Lasers

p-Tm:YAG systems rated the best for coagulation

The holmium:yttrium aluminum garnet (Ho:YAG) laser is the most common type of laser used for lithotripsy and laser enucleation of the prostate and has been used for over ten years and is considered the gold standard. However, with novel developments in laser technology, different laser types for lithotripsy and laser enucleation are now attracting attention.

Study: Preclinical comparison of a novel pulsed solid-state Tm: YAG laser versus TFL & Ho:YAG technologies

A novel pulsed thulium:yttrium aluminum garnet laser (p-Tm:YAG) has recently emerged, which is not to be confused with the continuous wave (CW)-Tm: YAG's and Thulium fiber laser's (TFL) technology. These laser technologies used in urology offer different emission wavelengths, resulting in different water absorption and thus slightly varying laser-tissue interaction (see Table 1). The lowest water absorption coefficient among these lasers has the Ho:YAG laser technology, followed by the p-Tm:YAG laser with about twice the absorption and the TFL laser technology with about four times the absorption compared to the Ho:YAG laser technology. This results in a lower penetration depth for p-Tm:YAG of about 0.3 mm and for TFL of about 0.2 mm compared to the gold standard Ho:YAG technology (~0.4 mm).

Specification	Ho:YAG laser	p-Tm:YAG laser	TFL
Wavelength (nm)	2100 nm	2013	1940
Absorption coefficient (1/m)	3198	5888	12392
Penetration depth into biological tissue (mm)	~0.4	~0.3	~0.2

▲ *Table 1: Comparison of wavelength and absorption coefficients between Ho:YAG laser, p-Tm:YAG laser, and TFL. Due to the different wavelength-related absorption coefficients, the two laser techniques have different penetration depths.*

Laser technology has been used to treat urinary stones or to cut soft tissue and enucleated prostate tissue for years. These applications are possible with lasers due to the various adjustable parameters such as laser pulse energy, pulse frequency, pulse duration, and laser output power. With well-matched laser parameters, various approaches for stone management such as dusting or fragmentation as well as tissue cutting such as ablation, vaporization, or coagulation can be achieved.

Objective

This literature review focuses on the novel p-Tm:YAG laser and its performance in preclinical studies for dusting and fragmentation of stones, tissue cutting, and enucleation in vitro settings.

Research Findings

Author and study title	Year	Key findings and benefits
Kraft, L. et al.[1] Dusting efficiency of a novel, pulsed Thulium: YAG laser versus a Thulium fiber laser	2022	**The p-Tm: YAG's dusting efficiency resembled TFL in the identical pulse energy and frequency laser configurations.** The ablation efficiency did not seem to be affected by the laser devices' differences in pulse duration. Slower laser fiber-motion speeds enhanced the dusting efficiency. **When using the high-frequency settings (e.g., 1600 Hz), TFL's dusting efficiency appeared to be inefficient.** A moderate frequency configuration (up to 200 Hz) seemed to yield satisfactory dusting efficiency from both laser devices since it went hand in hand with a sufficient energy configuration.
Kraft, L. et al.[2] In vitro fragmentation performance of a novel, pulsed Thulium solid-state laser compared to a Thulium fibre laser and standard Ho:YAG	2022	To fragment the stone models, both Ho:YAG and p-Tm:YAG required similar total energy ($p = 0.97$). **TFL's fragmentation efficiency is significantly lower than Ho:YAG and p-Tm:YAG.** Furthermore, we found that the novel p-Tm: YAG's fragmentation efficiency closely resembles Ho:YAG. The fragmentation efficiency is thought to be influenced by the pulse duration. TFL's shortest possible pulse duration was considerably longer than that of Ho:YAG and p-Tm:YAG, resulting in Ho:YAG and p-Tm:YAG exhibiting better fragmenting efficiency.
Yilmaz, M. et al.[3] Experimental ex-vivo performance study comparing a novel, pulsed thulium solid-state laser, chopped thulium fibre laser, low and high-power holmium:YAG laser for endoscopic enucleation of the prostate	2022	Different laser systems are increasingly used to treat LUTS in BPH patients surgically. The authors explored four laser systems in different settings suitable for EEP under standardized experimental ex-vivo conditions. The results deepened the knowledge about the targeted deployment of lasers in endourology. High power Ho:YAG was proven to be the most satisfactory laser device for the surgeon with the best enucleation performance, followed by the p-Tm:YAG. **The p-Tm:YAG coagulation performance was rated highest among all tested lasers.** However, as this research project was experimental in nature, its findings' clinical relevance is probably limited and will have to be further confirmed, particularly by clinical investigations.

Conclusion

The three preclinical studies examined the performance of a pulsed solid-state Tm:YAG (p-Tm:YAG) laser for stone dusting and fragmentation as well as enucleation and coagulation.

For dusting efficiency for urinary stone disintegration, the p-Tm:YAG laser demonstrated excellent dusting performance that resembled the TFL's performance. In addition, it was shown that very high-frequency settings (up to 1600 Hz) appeared to be inefficient, as only low pulse energy could be set with these settings. Furthermore, dusting efficiency did not appear to be affected by pulse duration but could be increased at slower fiber movement rates. For stone fragmentation, both Ho: YAG's and p-Tm: YAG's ablation efficiency were higher than TFL's. It was thought that the fragmentation efficiency was favored by shorter pulse duration, resulting in the Ho:YAG and p-Tm:YAG having better efficiency compared to the TFL, as its shortest pulse length was significantly longer than that of Ho:YAG and p-Tm:YAG. In terms of laser enucleation of the prostate, the high-power Ho:YAG laser system was the most satisfactory laser device for the surgeon, followed by the p-Tm:YAG laser system. Lastly, the p-Tm:YAG system was rated highest for coagulation performance among all tested laser systems.

Overall, the preclinical studies demonstrated that the p-Tm:YAG laser was similar to Ho:YAG fragmentation behavior and TFL dusting performance for urinary stone disintegration. Additionally, the p-Tm:YAG demonstrated better fragmentation performance than TFL technology and better coagulation performance than Ho:YAG technology.

Glossary

p-Tm:YAG: Pulsed Thulium:Yttrium-Aluminum-Garnet Laser

Ho:YAG: Holmium:Yttrium-Aluminum-Garnet Laser

TFL: Thulium Fiber Laser

References

1. Kraft, L. et al. (2022). *Dusting efficiency of a novel, pulsed Thulium:YAG laser versus a Thulium fiber laser.* J Endourol, 36(2):259-265. https://doi.org/10.1089/end.2021.0441
2. Kraft, L. et al. (2022). *In vitro fragmentation performance of a novel, pulsed Thulium solid-state laser compared to a Thulium fibre laser and standard Ho:YAG.* Lasers Med Sci, 37(3):2071-2078. https://doi.org/10.1007/s10103-021-03495-8
3. Yilmaz, M. et al. (2022). *Experimental ex-vivo performance study comparing a novel, pulsed thulium solid-state laser, chopped thulium fibre laser, low and high-power holmium:YAG laser for endoscopic enucleation of the prostate.* World J Urol, 40(2):601-606. https://doi.org/10.1007/s00345-021-03825-z

Manufacturer's note: The pulsed Tm:YAG (p-Tm:YAG) device is now the CE marked Dornier Thulio from Dornier MedTech.