

# Comparison of Er:YAG and Er:YSGG Medical Lasers

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## INTRODUCTION

The erbium Er:YAG laser has been recognized as the medical laser of choice for effective, precise and minimally invasive ablation of human soft and hard tissues. Of all infrared lasers, the Er:YAG laser wavelength of 2.94  $\mu\text{m}$  has the highest absorption in water and hydroxyapatite (see Fig. 1) and is thus optimal for “cold” ablation of human tissues. Another laser that emits in the 3  $\mu\text{m}$  region is the Er:YSGG (2.78  $\mu\text{m}$ ) laser, however this laser exhibits already 300% lower absorption and is thus less suitable for laser ablation.

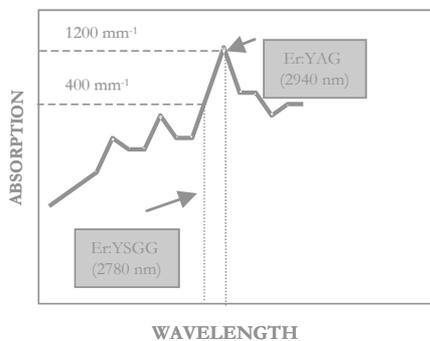


Fig.1: The Er:YAG (2.94  $\mu\text{m}$ ) laser has the highest absorption in water and hydroxyapatite. Another laser that emits in the 3  $\mu\text{m}$  region is the Er:YSGG (2.78  $\mu\text{m}$ ) laser, however this laser exhibits already 300% lower absorption and is thus less suitable for laser drilling.

## Er:YAG MEDICAL PHYSICS

It is now accepted and understood that depending on the laser pulse duration and the laser pulse energy (or more correctly, laser fluence, i.e. the laser energy per surface area (in  $\text{J}/\text{cm}^2$ )) there are four ablation regimes (See Fig.2).<sup>2</sup>

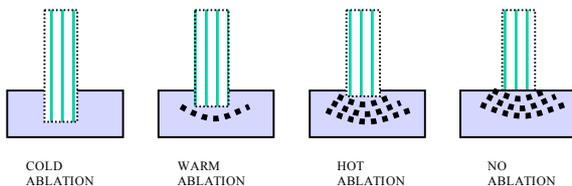


Fig.2: Schematic overview of the four ablation regimes.

At high energies and low pulse durations, the speed of ablation is faster than the diffusion of heat into the tissue

with all of the energy used up for COLD ABLATION. With decreasing energies and/or longer pulse durations, the thermally influenced layer of tissue becomes thicker by the end of the pulse. The thermal effects become more pronounced and the ablation efficiency is considerably reduced (WARM and at even lower energies HOT ABLATION). At energies below the ablation threshold there is NO ABLATION, consequently all the energy is released in the form of heat, independent of laser pulse duration.

It is important to note that by decreasing the laser energy, with the intention of working more safely, the operator may achieve precisely the opposite, i.e. more thermal effects in the tissue. The important factor that can be used to determine the effect of the laser energy on dental tissue is the Peclet<sup>6</sup> or the Laser – Tissue Number (LTN). LTN that is defined by:

$$LTN = \text{Laser Intensity} \times \text{LTF} ,$$

where

$$\text{Laser intensity} = \text{Laser Fluence} / \text{Laser Pulse Duration},$$

and the LTF (Laser Tissue Factor) is a constant factor that depends on the laser wavelength and the particular dental tissue physical properties:

$$LTF = 0.5 \times \text{Laser Absorp. Coeff.} \times \text{Tissue Therm. Relax. Time} / \text{Specific Heat of Ablation}$$

For laser fluences above the ablation threshold the cold ablation regime is characterized by  $LTN > 1$ .

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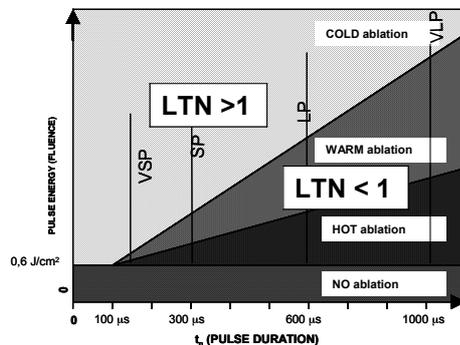


Fig.3: The influence of effect of the Er:YAG laser beam on human skin in the four ablation regimes. To achieve cold ablation the operator must select laser parameters where  $LTN > 1$ .

As can be seen from Figure 3, in order to perform very precise and fine treatments at low laser energies, the laser pulses must be sufficiently short in order for LTN to be greater than 1.

For standard work the Er:YAG VSP and SP pulses with LTN above 1 are recommended. When thermal coagulation effects are desirable, the LP and VLP modes are best suited.<sup>1</sup>

### COMPARISON OF Er:YAG and Er:YSGG

Since the absorption coefficient of Er:YSGG is three times smaller than that of Er:YAG the range of safe parameters that can be used is considerably reduced when using Er:YSGG (See Fig. 4). Firstly, the ablation threshold energy is three times higher. Secondly, in order to achieve  $LTN > 1$ , fluences that are three times higher are required. It is for this reason that most Er:YSGG lasers operate at considerably lower ablation efficiency and closer or inside the warm/hot ablation regimes. The Er:YSGG medical lasers are thus slower, less safe and a less versatile choice for medical use.

### REFERENCES

1. VSP, SP, LP and VLP are the variable square pulse technology Er:YAG pulse notations by Fotona d.d.. ([www.fotona.si](http://www.fotona.si)).
2. B. Majaron, D. Sustercic, M. Lukac, U. Skaleric, N. Funduk. Heat Diffusion and Debris Screening in Er:YAG Laser Ablation of Hard Biological Tissues. Appl. Phys. B 66,1-9 (1998).

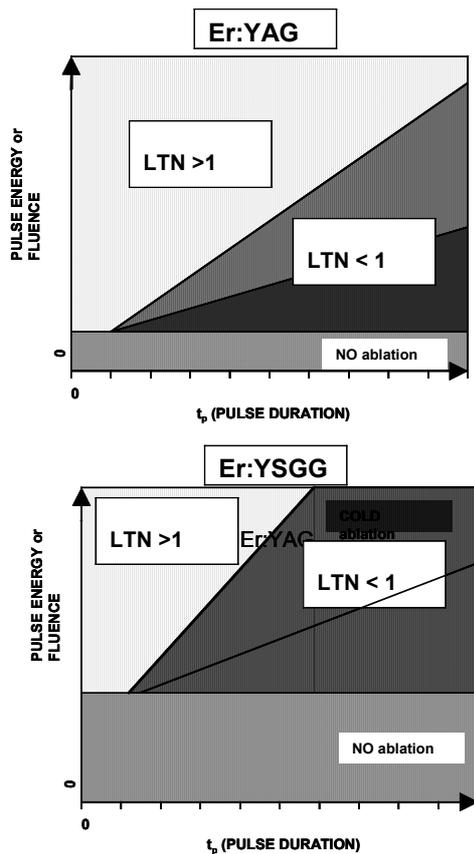


Fig.4: Comparison of treatment regimes for Er:YAG and Er:YSGG lasers. The ablation threshold is much higher, and the safe regime (where  $LTN > 1$ ) for cold skin treatments is much smaller when using an Er:YSGG laser.