Argos Verion Image-Guided System

20

Raiju J. Babu and Jessica Voegtle

Cataract surgery has evolved with improved technologies, advanced biometers, and increasing patient expectations to achieving complete spectacle independence. The goal of the cataract surgeon is to implant an intraocular lens (IOL) with an appropriate IOL power to compensate for the refractive error and leave the patient emmetropic (plano target). Based on the patient need, the surgeon may chose a target refraction of emmetropia at distance or, in certain instances, target a myopic outcome to address spectacle independence at near. Occasionally, a mono vision or mini mono vision approach where one eye is targeted for distance and the other eye is targeted for myopic outcomes is also seen in practice [1].

The planning and execution of the process involve several steps:

- A preoperative diagnostic examination of the eye captures all parameters necessary for the selection of the optimal spherocylindrical power. In addition, for patients needing astigmatism correction, the pre-op evaluation also determines the ideal toric IOL orientation relative to reference landmarks that will be visible to the physician at the time of surgery.
- Alternatively, on the day of surgery the clinician may use a femtosecond laser as a first treatment step, to create surgical incisions and sometimes also to treat astigmatism via additional corneal shape-altering cuts.
- During the actual surgery, the clinician implants the IOL with the correct spherocylindrical power and aligns each toric implant correctly to minimize astigmatism, if applicable.

Astigmatism Correction

Accurately determining the power of an IOL can be done using online web-based calculators or those supplied by the IOL manufacturer. The post-surgical refractive error is dependent upon the parameters used in the IOL power calculation. New generation calculators account for posterior corneal astigmatism (PCA), anterior chamber depth (ACD), effective lens position (ELP), and surgically induced astigmatism (SIA), in addition to the usual biometry parameters of keratometry and axial length [2]. If the patient has preoperative astigmatism, the surgeon can correct it using a toric IOL or other methods such as Limbal relaxing incisions [3]. When aligning the axis of a toric IOL, it is essential to accurately determine the steep axis of the cornea. This should be done with the patient in the seated position, to account for cyclotorsion that would occur when the patient is supine. Manual corneal

R. J. Babu (✉) · J. Voegtle
Alcon Vision LLC, Fort Worth, TX, USA
e-mail: raiju.babu@alcon.com;
jessica.voegtle@alcon.com

J. Aramberri et al. (eds.), *Intraocular Lens Calculations*, Essentials in Ophthalmology,
https://doi.org/10.1007/978-3-031-50666-6_20

Fig. 20.1 Figure displays the reference image captured by the Argos Biometer and the Alcon Vision planner used to create the surgical plan including IOL power calculation

marking consists of preoperative marking of the horizontal axis, intraoperative alignment of the reference marks with the degree gauge of the fixation ring, and intraoperative marking of the target axis. The marking may be done with a skin-marking pen with a thin slit beam, a weighted thread, a pendulum marker, or a bubble marker [4]. Femtosecond laser-assisted corneal and capsulotomy marking provides more permanent markings for postoperative assessment of IOL position [5]. Image-guided systems capture preoperative digital photography of iris landmarks and conjunctival, scleral, or limbal blood vessels (Fig. 20.1). Based on the features of the eye, an intraoperative registration with the surgery image allows displaying the preoperative calculated toric implantation axis in the microscope.

Intraoperative wavefront aberrometry provides refinement of IOL selection and axis rotation by providing intraoperative aphakic refractive information to the surgeon to determine the correct IOL power and pseudophakic refractive data to correctly align the axis of a toric IOL [6]. With respect to toric IOL axis determination, risks associated with manual reference marking include smudging or smearing, irregular or thick markings, parallax error, corneal abrasions, significant learning curve, intersurgeon variability, and anterior chamber bacterial contamination [4, 7, 8]. In one study, they showed that 30% of the ink markings were poorly visible due to washout [9]. Anterior stromal puncture offers the benefits of precise marking with no smudging [4].

Argos and Verion Digital Marking

The Argos Biometer with Image Guidance by Alcon is an integrated biometer that provides image guidance to the surgeons (Fig. 20.2). The image guidance is provided by having hardware (Verion Digital Marker) to provide overlays in the operating room and also at the Alcon LenSx Laser. The Verion Reference Unit is also an integrated keratometer with image guidance capability at Alcon LenSx system and Operating room. Verion Reference Unit is not capable of providing biometry; therefore, another biometer would be required to input the information into the Vision Planner.

The Digital Marker exists in 2 variants:

Digital Marker L (DML) and Digital Marker M (DMM)

The core of the Digital Markers is the Digital Marker Panel PC running software for image processing (registration and tracking) and displaying of tracking results during surgery. The Panel PC is placed at the LenSx Laser or next to the surgeon's microscope and receives the image signal of the microscope. Via established network connection or USB stick, preoperative data from the Argos Biometer or Verion Reference Unit is loaded into the planning screen of the system. If required, with user interaction, the planned surgery parameters can be modified.

Fig. 20.2 The Argos Biometer with Image guidance by Alcon

The Digital Marker L imports patient information and provides this to the Alcon LenSx Laser. Additionally, the eye image from the Argos Biometer is provided to the Digital Marker L to determine the cyclotorsion angle between reference image and image from the digital laser microscope. Based on the determined cyclotorsion angle and planned centration options for arcuate incisions and capsulotomy, positions of treatment patterns are proposed to the operator.

The Digital Marker M consists of the Panel PC, Microscope Integrated Display (MID), foot pedal, and optionally the VERION Link (established connection to Alcon Centurion phaco system). The Microscope Integrated Display (MID) is mounted into the surgery microscope and connected via communication cable to the Digital Marker M. The MID acquires digitally a microscope image, passing this to the Panel PC for the image processing, and injects context information received by the Digital Marker M into the surgeons optical microscopes view (Fig. 20.3). After potential adjustment and confirmation of the registration angle, the tracker will be initialized. A live image with the planned tracking overlay is shown. If the eye is moving and/or rotating, the difference to the new position of the eye will be determined and the overlay adjusted. According to every surgery step on the Digital

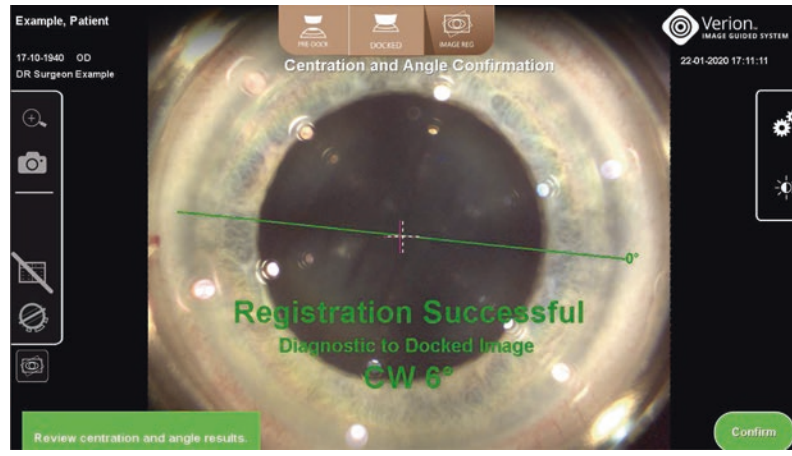

Fig. 20.3 The final registration angle determined by the Digital Marker L and provided to the LenSx Laser for adjustment of the treatment parameters, i.e., incisions and centration of Capsulotomy and Lens fragmentation

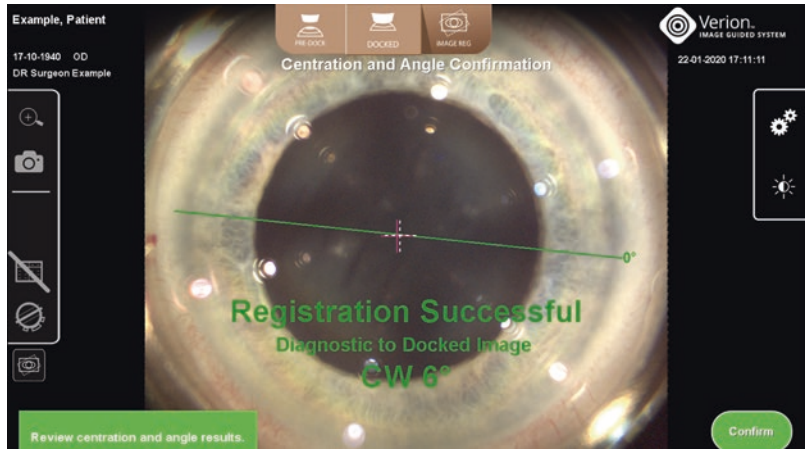

Fig. 20.4 Figure displays the toric overlay providing thereby image guidance with respect to IOL implantation axis based on the preoperative plan

Marker M, an equivalent overlay will be displayed at the MID. With the footpedal (connected via USB) user interactions with the Digital Marker can be controlled, without physical touch of the computer screen (e.g., getting into live mode, start, and confirmation of registration, and to toggle through the different surgery steps). Overlays may show incision locations, capsulorrhexis size and location, IOL centration, toric alignment axis, or IOL centration + toric alignment axis (Fig. 20.4). During surgery, the displayed overlay can be adjusted with appropriate buttons on the screen. Optional Aphakic, Pseudophakic, and Lens Axis Marker phases are available to trigger measurements with the ORA VerifEye Lynk System (Intraoperative aberrometer) or display corresponding information (e.g., measurement data) on the screen or in the MID.

In detail, the Digital Marker provides:

- Patient Eye Confirmation: Automated consistency check of reference image from VERION Reference Unit or Argos Biometer with Alcon Image guidance and patient eye image under microscope at the beginning of the surgery at the Digital Marker. The doctor receives feedback, whether the reference image and the microscope image do or do not match.
- Incision Guide: Online overlay of planned incision areas on the microscope live image. Lateral and rotational movements of the eye will be compensated relative to the reference image.
- Capsulorrhexis Guide: Online overlay of planned capsulorrhexis position and radius on the microscope live image. Lateral movements of the eye will be compensated relative to the reference image.
- Centration Guide: Online overlay of planned (multifocal) IOL position on the microscope live image. Lateral movements will be compensated relative to the reference image.
- Toric Alignment Guide: Online overlay of preop planned implantation axis on the microscope live image. Lateral and rotational movements of the eye will be compensated relative to the reference image (Fig. 20.4).
- Finalization check: Combined overlay of the centration and toric alignment information on the microscope live image for a final IOL position check. Lateral and rotational movements of the eye will be compensated relative to the reference image.
- Documentation: Storage of reference and measurement data, surgery, and surgery image data on an external storage.

The benefits of image-guided systems include accurate alignment of the toric axis relative to anatomic landmarks in photographs of the iris and limbal vessels [4, 6–8, 10–13] and minimizing marking errors and improving postoperative alignment [11, 13]. In a randomized controlled trial [14], the IOL misalignment was significantly less with image-guided system compared to manual marking. This has implications with respect to

astigmatic outcomes, as 1 degree of IOL misalignment can translate to 3.3% reduction in effectiveness of astigmatic correction [15] using one method. In another method where the vector difference between the target and achieved astigmatic outcomes, an error of 4.9 degree would result in remaining astigmatism magnitude of 17% of the preoperative astigmatism [16]. The randomized control trial did not find the difference in Uncorrected VA or residual astigmatism, although a statistically significant difference was seen in degree of IOL misalignment [14]. The key differentiation is that image-guided systems eliminates or accounts for the possible change in head position when keratometry and steep axis is determined impacts ability to account for cyclotorsion and thereby affecting precision [9, 17]. In addition, image-guided systems reduce the risk of anterior chamber bacterial contamination [7]. A risk of image-guided systems is that the eye tracker may disengage during surgery and a repeat registration may be required [4]. Additional risks include intraoperative changes in the appearance of the limbal vessels, including conjunctival chemosis, ballooning, and bleeding, which may interfere with intraoperative registration [4, 10]. Furthermore, registration may not be possible in extremely uncooperative patients or for difficult orbital anatomy, including extremely deep-set eyes or narrow palpebral apertures [4]. Image-guided technologies primarily help to reduce any source of error and variability from manual processes. It also helps in eliminating transcription errors as the data is integrated. An additional benefit is that the Vision Planner that is part of the image-guided system helps the surgeon to move away from additional tools and calculators for astigmatism correction for toric alignment axis and arcuate incision and Global IOL constants by providing personal optimization algorithms for constants and SIA which is intended to improve outcome.

Disclaimer Raiju Babu and Jessica Voegtle are employee's of Alcon Vision LLC.

References

1. Labiris G, Toli A, Perente A, Ntonti P, Kozobolis VP. A systematic review of pseudophakic monovision for presbyopia correction. Int J Ophthalmol. 2017;10(6):992–1000. https://doi.org/10.18240/ijo.2017.06.24.
2. Findl O, Hirnschall N. Principles of corneal measurement for intraocular lens power calculation. Exp Rev Ophthalmol. 2016;11(2):93–9.
3. Hirnschall N, Gangwani V, Crnej A, Koshy J, Maurino V, Findl O. Correction of moderate corneal astigmatism during cataract surgery: toric intraocular lens versus peripheral corneal relaxing incisions. J Cataract Refract Surg. 2014 Mar;40(3):354–61. https://doi.org/10.1016/j.jcrs.2013.08.049.
4. Kaur M, Shaikh F, Falera R, Titiyal JS. Optimizing outcomes with toric intraocular lenses. IJO. 2017;65(12):1301–13.
5. Diakonis VF, Swann BF, Weinstock RJ. Femtosecond laser–assisted capsulotomy markings for the alignment of toric IOLs: a new technique. J Refract Surg. 2018;34(10):711–2.
6. Donaldson K, Fernandez-Vega-Cueto L, Davidson R, Dhaliwal D, Hamilton R, Jackson M, et al. Perioperative assessment for refractive cataract surgery. J Cataract Refract Surg. 2018;44(5):642–53.
7. Panagiotopoulou EK, Ntonti P, Gkika M, Konstantinidis A, Perente I, Dardabounis D, et al. Image-guided lens extraction surgery: a systematic review. Int J Ophthalmol. 2019;12(1):135–51.
8. Sivagnanam S, Arunkumar GL, Srinivasan U, Kathirvel PSA, K, Gurubaran K. A new system of axis marking for toric intraocular lenses - the Toric max system. Del J Ophthalmol. 2016;27(1):62–3.
9. Lin H-Y, Fang Y-T, Chuang Y-J, et al. A comparison of three different corneal marking methods used to determine cyclotorsion in the horizontal meridian. Clin Ophthalmol. 2017;11:311–5.
10. Behshad S, Tucker J, Garg SS. Toric intraocular lens alignment: manual versus automated alignment techniques for toric IOLs. Int Ophthalmol Clin. 2016;56(3):71–84.
11. Coleman MJ, Stark WJ, Daoud YJ. A comprehensive guide to managing astigmatism in the cataract patient. Exp Rev Ophthalmol. 2014;9(6):539–44.
12. Thulasi P, Khandelwal SS, Randleman JB. Intraocular lens alignment methods. Curr Opin Ophthalmol. 2016;27(1):65–75.
13. Ventura BV, Wang L, Weikert MP, Robinson SB, Koch DD. Surgical management of astigmatism with toric intraocular lenses. Arq Bras Oftalmol. 2014;77(2):125–31.
14. Webers VSC, Bauer NJC, Visser N, Berendschot TTJM, van den Biggelaar FJHM, Nuijts

RMMA. Image-guided system versus manual marking for toric intraocular lens alignment in cataract surgery. J Cataract Refract Surg. 2017 Jun;43(6):781–8.
15. Lipsky L, Barrett G. Comparison of toric intraocular lens alignment error with different toric markers. J Cataract Refract Surg. 2019 Nov;45(11):1597–601.
16. Visser N, Berendschot TT, Bauer NJ, Jurich J, Kersting O, Nuijts RM. Accuracy of toric intraocular lens implantation in cataract and refractive surgery. J Cataract Refract Surg. 2011 Aug;37(8):1394–402. https://doi.org/10.1016/j.jcrs.2011.02.024.
17. Xiang W, Chen W, Liu R, et al. Ocular cyclorotation and corneal axial misalignment in femtosecond laser-assisted cataract surgery. Curr Eye Res. 2019;44(12):1313–8.