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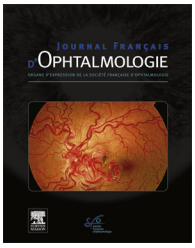

ORIGINAL ARTICLE

Phacoemulsification with implantation of a trifocal intraocular lens in eyes with asteroid hyalosis and synchysis scintillans

Phacoémulsification et implantation d'une lentille intraoculaire trifocale dans les yeux atteints de hyalopathie astéroïde et synchysis étincelant

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KEYWORDS
Asteroid hyalosis;
Synchysis scintillans;
Trifocal intraocular lens;

Summary
Purpose. — To compare the visual outcomes in both eyes of patients who undergo phacoemulsification and trifocal intraocular lens (IOL) implantation and have asteroid hyalosis (AH) or synchysis scintillans (SS) in only one eye.

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Multifocal intraocular lens

Methods. — A retrospective comparative case series was performed. We evaluated uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), uncorrected intermediate visual acuity (UIVA), uncorrected near visual acuity (UNVA), predictability, safety, efficacy, and satisfaction after implantation of the same model of trifocal IOL in both eyes (PhysIOL FineVision Pod-F and Micro-F and Rayner RayOne Trifocal).
Results. — A total of 164 eyes of 82 patients (41 females, 50%) met the inclusion criteria. There were no statistically significant differences in sphere, cylinder, spherical equivalent, UDVA, UIVA, or UNVA between the groups. Postoperative CDVA was slightly better in the control group (logMAR 0.03) than in the AH/SS group (logMAR 0.04) (*P*: 0.014). There were no statistically significant differences in predictability, safety index, or efficacy index between the groups. Overall subjective satisfaction was good (98.2%).
Conclusions. — Visual outcomes and satisfaction are good after implantation of trifocal IOLs in eyes with AH or SS. Therefore, trifocal IOLs should not be ruled out in these patients when no other vitreoretinal disorder is present.

MOTS CLÉS
Hyalopathie astéroïde ;
Synchysis étincelant ;
Lentille intraoculaire trifocale ;
Lentille intraoculaire multifocale

Résumé
Objectif. — Comparer les résultats visuels dans les deux yeux de patients qui subissent une phacoémulsification et une implantation de lentille intraoculaire (LIO) trifocale et qui présentent une hyalopathie astéroïde (HA) ou une synchysis étincelant (SE) dans un seul œil.
Méthodes. — Une série de cas comparatifs rétrospectifs a été réalisée. Nous avons évalué l'acuité visuelle de loin non corrigée (UDVA), l'acuité visuelle de loin corrigée (CDVA), l'acuité visuelle intermédiaire non corrigée (UIVA), l'acuité visuelle de près non corrigée (UNVA), la prévisibilité, la sécurité, l'efficacité et la satisfaction après l'implantation du même modèle de LIO trifocales dans les deux yeux (PhysIOL FineVision Pod-F et Micro-F et Rayner RayOne Trifocale).
Résultats. — Un total de 164 yeux de 82 patients (41 femmes, 50 %) répondaient aux critères d'inclusion. Il n'y a aucune différence statistiquement significative en termes de sphère, de cylindre, d'équivalent sphérique, d'UDVA, d'UIVA et d'UNVA entre les groupes. La CDVA postopératoire est légèrement meilleure dans le groupe témoin (logMAR 0,03) que dans le groupe HA/SE (logMAR 0,04) (*p* : 0,014). Il n'y a aucune différence statistiquement significative en termes de prévisibilité, d'indice de sécurité et d'indice d'efficacité entre les groupes. La satisfaction subjective globale est bonne (98,2 %).
Conclusions. — Les résultats visuels et la satisfaction sont bons après l'implantation de LIO trifocales dans les yeux atteints d'HA ou de SE. Par conséquent, les LIO trifocales ne doivent pas être exclues chez ces patients lorsqu'aucun autre trouble vitréo-rétinien n'est présent.

Introduction

Phacoemulsification with implantation of a trifocal intraocular lens (IOL) is widely used to treat presbyopia in patients with and without cataracts [1,2]. However, these IOLs are usually implanted in eyes not affected by other ocular conditions, except crystalline lens opacification or dysfunction.

The presence of floaters in the vitreous may lead to a loss of visual acuity and visual quality; therefore, most ophthalmologists avoid implanting trifocal IOLs in these eyes [3]. Asteroid hyalosis (AH) and synchysis scintillans (SS) are specific conditions in which opacities appear in the vitreous.

AH consists in tiny white or yellow-white opacities with a smooth spherical morphology composed of calcium, phosphorus, and oxygen that float evenly throughout the vitreous [4]. These particles measure 3 to 100 microns [5]. AH usually affects 1 eye (75—90%), and it is not clear whether it is more prevalent in men [6,7]. Prevalence increases with age. Studies based on autopsy specimens documented it to be 3.2% and 6.6% in patients aged 61—70 years and more than 91 years, respectively [6].

SS, or cholesterolosis bulbi is a degenerative process that involves small yellow-white, gold, or multicolored cholesterol crystals floating in the vitreous cavity or deposited in the subretinal space (rarely, in the anterior chamber) [8]. It usually appears in eyes affected by intravitreous hemorrhage, and the crystals tend to settle inferiorly after the patient develops posterior vitreous detachment. It may also

be secondary to eye trauma, long-term cataract, recurrent intraocular inflammation, or hyphema, secondary glaucoma [9], or vascular disorders.

Phacoemulsification may be difficult in affected patients because opacities can hamper correct measurement of the axial length of the eye. In addition, opacities can impair the view of the posterior capsule. Silicone IOLs should be avoided owing to possible deposition of calcium and phosphorus over the posterior lens surface [10,11].

The implantation of diffractive trifocal IOLs under these clinical conditions to improve spectacle dependence is controversial, since it is known to induce contrast sensitivity loss and a greater incidence of dysphotopsia. The objectives of this study were to assess the performance of trifocal IOLs in patients with AH or SS in 1 eye and to compare visual and refractive outcomes with the fellow eye (healthy vitreous).

Methods

Design

This multicenter, multisurgeon, single-protocol, retrospective, comparative case series study enrolled consecutive patients who had undergone bilateral lensectomy with implantation of the same trifocal IOL in both eyes. Only 1 eye was affected by AH or SS.

Subjects

Data were recorded from the central computerized clinical records system at Clinica Baviera, Spain (2014 to present). The study was approved by the Institutional Legal and Ethics Committee. All patients received detailed information before surgery and gave their written informed consent for multifocal lensectomy after corneal surgery and for the use of their anonymous and aggregated medical data for clinical research.

The study inclusion criteria were as follows: (1) same spherical trifocal IOL surgery (clear lens or cataracts) in both eyes; (2) presence of AH or SS in only 1 eye; and (3) at least 3 months of follow-up after lens surgery. The exclusion criteria included the following: eyes with any other baseline anatomical disorder (vitreoretinal or surface/anterior segment disorder) or any perioperative anatomical complications (corneal and/or lens surgeries).

Intraocular lenses

The diffractive trifocal IOLs implanted during the study period were the FineVision Micro-F, FineVision Pod-F (PhysIOL, Liege, Belgium), and the Ray One (Rayner, Worthing, United Kingdom). All 3 IOLs are made of foldable hydrophilic acrylic material. The FineVision Micro-F (single-piece 4-loop haptics) and FineVision Pod-F (single-piece, double-C loop haptics) combine 2 diffractive structures adjusted to offer a +3.50 diopter [D] addition for near vision and a +1.75 D addition for intermediate vision; both have a negative aspheric profile of 0.11 mm. The RayOne Trifocal IOL provides an aspheric optic (aspheric profile with 0 μm of SA) with 16 diffractive steps, a +3.50 D near addition, and a +1.75 D intermediate addition.

Surgical procedure

Surgical procedures were performed by experienced surgeons based on homogeneous perioperative protocols. Standard phacoemulsification with implantation of a trifocal IOL in the capsular bag was performed without complications. The postoperative target for the IOL power calculation was emmetropia in all cases. The postoperative pharmacologic treatment protocol consisted of a combination of antibiotic and steroidal anti-inflammatory drops and additional nonsteroidal anti-inflammatory drops.

Clinical evaluation

Lensectomies were performed at the authors' institution based on homogeneous preoperative assessment protocols: all patients underwent a complete ophthalmologic examination that included measurement of visual acuity data, namely, distance vision (Snellen Auto Chart Projectors, Topcon Europe Medical B.V., Capelle aan den Ijssel, The Netherlands), near vision (Runge Near Vision Card, Good-Lite Co., Elgin, IL, USA), refraction (uncorrected and corrected, manifest, and cycloplegic), topography, slitlamp biomicroscopy, ocular surface and tear film evaluation, and fundoscopy. However, because of diversity in practice locations and development of devices over time, the preoperative evaluation was not standardized. The preoperative examination also included endothelial cell count (SP 3000P, Topcon Europe Medical B.V.) and macular optical coherence tomography (SOCT Copernicus-REVO, Optopol Technology SA, Zawiercie, Poland). Biometric parameters were assessed using an optical biometer (IOLMaster 500, Carl Zeiss Meditec AG, Jena, Germany).

Refractive and visual measures

The main measures were visual and refractive outcomes obtained at the last available visit, with at least 3 months of follow-up after surgery or laser visual correction enhancement if needed. Visual results included mean logMAR uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), uncorrected intermediate visual acuity (UIVA), and UNVA (uncorrected near visual acuity); refractive data included postoperative sphere, cylinder, manifest refraction spherical equivalent (SE), and predictability (percentage of eyes within ± 0.50 D).

Patients were usually examined immediately after surgery, at 24 hours, and at 1 week, as well as at 1 and 3 months. Patients were then discharged, and annual follow-up was recommended. At the postoperative visits, UIVA was tested at 80 cm and UNVA at 40 cm under photopic conditions at approximately 85 cd/m^2.

The safety outcomes were defined as the percentage of eyes with a loss of 1 or more and 2 or more lines of CDVA. The efficacy outcomes were measured as the percentage of eyes with a difference between preoperative UDVA and postoperative CDVA of 0 or more lines.

Patient satisfaction questionnaire

Patient satisfaction and spectacle dependence were assessed using a questionnaire that has been used previously

Table 1 Preoperative data.

	Control ($n = 82$)	AH/SS ($n = 82$)	Total ($n = 164$)	*P* value
Sphere				0.492[a]
Mean (SD)	2.23 (1.66)	2.28 (1.62)	2.01 (1.47)	
Median (Q1, Q3)	2.25 (1.50, 2.81)	2.00 (1.69, 3.25)	2.00 (1.50, 3.00)	
Cylinder (D)				0.754[b]
Mean (SD)	−0.74 (0.74)	−0.70 (0.57)	−0.72 (0.66)	
Median (Q1, Q3)	−0.50 (−1.00, −0.25)	−0.62 (−1.00, −0.25)	−0.50 (−1.00, −0.25)	
Spherical equivalent (D)				0.537[b]
Mean (SD)	1.86 (1.67)	1.93 (1.60)	1.90 (1.63)	
Median (Q1, Q3)	1.81 (1.25, 2.50)	1.75 (1.34, 2.50)	1.75 (1.25, 2.50)	
UDVA (LogMAR)				0.672[a]
Mean (SD)	0.66 (0.45)	0.64 (0.42)	0.65 (0.43)	
Median (Q1, Q3)	0.52 (0.40, 0.80)	0.52 (0.35, 0.76)	0.52 (0.40, 0.80)	
CDVA (LogMAR)				0.555[a]
Mean (SD)	0.06 (0.10)	0.05 (0.07)	0.05 (0.09)	
Median (Q1, Q3)	0.02 (0.00, 0.05)	0.02 (0.00, 0.05)	0.02 (0.00, 0.05)	

SD: standard deviation; D: diopters; UDVA: uncorrected distance visual acuity; CDVA: corrected distance visual acuity; Q1: quartile 1; Q3: quartile 3; AH/SS: asteroid hyalosis/synchysis scintillans.
[a] Wilcoxon signed rank test.
[b] McNemar's Chi-squared test.

Table 2 Postoperative data.

	Control ($n = 82$)	AH/SS ($n = 82$)	Total ($n = 164$)	*P* value
Sphere				0.264[a]
Mean (SD)	0.15 (0.39)	0.22 (0.50)	0.19 (0.45)	
Median (Q1, Q3)	0.12 (0.00, 0.50)	0.00 (0.00, 0.50)	0.00 (0.00, 0.50)	
Cylinder (D)				0.591[a]
Mean (SD)	−0.47 (0.45)	−0.44 (0.45)	−0.45 (0.45)	
Median (Q1, Q3)	−0.50 (−0.62, 0.00)	−0.50 (−0.75, 0.00)	−0.50 (−0.75, 0.00)	
Spherical equivalent (D)				0.143[a]
Mean (SD)	−0.08 (0.34)	0.00 (0.41)	−0.04 (0.37)	
Median (Q1, Q3)	0.00 (−0.25, 0.06)	0.00 (−0.25, 0.25)	0.00 (−0.25, 0.12)	
UDVA (LogMAR)				0.239[a]
Mean (SD)	0.05 (0.07)	0.07 (0.09)	0.06 (0.08)	
Median (Q1, Q3)	0.03 (0.00, 0.10)	0.05 (0.00, 0.10)	0.03 (0.00, 0.10)	
UIVA (LogMAR)				0.395[a]
Mean (SD)	0.32 (0.17)	0.34 (0.18)	0.33 (0.17)	
Median (Q1, Q3)	0.30 (0.18, 0.30)	0.30 (0.18, 0.48)	0.30 (0.18, 0.43)	
UNVA (LogMAR)				0.948[a]
Mean (SD)	0.15 (0.11)	0.15 (0.10)	0.15 (0.11)	
Median (Q1, Q3)	0.10 (0.10, 0.18)	0.18 (0.10, 0.18)	0.18 (0.10, 0.18)	
CDVA (LogMAR)				0.014[a]
Mean (SD)	0.03 (0.04)	0.04 (0.05)	0.03 (0.05)	
Median (Q1, Q3)	0.01 (0.00, 0.05)	0.01 (0.00, 0.07)	0.01 (0.00, 0.05)	

SD: standard deviation; D: diopters; UDVA: uncorrected distance visual acuity; UIVA: uncorrected intermediate visual acuity; UNVA: uncorrected near visual acuity; CDVA: corrected distance visual acuity; Q1: quartile 1; Q3: quartile 3; AH/SS: asteroid hyalosis/synchysis scintillans.
[a] Wilcoxon signed rank test.

in patients implanted with multifocal IOLs and based on our clinical experience and patients' demands [1,12]. Patients rated their satisfaction after surgery on a scale of 1 to 5 (1 = very unsatisfied; 5 = very satisfied). Those who described their quality of vision as ''satisfied'' or ''very satisfied'' were considered as satisfied in this study. To assess spectacle dependency, patients were asked about the need to wear spectacles for near, intermediate, and far vision.

Table 3 Visual outcomes and patient satisfaction.

	Control ($n = 82$)	AH/SS ($n = 82$)	Total ($n = 164$)	*P* value
Predictability ± 0.50 D				0.505[b]
No (%)	7.6	11.4	9.5	
Yes (%)	92.4	88.6	90.5	
Safety (no change or gain)				0.617[b]
No (%)	1.4	4.1	2.7	
Yes (%)	98.6	95.9	97.43	
Safety index				0.383[a]
Mean (SD)	1.12 (0.49)	1.04 (0.15)	1.08 (0.37)	
Median (Q1, Q3)	1.00 (0.98, 1.11)	1.01 (0.97, 1.11)	1.00 (0.98, 1.11)	
Efficacy (loss of lines)				0.114[b]
No (%)	92.5	85.0	88.8	
Yes (%)	7.5	15.0	11.2	
Efficacy index				0.560[a]
Mean (SD)	1.06 (0.47)	0.98 (0.16)	1.02 (0.35)	
Median (Q1, Q3)	1.00 (0.91, 1.05)	1.00 (0.93, 1.05)	1.00 (0.92, 1.05)	
Bioptics (%)	9.8	9.8	9.8	1.000[b]

	Patient satisfaction
Satisfied with far vision (%)	92.7
Satisfied with intermediate vision (%)	90.7
Satisfied with near vision (%)	96.2
Spectacle independence (far) (%)	100.0
Spectacle independence (intermediate) (%)	100.0
Spectacle independence (near) (%)	100.0
Satisfied with night vision	100.0
Satisfied with night driving	98.0
Overall satisfied	98.2
Would undergo surgery again	98.2

SD: standard deviation; bioptics: laser visual correction enhancement; Q1: quartile 1; Q3: quartile 3; AH/SS: asteroid hyalosis/synchysis scintillans.
[a] Wilcoxon signed rank test.
[b] McNemar's Chi-squared test.

Statistical analysis

The statistical analysis was performed using R Development Core Team (2008). Continuous variables were tested using the Wilcoxon signed rank test or a paired *t* test depending on the assumption of the parametric test. The nominal variables were compared using McNemar's Chi-squared test for count data. A *P* value of less than 0.05 was considered statistically significant.

Results

The study sample comprised 164 eyes from 82 patients who had undergone bilateral lens surgery with implantation of the same model of trifocal IOL in both eyes during the period 2014 to 2021 and had AH or SS in only 1 eye.

The series was divided into 2 groups according to the eye affected by AH or SS: AH/SS group ($n = 82$ eyes from 82 patients) and control group ($n = 82$ eyes from 82 patients).

Patients were distributed evenly by sex (41 women and 41 men), with a mean age of 60 years (standard deviation: 7).

There were no statistically significant differences in any of the preoperative data of the patients between the AH/SS group and the control group (see Table 1).

Postoperative data are shown in Table 2. No statistically significant differences were recorded for sphere, cylinder, SE, UDVA, UIVA, or UNVA between the groups. Postoperative CDVA was better in the control group (*P*: 0.014).

Predictability, safety, and efficacy were similar in both groups (see Table 3 and Figs. 1—3). Eight eyes in the control group and 8 in the AH/SS group needed a laser visual correction enhancement procedure.

Patient subjective satisfaction based on a series of tasks and spectacle independence in far, intermediate, and near vision are shown in Table 3.

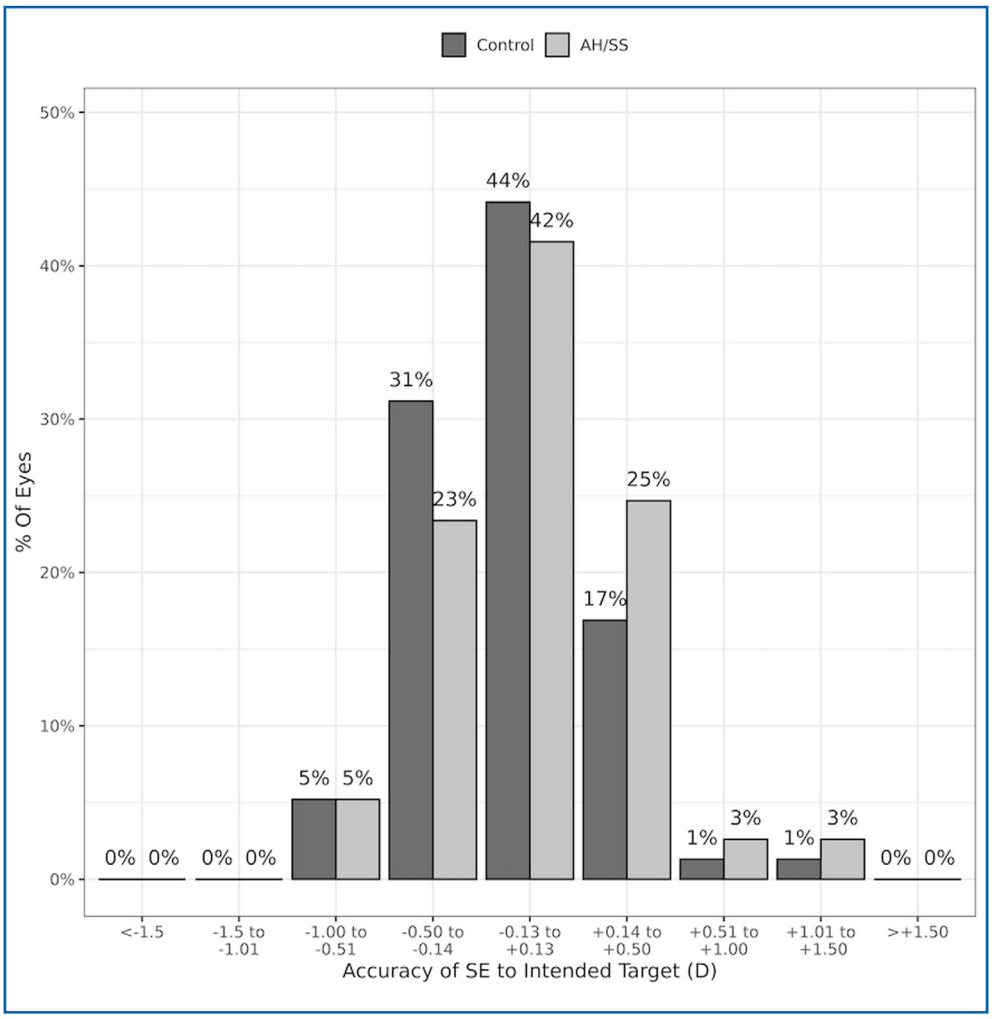

Figure 1. Accuracy of spherical equivalent (SE) to intended target.

Discussion

Vision is rarely affected in patients with AH and SS, probably because the smooth surfaces of the AH bodies minimize light scattering and visual disturbances. Other types of vitreous opacities, however, such as aggregates of vitreous collagen within the vitreous body occurring after posterior vitreous detachment or in myopic vitreopathy, have irregular surfaces and induce considerable straylight and light scattering. In addition, the more anterior location of AH opacities in the vitreous body may preclude visual disturbances. Even if AH and SS do not cause visual impairment, they can sometimes interfere with the eye fundus examination, with the result that special imaging techniques such as fluorescein angiography and ultrasonography may be required to obtain a more precise evaluation.

To our knowledge, this is the first study to evaluate the performance of trifocal IOLs in eyes with AH or SS.

For patient satisfaction and spectacle independence, the results obtained for patients with unilateral AH or SS were similar in the postoperative survey performed 3 months after the surgical procedure to those of patients without these vitreous opacities and published previously by our group in a very large cohort study [1]. Patients achieved 100% spectacle independence at all distances in this study group and in the previous population without AH and SS, namely, 99%, 98%, and 95% at distance, intermediate, and near vision, respectively, with the FineVision trifocal IOL. Satisfaction scores are also similar: 98.2% of patients were satisfied, and 98.2% would undergo surgery again in this group, whereas in the previous group (no AH and SS and implantation of a FineVision IOL), 98% were satisfied, and 97% would undergo surgery again.

Comparison of visual acuity results in the control and AH/SS groups revealed similar outcomes both before and after surgery. Preoperative visual acuity results confirm previously published findings, which show that vision is unaffected in most AH/SS cases. Equivalent postoperative results in both groups provide evidence that AH/SS vitreous opacities do not interfere with the visual performance of trifocal IOL. There was a statistically significant difference in CDVA between the groups, although it was not clinically significant (logMAR 0.03 vs. 0.04).

Very few patients with AH and SS experience significant symptoms of visual disturbance or sequelae of vitrectomy surgery. No patients with these conditions were included in the study group. Although optimal results have been published after pars plana vitrectomy for various vitreoretinal

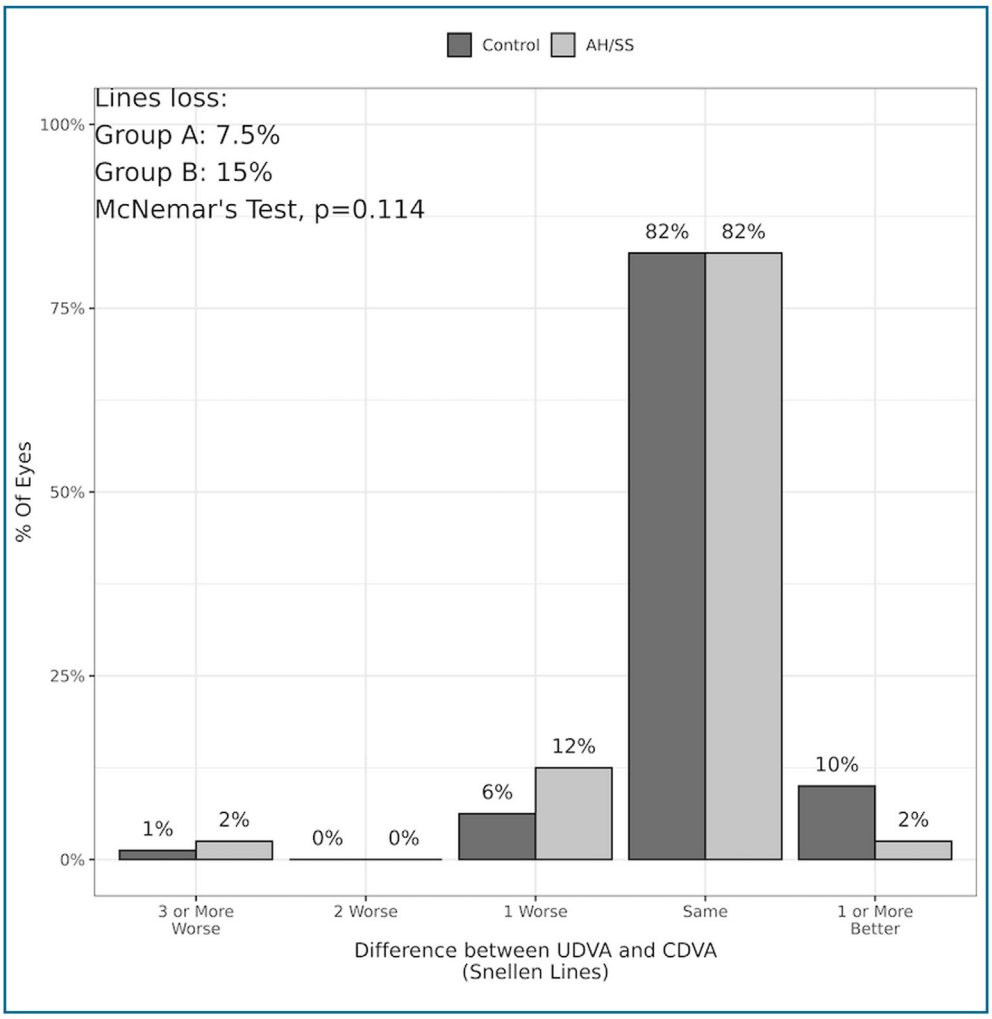

Figure 2. Efficacy: difference between uncorrected distance visual acuity (UDVA) and corrected distance visual acuity (CDVA).

conditions in patients who receive trifocal IOLs [12], caution should be exercised in patients with AH or SS and extremely dense vitreous opacities. Patients should receive careful counselling with realistic expectations before lens surgery and trifocal IOL implantation, with emphasis on the persistence of visual disturbances related to the vitreous opacities and the unlikely possibility that vitrectomy could be required in the future.

Besides, no interference in the eye fundus examination (which currently includes funduscopy and macular optical coherence tomography) was recorded in any of the patients in the AH/SS group before or after the lens surgery. Although AH and SS have not been associated with any other specific vitreoretinal disorder, a detailed macular evaluation is mandatory before implantation of a trifocal IOL. Thereafter, patients with AH or SS and dense vitreous opacities may require special care and ancillary tests to rule out macular or optic nerve disorders that may affect the performance of the diffractive trifocal IOL.

Regarding refractive results, no statistically significant differences were found in terms of predictability, efficacy, efficacy index, and percentage requiring laser enhancement. However, a clear trend towards better refractive outcomes was found in the control group. The difference was non-significant, probably because of the small sample size and the low incidence. These relatively poorer refractive outcomes could be due to the interference of the vitreous opacities in the optical interferometry system used (IOLMaster 500) to calculate axial length during ocular biometry. A falsely short axial length measurement with automated ultrasound biometry has previously been described in patients with AH [3,4]. The finding was related to the interference of the increased vitreous opacities in the ultrasound measurements. However, to our knowledge,

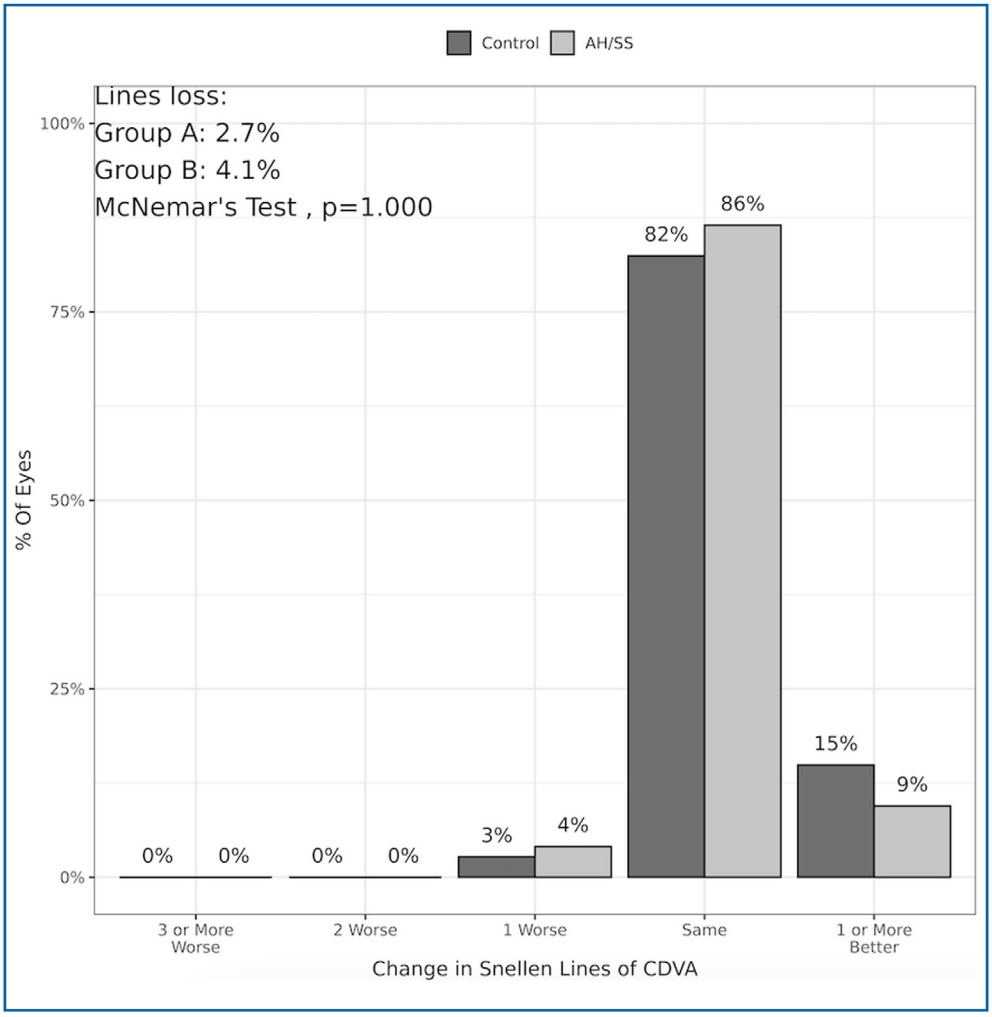

Figure 3. Efficacy: change in corrected distance visual acuity (CDVA).

this type of artifact or interference has not been specifically described with the IOLMaster 500 partial coherence interferometry system.

The current study is subject to a series of limitations. It is retrospective, includes data from multiple surgical centers, and is based on 3 different trifocal IOL models. However, surgeons and optometrists from all the centers followed the same protocol for patient management. In addition, visual outcomes with both trifocal models are equivalent [1], and although a larger number of cases could have influenced the significance of certain results (see above), the number of cases seems sufficiently large to confirm the optimal clinical outcomes achieved, especially given the comparison with a control group.

In summary, this study, which is the first to assess the performance of diffractive trifocal IOLs in patients with unilateral slight and moderate AH and SS, confirms favorable outcomes for trifocal IOLs and supports implantation of this type of multifocal IOL in patients with this type of vitreous opacities.

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None.

Disclosure of interest

The authors declare that they have no competing interest.

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