The CRS-Master Laser Blended Vision Module

Accurate LASIK treatment for presbyopia in plano, myopic, and hyperopic patients.

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There has recently been a tremendous increase in the interest of surgical presbyopic correction. Starting in 2003, I worked with Eckhard Schröder, of Carl Zeiss Meditec (Jena, Germany), to develop a module for pure presbyopia correction, and over those next few years modified and adapted things to a point where I am pleased to say that it is finally a commercially available reality. Laser blended vision combines nonlinear aspheric ablation profiles with micro-monovision to treat presbyopia in emmetropes as well as myopes or hyperopes, including astigmatism without compromising contrast sensitivity and night vision, while retaining functional stereoacuity.

Laser blended vision is different from traditional monovision because it increases the depth of field of each eye whereas contact lenses diminish the depth of field. This new presbyopic profile is based on nonlinear changes in asphericity. Similar to contact lens monovision, the dominant eye is mainly corrected for distance with a *nominal* target refraction of plano, and the non-dominant eye is mainly corrected for near with a *nominal* target refraction of -1.50 D. As a result, the brain merges the two images, creating a blend zone that allows the patient to see near, intermediate, and far without glasses. Laser blended vision is tolerated by more than 95% of patients,1 whereas contact lens monovision is tolerated by only 59% to 67% of patients.2 Additionally, it can be used for emmetropic presbyopia as well as presbyopia accompanied by a wide range of refractive errors (5.75 to -9.00 D) including the simultaneous correction of cylinder. Performed as a bilateral simultaneous LASIK treatment, the procedure takes 10 to15 minutes and recovers in a matter of a few hours.

BACKGROUND

To better understand the way laser blended vision works, instead of viewing presbyopia as the inability to accommodate, let's consider presbyopia as a decrease in depth of field—the inability to see distance and near objects. The mechanism of action for laser blended vision is different from other excimer–laser-based presbyopic treatments such as Q-slider (asphericity) adjustment or multifocal ablations. The profile in laser blended vision is an optimized ablation profile for increasing the depth of field of the eye without compromising visual quality, contrast sensitivity, or night vision. The optimization is based on the patient's age, refraction, preoperative spherical aberration, corneal topographical vertex, and tolerance for anisometropia.

During our early work, our initial aim was to be able to adjust corneal depth of field enough to provide vision from distance through intermediate to near, thus creating a 20/20 at distance eye that would see a computer screen but also read J1. However, as we learned, visual quality and contrast sensitivity can be compromised by excessive changes in aberrations of the cornea. We discovered that it was possible to safely increase the depth of field of the cornea to 1.50 D for any starting refractive error. Given

a 1.50 D depth of field, it would not be possible to get full distance and near vision monocularly; therefore, we borrowed from the time-tested concept of monovision and set up the non-dominant eye to be slightly myopic, so that the depth of field of the predominantly distance (dominant) eye was able to see at distance down to intermediate, while the predominantly near (non-dominant) eye was able to see in the intermediate as well as near range.

In the intermediate region, both eyes have similar acuity, and this draws on our knowledge of binocular fusion processing, the horopter—a volume centered on the fixation point that contains all points in space that yield single vision. Monovision, or in this case, micro-monovision, draws on the inherent cortical processes of neuronal gating and blur suppression (i.e., the ability for conscious attention to be directed to the part of the visual field with the best image quality). The distance vision of the near eye is improved vis-à-vis monovision due to both the low nominal myopic refraction of the eye combined with the depth of field effectively, enabling the near eye nominally refracting to -1.50 D to see at distance as if it were, for example, a -0.75 D refraction while at near a -2.25 D refraction. Because the distance vision of the near eye is in the range of 20/25 to 20/80, the tolerance of this micro-monovision is far higher than that of contact lens monovision. And because of the mechanism of action of laser blended vision, it is not possible (or necessary) to preoperatively test patients by a contact lens monovision trial.

A further component of laser blended vision is the increase in depth of field afforded by pupil constriction during accommodation: a component that persists even in eyes that have lost the ability to change crystalline lens power during the accommodative effort. The combination of controlled induced corneal aberrations and pupil constriction gives a significant increase in depth of field on the retinal image, albeit not a perfect image. However, intraretinal and cortical processing and edge detection is the final component working for us in laser blended vision. The pure retinal image, which is modified by spherical aberration, is further enhanced by central processing to yield the perception of clear and well-defined edges.

In summary, laser blended vision draws on five mechanisms for its success as a procedure—depth of field increase by (1) a specific controlled increase in corneal aberrations, (2) pupil constriction during accommodation affording further depth of field increase on the retinal image, (3) retinal and cortical processing for increasing contrast of the retinal image changes produced by spherical aberration, (4) micro-monovision to enable continuous distance to intermediate to near vision between the two eyes, and (5) relying on central cortical processing including neuronal gating and blur-suppression.

RESULTS

We recently analyzed the results of laser blended vision correction in 136 myopic patients, 111 hyperopic patients, and 119 emmetropic patients. All procedures were performed as routine LASIK procedures with the MEL80 excimer laser (Carl Zeiss Meditec) and the Hansatome Zero Compression microkeratome (16z head; Bausch & Lomb, Rochester, New York). We used the CRS-Master (Carl Zeiss Meditec) in expert mode for custom programming of the treatment profiles with our nonlinear aspheric ablation profile, setting the refractive target of the non-dominant eye to -1.50 D. All results presented include enhancements and are presented at 1-year with 95% follow-up.

Distance vision of distance eyes was excellent, with 98% of myopic, 86% of hyperopic, and 92% of emmetropic eyes achieving 20/20. The distance vision of the near eye was better than expected given the -1.50 D refraction, and approximately 80% of the eyes were 20/63 or better. The binocular results improve the results of the distance eyes alone due to neural summation (Figure 1).

Multifocal IOLs are usually reported in terms of rates of 20/25 at distance together with near vision. Near vision for laser blended vision was J3 for practically all eyes in all groups and J2 in 91% of all groups combined. For combined distance and near vision, 94% of myopic and more than 92% of emmetropic patients reached 20/25 and J2; despite the slightly lower accuracy of hyperopic corneal LASIK, 80% of these patients including hyperopia up to 5.75 D nevertheless achieved 20/25 and J2 (and 99% are 20/25 and J5). Of course, patients typically set the bar high for surgeons with the question: "Do I see as well as I could before surgery with my glasses?" In our study, we found that for all 226 patients combined, 94% were within 1 line of their preoperative BCVA.

To demonstrate the effect of neural summation, it was interesting to note that for all three groups combined (5.75 D to emmetropic to -8.50 D), distance vision was 20/63 in 80% of near (non-dominant) eyes and 20/20 in 92% of distance (dominant) eyes. When the relatively blurred non-dominant eye was added for binocular distance vision, the distance vision increased from 92% monocularly to 96% binocularly. In other words, the addition of a blurred non-dominant eye to the distance eye resulted in even better distance vision; unlike contact lens monovision in which it is demonstrated that there is reduction of distance vision obtained monocularly when the non-dominant blurred eye is added.

STEREOACUITY

Studies with monovision have demonstrated that, in many monovision patients, stereoacuity is lost; once this happens, it does not come back. We were somewhat concerned that we were going to induce this problem in our patients. However, results of our stereoacuity studies confirmed that while post-op uncorrected stereoacuity was lower than pre-op near-corrected stereoacuity, a functional level of stereoacuity was maintained; 68% of patients had stereoacuity of 100 seconds or better, and 93% had stereoacuity of 200 seconds or better. The study also found that near-correction restored preoperative near-corrected stereoacuity in the majority of patients; 5% of patients with 40 to 50 seconds of stereoacuity preoperatively showed a 1 patch decrease in best corrected stereoacuity, while 100% of patients initially 60 seconds or less showed no loss at all.

ONE-BUTTON SOLUTION

Programming a laser blended vision case with the CRS-Master is simple. Once the binocular planning laser blended vision (LBV) window appears, one may import the patient's wavefront and topography, enter the refraction of each eye and select full LBV or mini-LBV depending on whether the patient tested positive on the clinical tolerance test—a standard protocol test that is performed in the clinic without contact-lens trials. This function activates the rest of the program. The nominal target refractions are automatically set, but can be adjusted by the surgeon if required.

In conclusion, presbyopia correction remains a challenge because it requires correction of a wide area of refractive errors. Laser blended vision with the MEL80 and CRS-Master offers a solution to presbyopic patients with refractive errors between 5.75 and -9.00 D, including emmetropic presbyopes. With the safety advantages of modern femtosecond LASIK, the rapid bilateral surgical procedure, and the recovery time of a few hours, patient satisfaction is extremely high. Laser blended vision benefits from all of the wow factors of LASIK, with the ability to offer easy enhancement of vision if necessary in the future.

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