chapter 21

Femto-LASIK for Hyperopia and Hyperopic Astigmatism:

Practical Pearls From 8 Years of Experience With Topography-Guided Corrections for Hyperopic LASIK

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Refractive surgery has gained significant popularity in the past 2 decades by eliminating the need for spectacles or contact lenses.

I have come to realize that hyperopia is not just the opposite of myopia. Hyperopic patients have several distinct differences:

1. They are almost always undercorrected. This is due to variable degree of accommodating spasm, resulting in common "regression" following LASIK, and second and third treatments to be necessary.
2. The have large amounts of angle kappa. As we will expand herein, the visual axis of hyperopes is usually 0.5 to 1.5 mm off the geometric center of the pupil.
   This is in stark contrast to myopes and needs special attention during laser correction.
3. In our population of Southern Mediterraneans, PRK appears to be a poor option for hyperopic correction, even of small amounts, due to the increased regression percentages (up to 35%) and the invariable scarring associated with it, despite MMC use. LASIK therefore becomes the only laser correction option in my opinion in our patient population.
4. The mean age of the hyperope corrected in our practice is near or over the presbyopic age making overcorrection in the non-dominant eye a serious consideration in our practice to be discussed and demonstrated by contact lenses in all hyperopes as will be discussed below.

These are the basic reasons of why I feel hyperopic laser corrections with LASIK deserve a special chapter.

While the lasers and software that drives them become more sophisticated, there are still alignment errors during photoablation that could lead to decentration and nonhomogenous ablation patterns.

Decentered ablations can lead to negative visual effects including irregular astigmatism, reduced best-corrected visual acuity, glare, etc.[1,2] Thus, proper centration of the ablation zone during refractive procedures is an essential goal. However, a *large angle kappa,* which is defined as the difference between the primary line of sight and the pupillary axis, may cause alignment errors during photoablation. This issue is more important in hyperopic patients who tend to have larger angle kappas. Because of this, some refractive surgeons prefer to alter the location of the ablation to take into account a large angle kappa. However, there are few data in the literature concerning the normative values of angle kappa in healthy subjects.

Angle Kappa

Angle kappa is determined by the intersection between the line of sight and the pupillary axis. Because the fovea lies slightly temporal to the point at which the pupillary axis intersects with the posterior pole of the globe, the normal angle kappa is slightly positive. Evaluation of angle kappa before refractive surgery has gained significant importance because ablation zone centration during refractive surgery is a critical step. Uozato and Guyton asserted that centering on the pupil is the proper method of centration because the photoreceptors are aimed toward the center of a normal pupil; their method has

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Buratto L, Slade S, Tavolato M.
LASIK: The Evolution of Refractive Surgery (pp 139-144).
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Figure 21-1. This figure depicts the same planned excimer profile for the correction of hyperopic astigmatism, centered on the pupillary center.

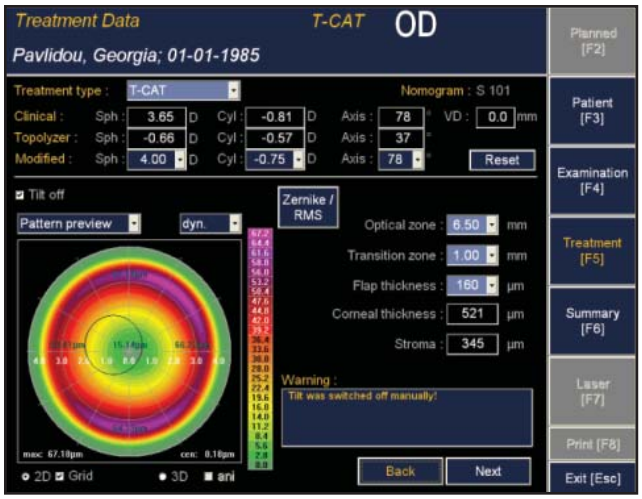

Figure 21-2. This figure depicts the same planned excimer profile for the correction of hyperopic astigmatism, adjusted by topography to take into consideration and adjust for angle kappa.

since become the standard practice. However, Pande and Hillman stated that the optimal centration is the corneal intercept of the visual axis because this is the line joining the fovea to the fixation point. They have concluded that coaxially sighted corneal reflex was nearest the corneal intercept of the visual axis. Recently Nepomuceno and colleagues[6,7] performed hyperopic LASIK with the ablation centered on the coaxially sighted corneal light reflex. They have concluded that the traditional centering method based on the entrance of the pupil could lead to decentration in the presence of a large angle kappa, especially in hyperopic patients. There are various methods that measure the amount of angle kappa. Synoptophore is one of the most widely used methods in the clinical practice. It measures angle kappa depending on the corneal reflection methods. Recently, newer devices such as Orbscan II (Orbtek Inc., Bausch + Lomb, Rochester, NY) have become commercially available and can be used in the evaluation of angle kappa. But, there are no published data evaluating the reliability of Orbscan in measuring angle kappa. We have reported the significance and magnitude of angle kappa when studying a normal hyperopic population.[8] Other authors have also underlined the importance of angle Kappa in refractive surgery.[9-12] We have also previously reported our experience in hyperopic LASIK utilizing a mechanical microkeratome (Moria M2) and the Wavelight Allegretto excimer laser.[13]

In a *Journal of Refractive Surgery* article in 2007 titled "Measurement of angle kappa with synoptophore and Orbscan II in a normal population" by Basmak, Sahin, Yildirim, Papakostas, and Kanellopoulos,[8] we found that there is a significant correlation between positive refractive errors and large positive angle kappa values. Refractive surgeons must take into account angle kappa especially in hyperopic patients in order to avoid complications related to decentration of ablation zone (Figures 21-1 and 21-2).

The LASIK flap may need to be de-centered as well to accommodate the angle kappa. This is challenging for the surgeon (Figures 21-3 and 21-4).

We have presented our experience in comparing hyperopic standard to topography-guided LASIK (AAO, 2007) (Figure 21-5).

Topography-guided femto-LASIK and standard LASIK appear to be both safe and effective for hyperopia. Topography-guided femto-LASIK appears be superior in regard to regression, residual astigmatism, contrast sensitivity, and estimated ablation decentration in regard to the visual axis. Hyperopic LASIK utilizing the topography-guided WaveLight Allegretto excimer laser appears to be safe and effective in the correction of low, moderate, and high hyperopia and/or hyperopic astigmatism. The results appear to be safe and predictable for the low and moderate hyperopia groups; they appear to carry similar promise in the high hyperopia/high cylinder group. The topography-guided platform appears to better center the ablation to the visual axis vs the pupillary center with high level of reproducibility in all cases, and compared to our previously published results with standard hyperopic treatments with this laser.

Measurements

We currently use as our treatment values the dilated (with one drop of mydriacyl 1%) pupil measurements and not cycloplegic measurements as we feel that they do not represent a physiologic condition. We make

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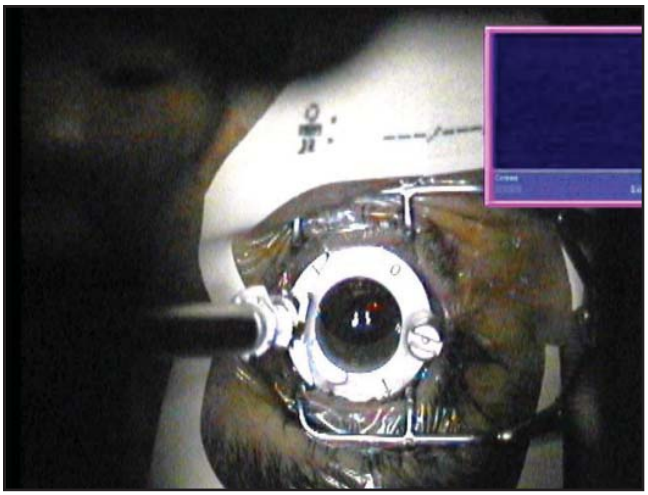


Figure 21-3. A hyperopic LASIK flap created with the M2 microkeratome by Moria showing the gross nasal decentration of the flap in order to accommodate the applicable ablation decentration in reference to the pupillary center.

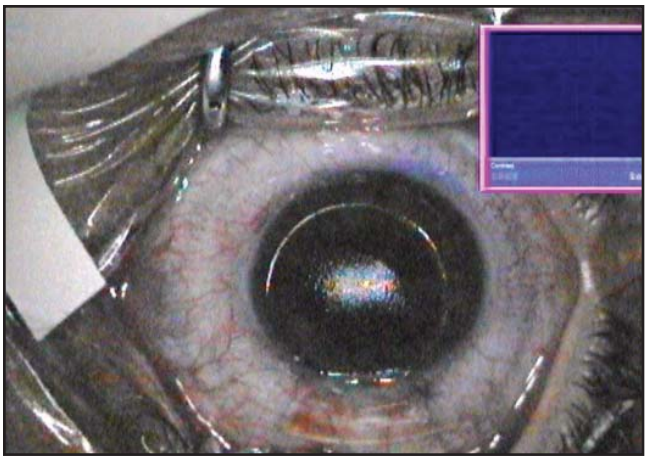
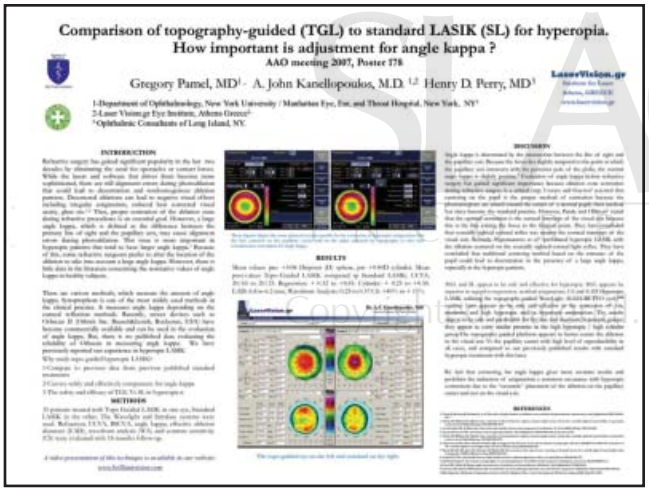


Figure 21-4. A hyperopic LASIK flap created with the M2 microkeratome by Moria showing the gross nasal decentration of the flap in order to accommodate the applicable ablation decentration in reference to the pupillary center.



Comparison of topography-guided (TGL) to standard LASIK (SL) for hyperopia. How important is adjustment for angle kappa ?

AAO meeting 2007, Poster 178

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INTRODUCTION

METHODS

RESULTS

DISCUSSION

REFERENCES

Figure 21-5. This is the poster presentation from the AAO meeting in 2007 on comparing standard to topography-guided LASIK in hyperopia.

it an *effort to try contact lenses on all hyperopic patients* prior to LASIK in order to appreciate the proposed correction better. This is the point that we showcase to them—overcorrecting the non-dominant eye by 0.5 D and how well they can tolerate this. This is well-tolerated by the majority and offers a great near advantage up to ages of 55!

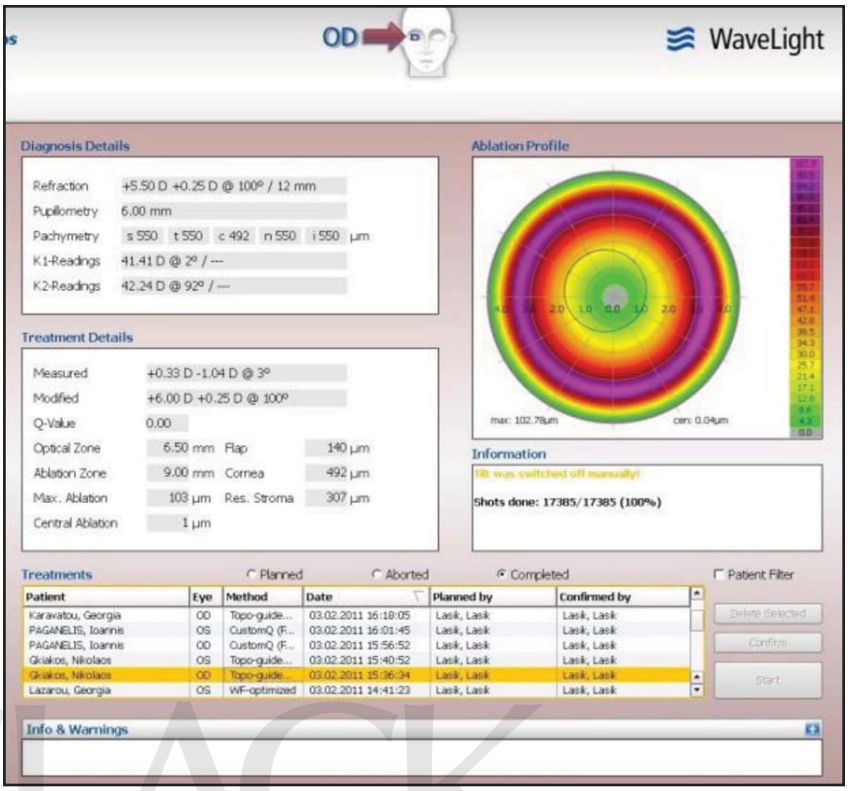
We use placido disk topography along with the Pentacam, a tool that better illustrates the degree of angle kappa.

As with most hyperopic measurements, the dilated pupil measurement is usually 0.5 to 1 D more hyperopic. *We use an optical zone of 6.5 mm (the treatment zone is 6.5 to 8.5 mm) and use the upper limit of 6 D of spherical equivalent—meaning up to +6 of hyperopia or up to +6 in spherical equivalent for mixed astigmatim (it is possible to treat a +7 -2.5 D astigmatism as this would be the equivalent of +4.5 +2.5 D of astigmatism).* We treat with these parameters, but discuss with patients prior to their surgery the fact that they may be myopic 0.5 to 1 D 1 to 3 weeks following the femto-LASIK, until their accommodative spasm relaxes. We have a 3% re-treatment rate with this protocol, a fact that greatly reinforces this approach. We have to share though the fact the hyperopes become extremely anxious during this 1- to 3-week myopic interval, and they require ample reassurance and plenty of discussion time.

We feel that correcting for angle kappa gives more accurate results and prohibits the induction of astigmatism, a common occurrence with hyperopic corrections due to the "eccentric" placement of the ablation on the pupillary center and not on the visual axis.

We have had the opportunity to enhance our hyperopic femtoLASIK treatments these last 12 months with the new Alcon/WaveLight refractive suite platform. This platform utilizes the FS200 femtosecond laser with a distinct advantage for hyperopes: a very large applannation area on the cornea allowing for comfortable "nasal" decentration of the flap in order to accommodate the angle kappa-corrected ablation center.

In Figures 21-6 and 21-7, the reader can appreciate the excimer treatment plan (the refractive suite utilizes the ultra-fast EX500 excimer that is linked to the Pentacam HD, called the Oculyzer II as a platform device) in reference to the pupil and can clearly understand the necessity of an equally nasally placed ablation. The actual 9.5-mm flap created by the FS200 femtolaser is noted in the second picture. As an additional safety feature, the refractive suite is inter-connected via its network not only between the



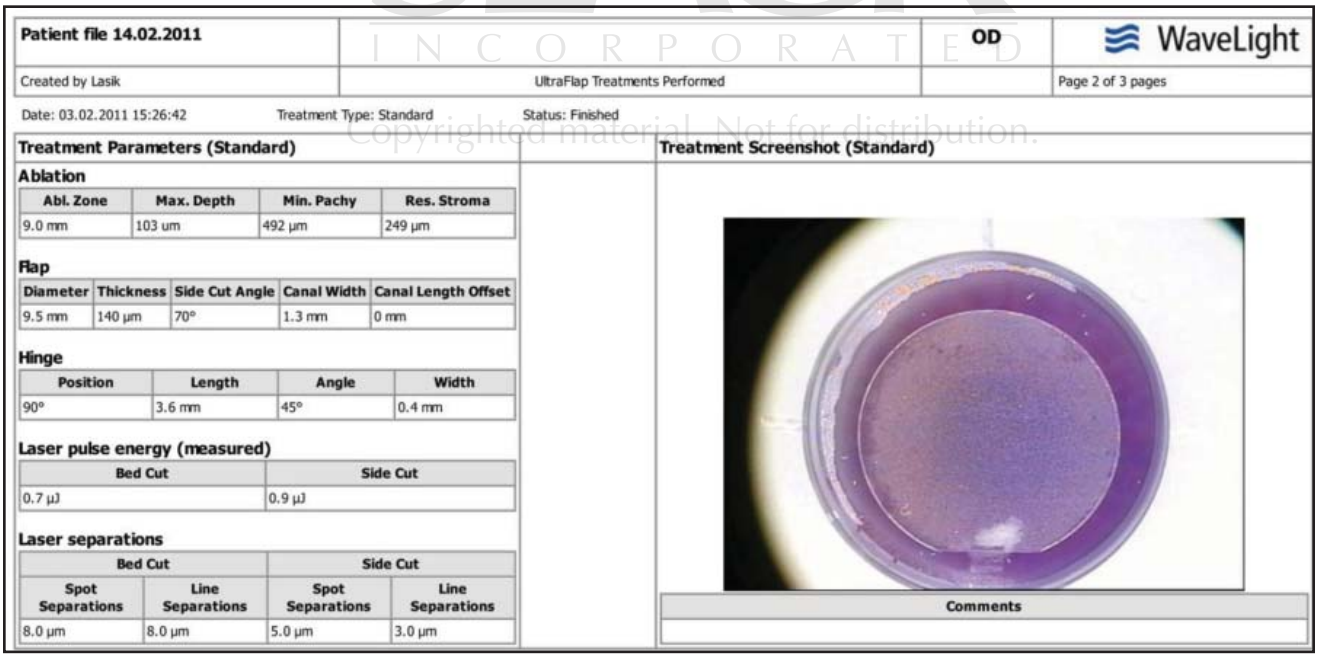


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Figure 21-6. The topography-guided treatment plan with the EX500 excimer laser by Alcon. The ablation is clearly decentered nasally in reference to the pupli, but centered to the visual axis.

Figure 21-7. This is the treatment report of the FS200 Femto laser by Alcon. A 9.5-mm diameter, 140 µm in depth flap was just completed. In anticipation of the above topography-guided hyperopic ablation, please note that the flap is intentionally decentered nasally (close to the limbus). The FS200 offers a great advantage to this purposes. The large applanated area on the cornea allows the surgeon to "move" the flap plan nasally, without limiting the flap diameter.

two lasers but additionally to the Pentacam device (the Oculyzer) for enhanced safety in data processing. The actual Pentacam scans of each eye of the patient are fed seamlessly to the EX500 and are processed by surgeon and staff. The treatment plan is viewed on the EX500 screen, but also superimposed over the femto flap planned on the relative flap-making process that precedes on the FS200 femtosecond laser. This is an extremely helpful tool for the learning curve of performing topography-guided hyperopic LASIK.

The picture below represents the final FS200 report documenting all flap parameters used, as well as the actual flap position at the termination of the side-cut. Please note the nasal (to the left) decentration of the flap in regard to the pupil.

A last consideration for hyperopes, especially the over 40 age group, is the increased incidence of narrow angles. We caution clinicians that hyperopes of over 3 D may have significantly narrow angles, a fact that needs to be evaluated thoroughly; especially when considering that the progressive cataract formation in these patients will further narrow the angle and potentially lead to angle closure attack(s). It is reasonable to consider premature cataract extraction in these patients and/or laser peripheral iridotomy as this approach may eliminate both the hyperopic correction and the phacomorphic danger of glaucoma.

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