ORIGINAL ARTICLE

3-Month experience in presbyopic correction with bi-aspheric multifocal central presbyLASIK treatments for hyperopia and myopia with or without astigmatism

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Received 12 September 2011; accepted 10 December 2011
Available online 22 February 2012

KEYWORDS
Simultaneous viewing;
Distance and near vision;
Aspherical;
Multifocal;
PresbyLASIK;
Presbyopia;
Addition;
LogRAD

Abstract

Purpose: To analyze simultaneous vision (distance and near) 3-month after bi-aspheric multifocal central presbyLASIK treatments for hyperopia and myopia with or without astigmatism.

Methods: Retrospective study analyzing patients that had been treated for correcting distance ametropia and alleviating presbyopic symptoms simultaneously. All patients had been treated in Presby Aspheric mode using FemtoLASIK. No eye had previous corneal refractive surgery. Preoperative corneal curvature ranged between 40 D and 48 D, with pachymetry thicker than 500 μm. Preoperative best distance corrected visual acuity (CDVA) was 0.1 LogMAR or better, with best corrected near vision (CNVA) of 0.2 LogRAD or better.

Results: 66 patients treated using PresbyMAX software (SCHWIND eye-tech-solutions GmbH and Co. KG, Kleinostheim, Germany) were reviewed. For 24 patients, 3-month follow-up was completed. At 3 months, 71% of patients achieved UDVA 0.1 LogMAR or better, 79% patients obtained UNVA 0.1 LogRAD or better, and 83% of eyes were within 0.75 diopters (D) of defocus. Postoperative mean spherical equivalent refraction was −0.15 ± 0.50 D. Stability was achieved from the 6-week follow-up. 92% of patients achieved UDVA 0.2 LogMAR or better and UNVA 0.2 LogRAD or better. No statistical differences between myopes/hyperopes or between males/females were found.

Conclusions: Patient selection and expectation management are essential to achieve patient satisfaction. Even though optically the results are quite predictable, some patients find it difficult to adapt to the compromise between far and near vision, and others are dissatisfied by the minor loss of distance VA.

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Experiencia de 3 meses tras la corrección de la presbicia con tratamientos presbyLASIK centrales multifocales biasféricos para la hipermetropia y la miopía con o sin astigmatismo

Resumen

Objetivo: analizar la visión simultánea (de lejos y de cerca) 3 meses después de tratamientos presbyLASIK centrales multifocales biasféricos para la hipermetropia y la miopía con o sin astigmatismo.

Métodos: Estudio retrospectivo que incluye pacientes que habían sido tratados para corregir ametropías de lejos y a la vez aliviar los síntomas de la presbicia. Todos los pacientes habían sido tratados en modo Presby Aspheric utilizando FemtoLASIK. Ningún ojo se había sometido a cirugía refractiva corneal anteriormente. La curvatura corneal preoperatoria se encontraba entre 40 D y 48 D, con una paquimetría mayor de 500 μm. La agudeza visual de lejos mejor corregida preoperatoria (AVLC) era de 0,1 logMAR o mejor, con una visión de cerca mejor corregida (AVCC) de 0,2 logMAR o mejor.

Resultados: se revisaron 66 pacientes tratados con el software PresbyMAX (SCHWIND eye-tech-solutions GmbH and Co. KG, Kleinostheim, Germany). Se completó el seguimiento de 3 meses para 24 pacientes. Al cabo de 3 meses, el 71% de los pacientes tenía una agudeza visual de lejos sin corregir (UDVA) de 0,1 logMAR o mejor, el 79% una agudeza visual de cerca sin corregir (UNVA) de 0,1 logMAR o mejor y el 83% de los ojos tenían hasta 0,75 dioptrías (D) de desenfoque. El equivalente esférico medio postoperatorio fue de -0,15 ± 0,50 D. A partir del seguimiento de 6 semanas se alcanzó la estabilidad. El 92% de los pacientes alcanzó una UDVA de 0,2 logMAR o mejor y una UNVA de 0,2 logMAR o mejor. No se detectaron diferencias estadísticas entre miopes e hipermetrópe ni entre hombres y mujeres.

Conclusiones: la selección de pacientes y la gestión de las expectativas son clave para lograr la satisfacción del paciente. Aunque desde el punto de vista óptico los resultados son bastante predecibles, algunos pacientes tienen dificultades para tolerar el compromiso entre visión de lejos y de cerca y otros están descontentos por la mínima pérdida de AV de lejos.

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peripheral presbyLASIK on the non-dominant eye with monofocal distance correction on the dominant eye.

From the coexistence of so many different and opposing techniques for approaching the same presbyopic problem, it can be inferred that a satisfying corneal laser correction is yet to be found.

**Methods**

**Patient population and examinations**

This study followed the tenets of the Declaration of Helsinki.

48 eyes of 24 patients undergoing bilateral LASIK for refractive presbyopic corrections were enrolled. The average age was 58 ± 4 years (range, 49 years to 66 years). Patients included in the study had manifest spherical refractive error ranging from −7.00 D to +3.25 D with up to 3.00 D of astigmatism, with presbyopic adds of up to +2.75 D. Patients were enrolled in the study if they had best corrected distance visual acuity (CDVA) of 20/25 or better using the Early Treatment of Diabetic Retinopathy Study (ETDRS) chart, stable refraction for 1 year prior to the study and discontinued contact lenses for at least 2 to 4 weeks (depending on contact lens type) prior to the preoperative evaluation. Patients were required to have normal keratometry and topography. For comparative analyses, all ablations were analyzed for a diameter of 6 mm.

Patients who suffered from systemic illness, had a calculated postoperative corneal bed thickness less than 300 μm after ablation, had preoperative central corneal thickness of less than 500 μm, had previous ocular surgery, or had abnormal corneal topography were excluded from the study.

Baseline examinations included measurement of uncorrected distance and near visual acuity (UDVA and UNVA respectively), CDVA, manifest refraction, distance corrected near visual acuity (DCNVA), corrected near visual acuity (CNVA), presbyopic add, contrast glare sensitivity, corneal topography, corneal wavefront, ultrasound corneal pachymetry, pupilometry, slit lamp examination of the anterior segment and a dilated fundus examination.

Preoperative and postoperative contrast sensitivities with and without glare, using Takagi Contrast Glare Test CGT-1000 (Takagi Seiko Co Ltd, Nagano-Ken, Japan), were measured at six target sizes: 6.3, 4.0, 2.5, 1.6, 1.0, and 0.7 after correcting the refractive error with spectacles. Log values of the contrast sensitivity scores were used for statistical analysis.

At one day postoperatively, UDVA and UNVA were measured and the patient underwent a slit lamp examination of the anterior segment. The same measurements as the baseline examination (with the exception of dilated funduscopy and pupilometry unless warranted and contrast sensitivity at 3 months only) were performed at 1 week, 6 weeks, and 3 months postoperatively.

**Treatment plan**

All treatments were prepared using the SCHWIND PresbyMAX treatment planning module in Aspheric mode (SCHWIND eye-tech-solutions GmbH and Co. KG, Kleinostheim, Germany). This module integrates bi-aspheric multifocal ablation profiles combining two focus-shifted aspheric profiles with different asphericities that compensate for the peripheral loss of energy due to an increased angle of incidence on the cornea and for biomechanical changes induced during LASIK (Fig. 1). The treatment of ocular or corneal wavefront aberrations was not intended in this study.

The sphere and cylinder values entered into the laser were based on the manifest refraction without nomogram adjustment, with both eyes attempting the same goal. Further, the flat and steep keratometry readings at 3 mm diameter as measured by the topographer were used for the compensation of the loss of ablation efficiency when the laser hits the cornea in non-normal incidence. All eyes underwent the refractive treatment using 6.2 to 7.0 mm diameter optical zones based on the preoperative scotopic pupil diameter and based on the kind of refractive error. For each treatment, the planning software calculated the size of the optimal transition zone, depending on the preoperative refraction and optical zone. The total ablation zone ranged from 6.5 mm to 9.0 mm.

Retreatments were not permitted during the course of this study. Once finalized, the treatment plan was directly entered or transferred via Secure Digital memory card to the SCHWIND AMARIS excimer laser.

**Surgery**

Drops of topical anesthetic were instilled in the upper and lower fornices. Flaps were made using Intralase 60 KHz femtosecond laser (AMO, Chicago, Illinois, USA) using 105 nominal flap thickness.

Additional drops of topical anesthetic were instilled, the lid margins and periorbicular region were disinfected using diluted povidone. A sterile drape was used to isolate the surgical field. A lid speculum was inserted to allow maximum exposure of the globe.

Proper alignment of the eye with the laser was achieved with a 1050 Hz infrared eye tracker with simultaneous limbus, pupil, and torsion22 tracking integrated into the laser system and centred on the corneal vertex. The eye tracker had a typical response time of 1.7 ms with a system total latency time of 2.9 ms. The flap was lifted and the excimer laser ablation was delivered to the stroma. Patients were requested to look at a pulsing green fixation light throughout the ablation. The flap was repositioned and the interface was irrigated with balanced salt solution, removing any debris. Patients received topical antibiotic drops QID for 1 week and corticosteroid drops QID tapering off in 1 week and ocular lubricants as needed.

**Excimer laser**

The laser ablation algorithm used a flying spot laser delivery system that operates at 500 Hz with a super-Gaussian beam profile of 0.54 mm Full Width Half Maximum. Depending on the planned refractive correction, approximately 80% of the corneal ablation is performed with a high fluence level (>400 mJ/cm²), thus decreasing treatment times. Fine correction is performed for the remaining ~20% of the treatment using a low fluence level (<200 mJ/cm²) which reduces
the ablation volume per pulse delivered in order to smooth out the ablated area. Spot placement is randomized in order to prevent heat buildup between laser pulses. Additionally, an aspiration system with laminar flow dynamics is incorporated to reduce debris and heat buildup.

**Data analysis**

Refractive and visual outcomes, changes in high-order aberrations and contrast and glare sensitivities were analyzed using Microsoft Excel software (Microsoft, Redmond, Washington, USA). LogMAR and LogRAD visual acuities was converted to Snellen or revised Jaeger acuities for data reporting purposes.

Box and whisker plots are reported in the form: the central line represents the median value, the box represents the percentile range 25% to 75% (1st and 3rd quartiles), and the whiskers represent the minimum and maximum values.

The paired single sided t-test was used to determine statistically significant changes. A p value less than 0.05 was considered statistically significant. Data for 6 weeks and 3 months after LASIK are reported here.

**Results**

Fig. 2 shows the preoperative distributions for spherical equivalent and astigmatism.
Visual acuities

Preoperative
UDVA ranged from $-0.2 \logMAR$ to $+2.0 \logMAR$ (20/12 to 20/2000), whereas CDVA ranged from $-0.4 \logMAR$ to 0.0 $\logMAR$ (20/8 to 20/20). DCNV A ranged from $+0.1 \logRAD$ to $+0.8 \logRAD$ (J1–J10), whereas UNVA ranged from $-0.2 \logRAD$ to $+1.5 \logRAD$ (J1 to J14), and CNVA ranged from $-0.2 \logRAD$ to $+0.2 \logRAD$ (J1–J2).

6-Week postoperative
Figure 3 shows values of UDVA at 6-week postoperative visit that ranged from $-0.1 \logMAR$ to $+1.0 \logMAR$ monocularly (20/16 to 20/200), and from $-0.2 \logMAR$ to $+0.5 \logMAR$ binocularly (20/12 to 20/63), whereas CDVA ranged from $-0.1 \logMAR$ to $+0.4 \logMAR$ monocularly (20/16 to 20/50). The loss in monocular CDVA was statistically significant ($p < 0.0001$). DCNV A ranged from 0.0 $\logRAD$ to $+0.6 \logRAD$ monocularly and binocularly (J1–J8), whereas UNVA ranged from $-0.1 \logRAD$ to $+0.6 \logRAD$ monocularly (J1–J8), and from $-0.1 \logRAD$ to $+0.4 \logRAD$ binocularly (J1–J6). The improvement in monocular DCNV A was statistically significant ($p < 0.0001$) and there were further improvements in this parameter between 6-weeks and 3-months ($p = 0.02$).

At 6-week postoperatively, 54% of the eyes could see uncorrected both 0.2 $\logMAR$ and 0.2 $\logRAD$ or better (20/32 and J2), and 88% of the patients could see uncorrected both 0.2 $\logMAR$ and 0.2 $\logRAD$ or better binocularly (20/32 and J2) (Fig. 4).

3-Month postoperative
Figure 3 shows values of UDVA at 3-month postoperative visit that ranged from $-0.1 \logMAR$ to $+1.0 \logMAR$ monocularly (20/16 to 20/200), and from $-0.2 \logMAR$ to $+0.5 \logMAR$ binocularly (20/12 to 20/63), whereas CDVA ranged from $-0.2 \logMAR$ to $+0.2 \logMAR$ monocularly (20/12 to 20/32). The loss in monocular CDVA was statistically significant ($p < 0.0001$) but no change in this parameter was noticed between 6-weeks and 3-months ($p = 0.2$). DCNV A ranged from 0.0 $\logRAD$ to $+0.6 \logRAD$ monocularly (J1–J8), and from $-0.1 \logRAD$ to $+0.5 \logRAD$ binocularly (J1–J6), whereas UNVA ranged from $-0.1 \logRAD$ to $+0.5 \logRAD$ monocularly (J1–J6), and from $-0.2 \logRAD$ to $+0.3 \logRAD$ binocularly (J1–J4). The improvement in monocular DCNV A was statistically significant ($p < 0.0001$) and there were further improvements in this parameter between 6-weeks and 3-months ($p = 0.02$).

At 3-month postoperatively, 79% of the eyes could see uncorrected both 0.3 $\logMAR$ and 0.3 $\logRAD$ or better (20/40 and J4), and 63% of the patients could see uncorrected both 0.1 $\logMAR$ and 0.1 $\logRAD$ or better binocularly (Fig. 4) (20/25 and J1).

Fig. 5 shows the scattergram of uncorrected visual acuities for far and near.
Refractive outcomes

Scattergram of the achieved versus attempted refractive corrections show only –5% an undercorrection rate of 5% for SEQ and an undercorrection of 6% for manifest astigmatism at 3M postop (Fig. 6). The global refractive deviation from target refraction was \(-0.2 \pm 0.5 \) D for SEQ, \(0.3 \pm 0.3 \) D for Ast, and \(0.5 \pm 0.3 \) D for the norm of the U-Vector (Fig. 7).

70% of the eyes were within 0.50 D of target refraction already at 6 W postop (Fig. 8).

Pseudoaccommodation

The change in DCNV A was taken as metric for the achieved pseudo-accommodation. The change in DCNV A from preop to 3-month postop ranged from 1 line loss to 6 lines gained. This change correlated to the planned addition (Fig. 9).

Table 1 Summary of the wavefront aberrations.

<table>
<thead>
<tr>
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<th>Pre op</th>
<th>6 W</th>
<th>3 M</th>
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<tr>
<td></td>
<td>RMS</td>
<td>Corn SA</td>
<td>Oc SA</td>
</tr>
<tr>
<td>n</td>
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<td>46</td>
<td>46</td>
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<tr>
<td>Mean</td>
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<tr>
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</tr>
<tr>
<td>Min</td>
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<tr>
<td>Max</td>
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<td>0.244</td>
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@6mm, at 6 mm analysis diameter; pre op, preoperatively; 6 W, at 6 week follow-up; 3 M, at 3 month follow-up; RMS, root mean square; Corn SA, corneal spherical aberration; Oc SA, ocular spherical aberration; n, number; StdDev, standard deviation.
3-Month experience bi-asperic presbyLASIK correction

3-Month postoperative

Asphericity

Table 2 shows the asphericity values before surbery, 6 week and 3 months after surgery.

Preoperative

The quotient of asphericity (Q) represents how fast the corneal surface deviates from a spheric surface. Q-value as reported by Pentacam ranged from −0.56 to +0.23, whereas Q-value reported by OPD-Scan ranged from −0.42 to +0.26.

6-Week postoperative

Q-value reported by OPD-Scan ranged from −2.05 to −0.24 (change p < 0.0001).

3-Month postoperative

Q-value as reported by Pentacam ranged from −1.19 to +0.86 (change p = 0.4), whereas Q-value reported by OPD-Scan ranged from −2.32 to −0.30 (change p < 0.0001). The change in Q-value reported by OPD-Scan from 6-week to 3-month was statistically significant (p = 0.03).

Figure 4  Histograms for the cumulative uncorrected visual acuities postoperatively. At 6-week postoperatively, 54% of the eyes could see uncorrected both 0.2 LogMAR and 0.2 LogRAD or better, and 88% of the patients could see uncorrected both 0.2 LogMAR and 0.2 LogRAD or better binocularly. At 3-month postoperatively, 79% of the eyes could see uncorrected both 0.3 LogMAR and 0.3 LogRAD or better, and 63% of the patients could see uncorrected both 0.1 LogMAR and 0.1 LogRAD or better binocularly.

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Binocular uncorrected visual acuities

Figure 5  Uncorrected visual acuities scattergram.

Scattergram Achieved versus Attempted refractive corrections

Figure 6  Scattergram of the achieved versus attempted refractive corrections for the spherical equivalent (Seq) and the manifest astigmatism (Ast).

Table 2  Summary of the corneal asphericities.

<table>
<thead>
<tr>
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<td>-1.14</td>
<td>-0.18</td>
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</tr>
<tr>
<td>1st quartile</td>
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<td>-1.49</td>
<td>-0.67</td>
<td>-1.60</td>
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<tr>
<td>Min</td>
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<td>-1.19</td>
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<td>Max</td>
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<td>0.26</td>
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<td>0.86</td>
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<tr>
<td>3rd quartile</td>
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</tbody>
</table>
3-Month experience bi-aspHERIC presbyLASIK correction

Figure 7 Postoperative predictability analyses. The global refractive deviation from target refraction was $-0.2 \pm 0.5$ D for SEq, $0.3 \pm 0.3$ D for Ast, and $0.5 \pm 0.3$ D for the norm of the U-Vector. SEq, Spherical equivalent; Ast, Astigmatism; U, U-vector; Dev, Deviation line.

Contrast sensitivity

Figs. 10 and 11 compare in logarithmic scale the contrast sensitivity without and with glare. Contrast measurements were slightly reduced post than pre ones. Glare measurements were always less scored than non-glare ones. Glare measurements were not reduced from pre to post. No significant differences in Contrast or Glare between 6W and 3M were detected.

Discussion

The main goal of a surgical procedure to correct presbyopia is to enhance not only distance but also near visual acuity and the range of relatively clear vision. The surgical techniques to correct presbyopia can be broadly categorized as follows: systems that mimic the crystalline lens and bi- or multifocal techniques that enhance depth of focus and monovision. The use of artificial aperture stops has also been established for increasing depth of focus. Patients may rate an intervention highly even though essential features of normal visual perception are degraded. For example, monovision is highly rated by patients even though binocular vision is compromised. Measuring the depth of focus is a useful marker but measuring acuity at typical near vision distances may be closer related to patients’ real expectations and concerns.

Monovision LASIK has been found to produce high levels of patient satisfaction, with Goldberg reporting 96% satisfaction and Miranda 92%.

Figure 8 Postoperative distribution of the refractive outcomes. 70% eyes were within 0.50D of target refraction already at 6W postop.
Contact lens monovision and LASIK-induced monovision traditionally use a nomogram for near addition, with the degree of anisometropia increasing from approximately −1.50D for a 45-year-old patient up to −2.50D for a 65-year-old patient. Tolerance for monovision reduces with the value of induced anisometropia and is no longer tolerated when it is larger than 2.50D.

The performance of different types of IOLs (refractive, diffractive, pseudo-accommodating, and multifocal) is constantly being improved, but the IOLs cause a decrease in near vision contrast sensitivity.

PresbyLASIK treatment uses the principles of LASIK surgery to create a multifocal corneal surface aimed at reducing near vision spectacle dependence in presbyopic patients. This treatment constitutes the next step in the correction of presbyopia after monovision LASIK.

The term presbyLASIK indicates a corneal surgical procedure based on traditional LASIK to create a multifocal surface able to correct any visual defect for distance while simultaneously reducing the near spectacle dependency in presbyopic patients.

Using a micro-monovision protocol, Reinstein et al. recently succeeded with an intended postoperative refraction of plano to low myopia for the dominant eye and in the range of −1.00 to −1.50D for the non-dominant eye, irrespective of the patient’s age, and determined that the near eye had a beneficial effect on binocular UDVA when compared to the monocular UDVA of the dominant (distance) eye.

Pinelli et al. investigated the outcome of the correction of presbyopic patients with hyperopia using a peripheral presbyLASIK algorithm called Peripheral Multifocal LASIK (PML). This treatment creates a multifocal corneal profile in a 6.5-mm diameter zone by the combination of a positive ablation performed over a 6.5-mm zone and a negative ablation performed over an optical zone no smaller than 5 mm. The hypothesis is that the ring between the 5- and 6.5-mm optical zones provides multifocality.

In several reports, Alió et al. demonstrated the efficiency, predictability, stability, safety, and visual quality of central presbyLASIK in presbyopic patients with hyperopia.

In another study, they reported the correlation of the clinical results of this presbyLASIK method with a theoretical predictive model, showing the adjustment of both.

Concerning pseudo-accommodation and multifocality, these methods can neither correct presbyopia, nor restore accommodation, nor stop the progress of presbyopia, nor slow down the progress of presbyopia. If the lens cannot accommodate, after any pseudo-accommodative or multifocal approach, the lens will still not accommodate. Using presbyLASIK techniques it is possible to benefit from pseudo-accommodation and multifocality, reducing dependency on reading-spectacles by providing controlled extended depth-of-focus. Treatments can be prescribed for preventing latent presbyopic symptoms, delaying reading-spectacles demands while presbyopia progresses and treatments may be repeated with minimum risk if reading-spectacles demands renew.

If no cataracts are present, but refractive defects exist, presbyLASIK techniques offer the potential to correct far-distance refraction and to alleviate the presbyopic symptoms, with the goal of spectacle-free vision at all distances.

The specific planning software platform allows using WaveFront diagnostic data together with Presbyopic compensation combining the advantages of both techniques (improved visual outcome through WaveFront guided correction and enhanced pseudo-accommodation). Finally, a Controlled Multifocal Vision is expected and the profile meets the requirements:

- Multifocally, the centre is corrected for near and the periphery for far vision.
- Optimized bi-aspheric profile.
- Adding a pre-calculated amount of different high order spherical aberrations.

![Induced pseudoaccommodation (extended depth-of-focus)](image)

**Figure 9** Postoperative pseudoaccommodation analysis. 70% eyes were within 0.50 D of target refraction already at 6 W postop. The change in DCNV was taken as metric for the achieved pseudo-accommodation. The change in DCNV from preop to 3-month postop ranged from 1 line loss to 6 lines gained. This change correlated to the planned addition.
In our cohort, patients have got (both objectively and subjectively) good distance vision, very good vision at the intermediate region, and excellent near vision. Combined, it offers a possible compromise for the whole distance range.

We have performed some permutations with the available data now based on the change of DCNVA as a metric for induced multifocality, and we have only observed statistically significant univariate correlations between DCNVA and preoperative SEq (higher hyperopic treatment implies...
higher gain in DCNV), preoperative ast (lower astigmatism preop implies higher gain in DCNV), OZ (larger OZ planned implies higher gain in DCNV), offset (larger offset implies higher gain in DCNV).

There was a wide range for the postoperative DCNV (0.3 ± 0.1 LogRAD (~J4.6), 0.0 LogRAD to +0.6 LogRAD monocularly (~J1–J8), and 0.2 ± 0.1 LogRAD (~J3.5), −0.1 LogRAD to +0.5 LogRAD binocularly (>J1–J6)), whereas the
outcome for near was excellent \((0.1 \pm 0.2 \text{ LogRAD} \sim \text{J2.7})\), 
\(-0.1 \text{ LogRAD} \text{ to } +0.5 \text{ LogRAD monocularly (\sim J1–J6), and}
\ 0.1 \pm 0.1 \text{ LogRAD (\sim J1.8), } \ 0.2 \text{ LogRAD to } +0.3 \text{ LogRAD binocularly (\sim J1–J4)}.\) This apparent contradiction can be explained at the light of the slightly myopic spherical equivalent postoperative \((-0.4 \pm 0.5 \text{ D}, -1.38 \text{ D to } +0.50 \text{ D})\) further improving UNVA at the cost of slightly diminishing UDVA \((0.2 \pm 0.2 \text{ LogMAR (\sim 20/35), } -0.1 \text{ LogMAR to } +1.0 \text{ LogMAR monocularly (20/16 to 20/200), and } 0.1 \pm 0.1 \text{ LogMAR (\sim 20/27), } -0.2 \text{ LogMAR to } +0.5 \text{ LogMAR binocularly (20/12 to 20/63)})\).

Nonetheless, it is really important to individually check whether a patient is a PresbyMAX candidate or not. The patients shall be asked for their profession, hobbies, and expectations comparing whether the postoperative visual performance provided with the ablation profile can comply with patient’s needs. A trial with adequate multifocal contact lenses or just providing slightly defocused images (via trial frame) to the retina simulates postoperative visual impressions in a way and verifies for patient’s acceptance.

The aim of this approach is a spectacle-free vision in usual day-life-situations but with possibly need of additives, i.e. spectacles for reading or distance, in case of special demands while focussing. Well-lit conditions provide best near performance, dimmed conditions are optimal for distance – patients profit wearing sunglasses for distance. Centring on corneal vertex is essential and helps to reduce the induction of unwanted high-order aberrations, especially disturbing asymmetrical aberrations like coma.

Controversy remains regarding where to centre corneal refractive procedures to maximize the visual outcomes. A misplaced refractive ablation might result in undercorrection and other undesirable side effects. The coaxial light reflex seems to lie nearer to the corneal intercept of the visual axis than the pupil centre (PC) and is, thus, recommended that the corneal coaxial light reflex be centred during refractive surgery. Boxer Wachler et al. identified the coaxial light reflex and used it as the centre of the ablation. De Ortueta and Arba Mosquera used the corneal vertex (CV) measured by videokeratoscopy as the morphologic reference to centre corneal refractive procedures.

The centre of the pupil considered for a patient who fixes properly is the locus where the line-of-sight passes through, which is the reference axis recommended by the OSA for representing the wavefront aberration.

Nevertheless, because the pupil centre is unstable, a morphologic reference is more advisable. It is well known that the pupil centre shifts with changes in the pupil size, moreover, because the entrance pupil we see is a virtual image of the real one.

Due to the smaller angle kappa associated with myopes compared with hyperopes, centration issues are less apparent. However, angle kappa in myopes may be sufficiently large to show differences in results. A pupillary offset of 0.25 mm seems to be sufficiently large to be responsible for differences in ocular aberrations, however, not large enough to correlate this difference in ocular aberrations with functional vision.

Nowadays, technology has evolved significantly and uses sophisticated algorithms, optimized tools in the planning, and proposes the challenge of improving surgery outcomes in terms of visual acuity and night vision. At the same time, patients have a better understanding and are better informed with regard to the potential of laser refractive surgery, raising quality requirements demanded to clinical staff and equipment.

In discussing visual benefit, although VA data are helpful, there may be patients with 20/20 vision who are unhappy with their visual outcomes due to poor mesopic and low-contrast VA.

Human vision is a binocular process. Having two eyes gives binocular summation in which the ability to detect faint objects is enhanced. It can give stereopsis in which parallax provided by the two eyes’ different positions on the head give precise depth perception. Such binocular vision is usually accompanied by binocular fusion, in which a single image is seen despite each eye is having its own image of any object.

Literature suggests that marked anisometropia is uncommon either in the magnitude of sphere or astigmatism, with few notable exceptions concluding that the axis of astigmatism does not follow any particular rule (mirror or direct symmetry) across right and left eyes.

Porter et al. confirmed in a large population that although the pattern of aberrations varies from subject to subject, aberrations, including irregular ones, are correlated in left and right eyes of the same subject, indicating that they are not random defects.

Wang et al. found that anterior corneal wave aberrations varied greatly among subjects, but a moderate to high degree of mirror symmetry existed between right and left eyes.

Our analysis suggests, that bi-aspheric multifocal central presbyLASIK treatments for hyperopia and myopia with or without astigmatism provides fair but sufficient simultaneous vision (distance and near) 3-month after surgery.

**Conclusions**

In our cohort, at 3 months, 71% of patients achieved UDVA 0.1 LogMAR or better, 79% patients obtained UNVA 0.1 LogRAD or better, and 83% of eyes were within 0.75 diopters (D) of defocus. Postoperative mean spherical equivalent refraction was \(-0.15 \pm 0.50 \text{ D}\). Stability was achieved from the 6-week follow-up. 92% of patients achieved UDVA 0.2 logMAR or better AND UNVA 0.2 logRAD or better. No significant differences among myopes, hyperopes, emmetropes or between males and females were found.

Patient selection and expectation management are essential to achieve patient satisfaction. Even though optically the results are quite predictable, some patients find it difficult to adapt to the compromise, and others are dissatisfied by the minor loss of distance VA. Certain individuals are best suited for PresbyMAX. A trial with multifocal contact lenses or trial frames that creates slightly defocused images to the retina can be used to simulate postoperative visual impressions and verify patient acceptance. Asking patients about their profession, hobbies, and expectations helps to understand whether the postoperative visual performance can meet their individual needs.
References


3-Month experience bi-aspheric presbyLASIK correction


