9 Multifocal Intraocular Lenses: Critical Analysis of Results

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9.1 Introduction

The advantages and disadvantages of the intraocular multifocal lens' performance have to fit patients' needs and the clinical situation. Knowing the difference between lenses is therefore crucial. Since no multifocal intraocular lens is perfect, choosing the lens to implant is actually doing a compromise, but while some compromise is good for one patient, it might be wrong for the other. This chapter does not claim to be an optimal guide in choosing multifocal intraocular lenses to implant, but merely to gather information available from different sources and to be a tool in helping the surgeon in his decision making. There is no substitute to personal experience and the best way to know how to do it is by doing it.

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9.2 Approach

After a thorough preparation and preoperative considerations, as described before, the surgeon has to choose a proper lens to implant.

The four most influencing factors in choosing a certain lens to implant are:

1. Patient's age, needs, lifestyle, and psychological profile
2. Patient's clinical ophthalmic condition
3. Pupil reactivity and size in different light environments
4. Evidence, published in peer review literature and independent from industry bias, supporting outcomes of the tentatively selected MFIOL, especially the defocus curve of the lens
5. Surgeon's prior experience

Patient's occupational and hobbies as well as his preferences (reading, watching TV, traveling, etc.) are to be taken into consideration. Matching the patients' needs with the lenses performance is essential. A surgeon will try to choose a lens that has less contrast sensitivity and produces less glare and halos for patients that drive a lot at night, for example, and on the other will not consider these qualities in patients that prefer to stay at home and concentrate on daily activities during day light hours. Patient's personality should affect these considerations as well.

The clinical ophthalmic situation has a major effect on the lens choosing procedure. Patients that

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already suffer from degrees of reduced contrast sensitivity might suffer more from these phenomena compared to others and might adapt slower to the new situation. This is even more important in patients that suffer from glaucoma and already have contrast sensitivity reduction or in patients that suffer from AMD and contrast sensitivity is some time the aim of achieving reading ability. Implanting multifocal intraocular lenses in these patients might turn into a "too much" situation in terms of neuroadaptation and visual performance. In patients with AMD, a slight myopic shift might be a great reading aid as it is actually a magnifier, while in other patients the aim should be emmetropia. Treating these patients and choosing their lenses should be done with extra caution.

Another issue while choosing a lens is the surgeon's prior experience with the lens and his confidence based on prior cases. It is not only personalizing the multifocal intraocular lens power calculation but also the ability to solve problems if they occur and the prior experience of the surgeon with the lens that gives him confidence.

On one hand there are the factors that affect the surgeon's decision, and on the other hand there is a large variety of lenses available in the market. In this chapter we will summarize the qualities of the most common multifocal intraocular lenses available in the market today in an attempt to give the reader a simple tool or guide to choosing these lenses.

In comparing intraocular lens qualities, we have to define what should be compared and on what scale. It is widely accepted that these lenses should be compared for their performances in far vision, intermediate vision, and near vision. As to far vision we related it to performance of 6 m in distance and defined good far vision as 20/20–20/25 which is 0.8–1.0 decimal and 0.1 LogMAR. The intermediate vision is measured in different studies in different ways and is strongly related to habits and way of life of the studied population. Based on quality of life studies and our own opinion, we defined intermediate vision as vision for a distance of 80 cm that enables us to go to office and do domestic visual tasks such as computer working. Most of the studies used this distance as the measured intermediate vision distance we defined good intermediate vision as 20/30 or 0.7 decimal or 0.2 in LogMar. Near vision was defined as the vision at a distance of 40 cm which is the acceptable near distance almost in all studies. Good vision was defined as Jaeger 2 or Radner 20/25 which is 0.8 or 0.2 LogMAR.

Contrast sensitivity, night vision, or disturbances were collected from patient's satisfaction and quality of life questionnaires. This data was collected from the literature published on the subject. Our summary is based on these studies and on our own experience.

The data of the most common multifocal intraocular lenses in the market were collected and summarized in Table 9.1. Along with technical data about the lenses, you will find an evaluation of the lenses in terms of visual acuity performance to far distance, near distance, and intermediate distance as well as contrast sensitivity reduction and night vision photopic phenomena if existing. These evaluations are based on the literature on the subject as published in the English language as well as of our own experience. The last rows give direction to further reading. In each column under each lens name, you will find the row of more reading and numbers indicating sources of more reading material. *These numbers are the numbers of the references attached at the end of the chapter*. At the bottom of the table, you will find abbreviations. If we could not find information about a certain quality of the lens, the initial NA will appear which means "not available yet."

9.3 Defocus Curves

Another way of comparing lenses' performance is by using defocus curves. A defocus curve is a universally accepted measure of evaluating the subjective range of clear vision in presbyopia-correction techniques such as accommodating and multifocal intraocular lenses.

A defocus curve provides an indication of the level of vision a patient can expect at various distances, simulated using minus and plus lenses in a phoropter to change the relative vergence of a distant eye chart. The first step in generating a defocus curve is by measuring the patients' far vision refraction. Using the patient's distance refraction removes the variability due to residual refractive error. The next steps are changing the power of lens in half diopter steps from slightly positive (+1.00 D or +2.00 D) to about −4.00 D. In each refractive correction vergence is measured. Defocus curves are graphs showing the relationship between lens vergence and distance focus. Usually the main interest is in three important points: infinite optical distance vision, intermediate distance at 80 cm, and a short-distance vision at 40 cm. These three points are actually representing the visual performance of the lens, as well as visual and optical quality of the patients in their daily lives.

If the patients' peak (best visual acuity) is at 0.00 diopters, it means that the intraocular lens provides good far vision. If the second peak is at around −2.50 diopters, it means that the lens provides good near vision (100/2.50 = 40 cm which is a comfortable reading distance). The height of the curve represents visual acuity in LogMAR, and the horizontal line is the additive lens power. Interpretation of defocus curve in brief is searching for the peaks and to what diopter do they match and the flatness of the curve. Peaks should be at the diopters where we expect good vision for far (0.00 D), intermediate (80 cm or −1.25), and near (40 cm or −2.50 D). Flatness of the curve means that the lenses' performance is similar in each correction. An ideal lens would produce a straight line at the height of LogMAR zero, but this is unachievable. In the following figure a typical defocus curve is represented (Fig. 9.1).

In a recent study done at VISSUM in Alicante, Spain, three multifocal lenses and two accommodative lens defocus curves were checked. The three multifocal lenses that were checked were the AT LISA tri 839 MP; the FineVision trifocal, single-piece, foldable aspheric intraocular lens; and the Bifocal AcrySof ReSTOR SN6AD1 (Alcon, Fort Worth, USA) and the Hanita SeeLens multifocal. The defocus curves of these lenses are in the following figure and represents typical defocus curves (Fig. 9.2).

As can be seen the four lenses have a peak close to zero which means good far vision. Two of the lenses have a second peak near −2.50 diopters which means good near vision at 40 cm, while the other two have a better near vision by the distance of 50 cm. As a rule, the flatter the curve, the better the performance of the lens. The flatter the curve means that same vision is kept at different distances. However, the visual acuity is important too as the height of the curve's peak means better visual acuity. In the figure one curve is the highest, which means that visual acuity with all corrections was better.

Defocus curves are a useful method to evaluate the effectiveness and visual performance for specific IOL models using different levels of defocus (equivalent to different viewing distances). The problem with defocus curves is that there is no standardized methodology for their measurement; an assortment of different lens powers has been used to evaluate IOLs; for multifocal IOLs, however, defocus curves can be useful for comparing lenses. In a current literature search that we have done, defocus curves of most of the lenses that exist in the market can be found. Different studies use different additive steps; however, comparing these studies does not show a significant difference in terms of the overall performance of the lenses.

We recommend using the table and defocusing curves as good tools to compare different multifocal intraocular lenses, but as mentioned before there is no good substitute to self-experiencing the lenses' implant and learning from the visual outcomes and patients' impression.

Compliance with Ethical Requirements Jorge L. Alio and Joseph Pikkel declare that they have no conflict of interest.
No human studies were carried out by the authors for this article.
No animal studies were carried out by the authors for this article.

Table 9.1 Comparison between various multifocal intraocular lenses

	Manfect									
Qual	Oculentis GmbH		Alcon			Hanita Lenses		Physiol	Aaren	Abbott medical optics
Lens	LENTIS Mplus	LENTIS Mplus T	ReSTOR 2.5	ReSTOR 3	ReSTOR 4	SeeLens	BunnyLens	FineVision	OptiVis	Tecnis
Material	Hydrophobic acrylic	Hydrophobic acrylic	Hydrophobic acrylic	Hydrophobic acrylic	Hydrophobic acrylic	Hydrophobic acrylic	Hydrophilic acrylic	Hydrophilic acrylic	Hydrophilic acrylic	Hydropho-bic acrylic
Design	Ref. Sector-shaped near zone	Ref. Sector-shaped near zone	Diffra. 1 piece 9-step	Diff. + Ref.	Diff. + Ref.	Diff.	Diff.	Diff. trifocal	Diff.	Diff.
Optical diameter	6 mm	6 mm	6 mm	6 mm	6 mm	6 mm	6 mm	6.15 mm	6 mm	6 mm
Total diameter	11 mm	11 mm	13 mm	13 mm	13 mm	13 mm	11 mm	10.75 mm	11 mm	13 mm
Implant location	Bag	Bag	Bag	Bag	Bag	Bag	Bag	Bag	Bag	Bag
A constant	118.1	118.1	118.9	118.9	118.9	118.6	118.5	118.59	118.1	118.8
Diopter range	0 to + 36	0 to +36	+6.0 to + 34.0	+6.0 to + 34.0	+6.0 to + 34.0	+7.5 to + 30.0	+10.0 to +30.0	+10 to + 35	+10 to + 30	+5.0 to +34.0
Near addition	+1.50,+3.00	+3.00	+2.50	+3.00	+4.00	+3.00	+3.00	+1.75 + 3.50	+2.80	+4.00
Contrast sensitiv.	Not affected	Not affected	Decreased	Decreased	Decreased	Decreased	Decreased	Not significantly decreased	Decreased	Decreased
Incision size	2.2–2.6 mm	2.2–2.6 mm	2.2 mm	2.2 mm	2.2 mm	2 mm.	2 mm	1.8–2.2 mm	2.2 mm	2.2 mm
Asphericity	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pupil depend	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Va far	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Va near	+3 Good +1.5 limited	Good	Limited	Limited	Limited	Limited	Limited	Good	Limited	Limited
Va intermed.	Good	Good	Good	Good	Good	Reduced	Reduced	Good	Reduced	Not good
Toric	No	Yes	Yes?	Yes	No	No	No	No	No	No
Night Vis	Sectoral halos	Sectoral halos	Halos	Halos	Halos	Halos + glare	Halos + glare	Halos	Halos	Halos +++
Addition. read	11–27		1–10			28		29–35	36	37–52

	Dr. Schmidt	Human	Hoya	Rayner			Carl Zeiss Meditec			Care group
ReZOOM	MS	Diffractive	iSii IOL	Mflex	Mflex T	SulcoFlex	Acrilisa Bi, Tri, T	AT Lisa	Gradiol	iDiff
Acrylic UV protect	Hydrophilic acrylic	Hydrophilic acrylic	Hydrophilic acrylic	Hydrophilic acrylic	Hydrophilic acrylic	Hydrophilic acrylic	Hydrophilic acrylic	Hydrophilic acrylic		Hydrophilic acrylic
Deffr. + Ref.	Diff add on	Diff.	Diff.	Ref.	Ref.	Ref. Add on	Diffr. + Ref. T-Diffractive	Diff.		Ref. + Diff. + asph. surface
6 mm	6 mm	6 mm	6 mm	6.25 mm	6.25 mm	6.5 mm	6 mm	6 mm		6 mm
13 mm	11/06/13	12.5 mm	12.5 mm	12.5 mm	12.5 mm	14 mm	11 mm	809.909- 11 MM 801, 802-12.5 mm		1-P: 11 mm 1-R: 12.5 mm
Bag	Sulcus	Bag	Bag	Bag	Bag	Sulcus	Bag	Bag		Bag
118.4	118.6	118.4	118.4	118.6	118.6	118.9	117.8 T −118.3& cyl. + 1 to + 12	809-117.8 909–118.3 801–118 802–118.1		
+6.00 to + 30.0	−3.0 to +31.0	+10 to + 34	+14.0 to +27.0	+14.0 to +25	+14.0 to +32.0	Toricity −3.00 to +3.00	−10.0 to + 32 & cyl. + 1 to + 12	0.0 to + 30.0		+10.0 to +34.0
+3.50	+3.50	+3.50	+3.00	+3.00,+4.00	+3.00, +4.00	+3.00 +4.00	+3.75	+3.75		+3.50
Decreased	Decreased	NA	NA	Not affected	Not affected	Not affected	Decreased	Decreased		NA
3.2 mm		2.2 mm	2.5 mm	1.8 mm	1.8 mm	2.6 mm	1.5 mm	801-2.2 mm, 802–2.8 mm, 809, 909- 1.5 mmnMM		?
No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes		Yes
Yes	Yes	Yes	Yes	Yes	Yes	Yes	No			?
Good	Good	NA	NA	Good	Good	Good	Good	Good		NA
Limited	Limited	NA	NA	Good	Good	Good	Good	Good		NA
Reduced	Reuced	NA	NA	Reduced	Reduced	Reduced	Good	Good		NA
No	No	No	NA	No	Yes	Yes	Yes	Yes		No
Halos + Glare	Halos	NA	NA	Halos + Glare	Halos + Glare	Halos + Glare	Halos + Glare	Halos		NA
78–85	53–55	56, 57	58, 59	60–65			66–77			NA

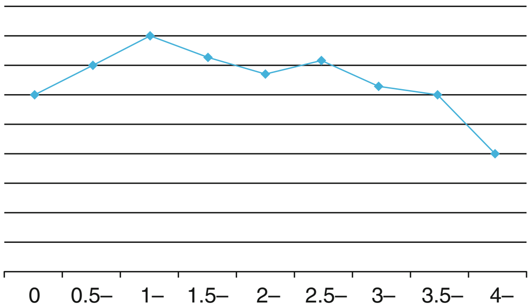

Fig. 9.1 Typical defocus curve: the highest peak is near-far vision. The second peak at near vision

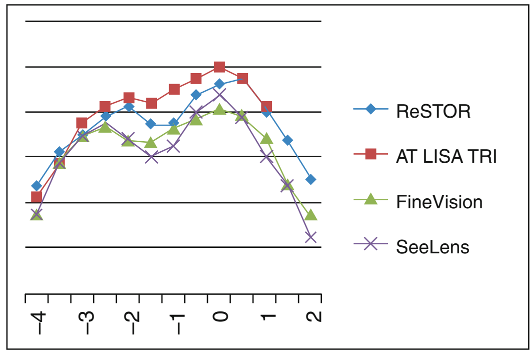

Fig. 9.2 Defocus curves of four multifocal intraocular lenses. The curves enable to quickly compare the performances of the lenses