

Evidence-Based IOL Functional Classification: ESCRS Classification

Filomena Ribeiro, MD, PhD, FEBO



Evidence-Based IOL Functional Classification: ESCRS Classification

- Evidence –Based

Evidence-Based IOL **Functional Classification:** ESCRS Classification

- Evidence –Based
- Patient Centered
- Clinically Relevant
- Support Decision-Making

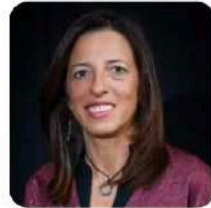
Real World
Patient
Outcomes



Clear Criteria

Standard for collecting and reporting outcomes of IOL-based refractive surgery: update for enhanced monofocal, EDOF, and multifocal IOLs

Joaquín Fernández, MD, PhD, Filomena J. Ribeiro, MD, PhD, FEBO, Manuel Rodríguez-Vallejo, OD, PhD, William J. Dupps Jr, MD, PhD, Liliana Werner, MD, PhD, Sathish Srinivasan, FRCSEd, FRCOphth, FACS, Thomas Kohnen, MD, PhD, FEBO



The **Standard** Collecting and Reporting of Outcomes is **Crucial** for Understanding and Taking Decisions for Intraocular Lens Implantation

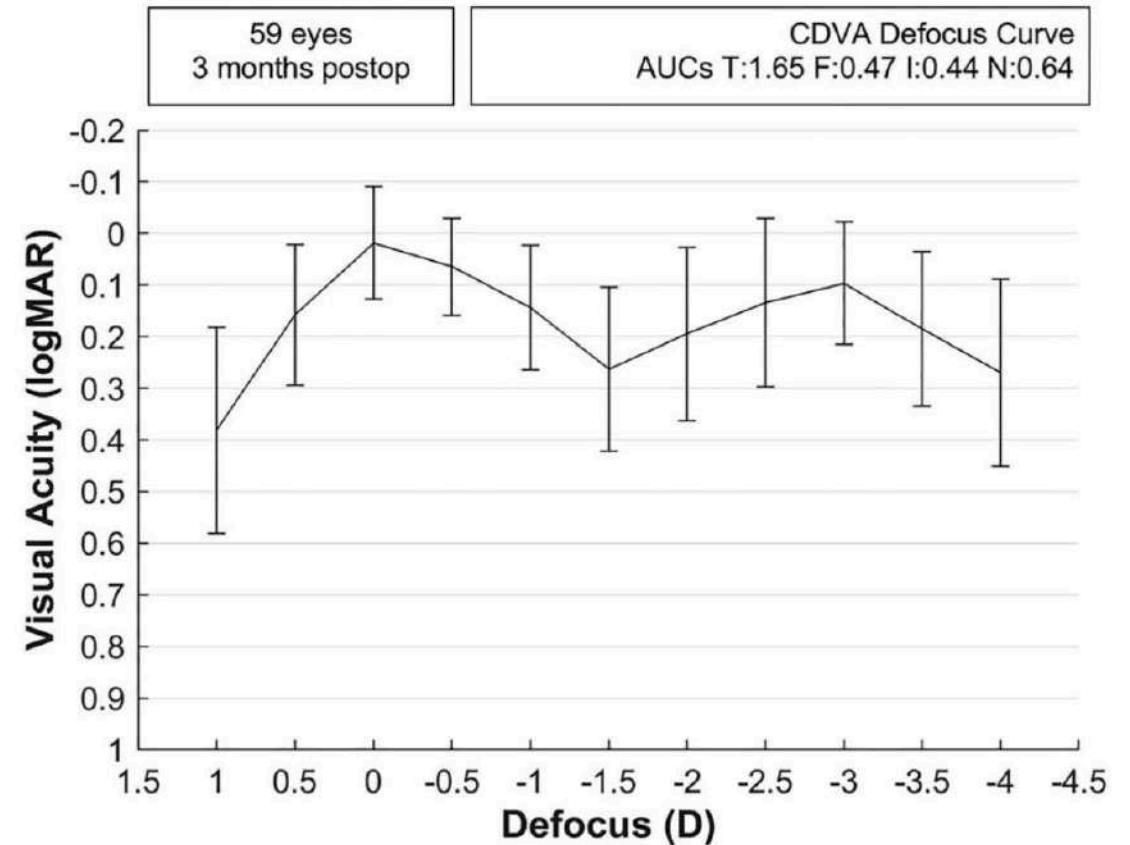
Defocus curve

Measured with **manifest refraction** and by **correcting the vergence induced** by the **presentation distance** of the test.

Apply methods for **avoiding memorization**: random letters, random defocus lenses, starting with negative lenses, ...

Defocus range determined by the IOL: Generally from +1 D to -4 D. Shorter for EDOF +1.5 to -2.5 D with ± 0.25 D around 0 D.

Areas under the defocus curve calculated **above 0.3 logMAR**.



Outcomes report standardization

Monocular with the best corrected distance refraction



IOL performance

Binocular without corrected distance refraction



Procedure outcome

Depth-of-field or Depth-of-focus

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CORRESPONDENCE

Depth of field or depth of focus?

Riaz, Kamran M. MD; Wendelstein, Jascha A. MD; Koch, Douglas D. MD

Author Information

Journal of Cataract & Refractive Surgery 50(12):p 1291-1292, December 2024. | DOI: 10.1097/j.jcrs.0000000000001548

BUY

Metrics



1291

CORRESPONDENCE

Depth of field or depth of focus?

Kamran M. Riaz, MD, Jascha A. Wendelstein, MD, Douglas D. Koch, MD



In modern practice, surgeons may choose from many advanced technology intraocular lenses (ATIOLs) to correct presbyopia during cataract surgery. Among ATIOLs, some have been referred to as extended depth-of-focus or extended depth-of-field IOLs, with articles using both terms interchangeably as "EDOF-IOLs."¹ EDOF-IOLs enhance patients' intermediate and near visual acuity by using one of several optical principles, including diffractive optics, pinhole optics, spherical aberration manipulation, or wavefront modification.²

Precise terminology is crucial for effective communication to ensure an accurate understanding of vision-related concepts. Our field has seen similar confusion when the terms "axis" (incorrectly) and "meridian" (correctly) were interchangeably used when referring to corneal astigmatism.³ An editorial in this journal by the late Emanuel Rosen identified and clarified definitions of the two terms.⁴ We believe we are at a similar crossroads regarding "depth of field (DOFi)" and "depth of focus (DOFo)" because these terms are used interchangeably with the assumption of similarity.

It is well-known that the eye has a tolerance to out-of-focus images, which is the DOFo; however, the distance range in which objects are visualized is known as the DOFi.⁵ Admittedly, both parameters refer to similar concepts. For a linear optical system, such as an IOL in the eye, they are related by the system's longitudinal magnification (m). Therefore, if one is calculated, the other can also be easily calculated. However, DOFi is more useful because it can be determined through calculations and measurements.⁶ Put another way, the DOFi refers to object space, whereas DOFo refers to image space, and both are related by the well-known equations for magnification.

DOFi and DOFo are commonly used in photography and optics. "DOFi" is defined as the range of object distances within which objects are imaged with acceptable sharpness.^{7,8} Thus, DOFi is the image quality of a stationary lens as the viewing object is repositioned. For the pseudophakic eye, the stationary lens is the ATIOL, which does not move within the capsular bag.

The DOFi for ideal lenses can be calculated using equations.⁹ Although several factors affect DOFi (eg, focal length and distance to object), the pupil aperture is salient for the pseudophakic eye because it most resembles the aperture of a camera. For the latter, a wider aperture gives

a brighter photograph and a shallower DOFi, while a smaller aperture gives a darker photograph and a deeper DOFi. Therefore, the concept of DOFi seems better aligned to describe the clinical goal of achieving optimal visual acuity at different distances with EDOF-IOLs. For completeness, the DOFo concept can be used to assess the IOL's performance stability under slight variations in eye or IOL position. Technically, the DOFo is the image-space complement of the DOFi, which may account for some of the misunderstandings by ophthalmologists.⁹

We believe this distinction is important as DOFi aligns with patients' functional vision across various distances (Table 1). For example:

Monofocal IOLs provide clear vision at one specific distance—near, intermediate, or far. However, their limited DOFi means that patients often require spectacles for other distances. They provide a broad DOFo at a single optimized distance, offering greater positional tolerance.

Multifocal IOLs offer multiple zones for clear vision at different distances, attempting to reduce dependency on spectacles. The trade-off often involves some loss of image quality, such as glare and halos, due to the splitting of light between different focal points. Hence, they have a narrower DOFo for each zone of vision.

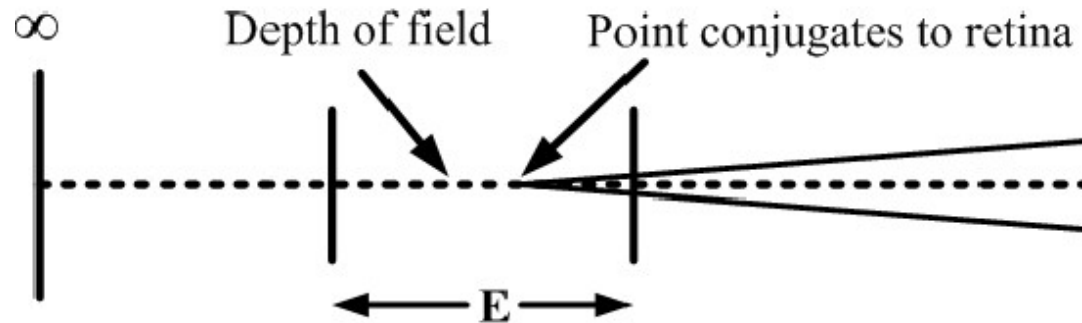
Enhanced depth of field (EDOF) IOLs enhance patients' far and intermediate visual acuity, reducing the need for recreational spectacle dependence. They use one of several optical principles, including diffractive optics, refractive optics, pinhole optics, and spherical aberration manipulation, to reduce overlapping of far and near images and secondary out-of-focus images caused by multifocal IOLs.³ The DOFo in diffractive EDOF IOLs is broader than that in traditional multifocal IOLs.

Moreover, the recently used marketing term "range of vision (ROV)" primarily addresses the entire visual field visible to the eye, including both DOFi and peripheral vision.¹⁰⁻¹³ Though comprehensive, it does not specifically address the sharpness or clarity of central vision across different distances. ATIOLs are designed to enhance the quality of central vision within that field across a range of distances. An IOL might offer a wide visual field, but without a corresponding DOFi, the usefulness of that wide range could be limited because not all seen distances would necessarily be in focus. On the other hand, if we define IOLs by their ROV, a pinhole IOL may be considered

Depth-of-field or Depth-of-focus

Depth-of-Field

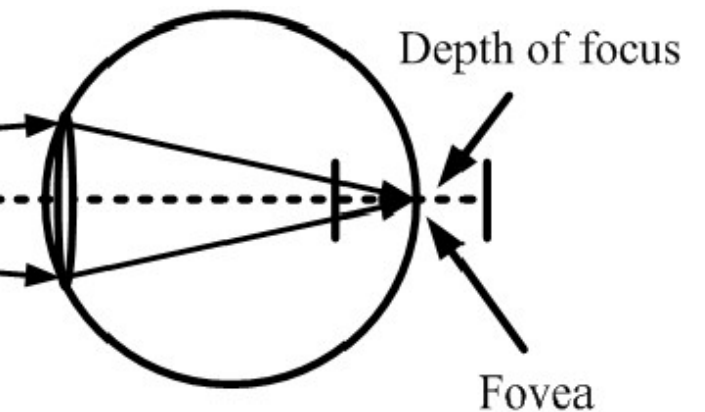
Visual Acuity Defocus Curve



“Allows you to see at different distances”

Depth-of-Focus

MTF trough Focus on a
Optical Bench

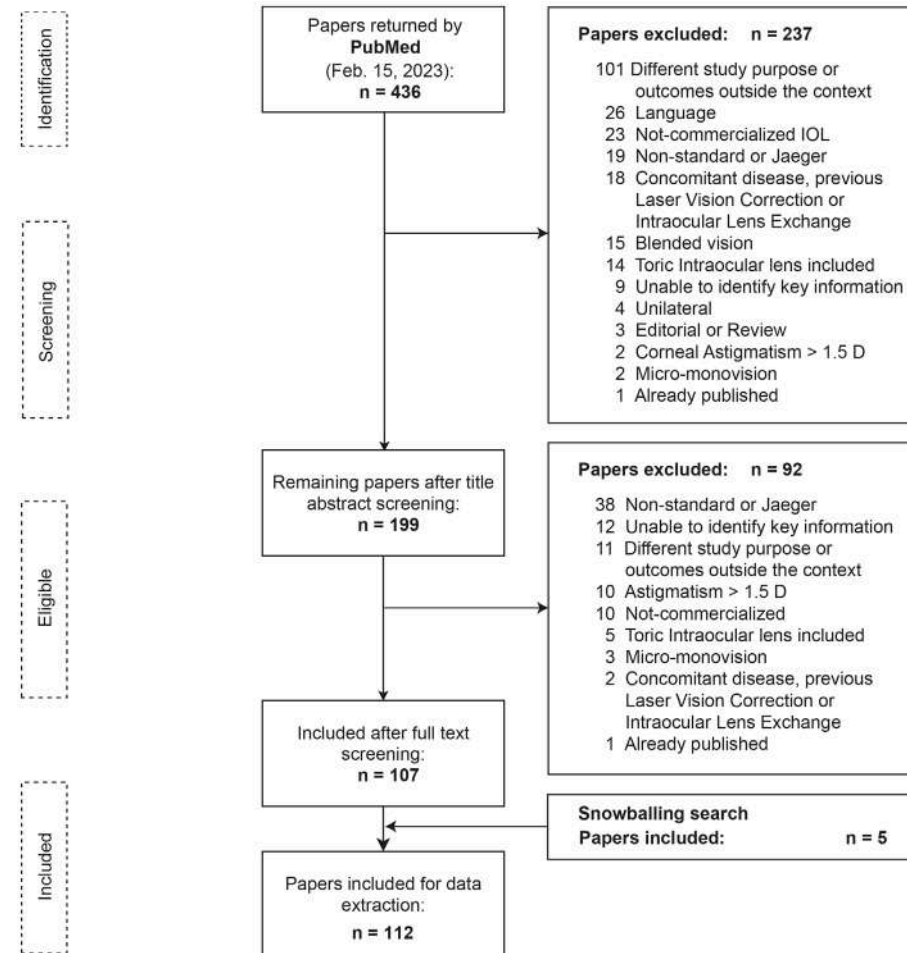


“Extends the focus image on your retina ”

PUBLISH EVIDENCE

2010 to Feb.2023

Scoping review of current literature
Methodology: **Joanna Briggs Institute (JBI)**
Reporting: **PRISMA-ScR** guidelines



CLUSTER ANALYSIS

Exploratory cluster analysis

of VADC outcomes

Based on **DoFi extent (above 0.2 logmar)**

and **curve shape**

Assessing **VA improvement from**

intermediate → near

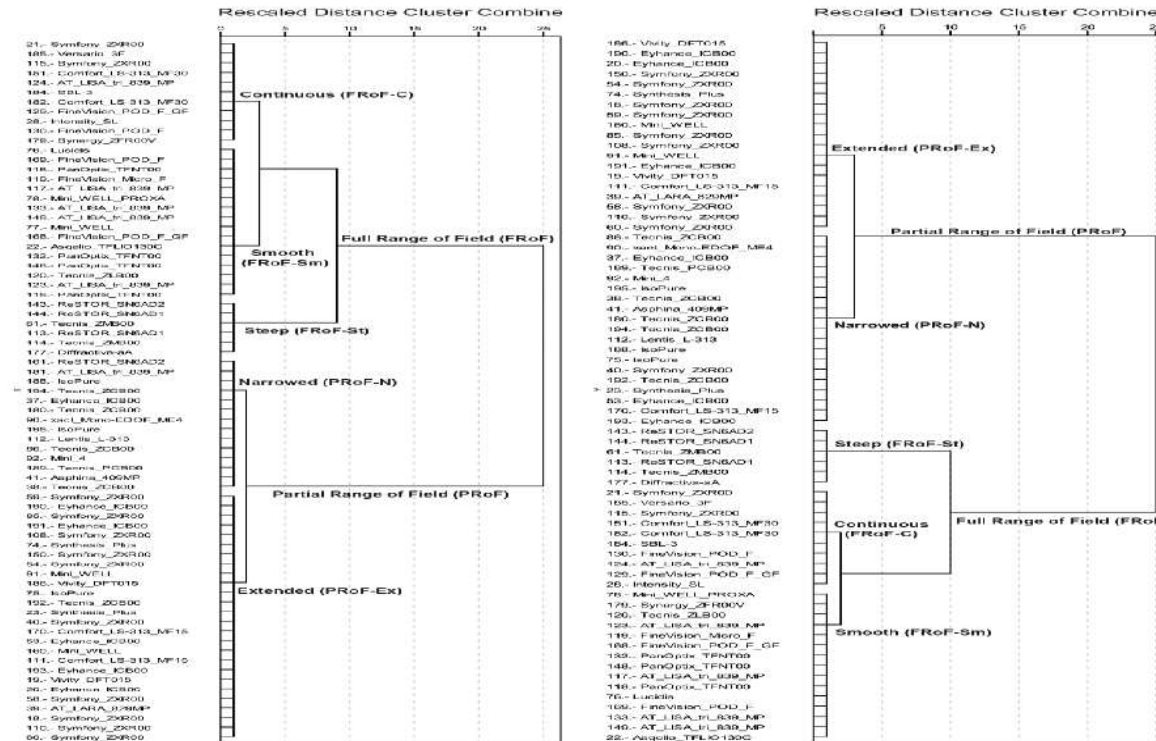


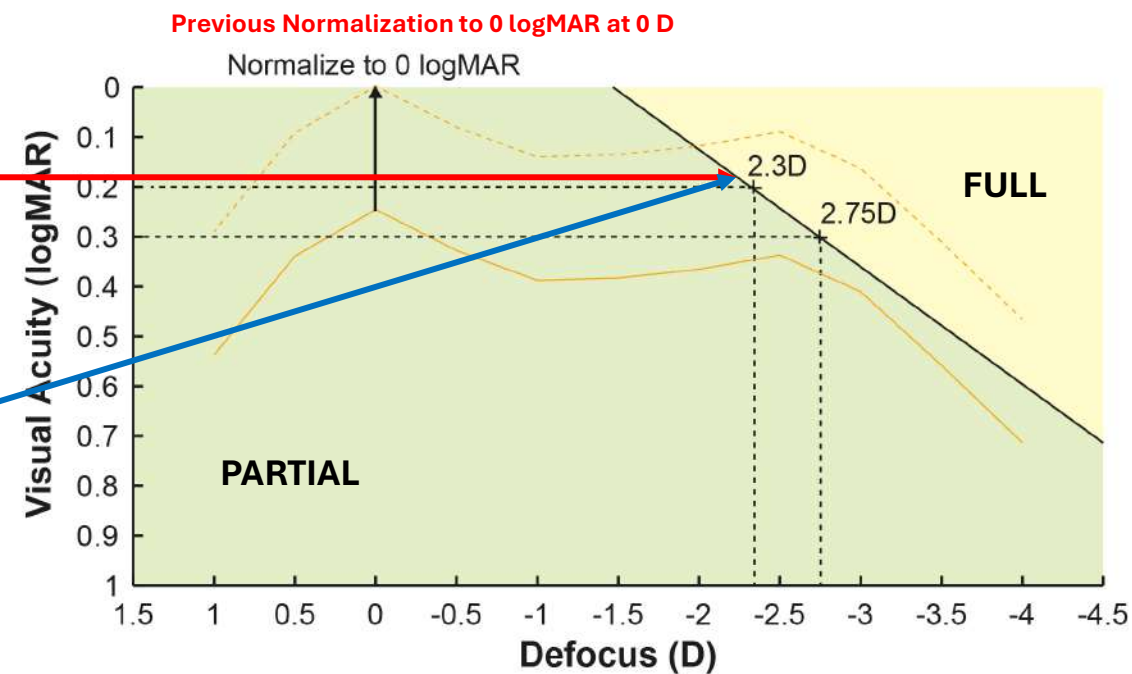
Figure S1. Dendrogram for the cluster classification using the increase of visual acuity from intermediate to near and the endpoints of 0.2 logMAR (left) or 0.3 logMAR (right) as cut-off range of field from the monocular defocus curve.

Introduction to **Primary cut-offs** based on Depth of Field for the **Monocular Distance Corrected Defocus Curve**

Monocular Visual Acuity Defocus Curve with Best Distance Correction

	DoFi for 0.2 logMAR (Diopters, D)
PARTIAL (Partial-DoFi)	< 2.3

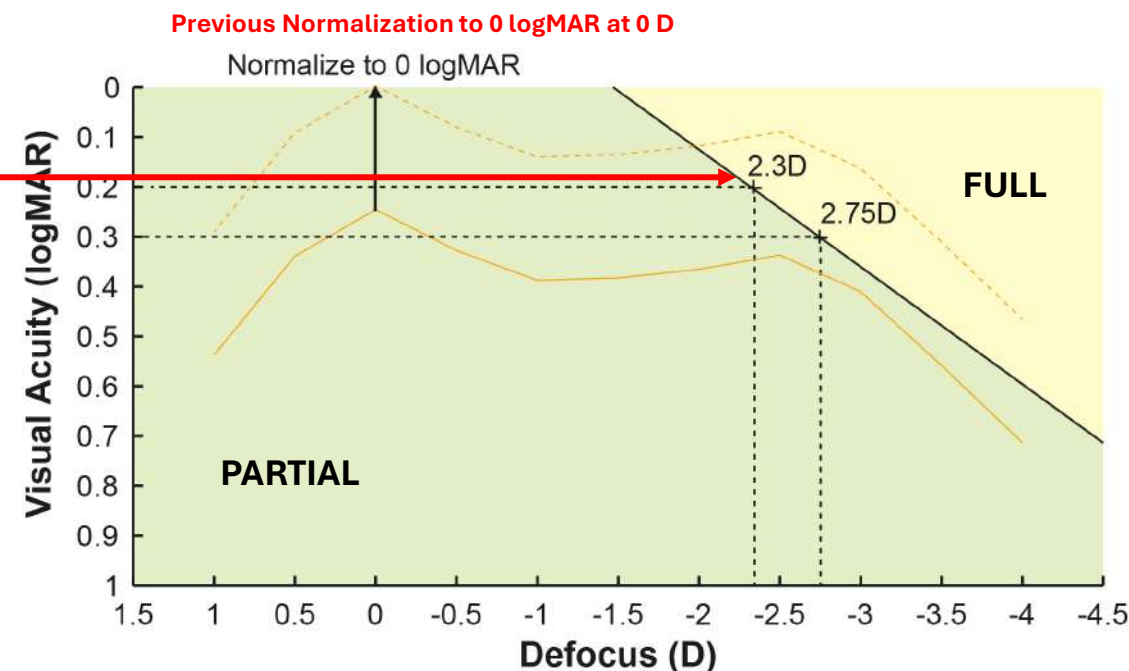
FULL (Full-DoFi)	≥ 2.3
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Introduction to **Primary cut-offs** based on Depth of Field for the **Monocular Distance Corrected Defocus Curve**

Monocular Visual Acuity Defocus Curve with Best Distance Correction

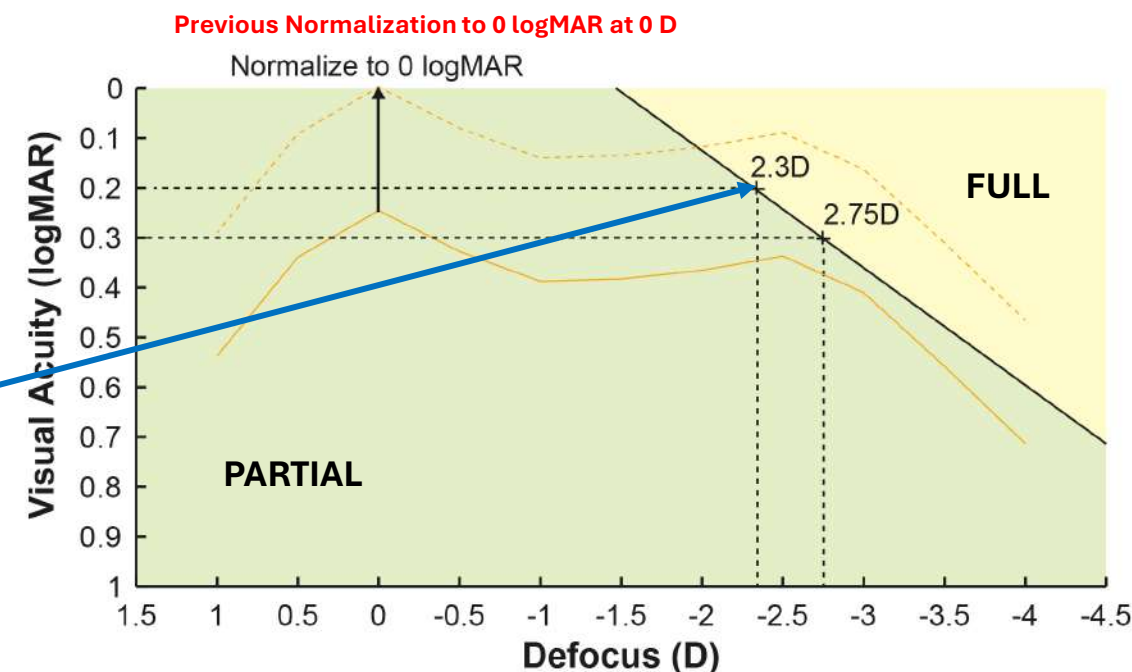
	DoFi for 0.2 logMAR (Diopters, D)	DoFi for 0.3 logMAR (Diopters, D)	ΔVA (logMAR)
PARTIAL (Partial-DoFi)	< 2.3	< 2.75	0
Narrowed	< 1.2	< 1.61	0
Enhanced	≥ 1.2 and < 1.58	≥ 1.61 and < 1.98	0
Extended	≥ 1.58 and < 2.3	≥ 1.98 and < 2.75	0
FULL (Full-DoFi)	≥ 2.3	≥ 2.75	≥ 0
Continuous	≥ 2.3	≥ 2.75	< 0.05
Smooth	≥ 2.3	≥ 2.75	≥ 0.05 and < 0.14
Steep	≥ 2.3	≥ 2.75	≥ 0.14



Introduction to **Primary cut-offs** based on Depth of Field for the **Monocular Distance Corrected Defocus Curve**

Monocular Visual Acuity Defocus Curve with Best Distance Correction

	DoFi for 0.2 logMAR (Diopters, D)	DoFi for 0.3 logMAR (Diopters, D)	ΔVA (logMAR)
PARTIAL (Partial-DoFi)	< 2.3	< 2.75	0
Narrowed	< 1.2	< 1.61	0
Enhanced	≥ 1.2 and <1.58	≥ 1.61 and <1.98	0
Extended	≥ 1.58 and <2.3	≥ 1.98 and <2.75	0
FULL (Full-DoFi)	≥ 2.3	≥ 2.75	≥ 0
Continuous	≥ 2.3	≥ 2.75	< 0.05
Smooth	≥ 2.3	≥ 2.75	≥ 0.05 and <0.14
Steep	≥ 2.3	≥ 2.75	≥ 0.14



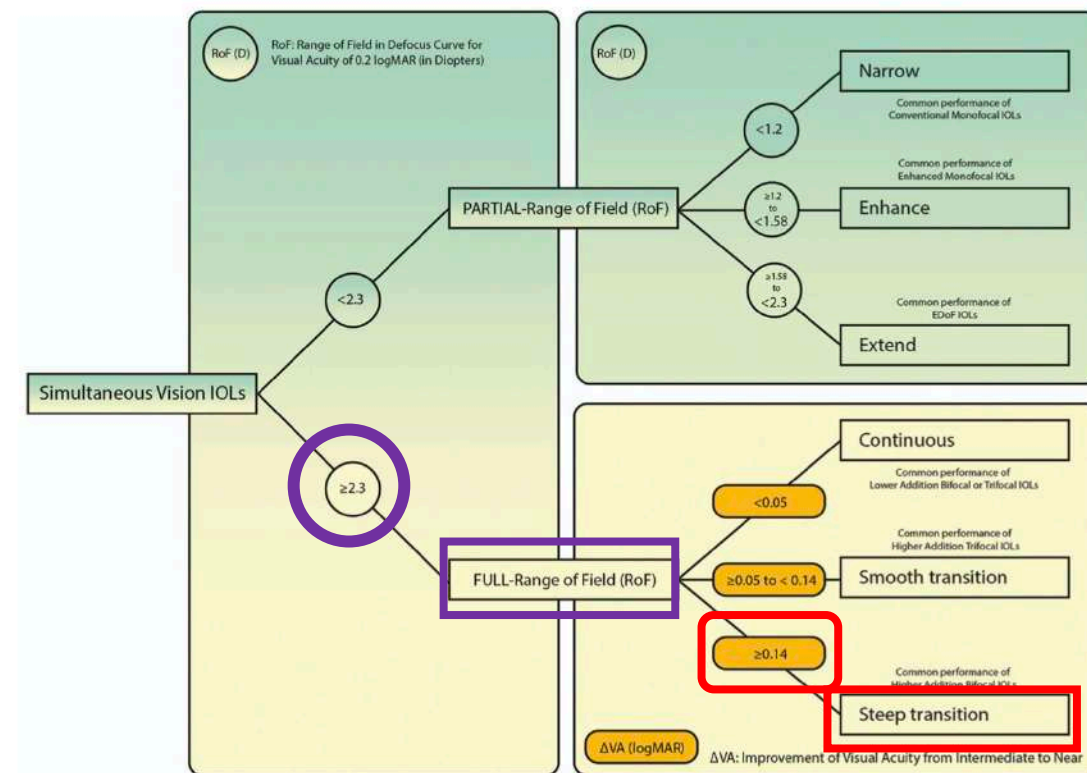
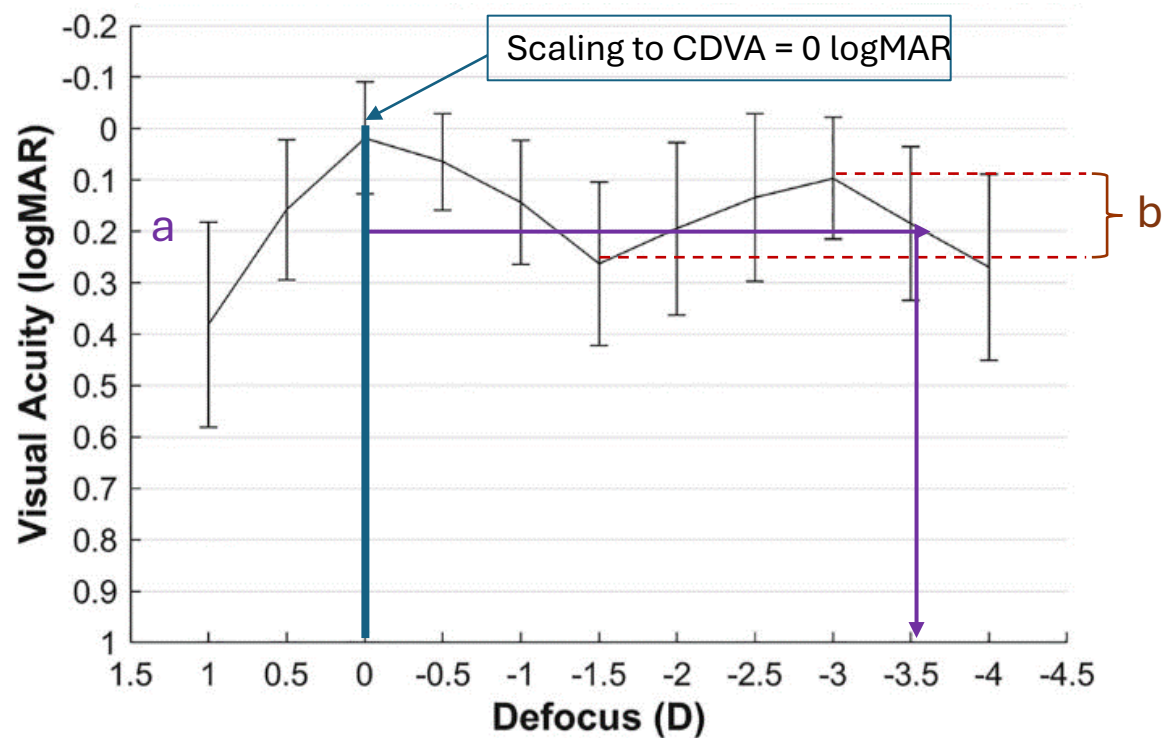


Figure 1. Diagram of functional classification depending on (1) the RoF achieved in the monocular defocus curve with best correction at distance at 0.2 logMAR VA level and (2) the improvement of VA from intermediate to near ΔVA. RoF = range of the depth of field

GUEST EDITORIAL

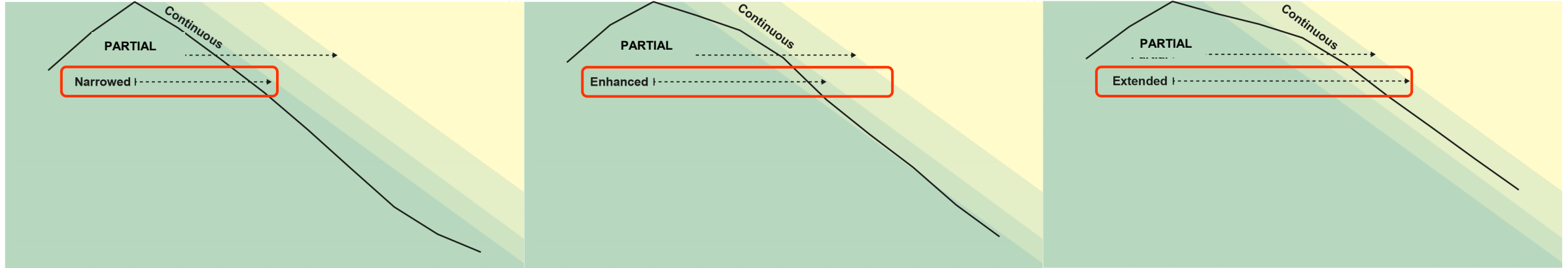
Evidence-based functional classification of simultaneous vision intraocular lenses: seeking a global consensus by the ESCRS Functional Vision Working Group

*Filomena Ribeiro, MD, PhD, H. Burkhard Dick, MD, PhD, Thomas Kohnen, MD, PhD, Oliver Findl, MD, PhD,
Rudy Nuijts, MD, PhD, Beatrice Cochener, MD, PhD, Joaquín Fernández, MD, PhD*

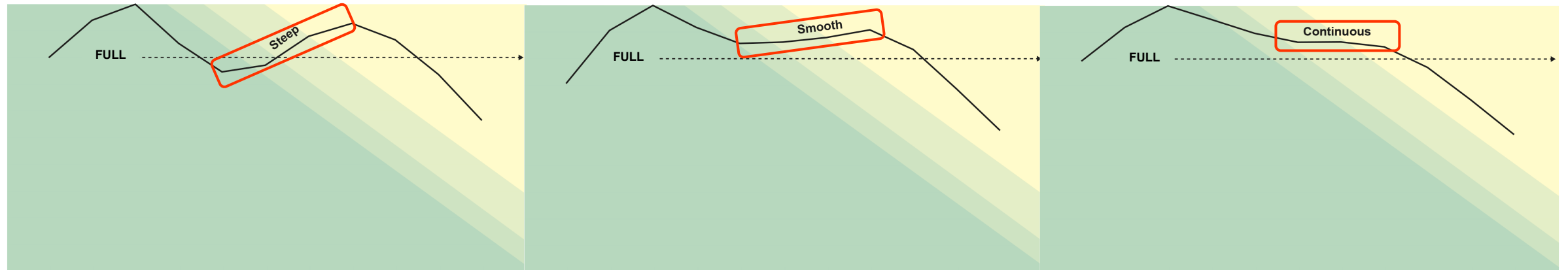


Ribeiro, F. et al. Evidence-based functional classification of simultaneous vision intraocular lenses: seeking a global consensus by the ESCRS Functional Vision Working Group. J. Cataract Refract. Surg. 50, 794–798 (2024).

Functional Classification Beyond Defocus Curves



FULL-DOFi: Full DOFi and 3 magnitudes of Decrease



Fernández J, Koch DD, Barrett GD, Andrade N Jr, Ribeiro F; Functional Vision Working Group. Global consensus on the evidence-based functional classification of simultaneous vision IOLs. J Cataract Refract Surg. 2026;52

Real World Outcomes?

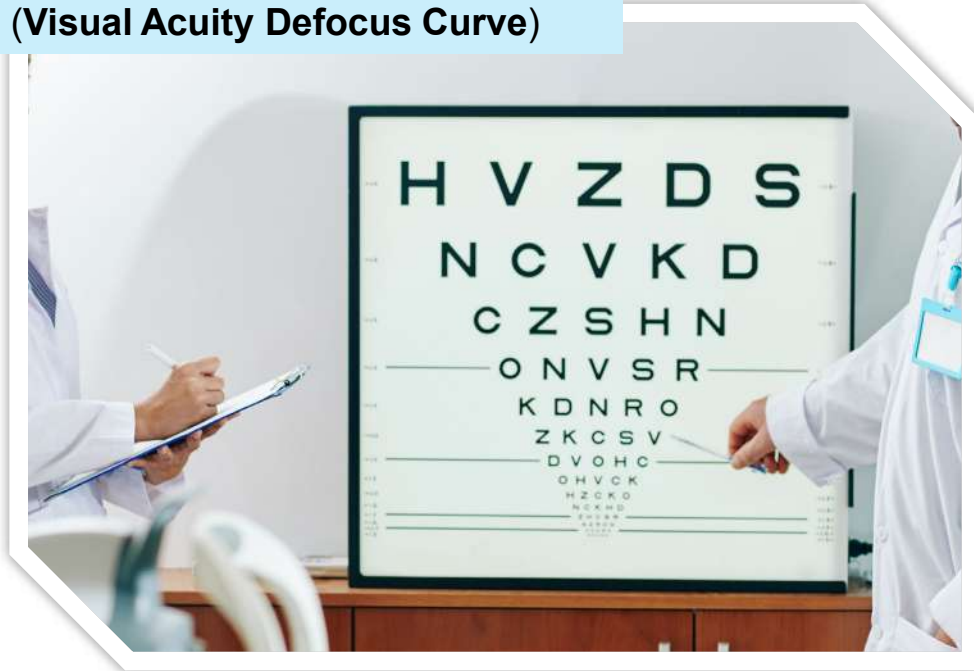
Towards a Global Consensus on IOL Classification

- The goal: inform patients better and create a fairer, evidence-based comparison
- *The key to global consensus is criteria:*
 - Should be scientific and data-driven
 - Should be based on Patient outcomes
- Proposed system based on 10 years of literature and **statistical methods** (e.g., cluster analysis), **not expert opinion**
- The road ahead is long – IOL recommendations should focus on patients, not just optical bench results

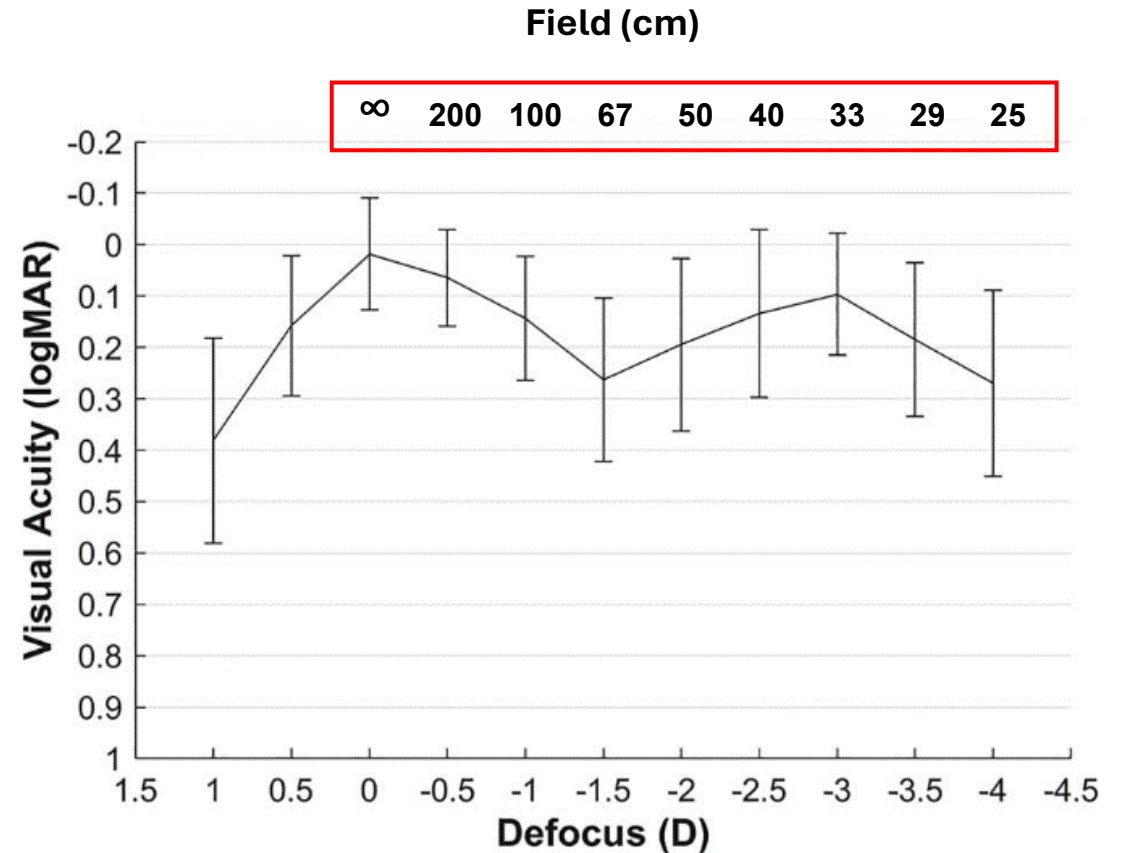
Functional Classification Beyond Defocus Curves

Depth of Field (DOFi)

(Visual Acuity Defocus Curve)



*“... will allow you to see these letters
at these distances”*



Binocular Visual Acuity and Functional Classification

Ophthalmol Ther
<https://doi.org/10.1007/s40123-025-01212-0>



PRACTICAL APPROACH

Navigating the Lens Labyrinth: A Practical Approach to Intraocular Lens Classification and Selection

Joaquín Fernández  · Filomena Ribeiro  · H. Burkhard Dick  ·
Carlos Rocha-de-Lossada  · Manuel Rodríguez-Vallejo 

Understanding **Procedure Efficacy** for
Functional Classification Categories

Table 2 Uncorrected binocular visual acuity reported in studies evaluating intraocular lenses by functional category

Category	N	Intermediate (66 cm)			N	Near (40 cm)		
		Pooled mean	95% CI	95% PI		Pooled mean	95% CI	95% PI
Partial DOFi narrowed	27	0.23	0.19–0.27	0.02–0.44	23	0.39	0.34–0.44	0.16–0.63
Partial DOFi enhanced	14	0.14	0.09–0.19	–0.07–0.35	16	0.31	0.27–0.35	0.14–0.49
Partial DOFi extended	21	0.07	0.05–0.10	–0.03–0.18	40	0.18	0.15–0.21	–0.01–0.38
Full DOFi continuous	6	0.00	–0.03–0.02	–0.09–0.08	12	0.04	0.03–0.05	–0.01–0.08
Full DOFi smooth	19	0.07	0.04–0.10	–0.05–0.19	63	0.06	0.05–0.07	–0.03–0.14
Full DOFi steep	2*	0.11	0.09–0.14	–	18	0.09	0.05–0.13	–0.08–0.26

Spectacle Independence and Functional Classification

Ophthalmol Ther
<https://doi.org/10.1007/s40123-025-01212-0>



PRACTICAL APPROACH

Navigating the Lens Labyrinth: A Practical Approach to Intraocular Lens Classification and Selection

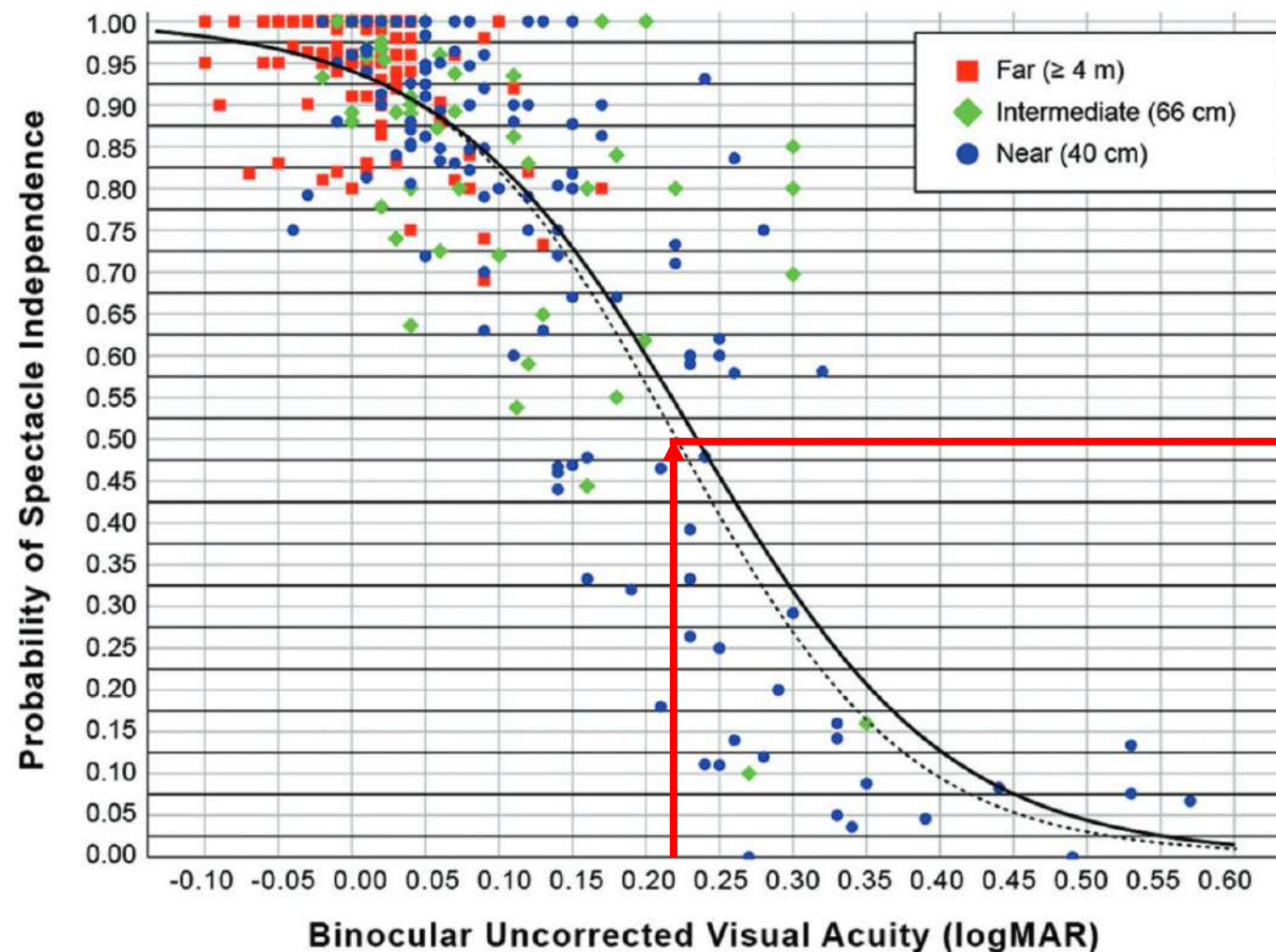
Joaquín Fernández  · Filomena Ribeiro  · H. Burkhard Dick  ·
Carlos Rocha-de-Lossada  · Manuel Rodríguez-Vallejo 

Understanding **Spectacle Independence** for Functional Classification Categories

Table 1 Probability of spectacle independence reported in studies evaluating intraocular lenses by functional category

Category	N	Intermediate			N	Near		
		Pooled mean	95% CI	95% PI		Pooled mean	95% CI	95% PI
Partial DOFi narrowed	17	0.52	0.44–0.60	0.23–0.80	18	0.12	0.07–0.19	0.01–0.56
Partial DOFi enhanced	12	0.77	0.66–0.85	0.33–0.96	19	0.30	0.21–0.42	0.05–0.79
Partial DOFi extended	27	0.90	0.85–0.93	0.61–0.98	47	0.65	0.56–0.73	0.13–0.96
Full DOFi continuous	5	0.96	0.92–0.98	–	8	0.91	0.81–0.96	0.47–0.99
Full DOFi smooth	64	0.95	0.93–0.96	0.74–0.99	87	0.89	0.87–0.91	0.67–0.97
Full DOFi steep	13	0.85	0.74–0.92	0.38–0.98	23	0.81	0.73–0.87	0.42–0.96

From Binocular Visual Acuity to Spectacle Independence

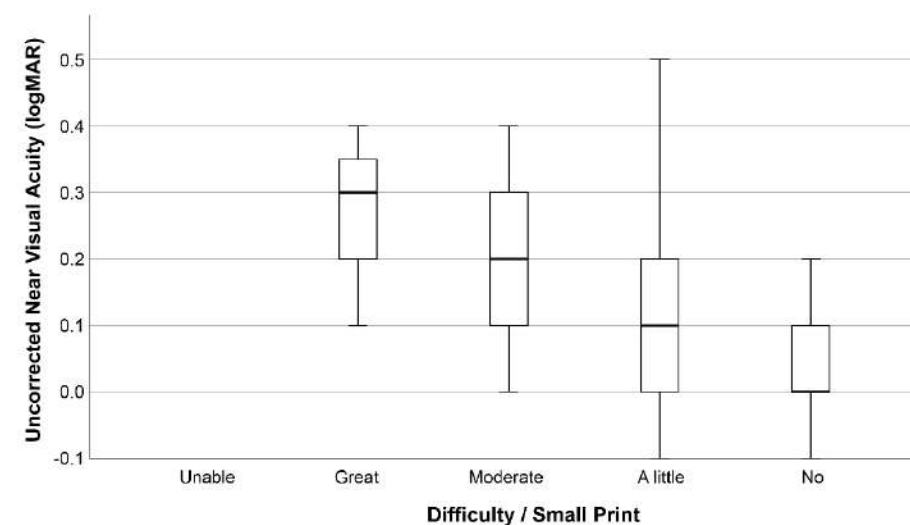
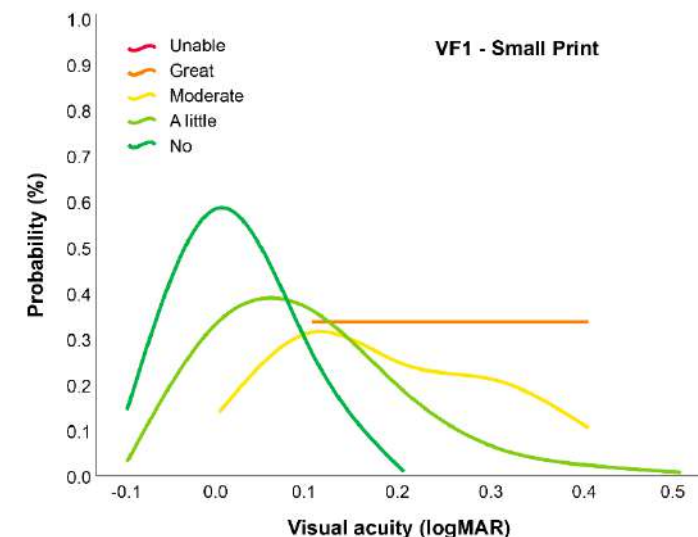


5 of each 10 patients achieving binocular uncorrected visual acuity of **0.2 logMAR** achieve **Spectacle Independence**

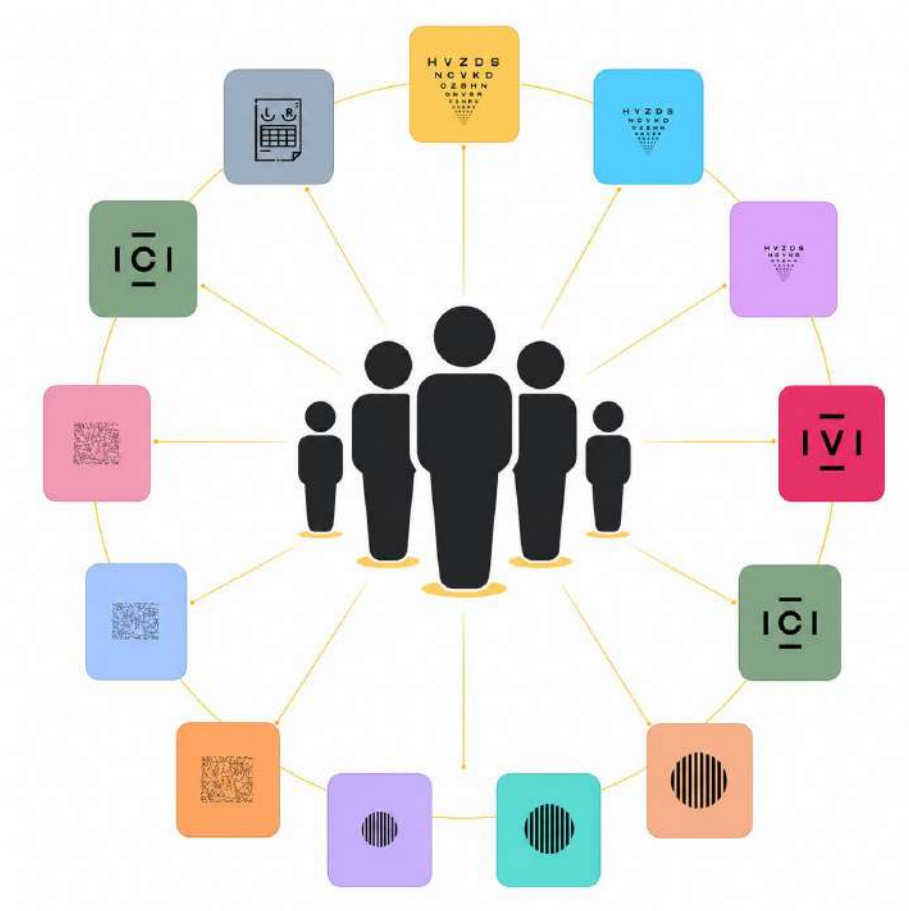
From Binocular Visual Acuity to Difficulties

Variable	UDVA logMAR, Y	UIVA logMAR, Y	UNVA logMAR, Y
1. Small Print	-	≤0.1, 0.47	≤0.1, 0.41
2. Newspapers	-	≤0.1, 0.53	-
3. Large Print	-	-	≤0.3, 0.64
4. Recognizing People	-	-	-
5. Seeing Steps	-	-	-
6. Traffic Signs	≤0.2, 0.40	-	-
7. Knitting	-	≤0.1, 0.45	≤0.1, 0.58
8. Filling out forms	-	-	≤0.1, 0.60
9. Playing card games	-	-	-
10. Sport activities	-	-	-
11. Cooking	-	-	-
12. Watching TV	≤0.1, 0.84	-	-
13. Driving in day	-	-	-
14. Driving at night	≤0.1, 0.34	-	-

To be able to read **Small Print** **without difficulty** or with **little difficulty**, we should turn to...

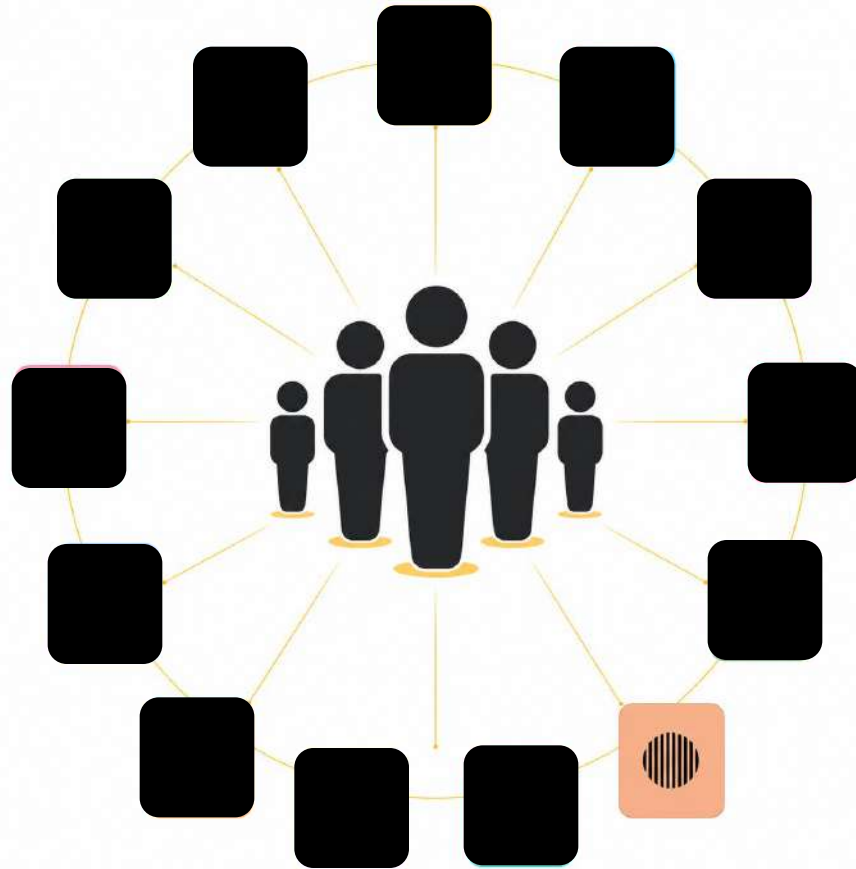


Functional Classification Beyond Defocus Curves



Visual Acuity is **not the only**
endpoint that **matters to**
patients

Functional Classification Beyond Defocus Curves

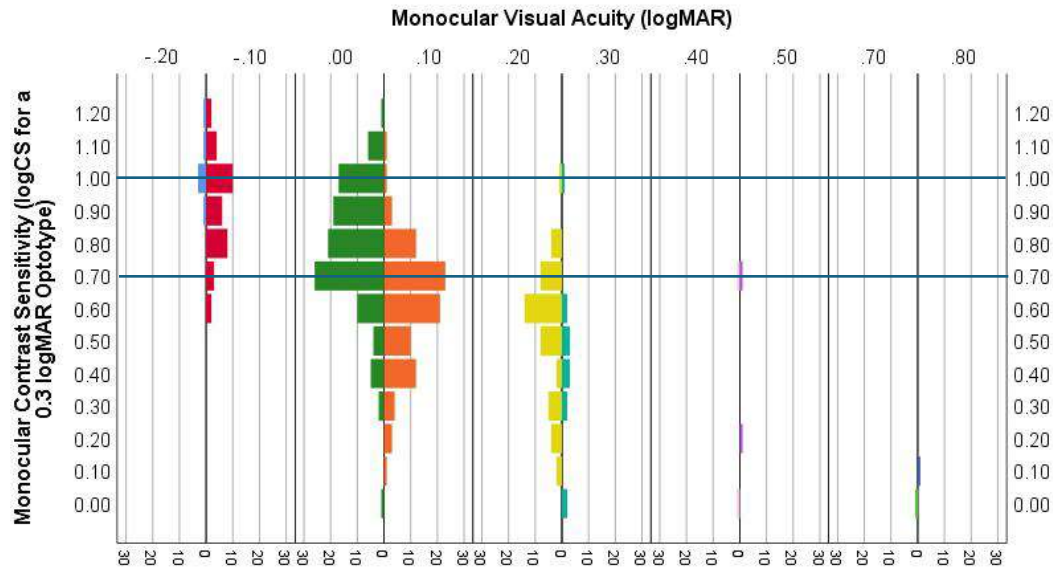


Contrast Sensitivity is also
considered a **Safety endpoint**

Category	FAR	INTERMEDIATE (66 cm)	NEAR (40 cm)
SVIOL all types	Δ (mesopic CS) $\leq 0,3$ log units at any frequency ^a		
MIOL	CDVA $\leq 0,20$ logMAR ^b		
EDF IOL	CDVA non-inferior to control 0,10 logMAR level		
EDF IOL			
EDF IOL	Negative defocus range at		
EDF IOL			
FVR IOL	CDVA non-inferior to control 0,10 logMAR level		
FVR IOL			
FVR IOL			

The mean **mesopic far contrast sensitivity (without glare)**
for all SVIOL shall be **no worse than 0,3 logCS**
units **below that of the control** at any test spatial frequency.

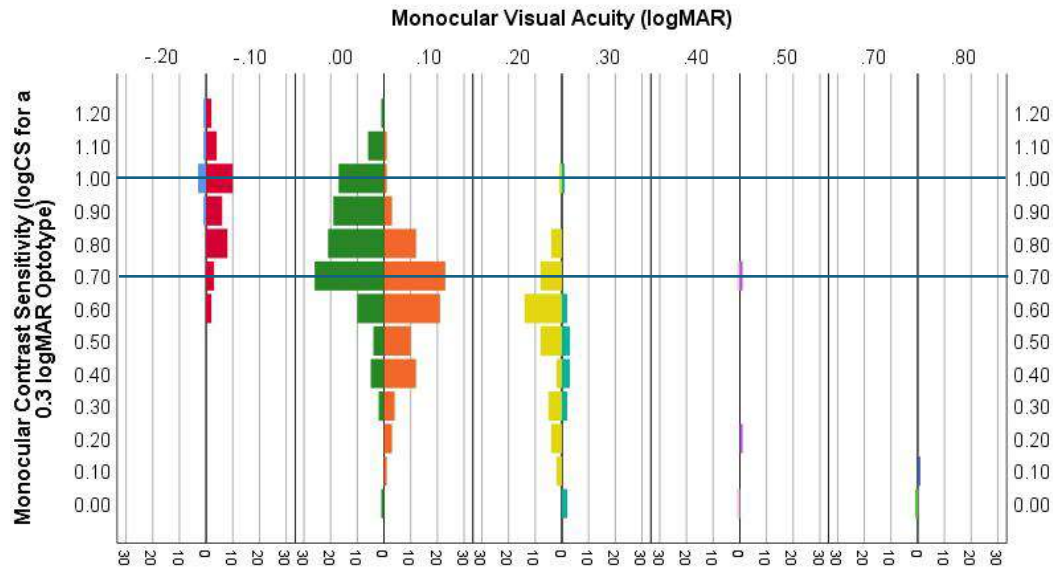
Functional Classification Beyond Defocus Curves



Patients with the **same value of CDVA** can have a **wide variation of CS**

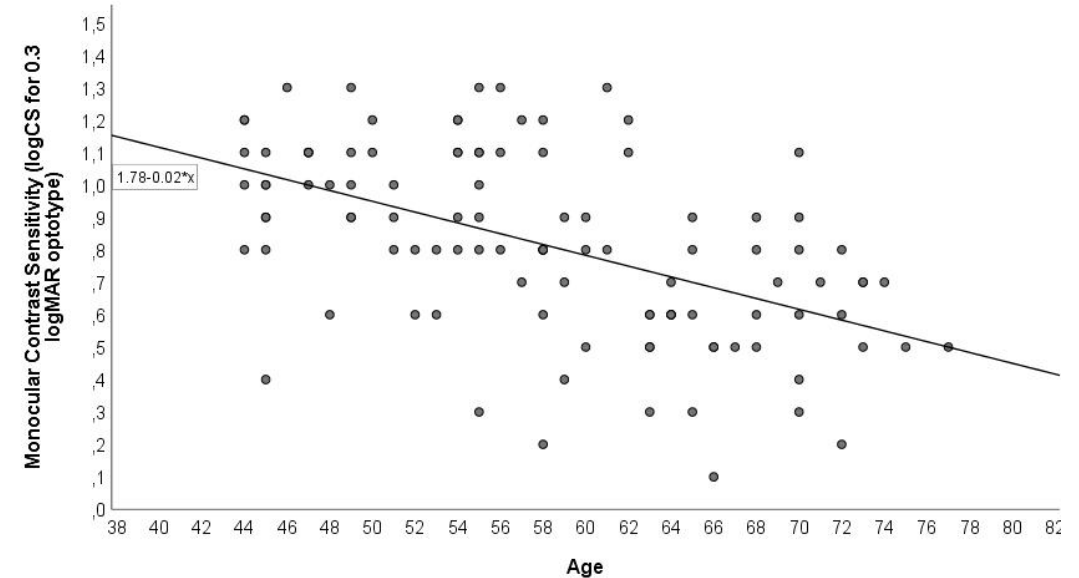
A change of **0.3 logCS** may occur with a decrease **up to 0.2 logMAR** in CDVA

Functional Classification Beyond Defocus Curves



Patients with the **same value of CDVA** can have a **wide variation of CS**

A change of **0.3 logCS** can happen in patient with a decrease **up to 0.2 logMAR** in CDVA



Each year a loss of 0.02 logCS is produced with age

To reduce **0.3 logCS** is to **make older 15 years** the visual quality of our eyes

Contrast Sensitivity: Cluster Analysis to Identify Possible Groups



Not Possible yet to Include other Functional Variables in the Classification

Monocular Photopic		N	Expected	Distribution	Parameters
3 cycles per degree	PRoF-N	5	1.68	Normal	μ : 1.68, s: 0.25
	PRoF-En	6	1.74	Normal	μ : 1.74 s: 0.22
	PRoF-Ex	5	1.78	Normal	μ : 1.78, s: 0.27
	FRoF-C	3	1.58	Normal	μ : 1.58, s: 0.11
	FRoF-Sm	16	1.69	Normal	μ : 1.69, s: 0.11
	FRoF-St	10	1.74	Normal	μ : 1.74, s: 0.18
6 cycles per degree	PRoF-N	5	1.80	Normal	μ : 1.80, s: 0.17
	PRoF-En	6	1.87	Normal	μ : 1.87 s: 0.17
	PRoF-Ex	5	1.77	Normal	μ : 1.77, s: 0.16
	FRoF-C	3	1.48	Normal	μ : 1.48, s: 0.17
	FRoF-Sm	16	1.70	Normal	μ : 1.70, s: 0.17
	FRoF-St	10	1.75	Normal	μ : 1.75, s: 0.17
12 cycles per degree	PRoF-N	5	1.39	Normal	μ : 1.39, s: 0.12
	PRoF-En	6	1.47	Normal	μ : 1.47 s: 0.17
	PRoF-Ex	5	1.37	Normal	μ : 1.37, s: 0.14
	FRoF-C	3	1.03	Normal	μ : 1.03, s: 0.44
	FRoF-Sm	16	1.23	Normal	μ : 1.23, s: 0.35
	FRoF-St	10	1.36	Normal	μ : 1.36, s: 0.12
18 cycles per degree	PRoF-N	5	0.91	Normal	μ : 0.91, s: 0.14
	PRoF-En	6	1.00	Normal	μ : 1.00 s: 0.19
	PRoF-Ex	5	0.84	Normal	μ : 0.84, s: 0.29
	FRoF-C	3	0.61	Normal	μ : 0.61, s: 0.53
	FRoF-Sm	16	0.77	Normal	μ : 0.77, s: 0.35
	FRoF-St	10	0.90	Normal	μ : 0.90, s: 0.34

N: Number of reports including outcomes for this variable; μ : mean of the normal distribution; s: standard deviation of the normal distribution.

The Magnitude of Variability is much larger than the Effect Size
Need to Improve Uniformity in Data Collection

Photic Phenomena/Dysphotopsias: Cluster Analysis to Identify Possible Groups



ESCRS
EUROPEAN SOCIETY OF
CATARACT & REFRACTIVE
SURGEONS

Not Possible yet to Include other Functional Variables in the Classification

	N	Expected	Distribution	Parameters
Halo Photic Phenomena				
PRoF-N	4	0.24	Gamma	k: 2.126, θ : 0.114
PRoF-En	4	0.16	Logistic	μ : 0.164, s: 0.117
PRoF-Ex	13	0.38	Normal	μ : 0.383, σ : 0.190
FRoF-C	3	0.40	Normal	μ : 0.397, σ : 0.065
FRoF-Sm	18	0.51	Normal	μ : 0.508, σ : 0.268
FRoF-St	8	0.37	Normal	μ : 0.371, σ : 0.24
Glare Photic Phenomena				
PRoF-N	4	0.40	Normal	μ : 0.399, σ : 0.221
PRoF-En	4	0.16	Logistic	μ : 0.171, s: 0.127
PRoF-Ex	11	0.38	Logistic	μ : 0.383, s: 0.078
FRoF-C	2	0.14	Normal	μ : 0.135, σ : 0.134
FRoF-Sm	14	0.23	Logistic	μ : 0.225, s: 0.082
FRoF-St	6	0.26	Gamma	k: 1.852, θ : 0.141
Starburst Photic Phenomena				
PRoF-N	3	0.26	Logistic	μ : 0.259, s: 0.128
PRoF-En	1	0.14	-	-
PRoF-Ex	7	0.33	Normal	μ : 0.328, σ : 0.258
FRoF-C	2	0.20	Normal	μ : 0.205, σ : 0.050
FRoF-Sm	6	0.22	Normal	μ : 0.222, σ : 0.197
FRoF-St	4	0.22	Normal	μ : 0.218, σ : 0.108

N: Number of reports including outcomes for this variable; μ , s, a, b, σ , k, θ : Parameters describing each one of the fitted distributions

	N	Expected	Distribution	Parameters
Halo Positive Dysphotopsia				
PRoF-N	6	0.06	Normal	μ : 0.063, σ : 0.080
PRoF-En	4	0.10	Normal	μ : 0.098, σ : 0.073
PRoF-Ex	6	0.12	Normal	μ : 0.116, σ : 0.088
FRoF-C	4	0.13	Normal	μ : 0.128, σ : 0.090
FRoF-Sm	16	0.23	Logistic	μ : 0.228, s: 0.141
FRoF-St	7	0.08	Logistic	μ : 0.076, s: 0.056
Glare Positive Dysphotopsia				
PRoF-N	6	0.07	Normal	μ : 0.069, σ : 0.090
PRoF-En	4	0.12	Normal	μ : 0.118, σ : 0.071
PRoF-Ex	5	0.10	Normal	μ : 0.096, σ : 0.076
FRoF-C	4	0.13	Normal	μ : 0.130, σ : 0.077
FRoF-Sm	10	0.16	Weibull	a: 1.244, b: 0.171
FRoF-St	6	0.09	Normal	μ : 0.090, σ : 0.086
Starburst Positive Dysphotopsia				
PRoF-N	6	0.07	Normal	μ : 0.071, σ : 0.078
PRoF-En	2	0.10	Normal	μ : 0.100, σ : 0.141
PRoF-Ex	4	0.01	Normal	μ : 0.013, σ : 0.025
FRoF-C	3	0.05	Logistic	μ : 0.050, s: 0.043
FRoF-Sm	6	0.12	Logistic	μ : 0.119, s: 0.048
FRoF-St	6	0.09	Normal	μ : 0.085, σ : 0.106

N: Number of reports including outcomes for this variable; μ , s, σ : Parameters describing each one of the fitted distributions

The Magnitude of Variability is much larger than the Effect Size
Need to Improve Uniformity in Data Collection

GUEST EDITORIAL

Standard for collecting and reporting outcomes of IOL-based refractive surgery: update for enhanced monofocal, EDOF, and multifocal IOLs

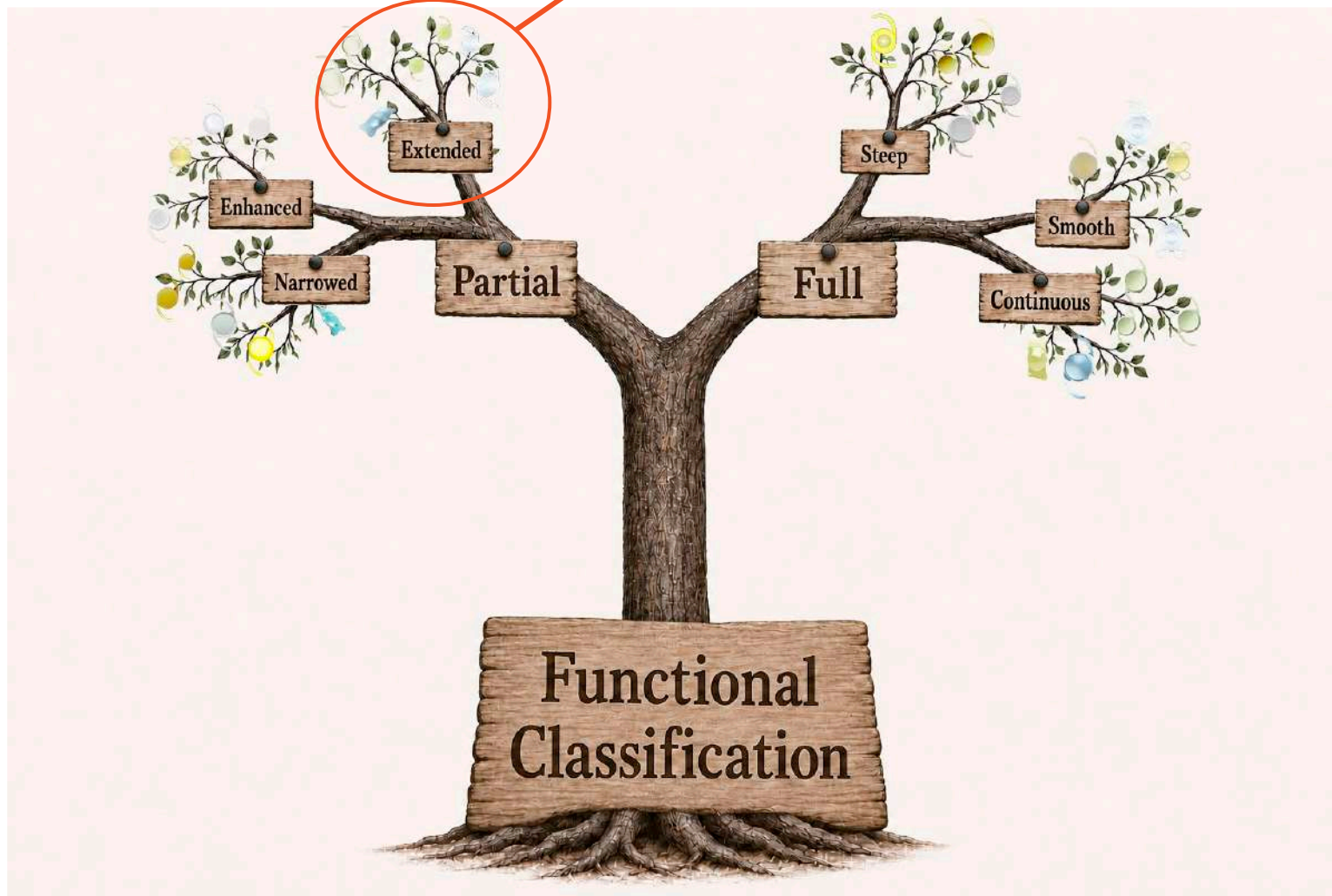


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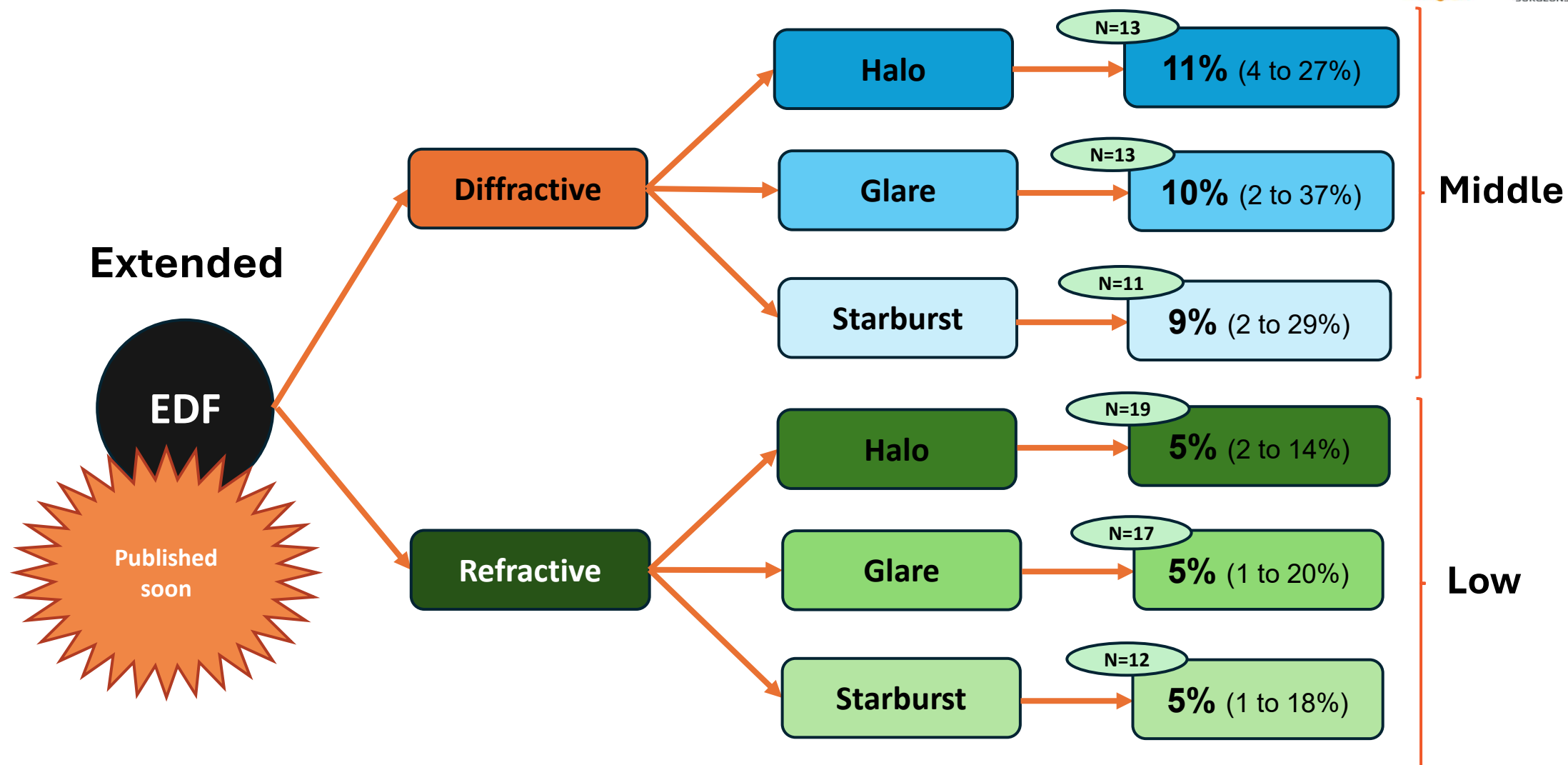
The **Standard** Collecting and Reporting of Outcomes is **Crucial** for Understanding and Taking Decisions for Intraocular Lens Implantation

Integrating Dysphotopsias and Contrast Sensitivity in Functional Classification

Focus on a Branch to reduce variability



Can Dysphotopsia vary within a category?



Conclusion

“Functional Classification extends beyond visual acuity defocus curves. Other endpoints, such as Spectacle Dependence and Binocular Uncorrected Visual Acuity, have shown different outcomes across category levels. Secondary endpoints, including dysphotopsia and contrast sensitivity, may also vary within individual categories.”

ESCRS' Functional Vision Working Group

- Functional Vision Framework represents a **patient-centered evolution of IOL classification.**
- Complements regulatory classifications by focusing on **real-world visual function.**
- Future integration of **PROMs and contrast sensitivity** will further enhance clinical relevance and shared decision-making.

Thank you!