Surgical Technique

Optimizing optical outcomes of intraocular lens implantation by achieving centration on visual axis

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In existing designs of intraocular lenses (IOLs), optical outcomes are compromised even after perfectly executed surgery. The reason for this is misalignment of optical axis of the eye and its visual axis. There is a need to design an IOL which compensates for this misalignment and hence enhances the optical outcomes of cataract surgery. The present innovation attempts to fulfill this unmet need and optimizes optical outcomes of all IOLs of different optical profiles – spherical, aspheric, toric, and multifocal. In addition, the improvised design of IOL offers other benefits such as delaying the formation of after-cataract and ameliorating negative dysphotopsia.

Key words: Angle alpha, centration, innovative intraocular lens design

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Since 1949, tremendous progress has happened in the surgical techniques and material as well as design of intraocular lenses (IOLs). However, because the IOLs of the present designs are symmetrically round, when these are implanted in capsular bag, their optical center coincides with the center of the bag. The center of the bag lies on the optical axis of the eye and not on the visual axis. This deficiency in existent designs prevents us in exploiting full advantage of advanced optics such as aspheric, toric, and multifocal. The present innovation aims to make up this deficiency in an attempt to optimize optical outcomes.

Innovation

The innovative IOL design is compared to existent design in Fig. 1. The optic of this innovative IOL is not spherical, but it is ellipsoid with its horizontal dimension longer to its vertical dimensions (6.6 mm × 5.8 mm). The two haptics are of the same size and shape, but these are attached asymmetrically onto the optic. For an IOL for emmetropic range of eyes, this asymmetry is 0.60 mm. When the IOL is placed in the capsular bag, then the overall geometrical center of IOL settles at the geometrical center of the bag, yet the optic of IOL gets decentered 0.3 mm nasal to the center of the bag. In this manner in a nominally emmetropic eye, where angle alpha (angle formed between optical axis and visual axis of a nominal emmetropic eye at its nodal point) measures, about 5°, optical center of IOL now falls on the visual axis. The IOL is implanted with its haptics oriented vertically, and a mark is placed to identify the nasal end of the IOL and guide the surgeon to leave the IOL in correct orientation. This asymmetry can be increased or decreased for hypermetropic or myopic eyes to compensate for angle alpha which may be different in these eyes in comparison to emmetropic eyes. Fig. 2 compares the existent design with new design once IOLs are implanted in the eye and depicts the alignment of optical center of this innovative IOL on visual axis.

Another added feature [Fig. 3] in new design is that central 3.00 mm of posterior surface of its optic is projecting 5 μ out of its base (black arrows). The sides of this posterior projection are parallel to the optical axis of the IOL; thus, it acts as a second barrier to prevent migration of lens epithelial cells (red dots) in addition to the first barrier presented by square edge (white arrows) of the optic. This projected part of back surface brings the posterior surface of IOL in closer contact with posterior capsule further delaying the after-cataract formation in central 3.00 mm around visual axis. The gap between posterior surface of the present day IOLs and posterior capsule has been well documented.[1] Posterior capsule being lax after cataract extraction theoretically we presume that this posterior projection will be an added barrier for the prevention of after-cataract formation in the center without having any impact on after-cataract formation in paracentral region.

Because of the asymmetrical insertion of haptics, the optic of the IOL is effectively shifted 0.6 mm to the nasal side. This shift in optic along with larger horizontal diameter may

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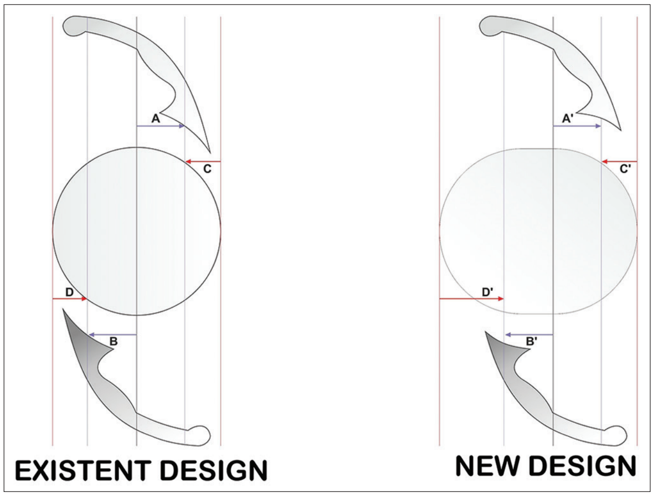

Figure 1: In existent design, optic is round and both haptics are symmetrically placed (A = B and C = D). In new design, optic is ellipsoid and haptics are asymmetrically placed with lower haptic being farther than the edge as compared to upper haptic (A = B but D is more than C)

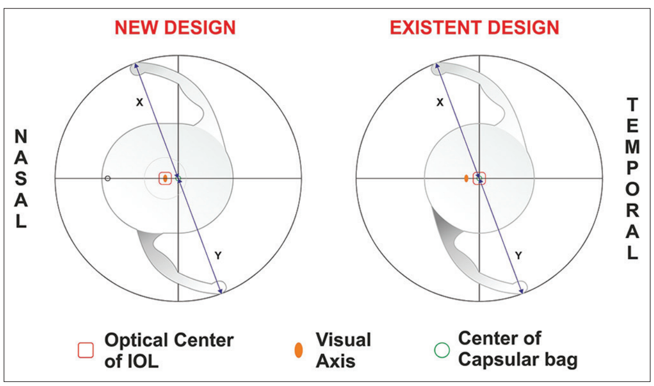

Figure 2: In new design, optical center of intraocular lens aligns with visual axis. In existent design, optical center of intraocular lens is not aligned with visual axis but falls on geometrical center of capsular bag

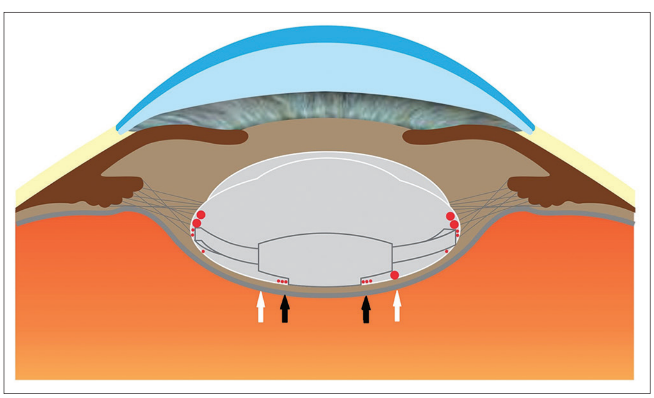

Figure 3: Central 3.00 mm diameter of optic of intraocular lens projected out posteriorly

result in much lesser incidence of negative dysphotopsia. This assumption is supported by the experimental study done by Holladay and Simpson.[2]

Results

In the experimental study using Zemax optical design program (a software program to study optical designs), an eye model with modular transfer function (MTF) of 50% at 50 lines pair per mm was taken as reference. Two models of biconvex IOLs, one spherical and other aspheric with Q = −0.26, were studied for MTF achieved at retina with IOLs in centered and 0.4 mm decentered position. A study was conducted with 2, 4, and 6 mm pupil sizes. In the study, MTF of decentered spherical and aspheric IOLs relates to existent design of IOLs while MTF for centered spherical and aspheric IOLs relates to IOLs of new innovative design. Results were analyzed for both and are shown in Fig. 4.

Expectedly in all conditions, MTFs achieved fell with larger pupil sizes. For 2 mm pupil, MTF achieved by both spherical and aspheric IOLs was not much different either in centered or decentered position. However, in decentered position, aspheric IOL achieved slightly less (56%) MTF in comparison to spheric IOL which achieved 58% MTF. In the present scenario, it implies that when one is reading in bright light and when pupil is constricted, spheric IOL of the present design provides a better contrast of image than the present day aspheric IOL. However, with proposed innovation even in this scenario, aspheric IOL will not perform worse to spheric IOL with both achieving MTF of 60%. For 4 mm pupil, in decentered position, spherical IOL achieved MTF of 39%, which improves by 5% to 41 if IOL is aspheric and it improves further by 10% to 45 if it is centered. In practical scenario, it can be deduced that asphericity improves the quality of vision, but centration is more beneficial for its improvement.

For 6 mm pupil, asphericity improved the MTF achieved from 18 to 24, an impressive gain of 33%, but if it is centered, it improves further to 32 that is further gain of 33%. By targeting asphericity, only, we are improving the quality of vision in the dark, but we are getting less than half of possible improvement due to lack of centration.

Conclusion

It is evident that variance in the optical axis and visual axis of the eye, aberrations induced by it, and changes in these with age has been subject matter of study in the past.[3] Studies have also proved and quantified the tilt and decentration of IOLs in relation to the visual axis *in vivo* because of this variance.[4] It has also been known that because of our inability to achieve centration on visual axis, we are limited in having a fully optimized shape factor and asphericity. It has also been documented that because of misalignment of optical and visual axis of the eye, we are neither able to align toric IOLs to the limbal markings nor can we get the optimum results. Similarly, the present multifocal IOLs are needed to be decentered nasally to achieve the best results.

However, there has been no effort in the past to compensate for the misalignment of optical and visual axis of the eye. With the present innovation, the inventor has been able to demonstrate that by changing the design of existent IOLs, better centration of IOLs on visual axis can be achieved. The experimental study proves that gain in MTF of IOLs once implanted in the eye resulting from this innovation exceeds

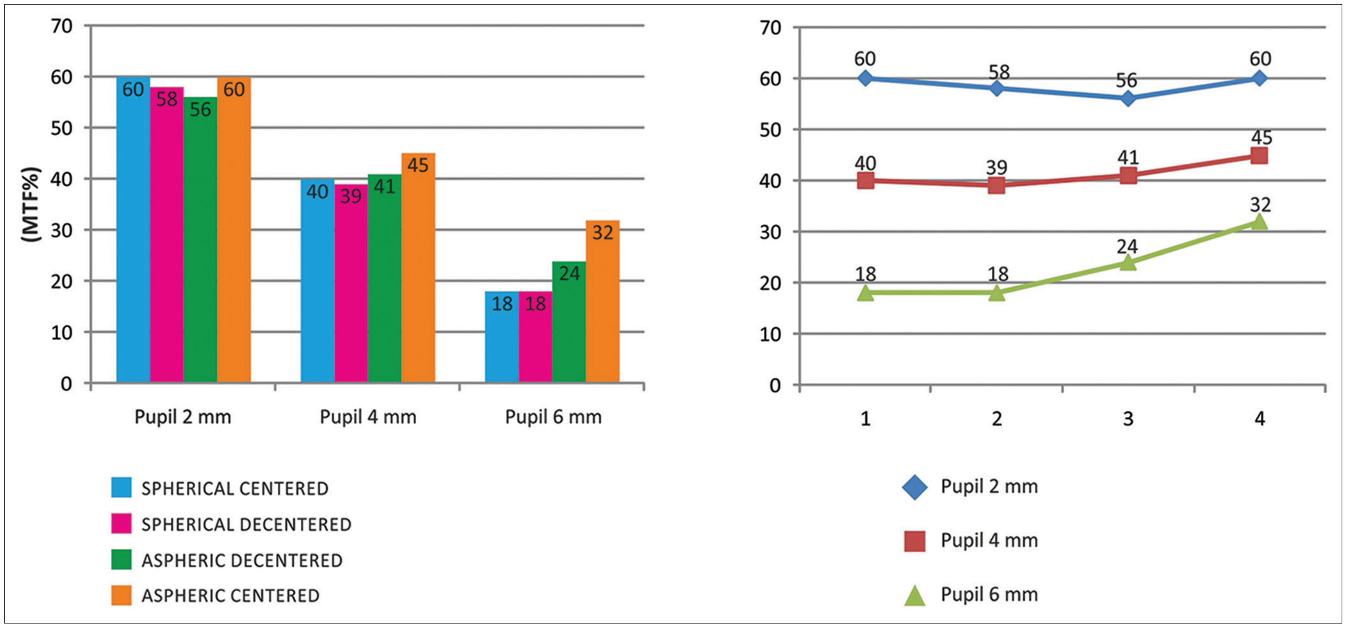

Figure 4: Modular transfer functions achieved by spherical and aspheric intraocular lens in centered and decentered position of 0.4 mm with respect to visual axis

the gain in MTF we have been able to achieve by compensating corneal asphericity for all pupil sizes. The advantages of this innovation are not limited to enhancing optical outcomes of the present IOL designs, but it holds promise of optimizing the shape factor and asphericity of IOLs further in future. Delaying of after-cataract and amelioration of negative dysphotopsia further enhance the significance of this innovation.

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Conflicts of interest

Dr.Prakhyat Roop has filed patent applications of the device described in the article in US and India, which are pending.

References

1. Lytvynchuk LM, Glittenberg CG, Falkner-Radler CI, Neumaier-Ammerer B, Smretschnig E, Hagen S, *et al.* Evaluation of intraocular lens position during phacoemulsification using intraoperative spectral-domain optical coherence tomography. J Cataract Refract Surg 2016;42:694-702.
2. Holladay JT, Simpson MJ. Negative dysphotopsia: Causes and rationale for prevention and treatment. J Cataract Refract Surg 2017;43:263-75.
3. Berrio E, Tabernero J, Artal P. Optical aberrations and alignment of the eye with age. J Vis 2010;10:34, 1-17.
4. de Castro A, Rosales P, Marcos S. Tilt and decentration of intraocular lenses *in vivo* from purkinje and scheimpflug imaging. Validation study. J Cataract Refract Surg 2007;33:418-29.