The Truth About Laser Fiber Diameters

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OBJECTIVE To measure the various diameters of laser fibers from various manufacturers and compare them with the advertised diameter.

METHODS Fourteen different unused laser fibers from 6 leading manufacturers with advertised diameters of 200, 270, 272, 273, 365, and 400 μm were measured by light microscopy. The outer diameter (including the fiber coating, cladding, and core), cladding diameter (including the cladding and the fiber core), and core diameter were measured. Industry representatives of the manufacturers were interviewed about the diameter of their fibers.

RESULTS For all fibers, the outer and cladding diameters differed significantly from the advertised diameter ($P < .00001$). The outer diameter, which is of most practical relevance for urologists, exhibited a median increase of 87.3% (range, 50.7%-116.7%). The outer, cladding, and core diameters of fibers with equivalent advertised diameters differed by up to 180, 100, and 78 μm, respectively. Some 200-μm fibers had larger outer diameters than the 270- to 273-μm fibers. All packaging material and all laser fibers lacked clear and precise fiber diameter information labels. Of 12 representatives interviewed, 8, 3, and 1 considered the advertised diameter to be the outer, the cladding, and the core diameter, respectively. Representatives within the same company frequently gave different answers.

CONCLUSION This study suggests that, at present, there is a lack of uniformity between laser fiber manufacturers, and most of the information conveyed to urologists regarding laser fiber diameter may be incorrect. Because fibers larger than the advertised laser fibers are known to influence key interventional parameters, this misinformation can have surgical repercussions. UROLOGY 84: 1301–1307, 2014. © 2014 Elsevier Inc.

In the last 2 decades, urinary stone management has changed markedly, largely because of advances in technology and the development of minimally invasive techniques. One technique that has shown particularly rapid development is endourologic laser lithotripsy.[1,2] The success of laser lithotripsy has promoted the appearance of increasing numbers of laser fiber manufacturers, some of whose fibers have been approved for use with various commercially available lithotripters rather than just 1 particular laser lithotripter machine.[3-5] However, a prevailing perception of the surgeons in our institutions is that the diameters of the laser fibers from different brands differ from the advertised diameters; this is particularly apparent when laser fibers with supposed equal diameters are compared. The surgeons have also noticed inconsistencies in the statements of industry representatives regarding the diameter of their laser fibers.

To date, studies that systematically verify the advertised diameter of laser fibers have not been accomplished. Consequently, the present study was performed to objectively confirm the diameter of several laser fibers and to assess how well the diameters reported by a broad range of industry representatives conformed to the actual practically relevant values.

METHODS

Definitions

There are many terms in the literature for the laser fiber components, including "plastic coating," "polymer jacket," "buffer," "cladding," "primary and secondary cladding," "fiber core," "optical core," "pure silica core," "outside diameter," "inner diameter," "total diameter," "core diameter," and "true diameter."[6-10] Some of these terms refer to the same component or comprise several components, which lead to misinterpretations. To avoid such misunderstandings, the authors called the tested fiber components according to strict and established definitions used by renowned authorities in the field.[8,10] Coating is defined as the usually blue polymer (ethylene tetrafluoroethylene) jacket that covers and protects the glassy optical elements of the fiber, that is, the cladding and the core. The cladding is the outermost glassy component that envelops the core and whose surface is exposed after stripping the coating from the laser fiber. The core is defined as the innermost component of the fiber, which can only be observed by light microscopy of the fiber tip. Thus,

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3 diameters can be defined, the outer diameter (including the fiber coating, cladding, and fiber core), the cladding diameter (comprising the cladding and the core), and the core diameter.

Laser Fibers and Their Preparation

Fourteen different brand-new laser fibers from 6 leading brands (SureFlex, American Medical Systems; EndoBeam, Bard; AccuMax, Boston Scientific; Lightguide, Dornier; SmartFibers, Electro Medical Systems; and SlimLine, Lumenis) were evaluated. These fibers had the numbers 200, 270, 272, 273, 365, or 400 printed on them and on their packaging material. Although careful inspection of all printed packaging and fiber material did not show any references to which diameter these printed numbers referred to, it was assumed to be the advertised diameter in micrometers. Consequently the authors were forced to compare these printed numbers with all possible measured diameters and addressed this issue in the comment section. All fibers tested were sequentially numbered and are listed together with their specifications in Table 1. Two centimeters of the coating on the free extremity of each laser fiber were removed by using a laser fiber stripper that was individually adjusted to each laser fiber (FOC&T GmbH, Burghausen, Germany). The tip of the fiber was then perpendicularly cleaved with a pair of ceramic scissors (CS-124; Kyocera Corporation, Kyoto, Japan).

Measurements

For each fiber, 3 diameters were measured. Eight lateral measurements for each of the outer diameter and the cladding diameter were made by using a calibrated optical microscope (Labophot 2; Nikon Corporation, Tokyo, Japan) and image processing software (Olympus DP-Soft 3.2; Soft Imaging System GmbH) (Fig. 1). Because this technique did not allow us to distinguish the individual optical elements from one another, additional 8 frontal measurements were made, thus allowing the fiber core to be identified and its diameter measured (Fig. 2).

Industry Representative Surveys

For each laser fiber brand that was tested, 2 specialized industry representatives were interviewed regarding the fiber diameter at 2 key urology congresses, namely, the 2013 American Urological Association Annual Meeting in San Diego, CA, and the 28th Annual European Association of Urology Congress in Milan, Italy. In total, 12 representatives were asked what the actual diameters of their fibers were and to which component their answer related.

Statistical Analyses

All measured laser fiber diameters were compared with their advertised diameter. A 10% diameter deviation was arbitrarily considered to be the maximum acceptable deviation. For each fiber, the means ± standard deviations of the measured diameters at the 3 locations were compared with the advertised fiber diameter using the Student t test and computer software (StatEL 2.6; ad Science, Paris, France).

RESULTS

For all fibers, the measured outer diameter differed significantly from the advertised diameter (all $P < .00001$). If the advertised diameter is deemed to be the outer diameter, none of the fibers had a measured diameter within the 10% tolerance range. The outer diameters of the fibers exceeded their advertised diameters by a median of 87.3% (range, 50.7%-116.7%). Four of the fibers (fiber numbers 1, 3, 7, and 13) were more than twice as large as advertised (Figs. 1, 3; Table 1). Three manufacturers had fibers that were advertised to have 200 μm and also had fibers that were advertised to have 270-273 μm. Comparison of the outer diameters of these 200-270 μm pairs (fiber numbers 1, 4, and 10 vs 2, 5, and 11) within each brand revealed that they differed on average by 30.5 μm. In 1 brand, this difference was <15 μm (fiber number 1 and 2). When all 5 fibers from various brands that were advertised as having 200 μm were compared with the 4 fibers that were advertised as having 270-273 μm, several of the presumed 200-μm fibers were actually larger than several of the presumed ~270-μm fibers (fiber numbers 7, 13 vs 2, 5, and 11). Furthermore, when the 4 fibers that were advertised as having 365 μm (fiber numbers 3, 6, 12, and 14) were compared, their outer diameters differed by >180 μm.

The cladding diameter of all fibers also differed significantly from the advertised diameter (all $P < .00001$). If the advertised diameter is deemed to be the cladding diameter, only 1 fiber (fiber number 9) respected the 10% margin. The cladding diameter of the remaining fibers exceeded the advertised diameter by a median of 30.9% (range, 16.7%-80.1%). When the cladding diameters of fibers with a supposed equal diameter were compared, they differed by up to 100 μm.

If the advertised diameter is deemed to be the core diameter, then the majority of the fibers (85.7%) respected the 10% margin. The core diameter of the fibers exceeded the advertised diameter by a median of 0.5% (range, −9.3% to 1.7%). One of the fibers (fiber number 9) was 9.3% thinner than advertised. Only 2 fibers were markedly larger than advertised (19.7% and 39.0% larger for fiber number 7 and 13, respectively). However, when the fibers with a supposed equal diameter were compared, their core diameters differed by up to 78 μm (Figs. 2, 3; Table 1).

In our survey, all industry representatives considered the numbers printed on the fibers or packaging material to represent its diameter. Eight representatives (66.7%) indicated that the advertised diameter was the outer diameter. Three representatives (25%) considered the advertised diameter to be the cladding diameter and acknowledged that the outer fiber diameter was larger than the advertised diameter. Only 1 representative (8.3%) referred the advertised diameter to be the core diameter. Several times, the answer given by 1 representative at 1 congress was different from the response given by another representative from the same company at the other congress.

COMMENT

The veracity of the advertised diameter of laser fibers used in medicine has not been investigated systematically.