How are novel IOL technologies increasing the range of vision after cataract surgery?

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Driving forward innovative IOL technologies: How to meet high patient expectations after cataract surgery?

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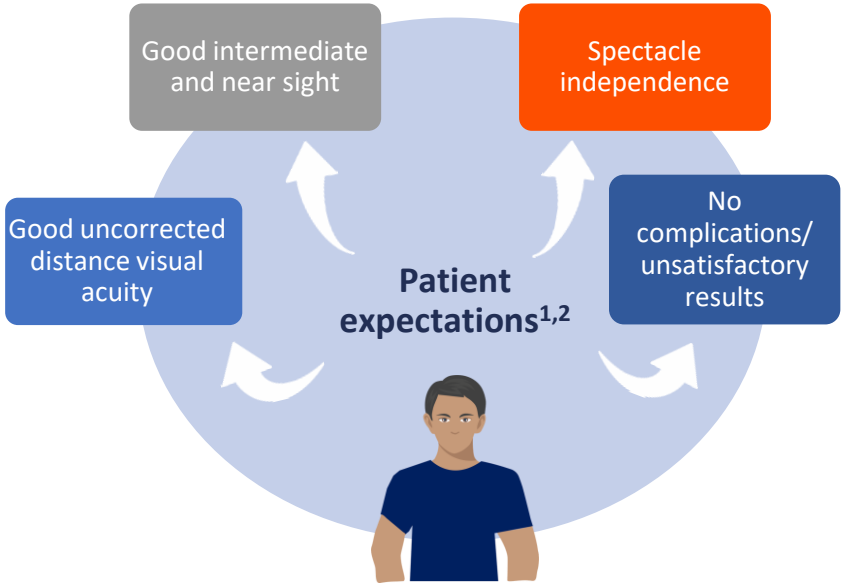
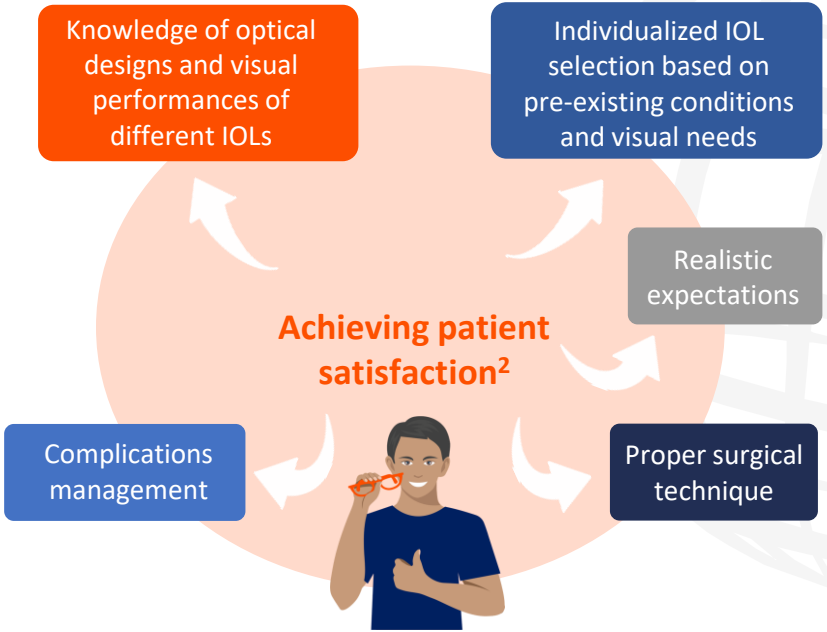
What are the key visual needs and expectations of patients after cataract surgery?

Patient visual needs and expectations after cataract surgery

Advances in manufacturing and surgical techniques mean an increasing variety of novel IOLs are available to the cataract surgeon





IOL, intraocular lens.

1. Bianchi GR. *Med Hypothesis Discov Innov Ophthalmol.* 2020;9:38–46; 2. Salerno C, et al. *Taiwan J Ophthalmol.* 2017;7:179–84.

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How might clinicians assess patient needs and preferences to help select the best IOL for individual patients?

Psychometrics can help assess patient needs and preferences

Psychometric testing to identify best candidates for cataract surgery

- Who is likely to do well with presbyopia correction?
- Who is really interested?
- What lens choice is ideal?

Collect information on patients' lifestyle and visual needs

Learn about visual needs

Deliver educational material on premium lens implants before the first visit

Patient-specific learning material

Predict which patients are most interested in premium IOL options

Create visual profile report

Suggest IOL options best suited to their needs

Productive conversations

IOL, intraocular lens.

Content provided courtesy of Dr John A. Hovanesian, Clinical Faculty, UCLA Jules Stein Eye Institute, Los Angeles, CA, USA..

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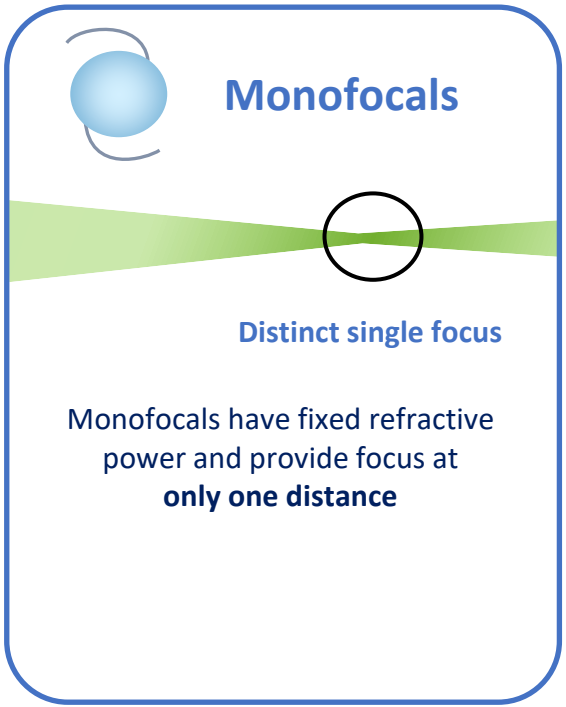
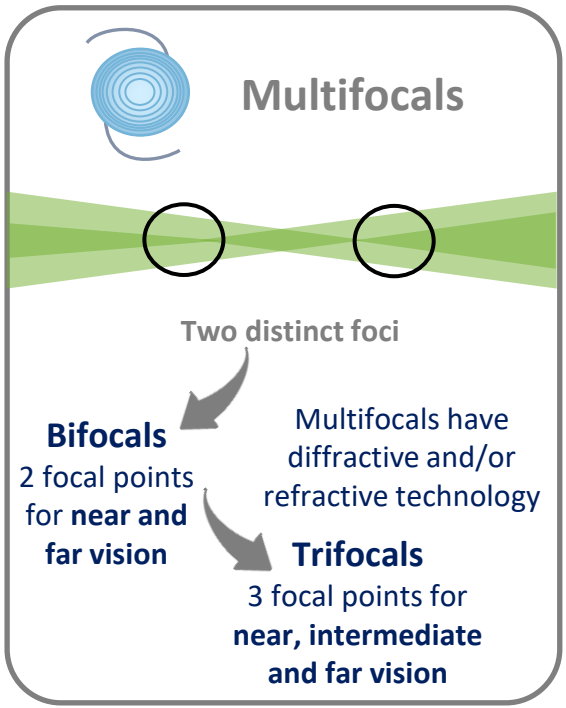
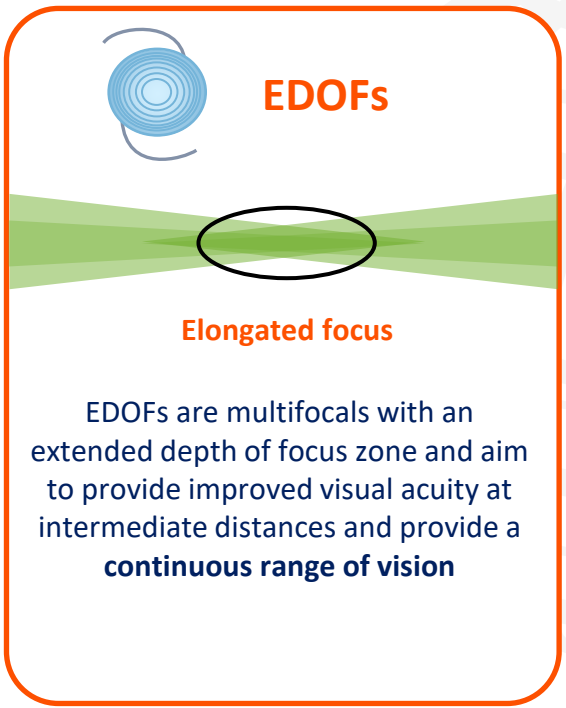
How do the designs of available IOLs address near, intermediate and far visual needs of patients?

IOL types for near, intermediate and distance vision correction







EDOF, extended depth of focus; IOL, intraocular lens.

Werner L. *Ophthalmology.* 2020;S0161-6420(20)30626–6.

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What is the optimal intermediate focal point?

- Traditional trifocal IOLs create an **intermediate focal point** that is located at **2 times** the distance of the **near focal point**

Patient can see clearly in the **distance,** at **intermediate (80 cm)** and at **near**

The intermediate focal point at **80cm is too far** for the average height person

The most common intermediate-vision activities are done at **relaxed arm length, which is ~60 cm**

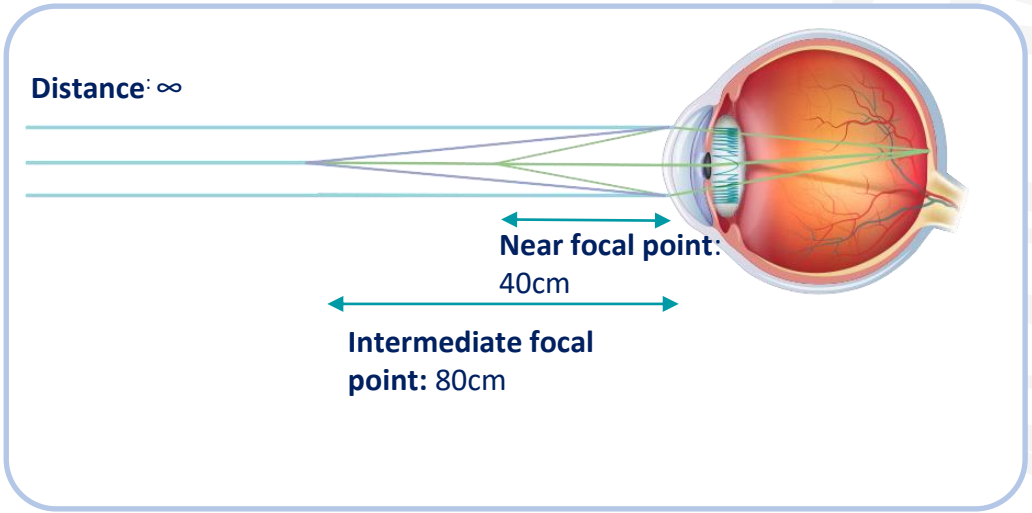

Image provided courtesy of Dr John A. Hovanesian, Clinical Faculty, UCLA Stein Eye Institute, Los Angeles, CA, USA.
Kim T, et al. *BMC Ophthalmol*. 2020;20:288.

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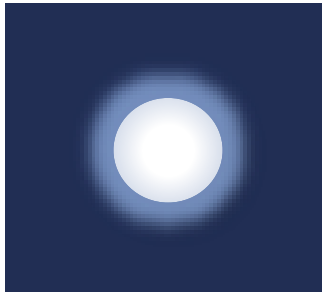
Do IOLs with improved range of vision tend to be associated with fewer/less severe visual disturbances?

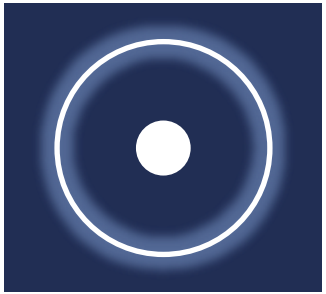
Trifocals: Balancing visual needs with undesirable optical phenomena

The division of light when passing through a trifocal IOL results in glare, halos and loss of contrast sensitivity[1]

Glare/flare
blurring or smearing of lights



Halos
distinct rings around lights



Loss of contrast sensitivity

Photopsias result from off-axis light[2]

IOL, intraocular lens.

1. Werner L. *Ophthalmology.* 2020;S0161-6420(20)30626–6; 2. Chang DH. Available at: https://crstoday.com/articles/2016-aug/night-vision-and-presbyopia-correcting-iols/ (accessed Nov 2020).

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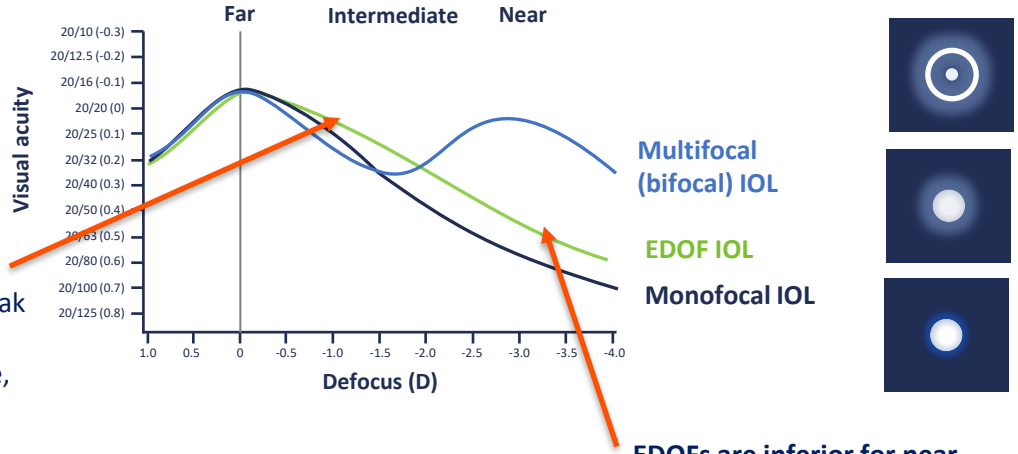
EDOF IOLs: Continuous range of vision while reducing undesirable optical phenomena

Simulated halo effects for a theoretical monofocal IOL, multifocal IOL, and EDOF IOL[1]



Glare and halos are closely related to the near vision multifocals provide[1]

EDOFs have a broad peak and a monotonically declining defocus curve, providing good vision over a wide range of defocus[1]

EDOFs are inferior for near vision vs multifocals[2]

EDOF, extended depth of focus; IOL, intraocular lens.

1. Chang DH. Available at: https://crstoday.com/articles/2016-aug/night-vision-and-presbyopia-correcting-iols/ (accessed Nov 2020); 2. Werner L. *Ophthalmology.* 2020;S0161-6420(20)30626-6; 2.

What new and emerging IOL technologies may further address patient visual needs?

New and emerging IOL technologies

Designed to improve patient expectations by enhancing range of vision with low incidence of photic phenomena[1]

EDOF with X-WAVE technology[2]

- A single-piece looped hydrophobic acrylic non-diffractive EDOF lens
- 2 smooth surface transition elements on the anterior optic surface (X-WAVE technology)

Small aperture monofocal IOL[2]

- A single-piece looped hydrophobic acrylic lens
- Achieves EDOF by combining small-aperture optics with a monofocal IOL
- The IOL is embedded with a central black circular mask with a nondiffractive clear circular aperture at the centre

Light adjustable IOLs allow the refractive power of the lens to be adjusted noninvasively after implantation[2]

Accommodating IOLs (e.g. fluid-driven lenses) are designed to allow for anterior optic movement or optic shape changes for accommodation[2]

EDOF, extended depth of focus; IOL, intraocular lens.

1. Salerno C, et al. *Taiwan J Ophthalmol*. 2017;7:179–84; 2. Werner L. *Ophthalmology*. 2020;S0161-6420(20)30626–6.

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Navigating novel IOL technologies: How can we differentiate between available IOL models?

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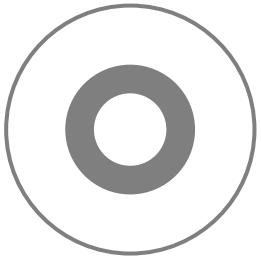
How do differences between refractive and/or diffractive technologies influence multifocal IOL choice?

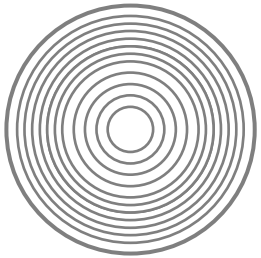
Multifocals can be be refractive, diffractive, or a combination of both designs

Refractive[1]



- Different refractive power annular zones
- Dependent of pupil dynamics
- Very sensitive to their centering
- May cause halos and glare and reduce the contrast sensitivity

Diffractive[1]



- Diffractive microstructures in concentric zones
- Not so dependent of pupil dynamics
- More tolerant to their centering
- Decreased contrast sensitivity at higher spatial frequencies

Hybrid lenses[2]

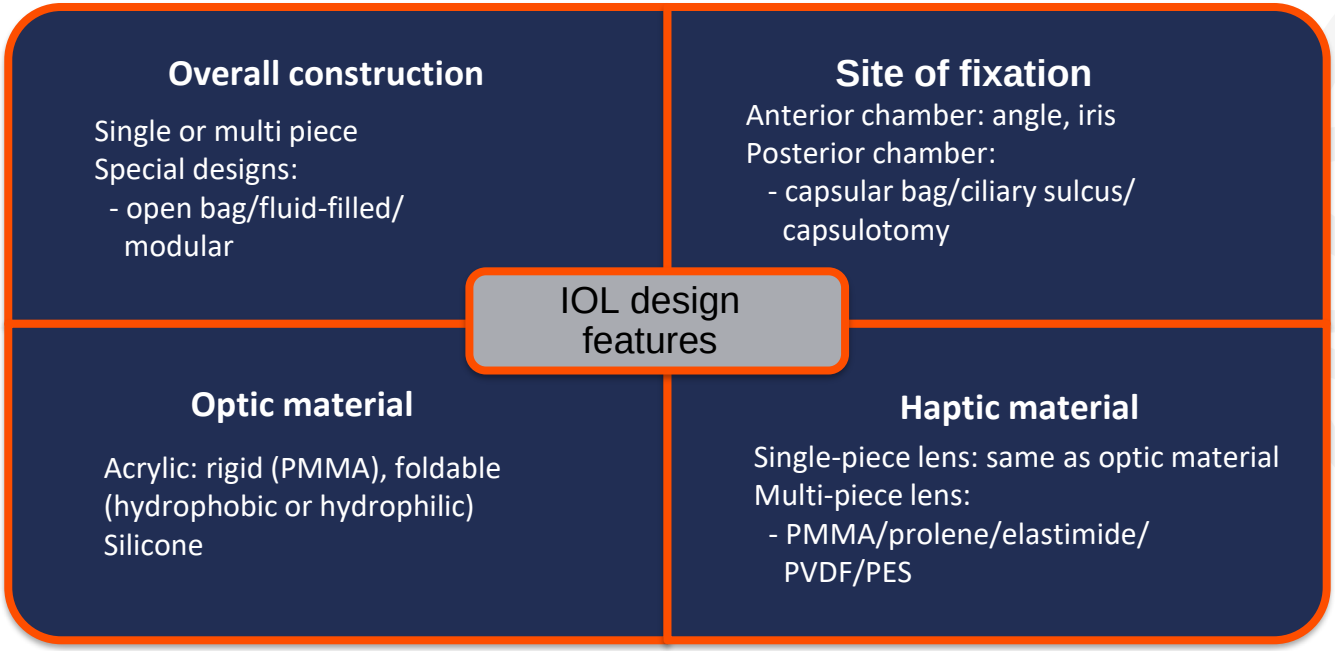
- Central progressive refractive zone surrounded by a diffractive zone
- Allows for far and near vision in a full range of pupil sizes
- Progressive power of refractive zone allows far and intermediate vision
- Apodized diffractive design minimizes light loss outside and reduces halos

1. Salerno C, et al. *Taiwan J Ophthalmol*. 2017;7:179–84; 2. Dyrda A, et al. *J Ophthalmol.* 2018; Article ID 8285637.

What other design features are important to consider when assessing IOL performance for individual patients?

Characteristics of IOL designs

Designs and materials used for the manufacture of IOLs for cataract surgery



IOL, intraocular lens; PES, polyether sulfone; PMMA, polymethyl methacrylate; PVDF, polyvinylidene fluoride.

1. Werner L. *Ophthalmology.* 2020;S0161-6420(20)30626–6..

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How does the biomaterial influence IOL performance?

Impact of IOL material on post-cataract surgery outcomes

IOL materials vary in water content, chemical composition, refractive index and tensile strength[1]

IOL material influences

Studies have shown:

- Lower PCO rates with hydrophobic than hydrophilic and PMMA IOL materials
- ACO rates lower for hydrophobic than for silicone and specifically for hydrophilic IOL materials
- Higher levels of glistening formation with hydrophobic IOLs than other materials. No correlation between glistening formation and visual performance

Post-cataract surgery

- PCO development
- ACO development
- Glistening formation

Factors affecting patients' visual outcomes and satisfaction after cataract surgery[1,2]

Secondary IOL features also have some influence

- Haptic materials and designs
- Edge profiles: sharp edges associated with lower PCO formation than round edges
- Optic size

ACO, anterior capsule opacification; IOL, intraocular lens; PCO, posterior capsule opacification; PMMA, polymethyl methacrylate.

1. Pérez-Vives C. *J Ophthalmol.* 2018:2687385. doi: 10.1155/2018/2687385; 2. Poyales F, et al. *Clin Ophthalmol.* 2020;14:3237–47.

How does awareness of different characteristics of available IOLs assist surgeons in the choice of the most appropriate lens?

The way forward in cataract surgery: What is the experience with specialised IOLs?

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What is the evidence for the effectiveness of available IOL technologies?

Effectiveness of monofocal vs multifocal IOLs

Systematic review and meta-analysis

1 Jan 2006–30 Apr 2017
25 eligible RCTs

Compared to monofocal IOLs, multifocal IOLs had:

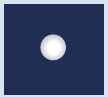
Statistically significantly **better** pooled results for

Near vision
(mean difference in logMAR=-0.26)

Spectacle dependence
(RR=0.27)

Borderline significantly **better quality of vision** (mean difference of -0.54)

Statistically significantly **worse** pooled results for:



Glare
RR=1.36

Halos
RR=3.14

Newer multifocal lenses had **statistically significantly better outcomes** than older diffractive or refractive lenses, when compared to monofocal IOLs, in near vision, quality of vision, and risk of halos

IOLs, intraocular lenses; logMAR, logarithm of the minimum angle of resolution; RCT, randomized controlled trial; RR, relative risk.
Khandelwal SS, et al. *Graefes Arch Clin Exp Ophthalmol*.2019;257:863–75.

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Effectiveness of multifocal and EDOF IOLs

Non-randomized prospective series of cases

Evaluation 3 mos postsurgery

N=120 eyes (60 patients)
Implanted IOLs (n=40 eyes each):

- **EDOF:** Tecnis Symfony
- **Trifocal**: PanOptix IQ; AT LISA tri 839MP

- All the tested IOLs provided good visual outcomes, reading performance and spectacle independence after cataract surgery

The two trifocal IOLs had better near VA vs the EDOF IOL ($p<0.05$ to $p<0.001$)

The EDOF IOL had better intermediate VA vs the trifocal IOLs ($p<0.05$ vs AT LISA)

No statistically significant difference between groups for **distance VA**

The EDOF IOL showed significantly better contrast sensitivity vs the trifocal IOLs ($p<0.001$)

EDOF, extended depth of focus; IOLs, intraocular lenses; mos, months; VA, visual acuity.
Mencucci R, et al. *Graefes Arch Clin Exp Ophthalmol*. 2018;256(10):1913–22.

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What do patient-reported outcomes tell us about multifocal IOLs?

PROs after multifocal IOL implantation

Comparison of PROs and satisfaction after multifocal IOL implantation in three groups

Patient questionnaire administered 2 months after uncomplicated cataract surgery and follow up

- Overall **PROs and satisfaction were similar** among the groups
- **Refractive outcomes and accuracy were similar** among the groups
- **Refractive outcome differences were not meaningful among the groups** and were not a differentiating factor in PROs

3.0/3.0 group (n=78)
bilateral implantation with AcrySof ReSTOR 3.0 lens

2.5 mini-monovision group (n=102)
implantation with the ReSTOR ActiveFocus 2.5 or the ReSTOR ActiveFocus 2.5 toric lens

2.5/3.0 blended vision group (n=89)
implantation with the ReSTOR 2.5 lens (dominant eye) and the ReSTOR 3.0 lens (non-dominant eye)

Substantially **fewer patients in the 2.5 mini-monovision group noticed glare and halo** vs the 3.0/3.0 group ($p<0.0001$)

The **2.5 mini-monovision group reported better intermediate vision** vs the other groups

PROs, patient-reported outcomes; IOL, intraocular lens.
Hovanesian JA, et al . *Clin Ophthalmol.* 2019;13:2591–8.

PROs in patients following trifocal IOL implant

Study of patient satisfaction, visual disturbances and uncorrected visual performance

PRO questionnaire ≥1 month after uncomplicated bilateral implantation with a **trifocal** Panoptix **(n=59)**

Comparison with 2 groups from previous studies:

- **2.5/3.0 group (n=89)**
  Active Focus (dominant eye)
  ReSTOR 3.0 (non-dominant eye)
- **2.5 mini-monovision group (n=102)**
  Active Focus

Group	Overall patient satisfaction	Spectacle need (All activities combined)
	"Very satisfied"	"Never need glasses"
Trifocal	85%	83%
2.5 mini-monovision	75%	36%
2.5/3.0	74%	31%

Greater spectacle independence with the trifocal vs other lens combinations (p<0.0001)

Severity of glare and halos was similar in all groups

The fear of blurry vision was more common than all other fears, including going blind

IOL, intraocular lens; PROs, patient reported outcomes.

Content provided courtesy of Dr John A. Hovanesian, Clinical Faculty, UCLA Stein Eye Institute, Los Angeles, CA, USA. Data presented at ASCRS 2020. Abstract available at: https://ascrs.org/clinical-education/presbyopia/2020-pod-sps-108-60552-the-panoptix-trifocal-iol-a-study-of-patient-satisfaction-visual (accessed January 2021).

What is the added value of PROs in assessing IOL outcomes for individual patients?

PROs: Assessment of patients' thoughts, beliefs and attitudes about their vision

Large subjective component to IOLS: Two individuals may have the same objective visual function but perceive their quality of vision differently

Objective assessment

Objective measures include:

- Uncorrected binocular acuity under multiple conditions and distances
- Residual refractive error
- Contrast sensitivity
- Glare disability
- Straylight levels
- Halometry

Holistic evaluation of QoL and vision after IOL implantation

Subjective assessment

PROs based on questionnaires to evaluate:

- Spectacle independence
- Visual function across a range of distances and circumstances
- Overall satisfaction with vision including preoperative expectations

IOL, intraocular lens; PROs, patient-reported outcomes; QoL, quality of life.

Grzybowski A, et al. *Graefes Arch Clin Exp Ophthalmol.* 2019;257:1091–9.

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How can we best pair patients with the right IOL technology?

Matching patients with the right IOL technology

Each patient's care requires careful history, examination and discussion[1]

Key considerations for IOL selection[2]

- No previous LASIK/PRK/RK
- No K pathology
- No dry eye
- No macular degeneration

- Low aberration
- Post-PRK/LASIK
- Mild irregular astigmatism
- Salzmann's nodular degeneration
- Significant dry eye
- Very mild maculopathy

- Loss of BVCA besides cataract
- Post-RK
- High corrections
- Mild maculopathy

IOL
'sorting' hat

Patient is best suited for

Binocular distance and near
Binocular distance (or near) only
Monovision success

BVCA, best corrected visual acuity; K, keratitis; LASIK, laser *in-situ* keratomileusis; IOL, intraocular lens; PRK, photorefractive keratectomy; RK, radial keratotomy.
1. Eisenberg JS. 2017. Available at :https://www.reviewofophthalmology.com/CMSDocuments/2017/1/rp0117i.pdf; 2. Content provided courtesy of Dr John A. Hovanesian, Clinical Faculty, UCLA Stein Eye Institute, Los Angeles, CA, USA.

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