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IntraLase FS Laser Results Update

Historical Background of Femtosecond Lasers

Femtosecond lasers have become so commonplace in laser vision correction that we often forget how remarkably advanced this technology is. These are, after all, the fastest lasers in the world. The energy pulses with a speed of one pulse every 10^{-15} seconds or one pulse every femtosecond. How fast is this? Just think - there are more femtoseconds in one second than there have been hours since the universe began 14 billion years ago!

This is so fast, in fact, that the laser emits pulses at a faster rate than the pulsating energy between the atoms in a molecule. The original application was actually in chemistry – femtosecond laser was used as an ultra-fast camera to photograph the bonds between the atoms in a molecule (Figure 1). This discovery led to a Nobel Prize. Since then, the femtosecond lasers have been applied not only to visualize but also to separate the bonds between the atoms in a molecule with unprecedented precision. The applications of this technology span a wide range of fields: metallurgy (to separate the bonds between the molecules of steel, Figure 2), semiconductor technology, cardiology (to create ultra-precise tiny stents for the blood vessels in the heart), biology (to alter organelles, such as mitochondria, for example, inside a single cell), and, of course, eye surgery (Figure 3).

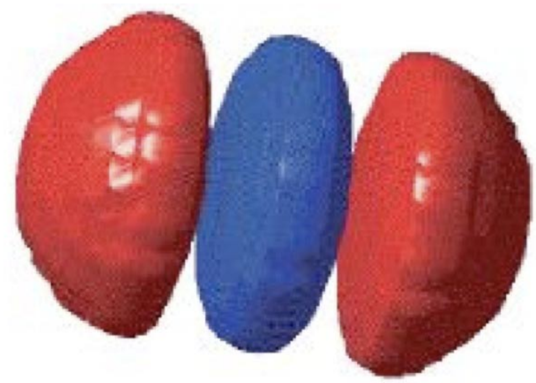


Figure 1: Nitrogen molecule photographed with a femtosecond laser. The red are the nitrogen atoms. The blue is the actual energy bond between the two atoms.

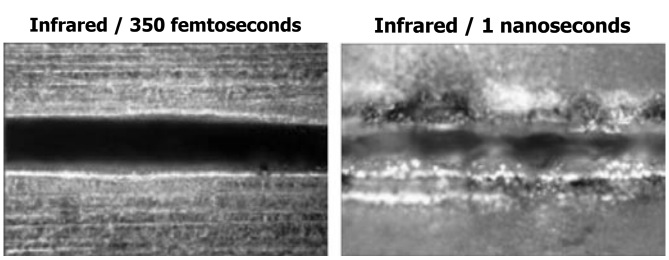


Figure 2: Layers of aluminum separated with femtosecond laser speed (left) vs. nanosecond laser speed (right). Femtosecond lasers are much faster than nanosecond lasers (1 pulse every 10^{-15} sec vs. 1 pulse every 10^{-9} sec), which minimizes the effect on the surrounding areas.

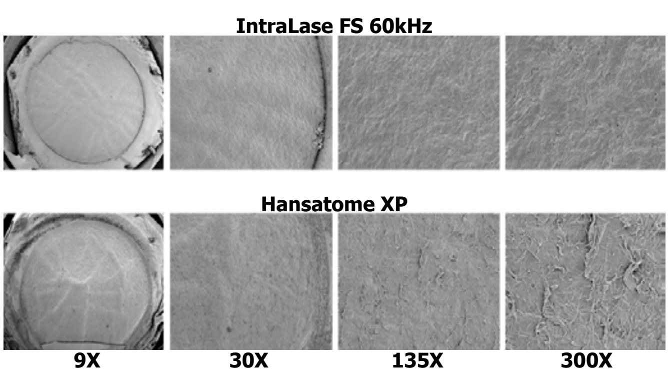


Figure 3: Corneal flap created with the 4th generation, 60 kHz IntraLase FS laser vs. Hansatome XP mechanical microkeratome. High magnification reveals extremely smooth quality of the corneal bed with 60 kHz IntraLase FS laser.

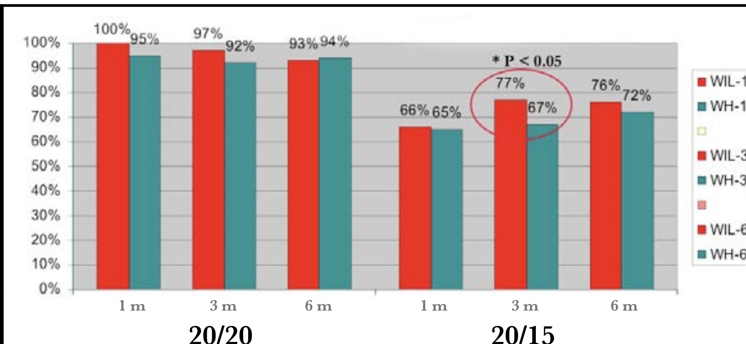


Figure 4A

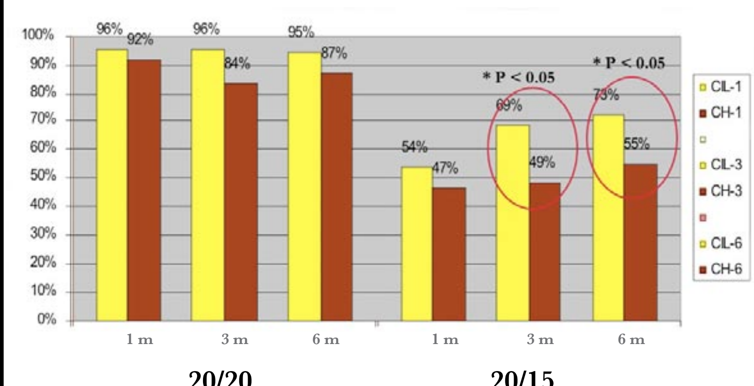


Figure 4B

Postoperative uncorrected visual acuity after wavefront (4A) and conventional (4B) LASIK with IntraLase FS laser vs. mechanical microkeratome.

Visual Acuity Results

Peer reviewed studies show better uncorrected visual acuity (UCVA) with IntraLase FS laser.[1,2] For example, in our study (presented at the 2005 American Academy of Ophthalmology), more eyes were seeing 20/15 or better with both wavefront and conventional LASIK treatments (Figures 4 A and 4B). Multivariate analysis showed better best-corrected visual acuity (BCVA) correlated with better UCVA (Figures 5A and 5B). Fewer eyes lost BCVA with IntraLase. Less induced cylinder has been reported after IntraLase procedures. [3]

Wavefront Aberrations Results

More favorable aberrations profile has been reported after the IntraLase procedures – in both wavefront and conventional excimer treatments. [1,2,4,5] Fewer higher order aberrations are observed. Figure 6A and 6B demonstrate less vertical coma, horizontal trefoil, total higher order aberations, and horizontal coma after IntraLASE procedures. IntraLase flaps are more aberrations-neutral (Figures 7 and 8).[5] Fewer induced aberrations lead to more accurate wavefront-guided corrections.

Femtodynamics

To optimize the outcomes with femtosecond laser technology, we developed a system called Femtodynamics. Femtodynamics is a system of optimizing femtosecond laser settings and procedure techniques to insure that "just enough" energy is delivered to create a

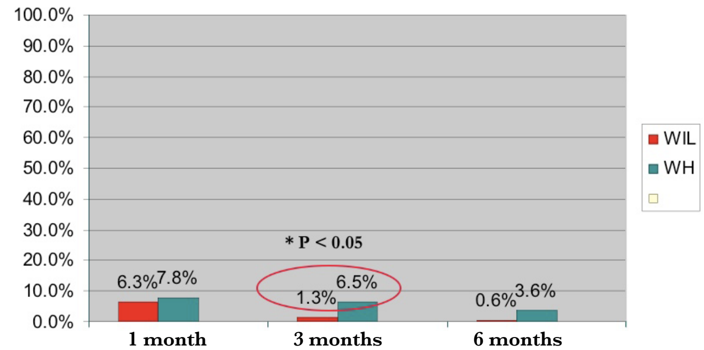


Figure 5A

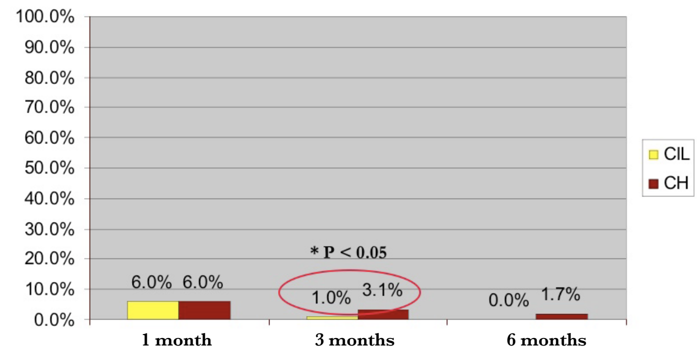


Figure 5B

Postoperative best-corrected visual acuity loss of ≥ 1 lineafter wavefront (5A) and conventional (5B) LASIK with IntraLase FS laser vs. mechanical microkeratome.

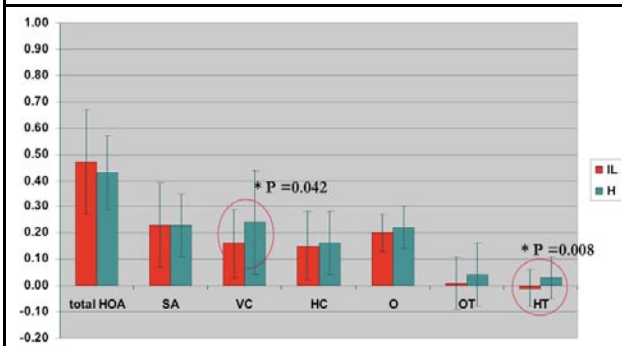


Figure 6A

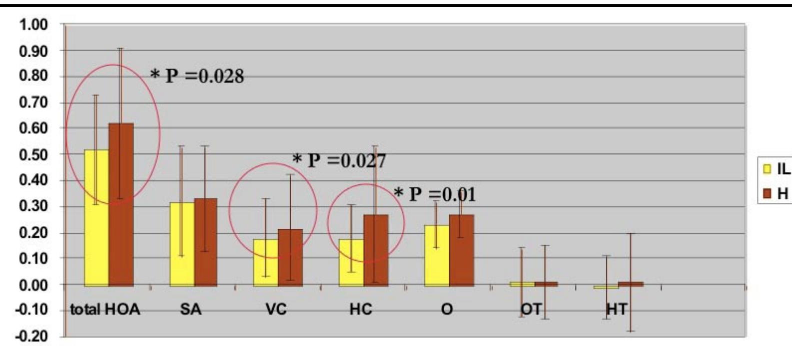


Figure 6B

Postoperative higher order aberrations after wavefront (6A) and conventional (6B) LASIK with IntraLase FS laser vs. mechanical microkeratome.

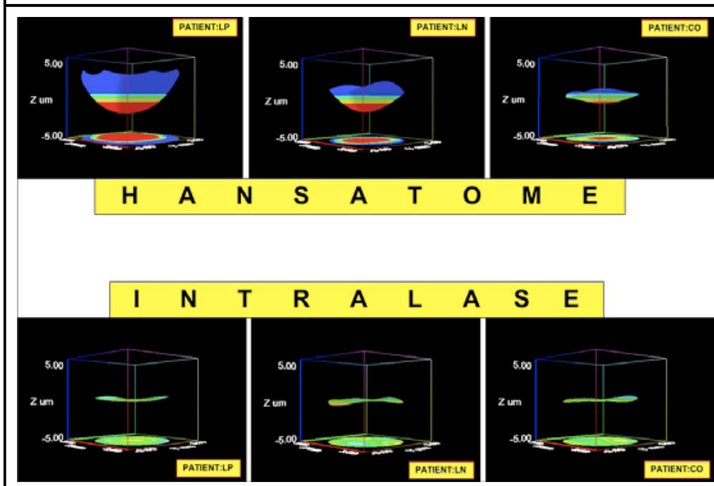


Figure 7

Wavefront map after flap creation with Hansatome mechanical microkeratome (above) vs. IntraLase (below). Flat wavefront of the IntraLase flap indicates fewer induced aberrations.

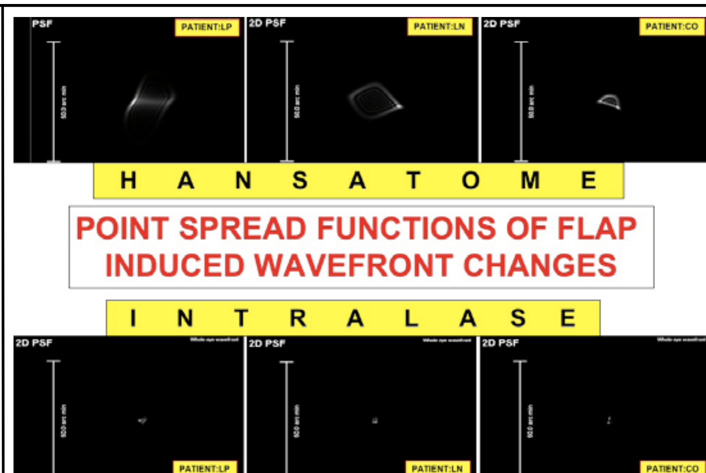


Figure 8

Point spread function with Hansatome mechanical microkeratome (above) vs. IntraLase (below). The images indicate how a point of light would be perceived through an eye that had a Hansatome flap vs. an IntraLase flap perfect corneal plane every time, regardless of the corneal size and anatomy, with minimal effect on the surrounding tissue. For example, peripheral DLK and light sensitivity have been correlated with excessive laser energy. In a recent study, Stonecipher et al demonstrated 1.1% incidence of photophobia (33/5667 patients) with the 15 kHz IntraLase. [6] When the laser energy was decreased by only 20%, the incidence of photophobia dropped to 0.2%. Increasing the frequency of the laser system, allows us to decrease the energy even further. So much so that with the 60 kHz IntraLase, the energy is at least 50% lower than with the 15 kHz system. Maximizing laser frequency, energy, and procedure techniques is the key to insuring excellent outcomes for the patients.

Optimal energy settings during the initial procedure and good procedure techniques are also required to insure the ease and efficacy of enhancement, if needed, in the future. A surgeon can lift IntraLase flaps as far out as 3+ years following the original procedure, provided that the initial energy was not too high to result in excessive healing and that the appropriate skill is used at the time of the enhancement to access the edge of the flap. Alternatively, excellent flap thickness predictability (standard deviation = +/- 4 microns) also gives us the confidence to create another flap, if necessary.

References

1. Durrie DS, Kezirian GM. Femtosecond laser versus mechanical keratome flaps in wavefront-guided laser in situ keratomileusis. J of Cataract and Refract Surg 31(1) 2005:120-126
2. Faktorovich EG. LASIK outcomes with Intralase FS laser vs. Hansatome microkeratome. American Academy of Ophthalmology. Oct 2005
3. Kezirian GM, Steoneciper KG. Comparison of the IntraLase femtosecond laser and mechanical keratomes for laser in situ keratomileusis. J of Cataract and Refract Surg 30(4) 2004:804-811
4. Lim T, Yang S, Kim M, et al. Comparison of the IntraLase femtosecond laser and mechanical microkeratome for laser in situ keraomileuesis. Am J Ophthalmol 2006 May;141(5):833-9
5. Tran DB, Sarayaba MA, Bor Z, et al. Randomized prospective clinical study comparing induced aberrations with IntraLase and Hansatome flap creation in fellow eyes. J of Cataract and Refract Surg 31(1) 2005:97-105
6. Stonecipher KG et al. Transient light sensitivity after femtosecond laser flap creation: Clinical findings and management. J Cataract Refract Surg 2006;32:91-94

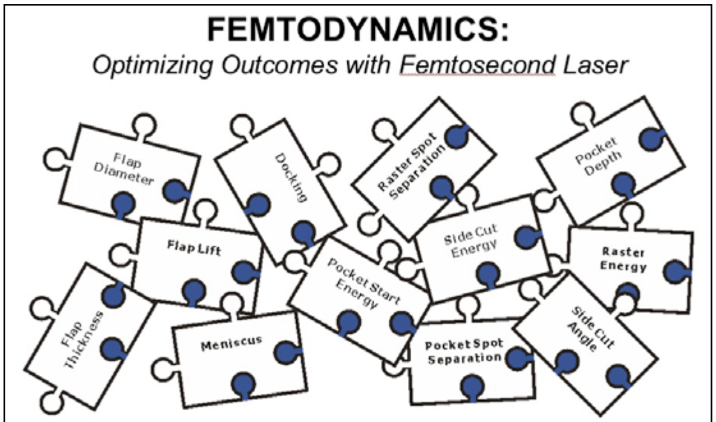


Figure 9A

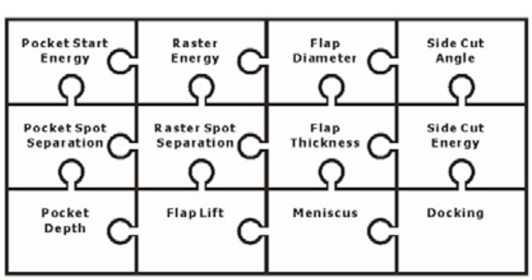
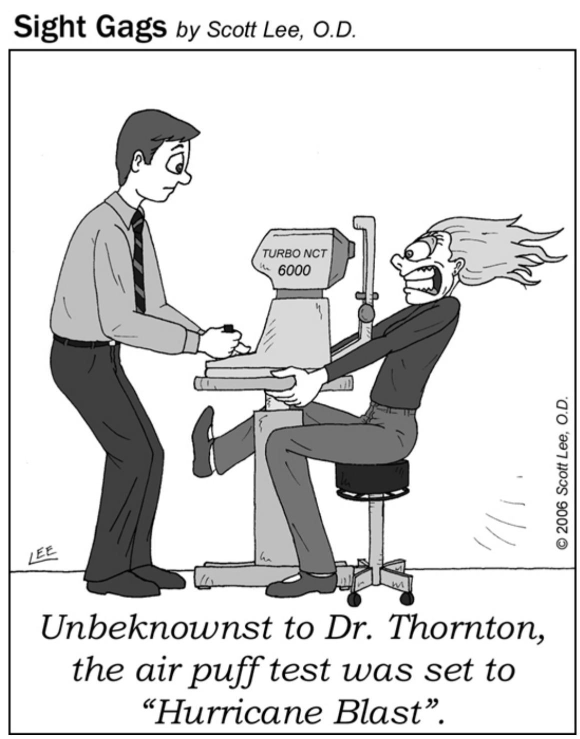


Figure 9B

Many laser settings and procedure techniques are involved in creating a perfect flap with an IntraLase FS laser (9A). Femtodynamics is a system of optimizing the settings and techniques to insure they all "fit" together perfectly to insure optimal outcomes for the patients.



2006 calendar of the Upcoming Events for PVI Affiliated Doctors:

08/23/06: PVI Grand Rounds - Conductive Keratoplasty (CK)
09/20/06: PVI Grand Rounds - Glaucoma
10/18/06: Staff Training
11/15/06: PVI Grand Rounds - Retina

Note from the Editor-in-Chief: *Thanks for reading and your continued interest in the latest in high technology eye care. We always appreciate your comments and feedback!* drlee@pacificvision.org.