspection and transmission. It should, however, be remembered that the situation may be different for a particular sample. For the other two fibers, ProLase II and UltraLine, no correlation could be found. Apart from the visual inspection as described here, one can make use of other (cystoscopic) indicators to assess the aging of a side-firing fiber. The absence of tissue effects (blanching or carbonization), white flashes generated at the tip of the device due to overheating of the tip, or excessive formation of vapor bubbles at the tip surface (not coming from the tissue) indicate that the device may be deteriorating. A proper transmission measurement can be used to confirm these indicators. Some parts of the power meter influence the amount of light that is detected. The glass window in front of the detector reflects and absorbs a small part of the laser light. The amount of water between fiber and detector or tissue absorbs some of the laser light as well. The total amount of laser light that does not reach the detector is estimated at about 5%. The results presented here are not influenced by these "errors," because the measurements are calculated relative to an end-firing fiber or relative to a new sample of a side-firing device. The mentioned percentile aberrations are constant in all circumstances. Only when calculating the energy that actually irradiates the tissue in the clinical situation should this 5% difference be considered.

FIGURE 6. The relationship between the visual aspect (either medium or high decay) and the transmission for the ProLase II (A), UltraLine (B), and UroLase (C) at 10, 20, 40, and 60 W input power (bars indicate standard deviation). *The difference in transmission is statistically significant, P < 0.01.

improvements, but there is a large variation. An explanation may be the difference in characteristics^{9,16,17} and the durability of the fibers during use, because for clinical relevance not the power delivered by the laser source but the power delivered by the fiber to the tissue is important, the first being the parameter reported in the literature. The laser light transmission of the fibers is one of the major parameters that describe the characteristics of the fiber and that can be used to quantify the durability. The transmission of eight different side-firing devices was studied here. Three devices (ProLase II, UltraLine, and UroLase) were studied during and after clinical use (durability). The study shows a large difference in laser light transmission,

The patients treated with the ProLase II, UltraLine, and UroLase fibers who were included

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in this study were all evaluated regarding symptom score and voiding parameters.^{14,15} The change in these parameters, however, did not correlate with the decay in transmission of these fibers as assessed in this study. Although the number of patients is small, the absence of correlation may be explained by the fact that transmission of the fiber does not decrease linearly during a procedure. In that case, more accuracy can be obtained by measuring at fixed intervals during a procedure.

Although the transmission is an important factor to take into account, at least for the transmission differences considered here, it does not disqualify one of these side-firing fibers for laser prostatectomy. It does, however, strongly indicate that the transmission should be considered when comparing different fibers. By measuring the delivered energy to the tissue more accurately with a setup such as the Aquarius power meter, one will be able to compare the results of different laser prostatectomy studies and understand the differences better. 7. Verdaasdonk RM, Borst C, and van Gemert MJ: Explosive onset of continuous wave laser tissue ablation. Phys Med Biol 35: 1129–1144, 1990.

8. Van Swol CF, Verdaasdonk RM, Mooibroek J, Lock MT, and Boon TA: Prediction of the necrotic zone depending on the optical and thermal characteristics of laser prostatectomy modalities. J Urol 151: 332, 1994.

9. Van Swol CF, Verdaasdonk RM, van Vliet RJ, Molenaar DG, and Boon TA: Side-firing devices for laser prostatectomy. An overview. World J Urol 13: 88–93, 1995.

10. Van Swol CFP, Verdaasdonk RM, Mooibroek J, and Boon TA: Optimization of laser prostatectomy. Prog Clin Biol Res 386: 511–519, 1994.

11. Cowles RS 3rd, and Rawlings CA: The effect of intraprostatic blood flow on laser energy penetration in the canine prostate. Lasers Surg Med 7 (suppl): 63, 1995.

12. Van Swol CFP, Verdaasdonk RM, Hermans F, van Vliet RM, and Boon TA: Monitoring of the quality of side-firing fibers using a special design power meter "Aquarius," in Watson GM, Steiner RW, and Johnson DE (Eds): Laser Prostatectomy and Lasers in Urology. Bellingham, Wash, SPIE, 1995, vol. 2395A, pp 14–19. 13. te Slaa E, van Ettergen AF, van't Hof CA, Debruyne FMJ, and de la Rosette JJ: Durability of laser fibers. World J Urol 13: 83–87, 1995. 14. Boon TA, van Swol CF, van Venrooij GE, Beerlage HP, and Verdaasdonk RM: Laser prostatectomy for patients with benign prostatic hyperplasia: a prospective randomized study comparing two different techniques using the Prolase II fiber. World J Urol 13: 123–125, 1995. 15. de la Rosette JJ, te Slaa E, de Wildt MJ, and Debruyne FM: Experience with the Ultraline and Urolase laser fibers: is there any difference? World J Urol 13: 98–103, 1995. 16. Anson K, Buonaccorsi G, Eddowes M, MacRobert A, Mills T, and Watson G: A comparative optical analysis of laser side-firing devices: a guide to treatment. Br J Urol 75: 328-334, 1995.

CONCLUSIONS

The present study shows a difference in laser light transmission between side-firing devices for laser prostatectomy. This transmission may change during clinical application in an unpredictable way. Despite using the same device and applying the same power settings, the energy delivered to the tissue during a clinical procedure can vary significantly.

Power measurement during a clinical treatment

17. Perlmutter AP, and Muschter R: The optimization of laser prostatectomy. Part I: free beam side fire coagulation. Urology 44: 847–855, 1994.

will contribute to a more controlled procedure and to a better comparison of clinical laser prostatectomy studies.

REFERENCES

1. Littrup PJ, Lee F, Borlaza GS, Sacknoff EJ, Torp-Pedersen S, and Gray JM: Percutaneous ablation of canine prostate using transrectal ultrasound guidance absolute ethanol and Nd:YAG laser. Invest Radiol 23: 734–739, 1988.

2. Bloiso G, Warner R, and Cohen M: Treatment of urethral diseases with neodymium:YAG laser. Urology **32**: 106– 110, 1988.

3. Johnson DE, Levinson AK, Greskovich FJ, Cromeens DM, Ro JY, Costello AJ, and Wishnow KI: Transurethral laser prostatectomy using a right-angle delivery system, in Watson GM, Steiner RW, Pietrafitta JJ (Eds): Lasers in Urology, Laparoscopy and General Surgery. Bellingham, Wash, SPIE, 1991, vol. 1421, pp 36–41.

4. Roth RA, and Aretz HT: Transurethral ultrasound-guided laser-induced prostatectomy (TULIP procedure): a canine prostate feasibility study. J Urol 146: 1128-1135, 1991.
5. Johnson DE, Price RE, and Cromeens DM: Pathologic changes occurring in the prostate following transurethral laser prostatectomy. Lasers Surg Med 12: 254-263, 1992.
6. Kabalin JN: Laser prostatectomy performed with a right angle firing neodymium:YAG laser fiber at 40 watts power setting. J Urol 150: 95-99, 1993.

EDITORIAL COMMENT

The authors present an interesting investigation of common side-firing neodymium:yttrium-aluminum-garnet (Nd:YAG) laser delivery fibers used for treatment of benign prostatic hyperplasia. Their findings may explain some variations in clinical outcomes achieved in individual men undergoing laser prostatectomy. First, the authors demonstrate once again the well-documented fact—but a fact that is too often neglected in clinical application—that even at baseline the laser light transmission characteristics of different fiber designs differ significantly.^{1,2} Thus, laser dosimetry and operative technique must be adjusted to maximize tissue effects and clinical outcomes.^{3,4} Second, the authors studied deterioration of fiber transmission of laser light during laser prostatectomy. Deterioration was observed with all three distinct categories of side-firing fiber design: those with external metal mirrors (such as UroLase) and polished-end silica glass fibers with a glass capillary cover (such as UltraLine) or without (such as ProLase II). Not only were all designs susceptible to intraoperative damage, but the external metal mirror design was not significantly more susceptible to deterioration, contrary to popular discourse but in agreement with prior objective studies.⁵ In fact, the metal mirror design conferred some advantage to the operator, since this was the only design wherein the extent of deterioration of transmission could be readily correlated with the visual appearance of the external metal mirror. With polished-end glass fibers, which rely on internal reflection of light, the authors could not accurately

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determine by visual inspection whether significant deterioration in light transmission had occurred.

Finally and importantly, the authors demonstrate that the deterioration in light transmission observed with these sidefiring fibers is not linear. In other words, these fibers were not observed to deteriorate gradually with increasing usage, but instead significant damage seemed to occur as isolated, discrete incidents during use (see the authors' Figure 4 for all fibers). Most of these incidents causing fiber damage can probably reasonably be ascribed to acute thermal events, with very high temperatures generated locally due to burying the fiber in tissue or inadequate irrigant flow to dissipate the generated heat. In some cases, acute mechanical trauma may also contribute to fiber deterioration, especially in those fibers with a distal glass capillary cover, but this should be relatively unusual in the hands of an experienced practitioner.

Given these findings, should a power meter be used during all Nd:YAG laser prostatectomy cases, and, if so, how often should readings be obtained? In current practice, we and many others are now regularly delivering upwards of 1500 J of Nd:YAG laser energy per gram of excess prostate tissue, which translates to 40,000 to 50,000 total joules in an average case and more in larger glands.⁶ In some facilities, these sidefiring delivery fibers are also being resterilized and reused for more than a single case. The nonlinear decline in fiber transmission documented in the present study and just discussed makes impossible the definition of a set level of fiber usage, up to which level adequate energy transmission can be assured and beyond which the fiber should be routinely checked or discarded. The external metal mirrors integral to many side-firing fiber designs can be visually monitored for deterioration with good accuracy by experienced operators. For those less experienced, and in cases in which a polished-end glass fiber that relies on internal light reflection is used, routine checks of power transmission may be useful to assure the adequacy of laser treatment and consistent clinical outcomes. Examining the data presentation in the scatter plots of the authors' Figure 4, a recommendation to check power transmission after every 10,000 J in such cases is not unreasonable, and certainly routine power checks after 25,000 J energy delivery would seem advisable. Of course, any visually perceptible change in the metal mirror or glass end of the fiber, or in tissue response to laser application, should warrant an immediate determination of adequacy of power transmission. In addition, any fiber that is resterilized should be checked for adequate power transmission prior to reuse. Such practices can only enhance the so-called learning curve of the beginning laser prostatectomist and also better guarantee consistent clinical results for all operators, as the authors suggest.

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REFERENCES

1. Anson K, Buonaccorsi G, Eddowes M, MacRobert A, Mills T, and Watson G: A comparative optical analysis of laser side-firing devices: a guide to treatment. Br J Urol 75: 328–334, 1995.

2. van Swol CF, Verdaasdonk RM, van Vliet RJ, Molenaar DG, and Boon TA: Side-firing devices for laser prostatectomy. An overview. World J Urol 13: 88–93, 1995.

3. Kabalin JN, Terris MKT, Mancianti ML, and Fajardo LF: Dosimetry studies utilizing the Urolase right-angle firing neodymium:YAG laser fiber in the human prostate. Lasers Surg Med 18: 72-80, 1996.

4. Kabalin JN, Sellers R, and Bite G: Neodymium:yttriumaluminum-garnet laser dosimetry for the ProLase II side-firing delivery system in the human prostate. Urology 45: 248–252, 1995.

5. te Slaa E, van Ettergem AF, van't Hof CA, Debruyne FMJ, and de la Rosette JJ: Durability of laser fibers. World J Urol 13: 83–87, 1995.

6. Kabalin JN, Bite G, and Doll S: Neodymium:YAG laser coagulation prostatectomy: 3 years of experience with 227 patients. J Urol 155: 181–185, 1996.



