Clinical Comparison of Visual and Refractive Outcomes of Two Models of Accommodative Intraocular Lenses

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ABSTRACT

Objective: To evaluate the visual and refractive outcomes of eyes implanted with the Crystalens HD and the Crystalens AO intraocular lens.

Methods: We retrospectively reviewed the records of 159 eyes of 100 patients implanted with the Crystalens HD IOL and 108 eyes of 66 patients implanted with the Crystalens AO IOL. Visual and refractive outcomes pre-operatively and postoperatively were assessed and compared between the lenses.

Results: At 1 year, uncorrected distance VA was 20/30 in 78% of eyes in the HD and 76% of eyes in the AO groups. Uncorrected intermediate VA was 20/30 in 90% of eyes in both groups. Uncorrected near VA was J3 in 92% in the HD and 90% in the AO groups. Comparing the two groups, the difference in uncorrected distance ($p=0.60$), intermediate ($p=0.77$), and near ($p=0.64$) vision was not statistically significant. Spherical equivalent was -0.42D +/-0.51D in the HD and -0.6 +/-0.48D in the AO groups ($p=0.10$).

Conclusion: Refractive outcomes were similar between the Crystalens HD and AO groups. Mild myopic refractive outcomes were targeted and achieved in both lens groups. These refractive outcomes provided good uncorrected distance, intermediate, and near vision postoperatively.

Keywords: Accommodating IOL, Crystalens, Capsular fibrosis, Z syndrome, Posterior capsular opacification

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The main goal of cataract surgery is to remove the cataractous lens that obstructs the field of vision and maintain an intact capsular bag so that an intraocular lens (IOL) can be implanted for visual rehabilitation. Wearing spectacles to further improve functional vision was acceptable and not uncommon. In recent years, however, cataract surgery has evolved from a mere sight-saving procedure into a refractive one. Advances in biometry and IOL technology have raised the bar of success in cataract surgery towards providing patients with optimum uncorrected vision at all distances with minimal or no spectacles.

Currently, there are three main types of intraocular lenses used in cataract surgery: monofocal non-accommodating, multifocal, and monofocal accommodating. For these lenses to perform as they are designed to, it is important that refractive outcomes after cataract surgery are on target and near emmetropia. The issue of restoring accommodation following cataract surgery has become an increasingly important topic because of ever-increasing patient expectations. It is not surprising that multifocal and monofocal accommodating IOLs are now at the forefront of providing surgical presbyopia-correcting solutions.

Monofocal IOLs can provide good unaided distance vision postoperatively but fail to address the effect of presbyopia. They provide a single focus of images but without any additional feature or any intentional deviation from an emmetropic refractive target, such as what is done in monovision. Postoperatively, patients have difficulty focusing on near objects and are obligated to wear reading glasses.

Multifocal IOLs work under the principle of splitting light as it enters the eye.[1] The concentric rings allow simultaneous focus for distance and near objects on the retina providing useful uncorrected vision for the tasks of everyday life.[2] However, multifocality is confounded by decreased quality of vision because of lowered contrast sensitivity, glare, and halos at night.[3-4]

In an effort to achieve excellent postoperative vision for all ranges of vision, and with the above-mentioned side effects of multifocal IOLs in mind, accommodating IOLs were developed.[2] Accommodating IOLs were inspired by the idea that a monofocal IOL can have forward axial movement inside the eye. A study by Nawa proved that accommodation can be achieved per 1.0 mm of forward IOL movement.[5] However, the accommodative effects varied with axial lengths from 0.8 D accommodation observed in a long eye to 2.3 D in a short eye. These findings paved the way for the quest to create the ideal accommodating IOL which could mimic the function and properties of the natural lens.[5]

The Crystalens accommodating IOL (Bausch and Lomb, CA, USA) is the only US Food and Drug Administration (FDA) approved accommodating IOL specially engineered to move anteriorly and posteriorly within the capsular bag. It has hinges that connect the two haptic plates to the optic allowing the lens to vault forward due to a pressure gradient from the vitreous cavity and move backward when the pressure dissipates.[6] When a pseudophakic eye tries to accommodate, the ciliary muscle contracts increasing the pressure inside the vitreous cavity. An IOL with flexible hinges can be pushed by the vitreous fluid forward whereas an IOL with fixed stiff hinges will most likely not move. Aside from vaulting of the entire optic forward, another proposed mechanism of action is arching of the center of the lens optic increasing its radius of curvature. The combined effects of these mechanisms change the vertex distance and focal point, thereby increasing the eye's effective positive power.[6] This enables the patient to see at different distances without the aid of spectacles.[3]

The Crystalens has undergone several design changes over the years. The first generation Crystalens AT-45 accommodating IOL is a silicone lens with a 4.5mm optic and trapezoidal haptic plates. The small optic was plagued by unpredictable outcomes, complaints of glare and haloes, and increased posterior capsular opacity (PCO) formation. The second generation Crystalens AT-45SE incorporated the square-edge design to decrease posterior capsular fibrosis. The third generation Crystalens AT-50SE involved enlarging the lens optic to 5 mm to decrease glare and halo effects, and increased arc length of the haptics for better stability.

The fourth generation Crystalens 50HD (Figure 1) utilizes an optic design that is modified to increase depth of focus and improve intermediate and near vision through a central 1.5D near addition (bump) for better reading performance. The fifth and current generation Crystalens AT-50AO (Figure 2) has an aspheric, aberration-neutral optic designed to improve the quality of distance vision and lessen its sensitivity to decentration. The lens optic was made thinner to

allow more arching and subsequently provide better near vision without the need for the central near add bump found in the Crystalens AT-50HD.[7-8] The Crystalens HD and AO are made of biocompatible silicone elastomer (Biosil) with refractive index of 1.427 and 1.4301 respectively. Both IOLs have an overall optic diameter of 5.0 mm and overall length available at 11.5 mm (17 to 33 D) and 12 mm (10 to 16.5 D).[2]

The scarcity of published literature on the Crystalens makes comparison of observations and validation of findings difficult. It is the objective of this study to report the clinical performance of the Crystalens HD and AO models in a private practice setting and to compare the refractive and visual outcomes of eyes implanted with these two accommodating lenses.

METHODOLOGY

This is a single center, single surgeon, retrospective, descriptive study comparing Crystalens HD and Crystalens AO IOLs. All patients who underwent uncomplicated phacoemulsification and Crystalens IOL implantation were included. Eyes with intra- and postoperative complications, previous refractive surgery prior to cataract surgery, and those with retina or glaucoma problems were excluded.

From the surgical registry, a list of patients who underwent cataract surgery implanted with Crystalens HD and AO IOLs from January 2009 to July 2011 was generated. The clinical investigators examined all corresponding medical records. The primary outcome measures were refractive; specifically, uncorrected distance visual acuity (UDVA), uncorrected intermediate visual acuity (UIVA), and uncorrected near visual acuity (UNVA). The secondary outcome measures were incidence of posterior capsular opacity and Z syndrome.

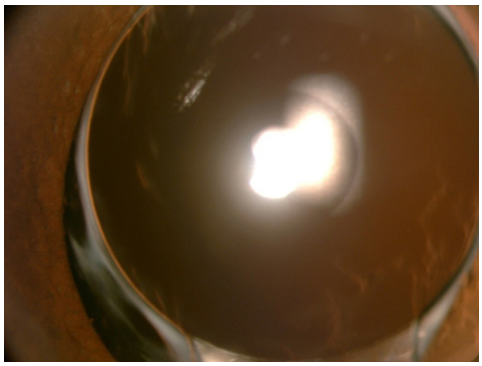

Figure 1. Crystalens HD.

Figure 2. Crystalens AO.

Distance visual acuity was measured using the Optec 6500 vision tester (Stereo Optical, Chicago, Illinois, USA). Intermediate visual acuity was measured using the Jaeger chart at a distance of 32 inches, while near visual acuity was measured using the Jaeger chart at 16 inches.

SURGICAL TECHNIQUE

Standard preoperative biometry measurements were taken using the Carl Zeiss IOLMaster (Carl Zeiss Meditec Inc., USA). The SRK-T formula was used for eyes with axial lengths measuring 22.01 mm or longer and the Holladay II formula for eyes with axial length measuring 22.0 mm or shorter. For both eyes, the optimal refractive target was -0.50 D postoperatively.

The surgical technique was the same in both IOL groups. All cases were performed by a single surgeon (RTA) over a 3-year period. Patients obtained medical clearance prior to the surgery. The patients signed informed consent and received a standardized regimen for preoperative, intraoperative, and postoperative care. Topical proparacaine (Alcaine, Alcon Laboratories Inc., Fort Worth, Texas, USA) and mild sedation were used in all cases. A 6.5 mm optical zone marker was indented over the central cornea to serve as landmark for capsulorrhexis. Clear corneal incisions were created temporally and two paracentesis incisions at 12:00 and 6:00. After viscoelastic injection, a 6.0 mm round capsulorrhexis was made. Standard divide and conquer phacoemulsification technique was employed. Bimanual irrigation-aspiration technique was used to remove any residual

cortex and to polish the underside of the anterior capsule. The corneal incision was enlarged to 2.8 mm and the Crystalens was injected into the capsular bag. The lens was dialed to settle at the 12:00-6:00 vertical axis. Residual viscoelastic material was aspirated. After securing a deep anterior chamber and ensuring no leaks on the incisions, antibiotic, steroid, and atropine sulfate (Isopto Atropine, Alcon Laboratories Inc., Fort Worth, Texas, USA) drops were instilled on the eye.

Topical levofloxacin (Oftaquix, Santen Pharmaceuticals, Osaka, Japan), prednisolone acetate (Pred Forte, Allergan, CA, USA), and ketorolac 0.1% (Acular, Allergan, CA, USA) were given postoperatively for 2 months. Neodymium:YAG (Nd:YAG) capsulotomy was performed relative to the development of posterior capsular opacity in patients several months after the surgery.

STATISTICAL ANALYSIS

All parameters collected were encoded and stored in Excel (Microsoft Corp., WA, USA). Statistical analyses were carried out using Statistical Package for the Social Sciences (SPSS) version 16. Descriptive, 2-tailed student's t-test, and multivariate analyses were used to compare values and to detect relationship between variables. The statistical level of significance was set at $p \leq 0.05$.

RESULTS

This retrospective study evaluated the records of 159 eyes of 100 patients implanted with the Crystalens HD IOL and 108 eyes of 66 patients implanted with the Crystalens AO IOL. Fifty-nine patients in the HD and 42 patients in the AO groups had binocular implantation. In the Crystalens HD, 44 were male and 56 were female with a mean age of 60.8 years. In the Crystalens AO, 28 were male and 38 were female with a mean age of 63.5 years (Table 1).

REFRACTION

The mean baseline sphere were 0.02D and 0.68D in the HD and AO respectively (Table 2). One year postoperatively, the mean sphere were -0.05D and -0.28D respectively. The difference in sphere outcome was not statistically significant (p=0.06).

Table 1. Patient Demographics

Parameter	HD	AO	ρ value
No. of eyes	159	108	n/a
Binocular	59 (118 eyes)	42 (84 eyes)	n/a
Age			
Mean ± SD	60.83 ± 9.91	63.54 ± 7.89	0.39
Range	41 to 82	40 to 80	
Patients, n (%)	100	66	
Male	44 (44%)	28 (42%)	n/a
Female	56 (56%)	38 (58%)	n/a

Table 2. Refractive Outcome: Sphere

	Mean	Min (D)	Max (D)	SD
HD SPHERE				
Preop	0.02	-8.75	8.75	3.08
1 Day	0.24	-1.25	3.5	0.62
1 Week	0.10	-1.00	3.00	0.49
1 Month	-0.03	-1.50	2.00	0.50
3 Months	-0.01	-1.00	2.25	0.48
6 Months	-0.11	-1.25	1.75	0.47
1 Year	-0.05	-1.25	2.00	0.52
AO SPHERE				
Preop	0.68	-10.00	4.50	2.48
1 Day	0.08	-1.00	1.75	0.52
1 Week	-0.10	-1.50	1.50	0.50
1 Month	-0.16	-1.50	0.75	0.44
3 Months	-0.15	-1.50	1.25	0.45
6 Months	-0.19	-1.50	1.50	0.58
1 Year	-0.28	-1.50	0.50	0.52

Table 3. Refractive Outcome: Cylinder

	Mean	Min (D)	Max (D)	SD
HD CYLINDER				
Preop	-0.90	-2.25	-0.25	0.50
1 Day	-0.76	-2.25	0.00	0.48
1 Week	-0.67	-2.00	0.00	0.45
1 Month	-0.74	-2.75	0.00	0.50
3 Months	-0.72	-2.75	0.00	0.53
6 Months	-0.66	-2.25	0.00	0.49
1 Year	-0.75	-2.25	0.00	0.46
AO CYLINDER				
Preop	-0.76	-3.00	0.00	0.53
1 Day	-0.72	-2.25	-0.25	0.37
1 Week	-0.57	-2.00	0.00	0.38
1 Month	-0.61	-2.00	0.00	0.37
3 Months	-0.62	-2.50	0.00	0.45
6 Months	-0.63	-2.25	0.00	0.42
1 Year	-0.67	-1.50	0.00	0.30

The mean preoperative cylinder was -0.90D in and -0.76D in the HD and AO respectively (Table 3). At one year, the mean cylinder was -0.75D and -0.67D respectively. The difference between the 2 groups was not significant (p=0.07).

The mean spherical equivalent (SE) preoperatively were -0.59D and 0.31D in the HD and AO respectively (Table 4). At 1 year postoperatively, the mean SE were -0.43D and -0.60D respectively. They were similar between the two groups (p=0.25).

DISTANCE VISUAL ACUITY

Preoperatively, the mean UDVA was 20/63 in the HD and 20/50 in the AO groups. At 1 year postoperatively, mean UDVA was 20/32 and 20/25 respectively. UDVA was 20/32 in 78% of eyes in the HD and 76% of eyes in the AO groups (Figure 3). The difference in monocular UDVA at 1 year (p=0.60) was not statistically significant.

In patients who had binocular implantation, the mean UDVA was 20/25 in the HD and 20/20 in the AO groups. At 1 year, 80% in the HD and all patients in the AO groups had 20/32 or better binocular UDVA (Figure 4). The difference between the 2 groups (p=0.09) was not statistically significant.

Table 4. Refractive Outcome: Spherical Equivalent

	Mean	Min (D)	Max (D)	SD
HD MRSE				
Preop	-0.59	-9.00	3.63	2.90
1 Day	-0.14	-1.63	2.50	0.60
1 Week	-0.29	-1.50	1.00	0.48
1 Month	-0.39	-2.00	1.50	0.52
3 Months	-0.42	-1.75	1.00	0.50
6 Months	-0.44	-1.75	1.00	0.51
1 Year	-0.43	-1.50	1.25	0.51
AO MRSE				
Preop	0.31	-10.38	4.25	2.49
1 Day	-0.24	-1.50	1.75	0.49
1 Week	-0.42	-1.88	0.88	0.47
1 Month	-0.20	-1.00	0.31	0.25
3 Months	-0.44	-2.38	1.25	0.53
6 Months	-0.52	-1.75	1.13	0.56
1 Year	-0.60	-1.88	0.25	0.48

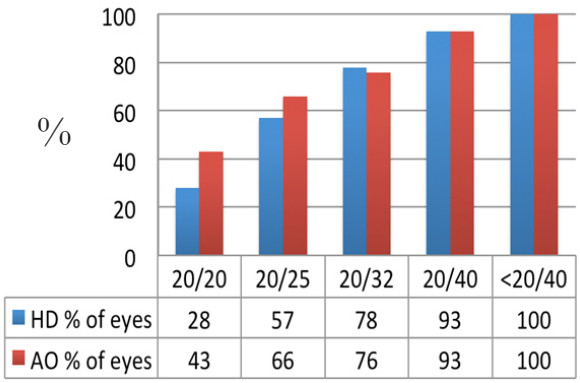

Figure 3. Monocular uncorrected distance VA at 1 year.

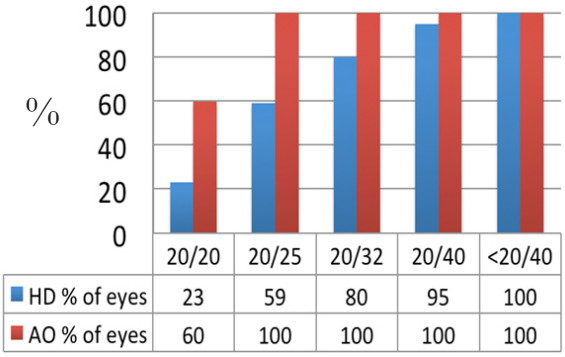

Figure 4. Binocular uncorrected distance VA at 1 year.

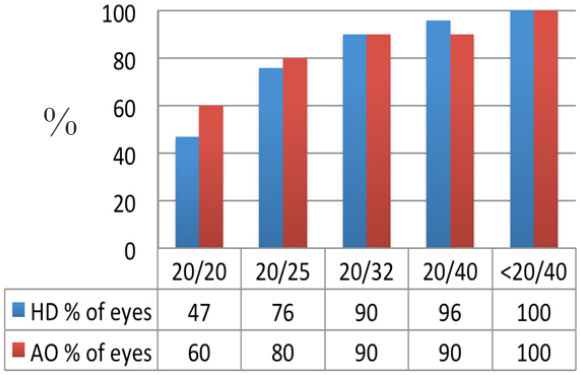

Figure 5. Monocular uncorrected intermediate VA at 1 year.

INTERMEDIATE VISUAL ACUITY

Preoperatively, the mean UIVA was 20/50 for both groups. At 1 year, the mean UIVA was 20/25 for both groups; 90% were 20/32 or better in both the HD and AO groups (Figure 5). The difference between the 2 groups was not significant (p=0.77).

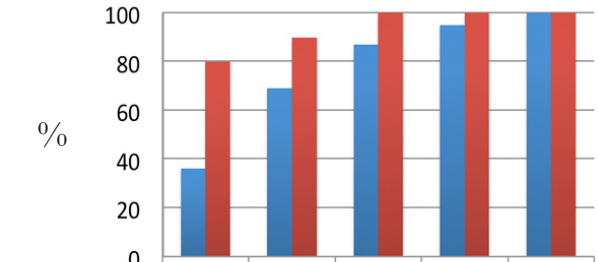

Figure 6. Binocular uncorrected intermediate VA at 1 year.

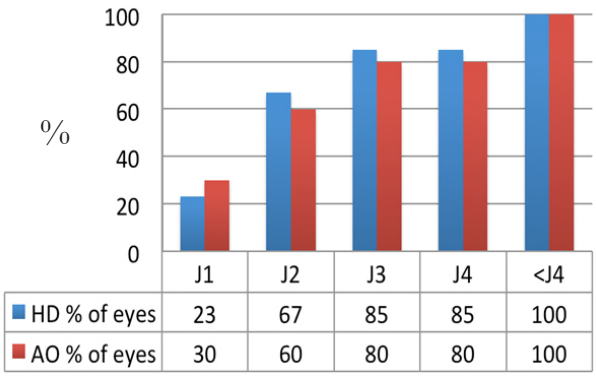

Figure 8. Binocular uncorrected near VA at 1 year.

Binocularly at 1 year, UIVA was 20/32 or better in 87% of patients in the HD and in all patients in the AO groups (Figure 6). The difference between the 2 groups (p=0.28) was not significant.

NEAR VISUAL ACUITY

Preoperatively, the mean UNVA was J3 in both groups. One year postoperatively, the mean monocular UNVA was J2 in both groups. UNVA was J3 in 92% of eyes in the HD and 90% of eyes in the AO groups (Figure 7). There was no statistically significant difference between the 2 groups (p=0.64).

One year after implantation, the mean binocular UNVA was J2 in both groups. Binocular UNVA was J3 in 85% of patients in the HD and 80% in the AO groups (Figure 8). The difference was not statistically significant between the 2 groups (p=0.44).

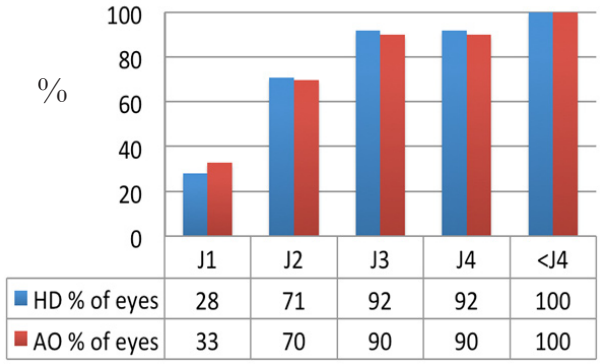

Figure 7. Monocular uncorrected near VA at 1 year.

POSTERIOR CAPSULE OPACIFICATION

Posterior capsule opacification (PCO) diagnosed by dilated slit lamp examination developed in 27% (43/159) of eyes in the HD and in 17% (19/108) of eyes in the AO groups. The mean time interval from cataract surgery to Nd:YAG capsulotomy was 12.41 ± 4.81 months for the HD and 6.58 ± 2.65 months for the AO groups.

Before Nd:YAG capsulotomy, the mean UDVA was 20/32 in the HD and 20/25 in the AO groups. Mean UIVA and UNVA were 20/25 and J3 for both groups respectively. The mean SE was -0.42 ± 0.51D in the HD and -0.47 ± 0.77D in the AO groups (Table 5).

After Nd:YAG capsulotomy, the mean UDVA was 20/32 for both groups. The mean UIVA was 20/25 in both groups. The mean UNVA was J2 in the HD and J3 in the AO groups. The mean SE was -0.51D and -0.50D respectively (Table 5). The difference in SE before and after Nd:YAG capsulotomy was not significant in the HD (p=0.39) and the AO (p=0.94) groups.

Table 5. Spherical Equivalent Pre- and Post - Nd: YAG Capsulotomy in the HD and AO Groups.

Spherical Equivalent	HD		AO	
	PRE YAG	POST YAG	PRE YAG	POST YAG
MEAN	-0.42 ± 0.51	-0.51 ± 0.47	-0.47 ± 0.77	-0.50 ± 0.80
MIN	-1.5	-1.5	-2.38	-1.75
MAX	0.75	0.38	1.13	1.13

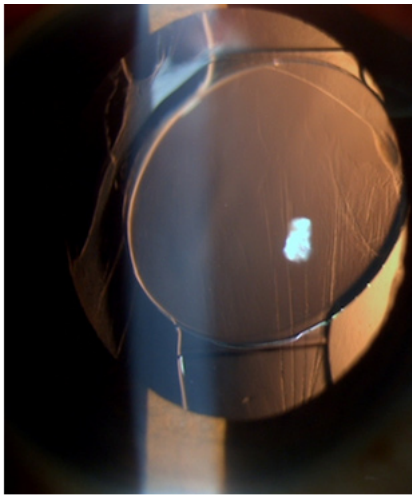

Figure 9. Z syndrome.

Z SYNDROME

The term Z syndrome is used to describe a condition when the Crystalens assumes a configuration resembling the letter Z in the capsular bag wherein one haptic plate vaults anteriorly and the other haptic remains posteriorly vaulted (Figure 9). This is caused by capsule fibrosis.[9] In our study, 6 patients were assessed to have Z syndrome, 3 from each group making the rate of occurrence of Z syndrome in our study 2% (3/159) in the HD and 3% (3/108) in the AO groups. The subjects identified with this condition all underwent Nd:YAG capsulotomy.

Prior to Nd:YAG capsulotomy, the mean UDVA was 20/40 in the HD and 20/32 in the AO groups. The UIVA was 20/32 and 20/25 respectively. The mean UNVA was J3 in the HD and J2 in the AO groups. The mean spherical equivalent was -0.79 ± 0.14D, and -1.04 ± 1.37D respectively.

After Nd:YAG capsulotomy, the mean UDVA was 20/32 and the mean UIVA was 20/25 in both groups. The mean UNVA was J2 in the HD and J1 in the AO groups. Their mean spherical equivalent were -0.58 ± 0.58D and -1.42 ± 0.29D respectively.

DISCUSSION

We reported our real-world experience with the two latest generations of the Crystalens – the HD and AO. Our paper compared the refractive (sphere, cylinder, MRSE) and visual outcomes (UDVA, UIVA, UNVA) of the HD and AO lenses because these are the outcome measures that significantly affect spectacle freedom and patient satisfaction.

From our experience, a mean refractive target of approximately -0.50D mean refractive spherical equivalent (MRSE) is highly recommended for achieving acceptable visual outcomes for all ranges of vision. In this study, the mean MRSE was -0.43 ± 0.51D in the HD and -0.60 ± 0.48D in the AO groups at 1 year. The difference between the 2 groups was not statistically significant (p=0.25).

With these mildly myopic outcomes, we achieved a mean uncorrected distance vision of 20/32 in the HD and 20/25 in the AO groups at 1 year post-operatively. The difference in the results between the 2 groups was not statistically significant. In a study by Cumming involving an earlier model, the Crystalens AT-45 IOL, their patients had UDVA of 20/40 in 88.9% of monocularly implanted eyes and in 98.4% of binocularly implanted eyes.[6] In our study, monocular UDVA was 20/40 in 93% of eyes in both the HD and the AO groups. Binocularly, 95% and 100% of patients in the HD and AO groups respectively achieved 20/40 or better. Alio[2] reported a mean UDVA of 20/25 (0.14 logMAR) in their Crystalens HD at 3 months postoperatively which was similar to our HD results at 1 year. Macsai[11] also revealed very good UDVA outcomes in the crystalens group in their study.

Uncorrected intermediate visual acuity at 1 year was 20/32 in 90% of eyes in both groups. Previous studies on the Crystalens AT-45 had similar findings and, additionally, showed significantly better monocular UIVA achieved by the Crystalens when compared to either the ReSTOR (Alcon Laboratories, Fort Worth, Texas, USA) or the ReZoom IOLs (Advanced Medical Optics, CA, USA) (p=0.002).[1]

Near visual acuity in our study was similarly impressive, just like other studies previously done on accommodating IOLs.[2,10-13] The mean UNVA was J2 for both groups at 1 year. Results were similar for both IOLs despite having different mechanisms for accommodation; namely, central bump for depth of focus for the HD and thinner optic for better arching for the AO. Our results were similar to findings by Macsai in their study comparing the Crystalens to a standard monofocal IOL where 90% of eyes in the Crystalens group were able to read J3 or better.[10] Our results were better than the previous model, the

Crystalens AT-45, whose mean UNVA was shown to be approximately J5.[11,14]

The Crystalens has been compared to other IOLs. Macsai showed significant improvement in UNVA both monocularly and binocularly when compared to monofocal IOLs illustrating the accommodating capacity of the Crystalens.[11] Pepose demonstrated in a prospective nonrandomized study that the Crystalens achieved good distance and intermediate vision but the ReSTOR IOL achieved the best near visual acuity.[1]

From our clinical experience with the Crystalens, capsular fibrosis and opacity not only decreased vision but also induced capsular contraction and striae which led to asymmetric tilt, otherwise, known as Z syndrome. We did not wait for significant visual deterioration or contraction. Once we visualized fibrosis at the slit lamp, we recommended Nd:YAG capsulotomy to the patient to prevent Z syndrome. In this study, the mean time interval from surgery to Nd:YAG capsulotomy was 12.4 ± 4.8 months for the HD and 6.6 ± 2.7 months for the AO groups. The difference in time interval was because we used the HD one year ahead of the AO resulting in longer follow-ups. In a study comparing clinical outcomes of 1CU accommodating IOL (HumanOptics AG, Erlangen, Germany) and a monofocal IOL, the authors reported a decrease in accommodative amplitude at 3 months and attributed it to the development of posterior capsular opacification (PCO).[13] Other studies demonstrated that Nd:YAG capsulotomy was performed to maximize performance of the accommodating IOL up to its full potential and to prevent IOL tilt secondary to capsule fibrosis.[13-14] In the study of Alio,[14] Nd:YAG capsulotomy was performed as required but there was no change in refractive outcome. In this study, refractive outcomes and visual acuities before and after Nd:YAG capsulotomy were similar because the main indication for laser treatment was prevention of unwanted fibrosis leading to lens tilt and not restoration of vision.

The occurrence of capsule fibrosis exerting unequal pressure on one of the haptic plates is believed to cause the development of the Z configuration of the IOL in Z syndrome. This is a unique complication of the Crystalens because of its hinged-plate haptic design. It has been recommended that extra steps be performed to help prevent early PCO development, such as creating an optimal 6.0 mm capsulorrhexis, thorough cortical removal, and if needed, capsule polishing.[9,15] Despite these measures, it is difficult to predict if a Z syndrome will occur. Signs that Z syndrome is occurring are decrease in uncorrected distance and near vision accompanied by increase in astigmatism. Upon dilation, an anteriorly vaulted plate haptic confirms the diagnosis. Nd:YAG capsulotomy usually resolves the situation. In rare instances, entering the anterior chamber and pushing the haptic plate down resolves a recalcitrant Z syndrome. In our review, three cases each in the HD and the AO groups were assessed to have developed Z syndrome. The mean time interval from surgery until these patients underwent Nd:YAG capsulotomy was 12.33 ± 1.15 months and 4.00 ± 1.00 months for HD and the AO groups respectively. In all 6 patients, the condition resolved after Nd:YAG capsulotomy. None of the patients who developed Z syndrome experienced eye pain which could be due to capsule contraction syndrome secondary to zonules pulling on the ciliary body causing the pain.[16]

This study presented a retrospective review of the clinical performance of the Crystalens HD and AO in a private clinical setting. It did not have the thoroughness of a prospective study wherein stringent follow-up requirements were imposed on study subjects. A search of the published literature revealed that this is the first paper documenting the outcomes of eyes implanted with the Crystalens AO. In clinical practice, patients opting to have cataract surgery aspire to have good uncorrected vision. Surgeons try to deliver by targeting the refractive outcome that will most likely provide the uncorrected vision that patients aspire for. From our experience, by targeting a spherical equivalent of approximately -0.50D, the Crystalens can deliver good functional vision at distance, intermediate, and near vision ranges. We, likewise, reviewed the incidence of posterior capsular opacity, Z syndrome, and Nd:YAG capsulotomy because they are part of the long term care of Crystalens implanted eyes.

Owing to the retrospective, descriptive nature of our study, we identified several limitations that included incomplete data in the charts, insufficient follow- up time, and the lack of a questionnaire that would quantify spectacle freedom. Our recommendations for a future study would be matching of subject numbers and follow-up time in a prospective manner, wavefront and contrast sensitivity measurements to differentiate the aberrations in the HD and AO lens given that the latter is aberration free, and inclusion of a questionnaire that will

document patient satisfaction and amount of spectacle independence.

In summary, refractive and visual outcomes were similar between the Crystalens HD and AO groups. Mild myopic refractive outcomes were targeted and achieved in both lens groups. These refractive outcomes provided good uncorrected distance, intermediate, and near vision after cataract surgery. Nd:YAG capsulotomy rates were more than other lenses because these were performed early to avoid unwanted consequences of capsular fibrosis. Likewise, the incidence of Z syndrome was low.

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