Comparing a bifocal and trifocal diffractive IOL

Study demonstrates significantly better overall visual performance with the trifocal lens

By Dr Peter Mojzis, PhD, FEBO, and Dr David P. Piñero, PhD

Multifocal diffractive intraocular lenses (IOLs) distribute light to different foci by assigning appropriate dimensions to the diffractive pattern (concentric rings) on the lens surface.[1]

Bifocal designs based on this diffractive technology were initially developed with an optic that generates two primary focal points; one corresponding to distance and the other to near vision.[2,3] Although this type of IOL has demonstrated excellent distance and near visual outcomes, visual function at intermediate distance remains relatively limited.[2–4]

Trifocal diffractive IOLs have recently been developed to overcome this potential limitation by generating three useful focal distances (far, intermediate and near) using a 100% diffractive technology.[5]

Some studies have confirmed the benefit at intermediate distance with this type of IOL, but there are no studies comparing the visual performance achieved with a bifocal versus a trifocal diffractive IOL.[6–8]

In our clinic, we performed a comparative study of the visual, refractive, contrast sensitivity and aberrometric outcomes obtained after cataract surgery with implantation of the AT LISA diffractive bifocal (AT LISA 801, Carl Zeiss Meditec, Jena, Germany) and trifocal IOL (AT LISA tri 839MP, Carl Zeiss Meditec).[9]

Methods

We performed a prospective comparative study that included 60 eyes of 30 patients who were randomly assigned to either a bifocal or trifocal implant. Two groups of 30 eyes of 15 patients were differentiated accordingly: the bifocal group received the bifocal diffractive IOL AT LISA 801 and the trifocal group received the trifocal diffractive IOL AT LISA tri 839 MP. The same type of IOL was implanted in both eyes of each patient.

Inclusion criteria were patients with cataract or presbyopic/pre-presbyopic patients suitable for refractive lens exchange seeking spectacle independence. Exclusion criteria were patients with history of glaucoma or retinal detachment, any active ocular disease, history of ocular inflammation or previous ocular surgery.

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Before surgery, a complete ophthalmological examination was performed including refraction, keratometry, uncorrected (UDVA) and corrected distance visual acuity [CDVA (assessed using ETDRS charts)], uncorrected (UIVA) and corrected intermediate visual acuity [CIVA (66 cm)], uncorrected (UNVA) and corrected near visual acuity and [CNVA (40 cm)], distance-corrected near (DCNVA) and intermediate visual acuity (DCIVA), tonometry,

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With the recent development of trifocal diffractive IOLs, to overcome the potential limitation of a lack in intermediate distance vision, studies have been published confirming the benefit of these lenses. However, until now, there has been no comparative study between the visual performance achieved with a bifocal versus a trifocal diffractive IOL. In this article, the authors reveal the details and results of their recent comparative study of the AT LISA diffractive bifocal and trifocal lenses.

TABLE 1: Comparative table showing the postoperative visual and refractive outcomes in the bifocal and trifocal groups of the current study.

Mean (SD) Median (Range)	Bifocal group	Trifocal group	P-value
LogMAR UDVA	0.00 (0.13) 0.00 (–0.10 to 0.40)	–0.05 (0.08) –0.10 (–0.20 to 0.10)	0.21
LogMAR CDVA	–0.03 (0.11) 0.00 (–0.20 to 0.40)	–0.06 (0.07) –0.10 (–0.20 to 0.10)	0.37
LogMAR UNVA	0.30 (0.15) 0.30 (0.10 to 0.60)	0.15 (0.09) 0.10 (0.00 to 0.40)	<0.01
LogMAR CNVA	0.27 (0.12) 0.30 (0.10 to 0.50)	0.12 (0.07) 0.10 (0.00 to 0.30)	<0.01
LogMAR DCNVA	0.32 (0.16) 0.30 (0.10 to 0.70)	0.14 (0.10) 0.10 (0.00 to 0.40)	<0.01
LogMAR UIVA	0.29 (0.18) 0.30 (–0.10 to 0.60)	0.06 (0.07) 0.05 (0.00 to 0.30)	<0.01
LogMAR CIVA	0.10 (0.11) 0.10 (–0.10 to 0.40)	0.05 (0.05) 0.00 (0.00 to 0.10)	0.03
LogMAR DCIVA	0.30 (0.17) 0.30 (0.00 to 0.60)	0.06 (0.07) 0.05 (0.00 to 0.30)	<0.01
Sphere (D)	–0.18 (0.38) –0.25 (–1.00 to +0.75)	–0.19 (0.35) –0.25 (–1.00 to +0.75)	0.85
Cylinder (D)	–0.46 (0.33) –0.50 (–1.00 to 0.00)	–0.20 (0.21) –0.25 (–0.75 to 0.00)	<0.01
Spherical equivalent (D)	–0.40 (0.42) –0.38 (–1.38 to +0.25)	–0.29 (0.33) –0.25 (–1.25 to +0.38)	0.22

**Abbreviations: SD, standard deviation; D, dioptres; UDVA, uncorrected distance visual acuity; CDVA, corrected distance visual acuity; UNVA, uncorrected near visual acuity; DCNVA, distance-corrected near visual acuity; CNVA, corrected near visual acuity; UIVA, uncorrected intermediate visual acuity; CIVA, corrected intermediate visual acuity; DCIVA, distance-corrected intermediate visual acuity.*

slit lamp examination, ocular aberrometry (OPD scan III, Nidek), corneal topography (OPD scan III, Nidek, Aichi, Japan), biometry (IOLMaster v.4.3, Carl Zeiss Meditec), and funduscopy. The same examination protocol was followed again, 3 month after surgery, with the additional evaluation of contrast sensitivity measurements under photopic conditions (CSV-1000) and the defocus curve binocularly.

All surgical procedures were performed by the same experienced surgeon (PM) using a standard technique of sutureless micro-coaxial 2.2-mm phacoemulsification in the bifocal group (AT LISA 801) and a technique of microincision (1.6-mm) phacoemulsification in the trifocal group (AT LISA tri 839MP).

Results

No statistically significant differences in visual and refractive outcomes between groups were found in postoperative UDVA and CDVA (Table 1). This confirms that the generation of a third focal point with the AT LISA trifocal diffractive IOL does not detrimentally affect the distance focal point.

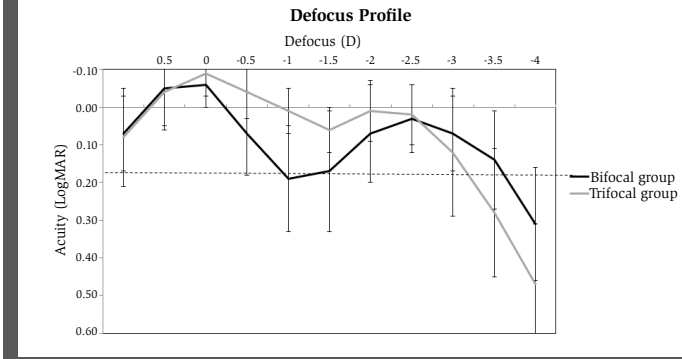
In contrast, UNVA, CNVA and DCNVA as well as UIVA, CIVA and DCIVA were significantly better in the trifocal group compared to the bifocal group.

Considering that there were no significant differences between groups in terms of spherical equivalent refraction, the IOL optical behaviour appears to be the main factor for this finding.

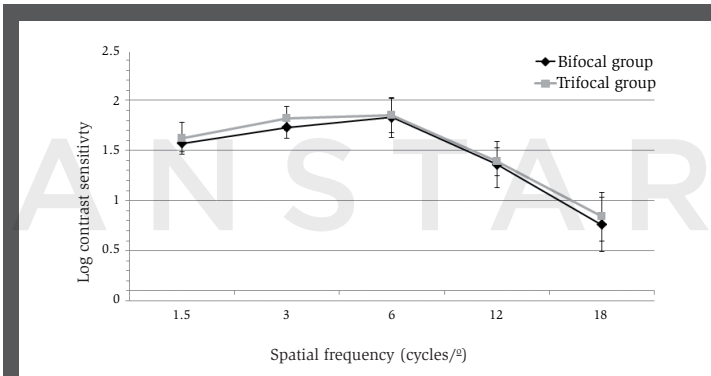
Therefore, the overall visual performance achieved at 40 cm with the AT LISA trifocal IOL was significantly better than that achieved with the AT LISA bifocal diffractive IOL.

The AT LISA trifocal IOL overcame the intermediate distance visual limitation of the AT LISA bifocal IOL. This was clearly visualized when the binocular defocus curve was analysed (Figure 1). Specifically, visual acuity was significantly better in the trifocal group compared to bifocal for the defocus levels of –0.50 (P = 0.01), –1.00 (P<0.01) and –1.50 D (P = 0.04) (Figure 1).

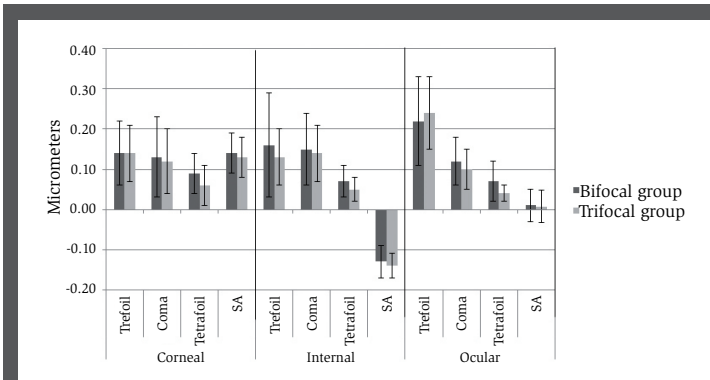
Gatinel and Houbrechts evaluated the differences in optical performance of nine multifocal IOLs, including one trifocal (FineVision, PhysIOL, Liège, Belgium) and several bifocal IOLs (one of them the AT LISA bifocal), using the same optical bench and also found that intermediate vision was more prominent with the trifocal IOL compared to bifocals.[10] In contrast, the AT LISA bifocal IOL in our study provided a better binocular visual acuity than the AT LISA trifocal IOL for



(FIGURE 1) Mean defocus curve in bifocal (black line) and trifocal (grey line) groups.



(FIGURE 2) Mean contrast sensitivity function in bifocal (black line) and trifocal (grey line) groups.



(FIGURE 3) Postoperative ocular, corneal and internal aberrometric data in bifocal (dark grey bars) and trifocal (clear grey bars) groups.

defocus levels equivalent to the near distances closest to the eye (around 30–25 cm) (Figure 1).

Finally, equivalent levels of contrast sensitivity (Figure 2) with both types of IOL were obtained in our study, as well as no significantly different levels in most ocular and intraocular higher order aberrations (Figure 3). Only significantly higher levels of tetrafoil were observed in the bifocal groups and were consistent with the significantly higher levels of corneal tetrafoil that were present postoperatively and even preoperatively (Figure 3). Therefore, the generation of a third focal point does not seem either to be associated to a decrease of the postoperative ocular optical quality.

Conclusions

The implantation of the trifocal IOL AT LISA tri 839 MP after cataract surgery provides effective distance, intermediate and near visual restoration, with better near and intermediate visual acuities than can be obtained with the bifocal IOL AT LISA 801, but while maintaining the same level of ocular optical quality. Therefore, in terms of visual outcome, the AT LISA tri 839 MP trifocal IOL appears to be a better option versus the AT LISA 801 bifocal diffractive IOL.

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