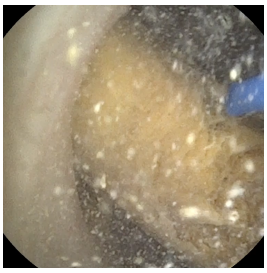

Conflicts of interest

Boston Scientific

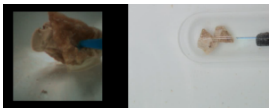
AZ Klina
voluit voor zorg



Ho:YAG laser

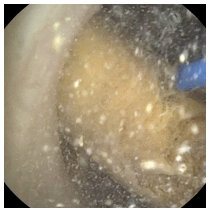
Thulium fiber laser

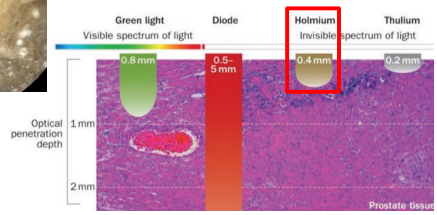
THULIUM FIBER LASER



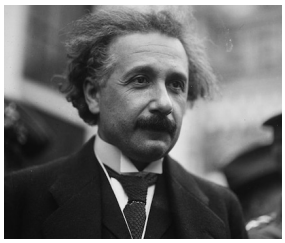
Lasers in Urology

AZ Klina
voluit voor zorg





- LASER
  - Light
  - Amplification by
  - Stimulated
  - Emission of
  - Radiation



- Holmium and Thulium

Marc Delafontaine
1838 - 1911
Swiss

Jaques-Louis Soret
1827 - 1890
Swiss

Per Teodor Cleve
1840 - 1905
Swedish

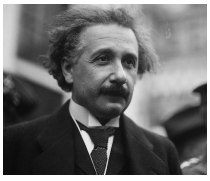

Per Teodor Cleve
1840 - 1905
Swedish

HOLMIUM THULIUM

## Holmium:YAG & Urology

A historical reminder

- LASER
  - Light
  - Amplification by
  - Stimulated
  - Emission of
  - Radiation



AZ Klina
voluit voor zorg

- First Application of Ho:YAG in Urology

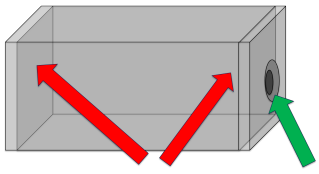
Lasers in Surgery and Medicine 12:353–363 (1992)

**Use of the Holmium:YAG Laser in Urology**

Douglas E. Johnson, MD, Douglas M. Cromeens, DVM, and Roger E. Price, DVM, PhD

*Departments of Urology (D.E.J.) and Veterinary Medicine and Surgery (D.M.C., R.E.P.), University of Texas M. D. Anderson Cancer Center, Houston, Texas 77030*

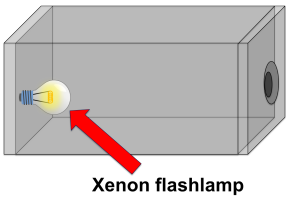
- Holmium:YAG Laser cavity



Laser cavity with two mirrors and one opening

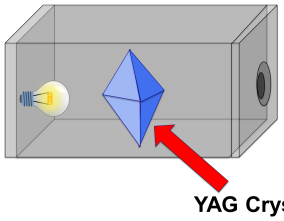
Traxer O., WJUrol 2019

- Holmium:YAG Laser cavity



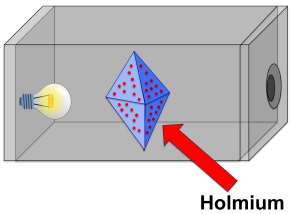

Traxer O., WJUrol 2019

- Holmium:YAG Laser cavity



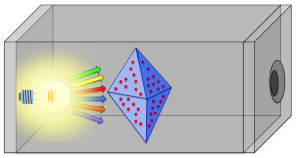

Traxer O., WJUrol 2019

- Holmium:YAG Laser cavity




Traxer O., WJUrol 2019

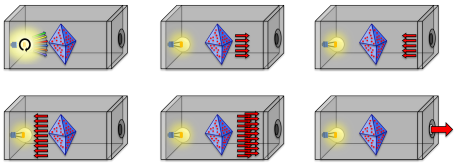
- Holmium:YAG Laser cavity



Laser pumping → exited Holmium ions

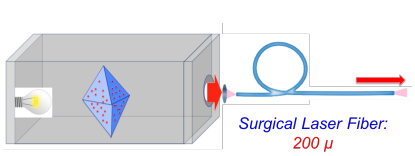
Traxer O., WJUrol 2019

- Holmium:YAG Laser cavity



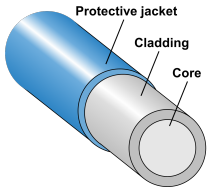

Traxer O., WJUrol 2019

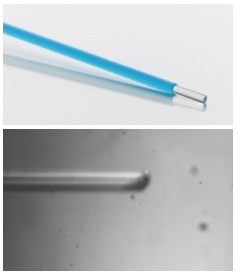
- Holmium:YAG Laser



*Surgical Laser Fiber:*
*200 µ*
*275 µ*
*365 µ*
*550 µ*
*800 µ*

Traxer O., WJUrol 2019

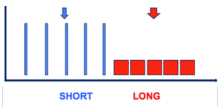


Courtesy of EX Keller

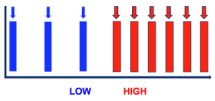
## Laser parameters

- Pulse duration



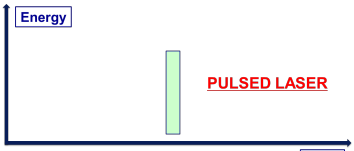

- Energy


- Frequency




Courtesy of O. Traxer

- Laser Power



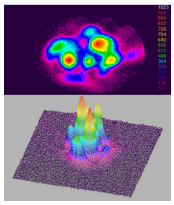

(Power = Energy x Frequency)

Watt = Joule x Hertz

Courtesy of O. Traxer

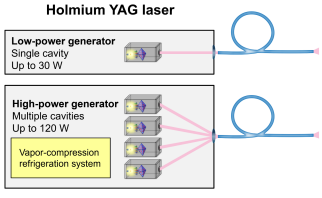
- Holmium:YAG – Advantages
  - Applicable to all urinary stones
  - Flexible laser fibers
  - Minimal tissue penetration

- Holmium:YAG – Limitations
  - Poor output beam profile
    - Smallest laser fiber core >200 µm
  - Vulnerable to external shocks
  - Laser cavity heating
    - Water-cooling system
    - Maximal power <30 W
    - Maximal frequency <30 Hz



Blackmon et al., Optical Engineering 2014

- High-power Holmium:YAG




Traxer O., WJUrol 2019

- High-power Holmium:YAG – Limitations
  - Laser cavity heating
    - Water-cooling system
    - ~~Maximal power <30 W~~ → Up to 120-180W
    - ~~Maximal frequency <30 Hz~~ → Up to 80-100 Hz
  - Poor output beam profile
    - Smallest laser fiber core >200 µm
  - Vulnerable to external shocks

Traxer O., WJUrol 2019


- High-power Holmium:YAG – Limitations
  - Laser cavity heating
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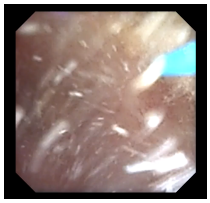
Traxer O., WJUrol 2019


## What do we need?

Future of laser lithotripsy



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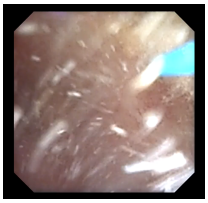
## What do we need?

Future of laser lithotripsy


- Smaller fibers
- Higher efficiency
- Less retropulsion

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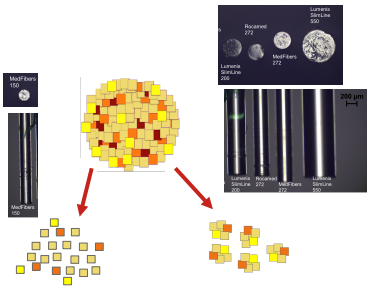
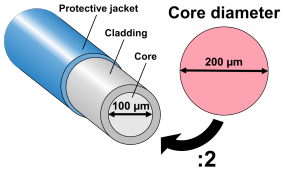
Courtesy of Traxer O.

We need smaller fibers!

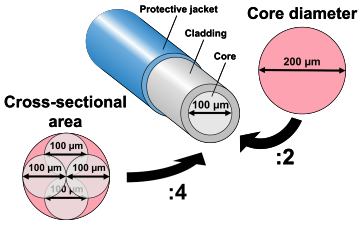



Courtesy of Traxer O.

- Laser fibers

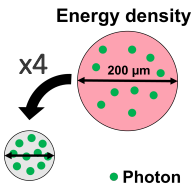



- Laser fibers



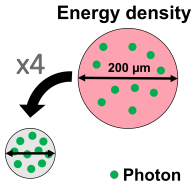

- Laser fibers

We need low pulse energy!

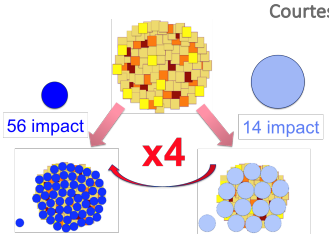



- Laser fibers

We need low pulse energy!




We need a very high frequency!

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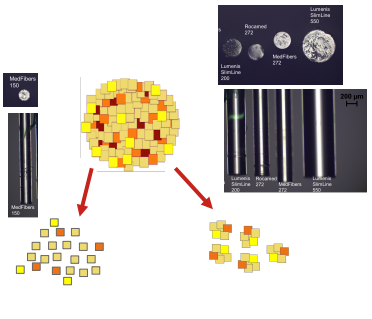

- Laser fibers

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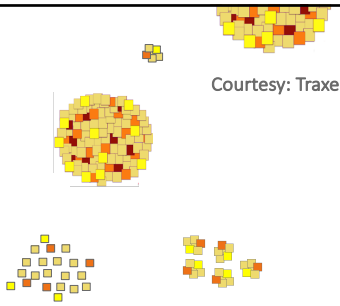
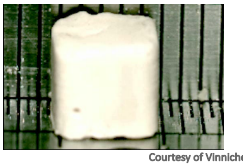


Courtesy: Traxer O.

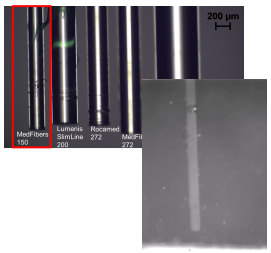
- IDEAL LASER
  - Smaller fibers
    - Smaller fragments
    - Instrument miniaturization
    - Better flow → better visibility
  - High efficiency
    - Low energy: stone dusting
    - High frequency: speed
  - Low retropulsion

Courtesy of Traxer O.



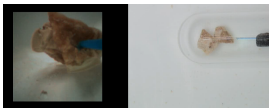
Courtesy of Vinnichenko V.

- IDEAL LASER
  - Smaller fibers
    - Instrument miniaturization
    - Better flow → better visibility
  - Lower pulse energy
    - Stone dusting
  - Higher frequency
    - Ablation efficiency

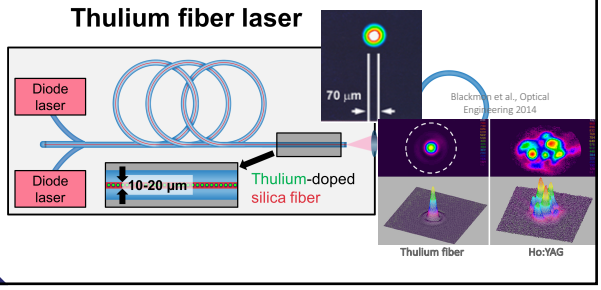



- THULIUM FIBER LASER

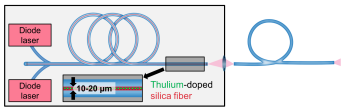
The new player!




**Thulium fiber laser**




**Thulium fiber laser**




≠

**Thulium:YAG laser**

**Solid state cavity**
Continuous wave

## • Ho:YAG versus Tm Fiber Laser

**Table 1** Characteristics of two generators: Holmium:YAG laser and Thulium fiber laser

| Parameter | Holmium:YAG laser (Lumenis Pulse 120H) | Thulium fiber laser (IPG Medical, Superpulse) |
|---|---|---|
| Wavelength | 2120 nm | 1940 nm |
| Pulse energy range | 0.2–6.0 J | 0.025–6.0 J |
| Pulse duration range | 0.05–1 ms | 0.05–12 ms |
| Pulse shape | Dictated by the pumping pulse | Electronically modulated |
| Maximum pulse frequency | 120 Hz | 2000 Hz |
| Maximum average power | 120 W | 60 W |
| Lowest proximal laser fiber core diameter | ≥ 200 µm | ≥ 150 µm |
| Cooling system | Low-power generators: self-contained water-cooling system with fan<br>High-power generators: vapor-compression refrigeration system | Fan |
| Resistance to external shocks | Low | High |

Traxer and Keller, WJUrol 2019

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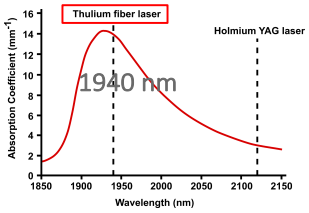
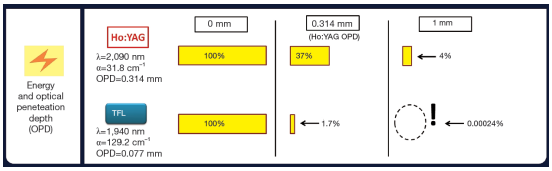
Traxer and Keller, WJUrol 2019

## • Water absorption peak




closely matching water absorption peak in stones and tissue

**4.5x lower ablation threshold of stones and tissue**




Kronenberg P and Traxer O, Transl Androl Urol, 2019

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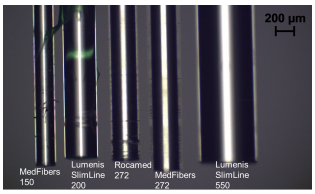
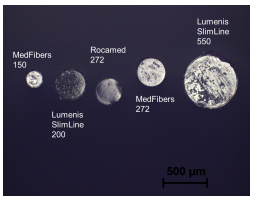
Traxer and Keller, WJUrol 2019

## • Laser fibers

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Traxer and Keller, WJUrol 2019

## What else?

Future of laser lithotripsy

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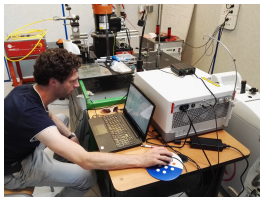
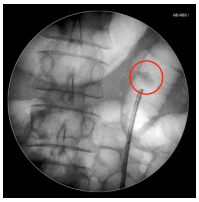
## Where is the evidence?

Thulium fiber laser





AZ Klina
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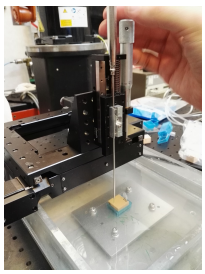

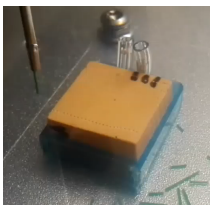

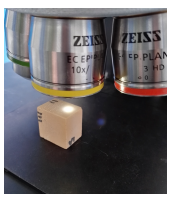

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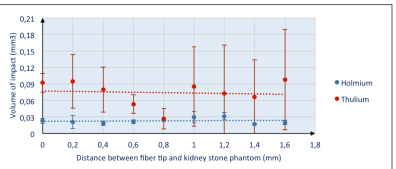
# SuperPulsed Thulium Fiber Laser for endocorporeal lithotripsy: superior from the very first pulse?

P. Chiron [1,2], L. Berthe [2], V. De Coninck [3], E.X. Keller [3], S. Doizi [3] and O. Traxer [3]




| Distance between optical fiber and stone (mm) | 0 | 0,2 | 0,4 | 0,6 | 0,8 | 1 | 1,2 | 1,4 | 1,6 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| Ablation volume with Thulium ($mm^3$) | 0,09 | 0,10 | 0,08 | 0,06 | 0,03 | 0,07 | 0,05 | 0,05 | 0,07 | 0,07 |
| Ablation volume with Ho:YAG ($mm^3$) | 0,02 | 0,02 | 0,02 | 0,02 | 0,03 | 0,03 | 0,03 | 0,02 | 0,02 | 0,02 |
| Ratio | **4,11** | **4,70** | **4,30** | **2,60** | **1,01** | **2,45** | **1,62** | **2,95** | **3,66** | **3,04** |

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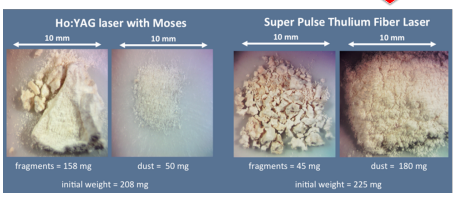
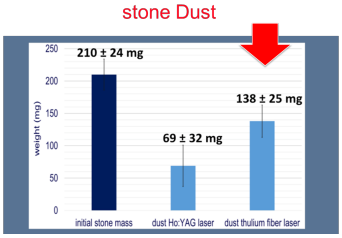
# Dusting Efficiency Comparison between **Moses Technology** of Ho:YAG Laser and **SuperPulse Thulium Fiber Laser**

**Vincent De Coninck**, E.X. Keller, P. Chiron, A. Kovalenko, V. Andreeva, O. Traxer

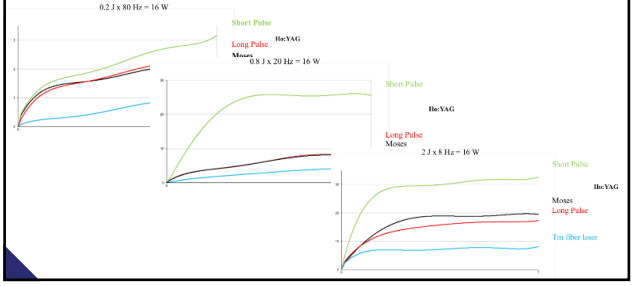
## THULIUM FIBER produced TWICE as much stone Dust




## THULIUM FIBER produced TWICE as much stone Dust




## • RETROPULSION: Tm Fiber versus Moses



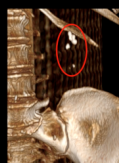
# Thulium fiber laser for lithotripsy of large renal stones: initial experience

Etienne Xavier Keller[1,2], Vincent De Coninck[1,2], Paul Chiron[1,2], Steeve Doizi[1,2], Mirab Guseynov[3], Dmitry Ergakov[3], Alexey Martov[3] and Olivier Traxer[1,2]

1. Service d'Urologie, AP-HP, Hôpital Tenon, Paris, France
2. Sorbonne Université, GRC n°20, Hôpital Tenon, Paris, France
3. Federal Medical-Biological Agency of Russian Federation State Institute of Continuous Medical Education, Division of Urology, Moscow, Russia

## Case

- Five stones, 6 to 12 mm
- Operative time
  - Dusting: 30 min
  - Pop-corning: 10 min
  - **Total: 40 min**



## Case

- One stone, 30 x 20 x 20 mm
- Operative time
  - Dusting: 23 min
  - Pop-corning: 14 min
  - Total: 37 min

## Case 2

## Ultra mini Perc with Tm Super Pulse

- 34 patients
- 7.5 Fr Nephroscope
- 200µm TSPFL
- Effective and safe

| Results | Value |
|---|---|
| Stone free-rate (no residuals) | 94 % (32/34) |
| Clinically insignificant residuals (<3mm) | 6% (2/34) |
| Op time, min | 29 ± 9 |
| Lasering time, min | **8 ± 6** |
| Complications | No bleeding or perforation |
| Drainage | Nephrostomy tube (10F) for 1 day 67% (23/34), JJ-stent – 33% (11/34) |
| Hospitalization time, days | 3.4 ± 1.2 |

First Ultra-mini-percutaneous Nephrolithotripsy (UM-PCNL) with the New Thulium SuperPulse Fiber Laser (TSPFL)

MP 12-3 Martov et al.

## Possibly use for UTUC management

11 patients

1 to 4 cm Tumors

The initial data suggests that TSPFL is a capable modality for fast and safe removal of UTUC SPIES or NBI assisted ureteroscopies are justified. Further clinical studies are required.

Thulium SuperPulse Fiber Laser (TSPFL) in the endourological management of upper urinary tract urothelial carcinoma (UTUC).

MP 23-19 Martov et al

## • Systematic review

World Journal of Urology
https://doi.org/10.1007/s00345-019-02654-5

INVITED REVIEW

**Thulium fiber laser: the new player for kidney stone treatment? A comparison with Holmium:YAG laser**

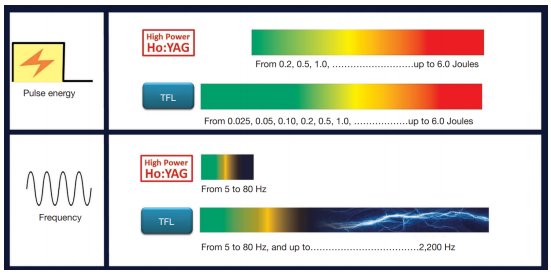
Olivier Traxer[1,2] · Etienne Xavier Keller[1,2,3]

Received: 6 January 2019 / Accepted: 24 January 2019

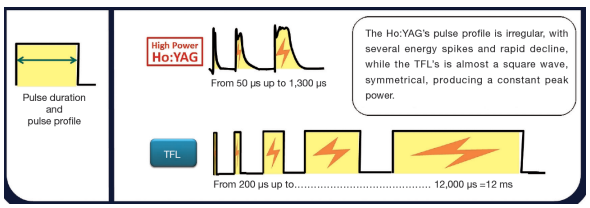

**Abstract**
**Purpose** To compare the operating modes of the Holmium:YAG laser and Thulium fiber laser. Additionally, currently available literature on Thulium fiber laser lithotripsy is reviewed.
**Materials and methods** Medline, Scopus, Embase, and Web of Science databases were searched for articles relating to the operating modes of Holmium:YAG and Thulium fiber lasers, including systematic review of articles on Thulium fiber laser

Table 2 Prior experimental studies comparing Holmium:YAG laser and Thulium fiber laser for lithotripsy

| References | Year | Aim of the study | Study settings | Laser settings | | Primary outcome | Secondary outcomes |
|---|---|---|---|---|---|---|---|
| | | | | Holmium | Thulium | | |
| Blackmon et al. [55] | 2010 | To compare lithotripsy efficiency between the Holmium:YAG laser and the Thulium fiber laser | 100 µm core diameter fiber; lithotripsy on COM and UA stones | 0.07 J<br>3 Hz<br>220 ms pulse duration | 0.07 J<br>10 Hz<br>1000 µs pulse duration | 5–10 times higher ablation efficiency in favor of the Thulium fiber laser | At 0.07 J, the Thulium fiber laser produces cleaner craters on stones at 1 ms compared to 20 ms pulse duration |
| Blackmon et al. [56] | 2011 | To compare ablation threshold and retropulsion between the Holmium:YAG laser and the Thulium fiber laser | 200–270 µm core diameter; lithotripsy on COM, UA and PuP stones | 0.03–0.55 J<br>10 Hz<br>30–500 µs pulse duration | 0.005–0.035 J<br>10–400 Hz<br>500 µs pulse duration | 4 times lower ablation threshold in favor of the Thulium fiber laser | Holmium: linear increase of stone retropulsion with pulse energy; Thulium: minimal retropulsion at 0.035 J and ≤ 100 Hz |
| Blackmon et al. [70] | 2013 | To compare the stone-suctioning effect of the Holmium:YAG laser with the Thulium fiber laser | 272 µm core diameter fiber; lithotripsy on PuP stones | 0.035–0.36 J<br>20 Hz<br>300 µs pulse duration | 0.035 J<br>10–150 Hz<br>500 µs pulse duration | Stone-suctioning effect is possible | Better stone-suctioning in favor of the Thulium fiber laser |
| Hardy et al. [57] | 2014 | To compare lithotripsy efficiency and irrigation temperature between the Holmium:YAG laser and the Thulium fiber laser | Holmium: 272 µm core diameter fiber; Thulium: 100 µm core diameter fiber; lithotripsy on COM stones | 0.6 J<br>6 Hz<br>350 µs pulse duration | 0.035 J<br>150–500 Hz<br>500 µs pulse duration | 1.5, 4.3, and 7.3 times faster lithotripsy in favor of the Thulium fiber laser at 150, 300 and 500 Hz | Mean peak irrigation temperature of 24 °C for Holmium:YAG lithotripsy and 33 °C, 33 °C and 39 °C for Thulium fiber laser lithotripsy at 150, 300 and 500 Hz |
| Wilson [58] | 2016 | To compare proximal fiber tip damage between the Holmium:YAG laser and the Thulium fiber laser | Holmium: 270 µm core diameter fiber after in vivo lithotripsy; Thulium: 105 µm core diameter fiber after lasing in air | 0.6 J<br>6 Hz<br>350 µs pulse duration | 0.035 J<br>50–400 Hz<br>500 µs pulse duration | No damage after laser delivery with the Thulium fiber laser; microscopic damages on all fibers after Holmium lithotripsy | – |




Kronenberg P and Traxer O, Transl Androl Urol, 2019

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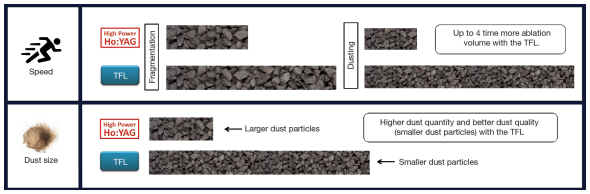
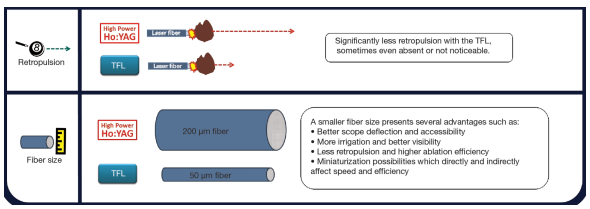
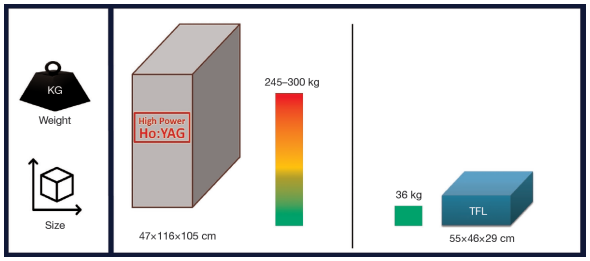



Kronenberg P and Traxer O, Transl Androl Urol, 2019




Kronenberg P and Traxer O, Transl Androl Urol, 2019

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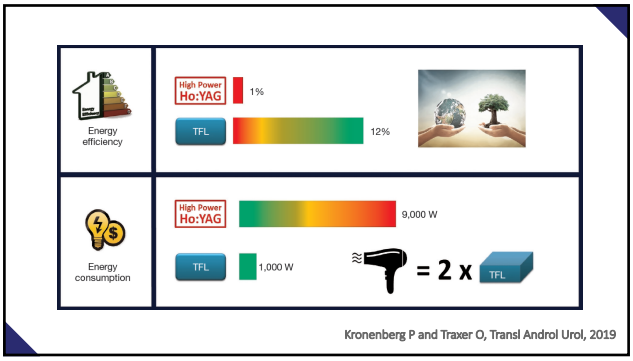
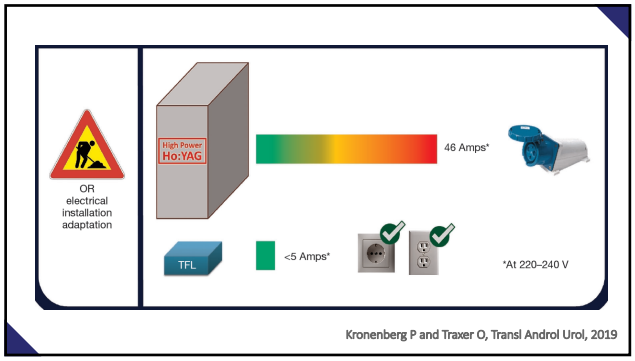

Energy efficiency
High Power Ho:YAG
1%
TFL
12%
Energy consumption
High Power Ho:YAG
9,000 W
TFL
1,000 W
≈
= 2 x
TFL
Kronenberg P and Traxer O, Transl Androl Urol, 2019


OR
electrical
installation
adaptation
High Power Ho:YAG
46 Amps*
TFL
<5 Amps*
*At 220–240 V
Kronenberg P and Traxer O, Transl Androl Urol, 2019


The type of laser matters
BAU 2019, Oostende| Vincent De Coninck, MD, FEBU | November 29, 2019
@vdconinck
AZ Klina
voluit voor zorg