

Therapeutic Factors Related to Solid State Laser Wavelengths for Custom Surgery

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Generation of Laser Wavelengths

Excimer 193 nm:

Gas-Halide Mixtures

Solid State 213 nm:

Nd:YAG laser delivered through Non-linear Crystals for frequency conversion.

Histology

213 nm

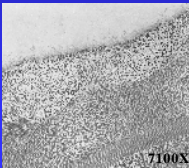


40X

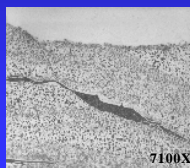
193 nm



40X



7100X



7100X

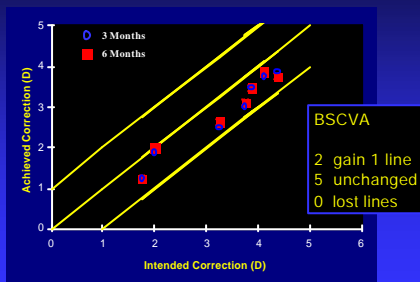
Clinical Course & Histopathology

In vivo rabbit

- PRK with a solid state 213nm laser
- Clinical time course of 3 months
- Results revealed similar clinical and histopathology course to the 193nm PRK study in rabbits

Ren, Q., G. Simon, et al. (1993). "Ultraviolet Solid-state Laser (213nm) Photorefractive Keratectomy In Vivo Study." *Ophthalmology* 101: 883-889.

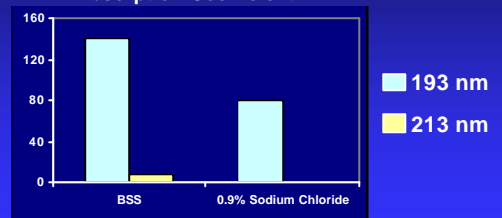
3 and 6 Months Post PRK with 213nm Ablation



Absorbance Characteristics

Attenuation through BSS and NaCl at 213nm is significantly less than for 193nm

Absorption Coefficient



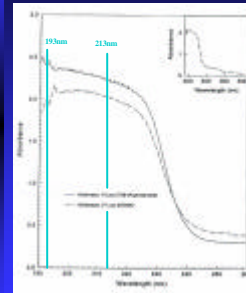
Dair, G.T., Ashman, R.A., Eikelboom, R.H., Reinholz, F., van Saarloos, P.P. (2001) Absorption of 193 and 213 nm laser wavelengths in sodium chloride solutions and balanced salt solution. *Archives of Ophthalmology*, 119: 533-537.

Absorption: Clinical Significance

“The absorbance of 213nm light in BSS & Na Cl is much lower than 193nm”

- More reliable, predictable treatment outcomes
- Fluctuations in corneal hydration or environmental humidity are unlikely to have a significant effect upon the performance of the solid state laser

UV Absorption Spectra of Human Cornea



- The absorbance dependence on the wavelength for two human corneal samples between 260nm and 190nm
- A “window of ablation” in the far UV region between 220nm-190nm.

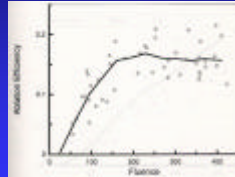
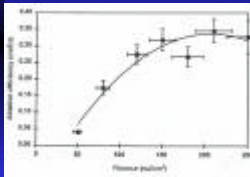
Lembares, A., Hu, X., & Kalmus, G. W. (1997). Far ultraviolet absorption spectra of porcine and human corneas. *SPIE*. 2971: 277-786.

Ablation Efficiency

- Calculated efficiency (mm²/J) of ablation of bovine (193nm) and porcine (213nm) corneal stroma plotted as a function of fluence (mJ/cm²)

213 nm

193 nm

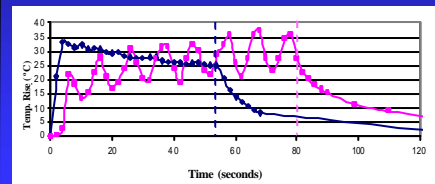


Dair, G.T., Pelouch, W.S., van Saarloos, P.P., Lloyd, D.J., Paz Linares, S.M., Reinholz, F. (1999). Investigation of Corneal Ablation Efficiency Using Ultraviolet 213nm Solid State Laser Pulses. *IOVS* 40 (1): 2752-2756.

Van Saarloos PP, Constable U. (1990) Bovine corneal stroma ablation rate with 193nm excimer laser radiation: Quantitative measurement. *J. Refrac. Corneal Surg.* 6: 424-429.

Tissue Thermal Effect

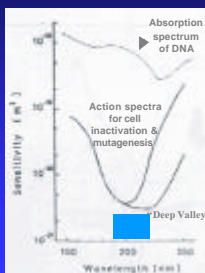
- Infra-red camera (Thermocam SC 1000)
- PMMA samples
- Ablation plan: -9D, 6mm diameter



□ Pulzar 213nm
□ 193nm

Cytotoxicity & Mutagenicity

Action spectra for cell inactivation and mutagenesis for bacterial and yeast cells after exposure to radiation in a vacuum



- 190- 220nm range less sensitive
- Nuclear DNA could be protected from this range of UV light by the surrounding cytoplasmic components

Munakata et al (1986) plus supplementary data (Hieda & Ito, 1986)

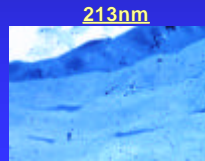
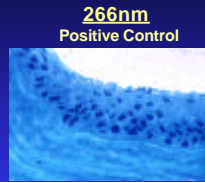
In Vitro: Cytotoxicity & Mutagenicity

- Free radical production: Comparable levels for both 193nm and 213nm (Ediger *et al.*, 1997)
- In vitro* study, Kaido *et al.*, (2002) (Coherent Medical) compared mutagenic and cytotoxic potential between 193nm and 213nm
- Technical issues with in vitro studies:-
 - Cells wet- shielded 193nm radiation
 - 213nm beam contaminated with 266nm radiation.

DNA Damage *In vivo* study:

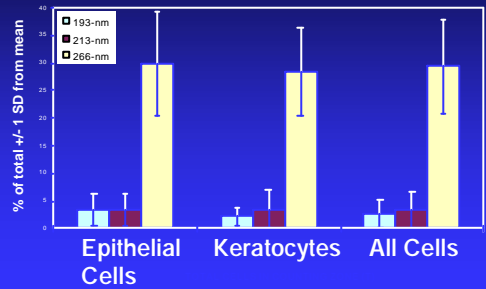
Unscheduled DNA Synthesis (UDS)

- Eyes Ablated with 193, 213 and 266nm.
- For 193 & 213 nm: < 5% (average) of cells were affected.
- 193 & 213 nm Produce Minimal DNA damage.



(Eikelboom, R., van Saarloos, P.P., Pelouch, W., Lloyd, D., Paz, S. New Solid State laser (213 nm) tested for refractive surgery in rabbits. LEI, W.A.)

Percentage of cells with Unscheduled DNA Synthesis



Solid State Lasers May Be An Improved Option for Refractive Surgery

SAFE

Molecular and histological studies reveal similar results to 193nm

In vivo mutagenicity studies – greater significance

PERFORMANCE ADVANTAGES

- Transmission through Aqueous solutions
- Higher Corneal Ablation Efficiency
- May Produce Less Thermal Effect

For further information on 213nm Characteristics, see poster: 'Laser Wavelengths in Ophthalmology: Critical Review'; Ian Anderson, MD

THANK YOU!!!!