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Cataract & Refractive Surgery Today

THE SCIENCE BEHIND TRIFOCAL IOL TECHNOLOGY

BY ELIZABETH YEU, MD

Patients undergoing cataract surgery have very high but mostly unmet visual expectations.[1] These expectations include a desire to be independent from spectacles after surgery. Current multifocal IOLs provide a compromise for patients; patients can either see crisply at distance and near or at distance and intermediate, but there is no option for distance and both intermediate and near vision. Consequently, many patients using current generation multifocal IOLs still require spectacles at times. Mixing and matching of multifocal IOLs has somewhat addressed this limitation, but this surgical option requires additional planning time during the preoperative patient work-up to determine eye dominance, refractive power targeting, mixed IOL design use, and patient education time. Additionally, significant chair time is spent managing patient expectations after surgery.

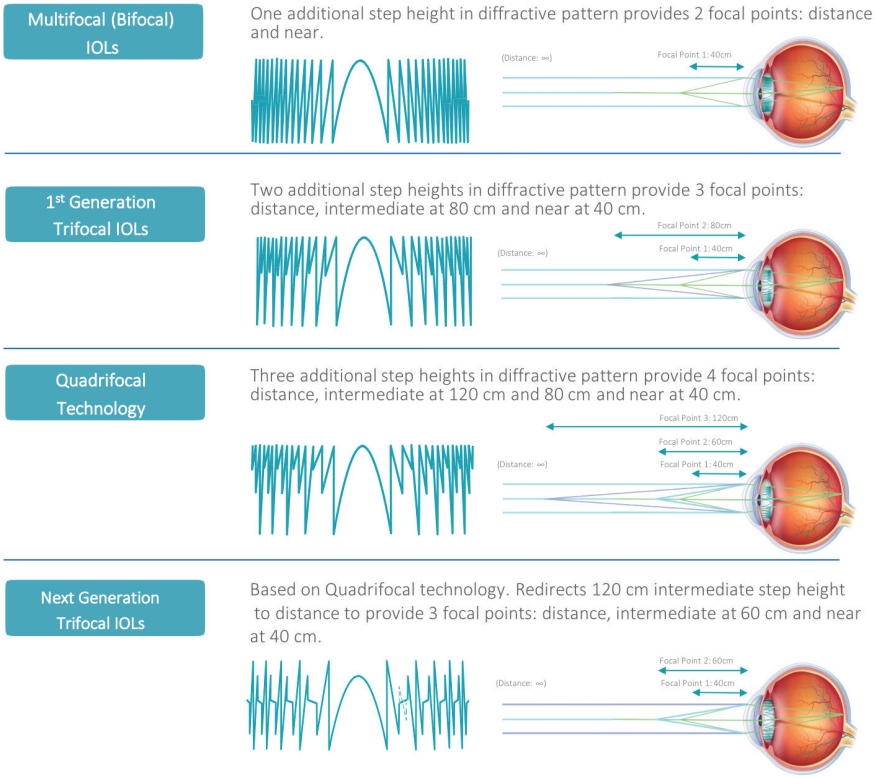

Figure 1. Diffractive optical patterns of presbyopia-correcting IOLs. The distribution of light into different foci is enabled by diffractive rings. Here, diffractive rings are presented in a cross-sectional view. The step height of the diffractive ring determines the focal length of the foci.

Trifocal IOLs may present a solution to address these shortcomings and improve patient satisfaction, however, they are not yet available in the United States. Trifocal IOLs provide the patient with an opportunity to experience a full range of vision from distance to near. Trifocal IOLs utilize diffractive technology to split light energy into three focal points: near, intermediate, and far (Figure 1). As with any diffractive multifocal technology that distributes light into different foci, it is important to distribute enough light to each foci since contrast sensitivity and the quality of the patient's vision can be impacted.

PC-IOL Evolution

Figure 1 illustrates the history of technology used in diffractive IOLs and helps to explain how focal points are created. Multifocal (bifocal) IOLs have two focal points that are obtained through the introduction of one additional step height in the diffractive ring profile. This means the patient can see clearly at distance and at near, but not at intermediate distances.

Trifocal IOLs have three focal points, which are enabled through two additional step heights in the diffractive ring pattern, allowing the patient can see clearly at distance, intermediate and near. The intermediate focal point for these first generation trifocal IOLs is generally at 80 cm (32 inch) as a result of optical principles, which may be a little bit " too far" for intermediate since most tasks are done at 60 cm.

Theoretically, quadrifocal IOLs would have 4 focal points from the addition of three step heights in the diffractive ring pattern with focal points at distance, intermediate at 120 cm (47 inch) and 60 cm (24 inch) as well as near at 40 cm (16 inch). However, splitting light that enters the eye four ways may sacrifice distance visual performance.

Next-Generation Trifocal

A next-generation trifocal IOL is based on quadrifocal technology. However, instead of 4 foci, the light of the 120 cm intermediate focal point is truncated and the light is directed to the distance foci to preserve contrast and visual performance at distance. The IOL's central diffractive portion creates three focal points: one for distance, intermediate at 60 cm and near at 40 cm. This technology, differing from traditional trifocal IOL designs with an 80 cm intermediate focal point (Figure 1), allows for a 60 cm intermediate working distance, which is closer to the ideal intermediate distance, such as when reading a computer screen, for the majority of patients (63 to 67 cm).[2,3] The central diffractive portion in this advanced trifocal IOL technology splits the light energy entering the eye 50:25:25. About 50% of the transmitted light is directed to distance and the rest splits evenly between intermediate and near. The combination of the 4.5 mm diffractive zone and the light energy distribution also provides less dependence on pupil size and lighting conditions. Figure 2 shows that the light energy distribution is consistent over a range of pupil diameters (ie, up to 5.0 mm pupil diameter).

In summary, trifocal IOLs will be a great future option in the United States to increase patient satisfaction by offering a full range of vision to your patients. ■

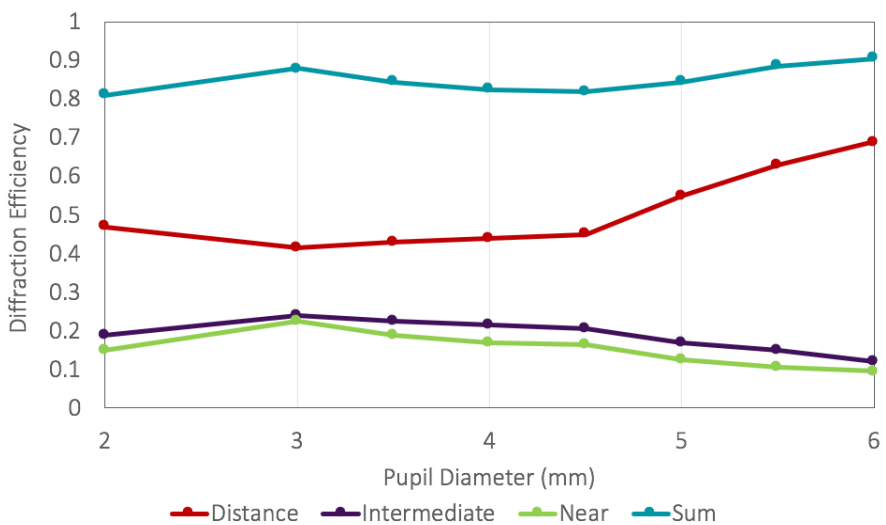

Figure 2. Theoretical light distribution for distance, intermediate, and near in relation to pupil size.

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3. Jaschinski W. The proximity-fixation-disparity curve and the preferred viewing distance at a visual display as an indicator of near vision fatigue. *Optom Vis Sci.* 2002;79(3):158-169.

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