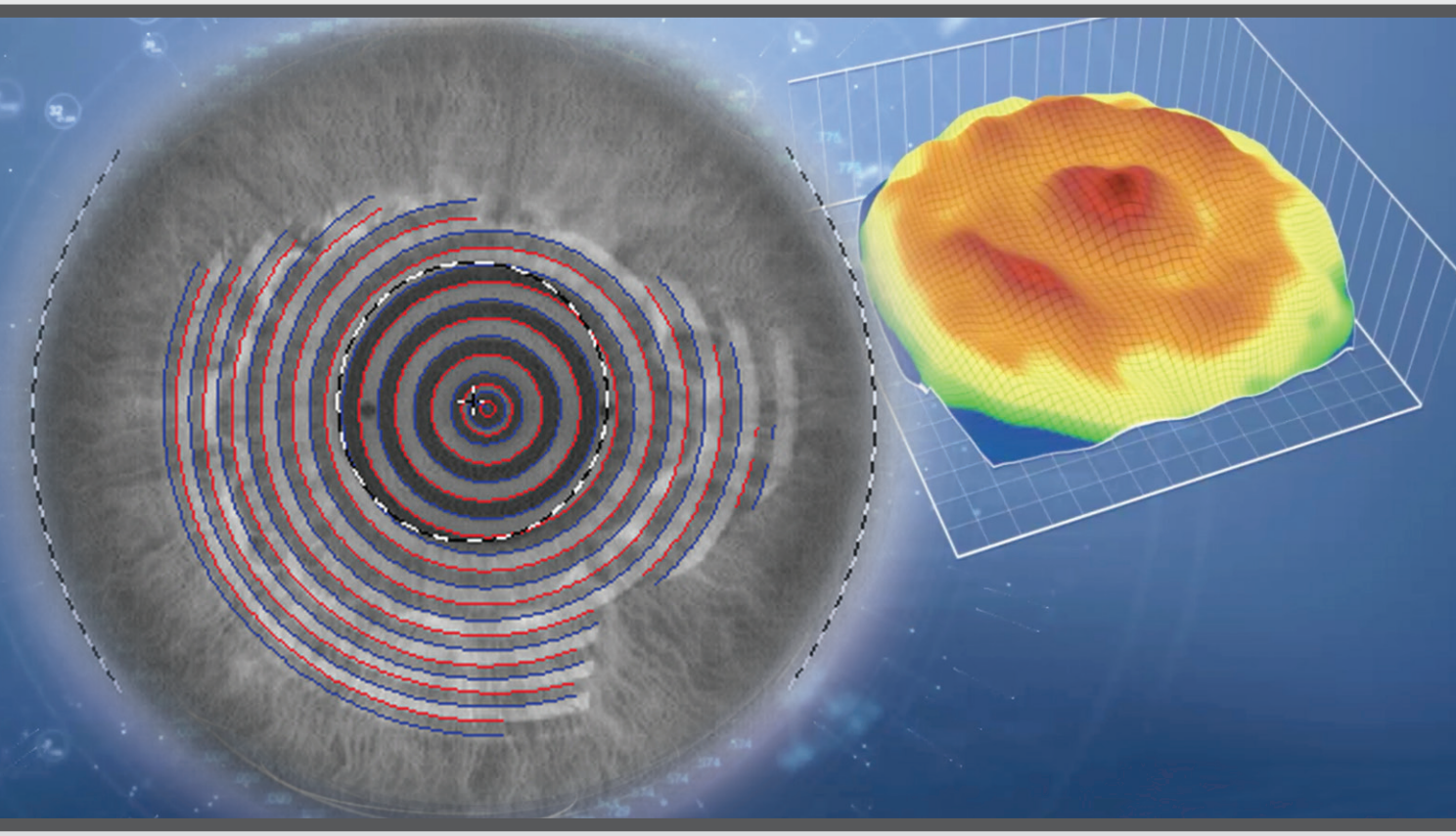
Sponsored by Alcon
a Novartis company

TOPOGRAPHY-GUIDED REFRACTIVE SURGERY

Successful Planning With Topography-Guided LASIK Custom Treatments



The procedure achieved a 98.4% satisfaction rate in the clinical trial.[1]

Successful Planning With Topography-Guided LASIK Custom Treatments

BY R. DOYLE STULTING, MD, PHD, AND DAVID W. FRIESS, OD, FAAO

Topography-guided LASIK custom treatments (Alcon) incorporate corneal higher-order aberrations using the preoperative topography, so topography acquisition has to be accurate. Accurate topographic maps are achieved through carefully acquiring and reviewing the images obtained and then comparing those images to each other to make sure their findings are consistent (Figure 1). The investigators in the clinical trials of topography-guided LASIK custom treatments were required to obtain at least four consistent topographic images within a minimum-sized coverage area for each patient. Incorporating several image acquisition techniques and screening methods into planning for topography-guided LASIK custom treatments is recommended to help ensure the most accurate patient outcomes.

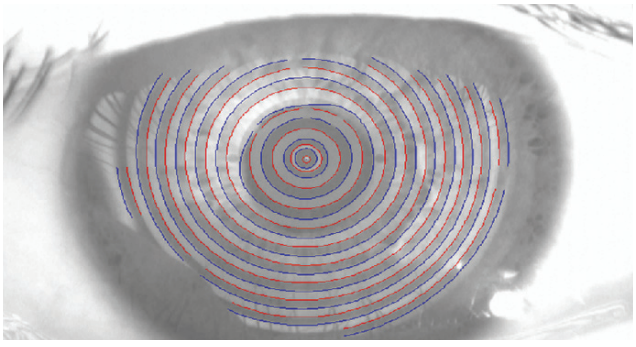


Figure 1. In this Topolyzer image, the patient's eyelid interfered with the data capture. Adjustments made to the WaveLight Topolyzer's software since the clinical trial helps prevent this capture error, but surgeons must still check each image for accuracy.

SCREENING METHODOLOGY

Obtaining accurate maps can sometimes be challenging, either because the orbital or facial structure makes imaging difficult (e.g., deep-set eyes), or because the tear film is not stable. Eyes with marginal dryness and tear-film breakup can produce artifactual information in topographic mapping.

Screen Failure

In the clinical trial for topography-guided LASIK custom treatments, *screen failure* referred to individuals who did not meet the inclusion criteria for the study. These clinical study subject enrollment criteria are described in the safety and effectiveness portion of the study results.

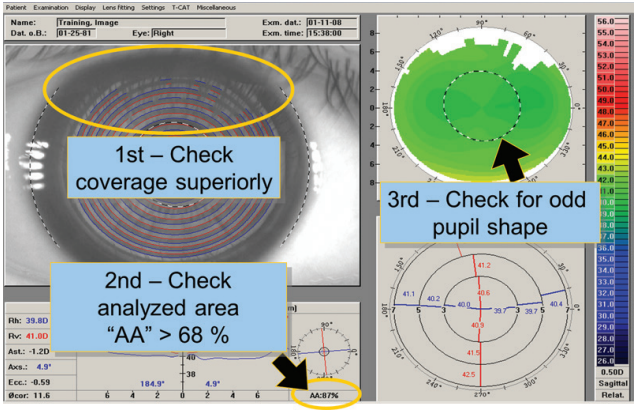


Figure 2. When comparing difference maps from the Topolyzer, look for less than or equal to 1.00 D of difference in the pupillary diameter.

WHEN TO PERFORM TOPOGRAPHY-GUIDED LASIK CUSTOM TREATMENTS VERSUS WAVEFRONT-GUIDED PROCEDURES

From the clinical findings of the prior FDA study, Table 1 illustrates the efficacy of Wavefront-Optimized and wavefront-guided corneal ablations in terms of the amount of higher-order aberrations (see the vertical axis of the chart). The horizontal axis shows the amount of attempted correction. The findings demonstrate that Wavefront-Optimized treatments work better for lower degrees of higher-order aberrations and higher degrees of refractive error. As described previously, wavefront-guided treatments can create a certain amount of noise, or variabilities within the final refraction. If the cornea has a lot of higher-order aberrations, then the noise becomes minimal compared to the benefit of the treatment. If a cornea contains minimal higher-order aberrations, then the noise becomes large compared to the benefit gained from the treatment. This is why Wavefront-Optimized treatments are more beneficial for lower amounts of higher-order aberrations.

The same is true for the amount of myopia. With high degrees of myopia, the noise generated by a wavefront-guided treatment is high compared to the benefit it imparts, versus a Wavefront-Optimized treatment, which is based on a simple refraction and creates less noise.

Please see page 4 for important product information.

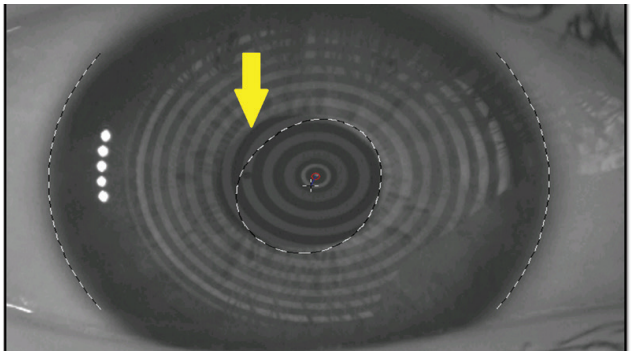


Figure 3. The pointer shows where the Topolyzer detected an irregular pupillary shape.

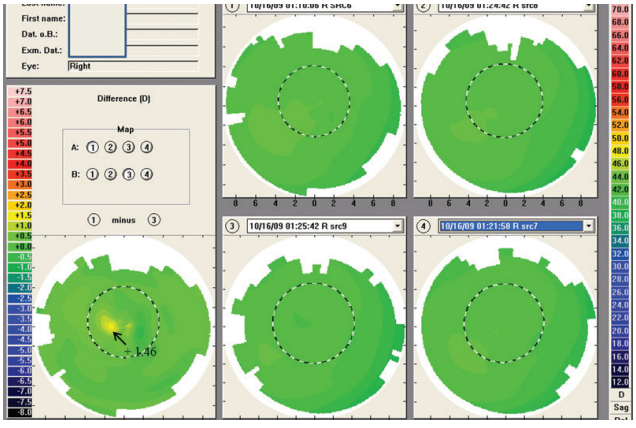


Figure 4. The pointer in the bottom left-hand map shows an elevation map differential. Ideally, the pupil's diameter should show <1.00 D of difference betwee multiple elevation maps.

Based upon the clinical study, properly screened eyes within the approved treatment range are expected to benefit from a personalized topography-guided LASIK custom treatment while adhering to the methods used during the study. Topography-guided LASIK custom treatments do require significantly more planning than Wavefront-Optimized procedures and attention to diagnostic topographic scans.

CAPTURE ERRORS

Errors in the capturing of topographic data can include inadequate coverage and problems with pupil tracking and mire recognition. The software draws a line where it identifies the pupil's border, and sometimes, it does not correctly recognize the margins of the pupil or the edge of the Placido mires. Figure 1 demonstrates inadequate coverage due to interference from a patient's eyelid. Improvements that have been made to the software since the clinical study can help this process, but it is important for surgeons to review the topographic images and pupil recognition to ensure accuracy. Incorrect images must be thrown out and repeated. Also, patient fixation can be a source of error when patients do not sight perfectly under the eyepiece of the topographer.

SELECTION CRITERIA FOR ADEQUATE TOPOGRAPHIC IMAGES

Investigators in the clinical trial of topography-guided LASIK custom treatments used general criteria to review and evaluate captured Topolyzer images (Figure 2) for adequate Placido ring (mires) quality and data prior to image selection and export. These criteria were developed from prior international experience with the procedure and included:

- **Analyzed Area:** ≥ 68% unless due to peripheral ring artifact.
- **Coverage:** Measuring from the center of the pupil, there should be at least 3 mm of ring coverage in all directions that is free of artifacts and has only minor ring breaks.
- **Rings:** Rings should be regular with minimal breaks.
- **Pupil Tracking:** Ensure that the software accurately identifies the pupil border.
- **Pupil Diameter/Shape:** Evaluate the pupil's shape and diameter for consistency among selected topographic maps (Figure 3).
- **Repeatability:** A difference map of the selected topographies should be performed, and there should be ≤ 1.00 D of difference within the area of the pupil diameter among the selected topographic elevation maps (Figure 4).

ERRORS IN TREATMENT AND REFRACTIVE CORRECTION

In the clinical study, no treatment delivery errors were detected specific to the topography-guided LASIK custom treatments of the ALLEGRETTO WAVE laser. Of course, as with any laser treatment, it is possible for surgeons to make

TABLE 1. WFO/WFG PATIENT SELECTION BASED ON PREOPERATIVE HIGHER-ORDER ABERRATIONS (HOAs)

	Spheroequivalent Treatment Range (D)					
Preop RMSh	-1 to < -2 D	-2 to < -3 D	-3 to < -4 D	-4 to < -5 D	-5 to < -6 D	-6 to < -7 D
≤ 0.2 µ	WG/WO	WG/WO	WG/WO	WG/WO	WG/WO	WG/WO
0.2 – 0.3 µ	WG/WO	WG/WO	WG/WO	WG/WO	WG/WO	WG/WO
0.3 – 0.4 µ	WG	WG	WG	WG/WO	WG/WO	WG/WO
> 0.4 µ	WG	WG	WG	WG	WG	WG

Table 1. Treatment recommendations based on preoperative spheroequivalent and RMSH values. (WG = Wavefront-Guided LASIK; WO = Wavefront-Optimized LASIK; WG/WO = both equally safe and effective).[1]

treatment refraction entry errors, but following sound protocols for surgical planning should help minimize these errors.

R. Doyle Stulting, MD, PhD, is the director of the Stulting Research Center at the Woolfson Eye Institute in Atlanta. He was a clinical investigator for T-CAT LASIK performed with the Alcon WaveLight ALLEGRETTO WAVE Eye-Q Excimer Laser. Dr. Stulting may be reached at (770) 255-3330; dstulting@woolfsoneye.com.

David W. Friess, OD, FAAO, is president of Optimus Clinical Partners LLC in Glen Mills, Pennsylvania. He was a clinical regulatory consultant for the FDA clinical trial of T-CAT LASIK performed with the Alcon WaveLight ALLEGRETTO WAVE Eye-Q Excimer Laser. Dr. Friess may be reached at dwfriess@gmail.com.

1. Summary of Safety and Effectiveness Data, WaveLight ALLEGRETTO WAVE Excimer Laser System and the ALLEGRO Analyzer. July 26, 2006. Table 22, pg. 40. Available at: http://www.accessdata.fda.gov/cdrh_docs/pdf2/p020050s004b.pdf. AccessedJune 24, 2014.

Important Product Information about the WaveLight® Excimer Laser Systems

This information pertains to all WaveLight® Excimer Laser Systems, including the WaveLight® ALLEGRETTO WAVE®, the ALLEGRETTO WAVE® Eye-Q , and the WaveLight® EX500.

Caution: Federal (U.S.) law restricts the WaveLight® Excimer Laser Systems to sale by or on the order of a physician. Only practitioners who are experienced in the medical mangement and surgical treatment of the cornea, who have been trained in laser refractive surgery (including laser calibration and operation) should use a WaveLight® Excimer Laser System.

Indications: FDA has approved the WaveLight® Excimer Laser systems for use in laser-assisted in situ keratomileusis (LASIK) treatments for:

- the reduction or elimination of myopia of up to - 12.00 D and up to 6.00 D of astigmatism at the spectacle plane;
- the reduction or elimination of hyperopia up to + 6.00 D with and without astigmatic refractive errors up to 5.00 D at the spectacle plane, with a maximum manifest refraction spherical equivalent of + 6.00 D;
- the reduction or elimination of naturally occurring mixed astigmatism of up to 6.00 D at the spectacle plane; and
- the wavefront-guided reduction or elimination of myopia of up to -7.00 D and up to 3.00 D of astigmatism at the spectacle plane.

In addition, FDA has approved the WaveLight® ALLEGRETTO WAVE® Eye-Q Excimer Laser System, when used with the WaveLight® ALLEGRO Topolyzer® and topography-guided treatment planning software for topography-guided LASIK treatments for the reduction or elimination of up to -9.00 D of myopia, or for the reduction or elimination of myopia with astigmatism, with up to -8.00 D of myopia and up to 3.00 D of astigmatism.

The WaveLight® Excimer Laser Systems are only indicated for use in patients who are 18 years of age or older (21 years of age or older for mixed astigmatism) with documentation of a stable manifest refraction defined as ≤ 0.50 D of preoperative spherical equivalent shift over one year prior to surgery, exclusive of changes due to unmasking latent hyperopia.

Contraindications: The WaveLight® Excimer Laser Systems are contraindicated for use with patients who:

- are pregnant or nursing;
- have a diagnosed collagen vascular, autoimmune or immunodeficiency disease;
- have been diagnosed keratoconus or if there are any clinical pictures suggestive of keratoconus;
- are taking isotretinoin (Accutane®) and/or amiodarone hydrochloride (Cordarone®);
- have severe dry eye;
- have corneas too thin for LASIK;
- have recurrent corneal erosion;
- have advanced glaucoma; or
- have uncontrolled diabetes.

Warnings: The WaveLight® Excimer Laser Systems are not recommended for use with patients who have:

- systemic diseases likely to affect wound healing, such as connective tissue disease, insulin dependent diabetes, severe atopic disease or an immunocompromised status;
- a history of Herpes simplex or Herpes zoster keratitis;
- significant dry eye that is unresponsive to treatment;
- severe allergies;
- a history of glaucoma;
- an unreliable preoperative wavefront examination that precludes wavefront-guided treatment; or
- a poor quality preoperative topography map that precludes topography-guided LASIK treatment.

The wavefront-guided LASIK procedure requires accurate and reliable data from the wavefront examination. Every step of every wavefront measurement that may be used as the basis for a wavefront-guided LASIK procedure must be validated by the user. Inaccurate or unreliable data from the wavefront examination will lead to an inaccurate treatment.

Topography-guided LASIK requires preoperative topography maps of sufficient quality to use for planning a topography-guided LASIK treatment. Poor quality topography maps may affect the accuracy of the topography-guided LASIK treatment and may result in poor vision after topography-guided LASIK.

Precautions: The safety and effectiveness of the WaveLight® Excimer Laser Systems have not been established for patients with:

- progressive myopia, hyperopia, astigmatism and/or mixed astigmatism, ocular disease, previous corneal or intraocular surgery, or trauma in the ablation zone;
- corneal abnormalities including, but not limited to, scars, irregular astigmatism and corneal warpage;
- residual corneal thickness after ablation of less than 250 microns due to the increased risk for corneal ectasia;
- pupil size below 7.0 mm after mydriatics where applied for wavefront-guided ablation planning;
- history of glaucoma or ocular hypertension of > 23 mmHg;
- taking the medications sumatriptan succinate (Imitrex®);
- corneal, lens and/or vitreous opacities including, but not limited to cataract;
- iris problems including , but not limited to, coloboma and previous iris surgery compromising proper eye tracking; or
- taking medications likely to affect wound healing including (but not limited to) antimetabolites.

In addition, safety and effectiveness of the WaveLight® Excimer Laser Systems have not been established for:

- treatments with an optical zone < 6.0 mm or > 6.5 mm in diameter, or an ablation zone > 9.0 mm in diameter; or
- wavefront-guided treatment targets different from emmetropia (plano) in which the wavefront calculated defocus (spherical term) has been adjusted;

In the WaveLight® Excimer Laser System clinical studies, there were few subjects with cylinder amounts > 4 D and ≤ 6 D. Not all complications, adverse events, and levels of effectiveness may have been determined for this population.

Pupil sizes should be evaluated under mesopic illumination conditions. Effects of treatment on vision under poor illumination cannot be predicted prior to surgery.

Adverse Events and Complications

Myopia: In the myopia clinical study, 0.2% (2/876) of the eyes had a lost, misplaced, or misaligned flap reported at the 1 month examination.

The following complications were reported 6 months after LASIK: 0.9% (7/818) had ghosting or double images in the operative eye; 0.1% (1/818) of the eyes had a corneal epithelial defect.

Hyperopia: In the hyperopia clinical study, 0.4% (1/276) of the eyes had a retinal detachment or retinal vascular accident reported at the 3 month examination.

The following complications were reported 6 months after LASIK: 0.8% (2/262) of the eyes had a corneal epithelial defect and 0.8% (2/262) had any epithelium in the interface.

Mixed Astigmatism: In the mixed astigmatism clinical study, two adverse events were reported. The first event involved a patient who postoperatively was subject to blunt trauma to the treatment eye 6 days after surgery. The patient was found to have an intact globe with no rupture, inflammation or any dislodgement of the flap. UCVA was decreased due to this event. The second event involved the treatment of an incorrect axis of astigmatism. The axis was treated at 60 degrees instead of 160 degrees.

The following complications were reported 6 months after LASIK: 1.8% (2/111) of the eyes had ghosting or double images in the operative eye.

Wavefront-Guided Myopia: The wavefront-guided myopia clinical study included 374 eyes treated; 188 with wavefront-guided LASIK (Study Cohort) and 186 with Wavefront Optimized® LASIK (Control Cohort). No adverse events occurred during the postoperative period of the wavefront-guided LASIK procedures. In the Control Cohort, one subject undergoing traditional LASIK had the axis of astigmatism programmed as 115 degrees instead of the actual 155 degree axis. This led to cylinder in the left eye.

The following complications were reported 6 months after wavefront-guided LASIK in the Study Cohort: 1.2% (2/166) of the eyes had a corneal epithelial defect; 1.2% (2/166) had foreign body sensation; and 0.6% (1/166) had pain. No complications were reported in the Control Cohort.

Topography-Guided Myopia: There were six adverse events reported in the topography-guided myopia study. Four of the eyes experienced transient or temporary decreases in vision prior to the final 12 month follow-up visit, all of which were resolved by the final follow-up visit. One subject suffered from decreased vision in the treated eye, following blunt force trauma 4 days after surgery. One subject experienced retinal detachment, which was concluded to be unrelated to the surgical procedure.

Clinical Data

Myopia: The myopia clinical study included 901 eyes treated, of which 813 of 866 eligible eyes were followed for 12 months. Accountability at 3 months was 93.8%, at 6 months was 91.9%, and at 12 months was 93.9%. Of the 782 eyes that were eligible for the uncorrected visual acuity (UCVA) analysis of effectiveness at the 6-month stability time point, 98.3% were corrected to 20/40 or better, and 87.7% were corrected to 20/20 or better. Subjects who responded to a patient satisfaction questionnaire before and after LASIK reported the following visual symptoms at a "moderate" or "severe" level at least 1% higher at 3 months post-treatment than at baseline: visual fluctuations (28.6% vs. 12.8% at baseline).

Long term risks of LASIK for myopia with and without astigmatism have not been studied beyond 12 months.

Hyperopia: The hyperopia clinical study included 290 eyes treated, of which 100 of 290 eligible eyes were followed for 12 months. Accountability at 3 months was 95.2%, at 6 months was 93.9%, and at 12 months was 69.9%. Of the 212 eyes that were eligible for the UCVA analysis of effectiveness at the 6-month stability time point, 95.3% were corrected to 20/40 or better, and 69.4% were corrected to 20/20 or better. Subjects who responded to a patient satisfaction questionnaire before and after LASIK reported the following visual symptoms as "much worse" at 6 months post-treatment: halos (6.4%); visual fluctuations (6.1%); light sensitivity (4.9%); night driving glare (4.2%); and glare from bright lights (3.0%).

Long term risks of LASIK for hyperopia with and without astigmatism have not been studied beyond 12 months.

Mixed Astigmatism: The mixed astigmatism clinical study included 162 eyes treated, of which 111 were eligible to be followed for 6 months. Accountability at 1 month was 99.4%, at 3 months was 96.0%, and at 6 months was 100.0%. Of the 142 eyes that were eligible for the UCVA analysis of effectiveness at the 6-month stability time point, 97.3% achieved acuity of 20/40 or better, and 69.4% achieved acuity of 20/20 or better. Subjects who responded to a patient satisfaction questionnaire before and after LASIK reported the following visual symptoms at a "moderate" or "severe" level at least 1% higher at 3 months post-treatment than at baseline: sensitivity to light (52.9% vs. 43.3% at baseline); visual fluctuations (43.0% vs. 32.1% at baseline); and halos (42.3% vs. 37.0% at baseline).

Long term risks of LASIK for mixed astigmatism have not been studied beyond 6 months.

Wavefront-Guided Myopia: The wavefront-guided myopia clinical study included 374 eyes treated; 188 with wavefront-guided LASIK (Study Cohort) and 186 with Wavefront Optimized® LASIK (Control Cohort). 166 of the Study Cohort and 166 of the Control Cohort were eligible to be followed at 6 months. In the Study Cohort, accountability at 1 month was 96.8%, at 3 months was 96.8%, and at 6 months was 93.3%. In the Control Cohort, accountability at 1 month was 94.6%, at 3 months was 94.6%, and at 6 months was 92.2%.

Of the 166 eyes in the Study Cohort that were eligible for the UCVA analysis of effectiveness at the 6-month stability time point, 99.4% were corrected to 20/40 or better, and 93.4% were corrected to 20/20 or better. Of the 166 eyes in the Control Cohort eligible for the UCVA analysis of effectiveness at the 6-month stability time point, 99.4% were corrected to 20/40 or better, and 92.8% were corrected to 20/20.

In the Study Cohort, subjects who responded to a patient satisfaction questionnaire before and after LASIK reported the following visual symptoms at a "moderate" or "severe" level at least 1% higher at 3 months post-treatment than at baseline: light sensitivity (47.8% vs. 37.2% at baseline) and visual fluctuations (20.0% vs. 13.8% at baseline). In the Control Cohort, the following visual symptoms were reported at a "moderate" or "severe" level at least 1% higher at 3 months post-treatment than at baseline: halos (45.4% vs. 36.6% at baseline) and visual fluctuations (21.9% vs. 18.3% at baseline).

Long term risks of wavefront-guided LASIK for myopia with and without astigmatism have not been studied beyond 6 months.

Topography-Guided Myopia: The topography-guided myopia clinical study included 249 eyes treated, of which 230 eyes were followed for 12 months. Accountability at 3 months was 99.2%, at 6 months was 98.0%, and at 12 months was 92.4%. Of the 247 eyes that were eligible for the UCVA analysis at the 3-month stability time point, 99.2% were corrected to 20/40 or better, and 92.7% were corrected to 20/20 or better. Subjects who responded to a patient satisfaction questionnaire before and after LASIK reported the following visual symptoms as "marked" or "severe" at an incidence greater than 5% at 1 month after surgery: dryness (7% vs. 4% at baseline) and light sensitivity (7% vs. 5% at baseline). Visual symptoms continued to improve with time, and none of the visual symptoms were rated as being "marked" or "severe" with an incidence of at least 5% at 3 months or later after surgery.

Long term risks of topography-guided LASIK for myopia with and without astigmatism have not been studied beyond 12 months.

Information for Patients: Prior to undergoing LASIK surgery with a WaveLight® Excimer Laser System, prospective patients must receive a copy of the relevant Patient Information Booklet, and must be informed of the alternatives for correcting their vision, including (but not limited to) eyeglasses, contact lenses, photorefractive keratectomy, and other refractive surgeries.

Attention: Please refer to a current WaveLight® Excimer Laser System Procedure Manual for a complete listing of the indications, complications, warnings, precautions, and side effects.

* Trademarks are property of their respective owners.

WVL15012JS-B