Refraction planning in cataract: avoid creating an unhappy patient

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"It is much more important to know what sort of a patient has a disease than what sort of a disease a patient has." William Osler

The focus of this paper is the prevention of an unhappy patient following cataract surgery. Such patients often have technically perfect cataract operations but are unhappy with their result. There may be other reasons but commonly this is because of the refractive outcome. Information, which might have prevented such a disaster is accessible preoperatively. These include taking a careful history of prior refractive correction (contact lenses / glasses / refractive surgery), age, lifestyle and the characteristics of the preoperative refraction (hypermetropia, myopia, astigmatism, anisometropia). Thinking about anisometropia reminds the surgeon that patients have two eyes, with the second eye an important consideration in refractive planning. Information from the biometry measurements (axial lengths and keratometry) should be factored in. Lastly, the patient should be consulted about their preferred refractive outcome, and the consequences of their choice.

This article is a personal perspective from the authors. The diagnosis of cataract is not difficult and the decision whether to operate is not usually complex, although there are important factors to consider in determining the risk / benefit ratio for each individual. These become more important if the preoperative visual acuity is still quite good. The general assumption made in this article is that the biometry is performed correctly, the correct lens is selected with the correct formula and the error rate is of the order of 30% of cases having 0.5 dioptre error from aim. This may be greater in patients with high ammetropia. We do not intend to discuss limitations of biometry.

This article uses a variety of clinical examples loosely based on fact, but the details are all made up. The tables are presented in a manner that is consistent, with the intraocular lens power on the left in dioptres (D) and the predicted spherical equivalent (SE) on the right. This article assumes that refractive planning considers both eyes, i.e. the fellow eye extraction is feasible, if indicated.

There may be many alternatives to the solutions given, which may include toric lenses, multifocal lenses and top up laser. The solutions discussed here are aimed at making the reader think about what might be achieved if these more complex and expensive options are unavailable.

Case 1

An 81-year-old male presents with reduced vision. He drives. He wears glasses only for close work.

Refraction and best corrected acuity:
Right +0.25/+0.25x90 6/9
Left +0.25/+0.25x90 6/12
It is agreed to operate on the left eye.
Calculated lens implant choices:

LEFT EYE	
22.5	-1.20
22.0	-0.81
21.5	-0.45
21.0	-0.11
20.5	+0.25

Refractive planning

The question here relates to picking a 21.0 or 21.5 dioptre lens. Let us assume he wishes distance vision (as he has now) and is happy with reading glasses. In a third of cases the error in biometry is in the order of 0.5 dioptre sphere. A 21.0 D lens will result in a spherical equivalent in the range +0.39 to -0.61 in two thirds of cases. A 21.5 D lens might leave him almost -1.00 with which he might easily read, at least large print or in good light.

If such a patient is able to understand these risks, this can be discussed. If his lifestyle avoids reading then perhaps the 21 D lens is the correct decision. Either would probably be a good result.

Message: in general operate on the eye with the worst visual acuity first, although be careful about pre-existing amblyopia, particularly if patients have prior history of strabismus, anisometropia or high hypermetropia (see later). If acuity is equal, it is acceptable to operate on the eye the patient prefers.

For the otherwise uncomplicated patient aim for about -0.3 DS. If their historic refraction (prior to cataract) was hypermetropic, pick slightly more plus, if myopic, slightly more minus.

Case 2

A 61-year-old female presents with reduced vision in the left eye. She rarely wears glasses for near or distance and has never worn contact lenses. She drives.

Refraction and best corrected acuity:
Right -0.75/+0.50x180 6/9
Left -1.25/+0.50x180 6/18
A decision is made to operate on the left eye cataract first.
Calculated lens implant choices:

RIGHT EYE	
21.0	-0.81
20.5	-0.52
20	-0.12
19.5	+0.2

LEFT EYE	
20.5	-1.20
20	-0.81
19.5	-0.45
19.0	-0.14

Refractive planning

The preoperative spherical equivalent in the left eye is -1.00 and the right is -0.50 which explains how she manages for some near vision activities without glasses. She also has a small amount of astigmatism, which will increase her depth of focus – which may or may not be reflected in the keratometry (see later).

The pre-existing anisometropia is important and should influence the postoperative aim. If the anisometropia is historic (and not just a consequence of the cataract) it might lead to the decision to preserve this patient's pre-existing

anisometropia and aim for -1.00 spherical equivalent in the left eye and -0.3 in the right. In this scenario, warnings need to be given to ensure she understands that distance vision may appear blurred postoperatively in the left eye. In addition the pre-existing glasses-independence may not be recreated – particularly if the keratometry does not reflect the astigmatism.

Patients are often under the impression that they will be glasses independent after routine cataract surgery. This may be the case, but is not guaranteed.

The biometry calculation reflects the pre-existing anisometropia with a lower power dioptre lens for emmetropia in the left eye. It is worth checking the axial lengths are consistent with this as well (the more myopic eye should be longer). Index myopia may create or neutralise a pre-existing anisometropia, which might influence your refractive aim.

Assuming there is no particular demand from the patient to have both eyes the same, then using the same dioptre lens for each eye is attractive, probably a 20.0 D lens implant in this example. This philosophy rarely leads to postoperative intolerance as the result reflects the preoperative anisometropia, to which the patient has often adapted in their life time.

Case 3

A 73-year-old man presents with difficulty driving at night. He has required frequent changes in glasses over the last two years. His first glasses were for reading when 45-years-old.

Current refraction and best corrected acuity:

Right -3.00/+0.50 x180 6/12
Left -3.00/+0.50x175 6/18
Calculated lens implant choices:

LEFT EYE	
24.5	-2.0
24.0	-1.9
23.5	-1.58
23.0	-1.23
22.5	-0.81
22.0	-0.52
21.5	-0.12
21.0	+0.23

Refractive planning

The history is important. The first glasses used were for reading, suggesting that the myopia is secondary to cataract formation (index myopia). This is a good example of where looking at the biometry measurements before making a lens choice is worthwhile. Although not displayed, the history would imply index myopic change. The lens implant calculations seem to suggest a normal axial length. This patient group usually dislike having to wear distance glasses, are often seen in the clinic not wearing glasses, and are usually relieved to find that you can aim for unaided distance focus postoperatively. In this scenario, patients have to be warned that they will need reading glasses. In the experience of the authors such patients rarely read unaided preoperatively but it is worth checking.

If it is agreed to aim for unaided distance focus, the readings again fall between choosing a 22.0 or 21.5 D lens. Some patients will guide you as to which of the two choices is preferred.

If both eyes are similar, one option is to operate on the dominant eye first and aim for nearer zero, and on operating on the non-dominant eye, aim to be a fraction more myopic, but this all depends on the exact biometry calculations and patient preference.

Case 4

A 65-year-old librarian presents with difficulty seeing small print. She has worn glasses since she was a teenager. She reads unaided.

Best corrected acuity:

-3.00/+0.50 x180 6/12
-3.00/+0.50x175 6/12
Calculated lens implant choices:

RIGHT EYE	
20.0	-2.10
19.5	-1.83
19.0	-1.55
18.5	-1.28
18.0	-0.83
17.5	-0.51
17.0	-0.32
16.5	+0.15

Refractive planning

It is impossible to predict what sort of postoperative refraction this patient might choose. A discussion is required. An obvious option is to aim for a degree of myopia so that the patient will again read without glasses. If this is the aim it may not be necessary to aim for a similar spherical equivalent, as usually about -2.00 spherical equivalent is sufficient for comfortable reading. If a patient reads without glasses, particularly if they read late into the night, and then chooses to aim for an emmetropic end result, it is important to have them understand that they are unlikely to read without glasses post-op. Some patients struggle to comprehend this as they have always read easily without glasses in the past.

Patients often have a slight underlying anisometropia, which may be masked by index changes. This is another example where it is important to check the axial lengths and keratometry readings. If there is anisometropia, the lenses chosen should be selected to respect this. If patients are undecided, the fall back position is to leave them myopic enough to read without glasses, so in this example 20.0 D for -2.10 spherical equivalent. Note it is rarely necessary to leave patients with -3.00, particularly if there is a small amount of corneal astigmatism.

If the cataract is unilateral this raises a different problem. If the patient prefers to aim for emmetropia this might create a problem postoperatively with binocular balance. There are a number of options, which include correcting the myopia in the unoperated eye with a contact lens, or proceeding to extraction in the second eye to balance the eyes. Warning the patient of these difficulties is essential.

Case 5

A 66-year-old female presents with reduced vision in both eyes. She gives a history of wearing glasses as a child but no surgery or patching.

Refraction and best corrected acuity:

+5.00/+0.50 x180 6/18 right
+5.00/+0.50 x180 6/12 left

RIGHT EYE	
Hoffer Q	AL 21.5
31.0	-1.50
30.5	-1.20
30.0	-0.81
29.5	-0.45
29.0	-0.11
28.5	+0.23
28.0	+0.59

This patient presents a number of potential problems that need careful consideration. The patient has a lot to gain from cataract surgery including eliminating her undesirable hypermetropia. In theory there is the magnification of hypermetropia that may be beneficial if there is co-existing macular disease. Warning patients of lack of magnification is prudent, even if this is rarely a problem.

Enquiry should be made about amblyopia (sometimes termed by patients as lazy eye). Patients may give a good history of this,

although some patients are unaware of its presence. If the cataract is not too severe confirmation of normal binocular vision is helpful as patients with hypermetropia may have an eso deviation. Some binocular tests become unreliable if cataract is advanced or unilateral.

The second potential problem is the presence of a manifest strabismus. This may not be obvious from initial inspection and again a history of strabismus is sometimes not present. Confirmation of aligned eyes with a cover test is reassuring. Further workup, for example assessment of suppression, binocular vision and ocular alignment, would be encompassed by an orthoptic report.

Cataract surgery in the presence of binocular vision abnormalities can lead to large angle strabismus or intractable double vision. As a general rule, operate on the better potential eye and if the history is vague, the eye with the longer axial length (in hypermetropia) and or least corneal astigmatism, and warn patients of these risks.

Calculated lens implant choices:

Refractive planning

This patient gives no history of strabismus surgery or patching so probably has normal binocular vision. In addition, her refraction is equal (axial lengths should be checked to exclude axial anisometropia masked by index myopic shift).

In the absence of a large corneal astigmatism, the choice of a 29.0 D lens would seem to be appropriate. Note the use of Hoffer Q formula because of the short axial length [1].

Case 6

A 65-year-old female complains of reduced vision. She gives a history of reduced vision in the left eye all her life. She has had no strabismus surgery.

Refraction and best corrected acuity:
-0.25/+0.75x180 6/18
+4.00/+2.00x180 6/60
Biometry right eye: SRK-T

Axial length	22mm
24.0	-1.2
23.5	-0.81
23.0	-0.52
22.5	-0.12
22.0	+0.35
21.5	+0.72
21.0	+1.1

Biometry left eye: Hoffer Q

Axial length	20mm
29.5	-1.2
29.0	-0.81
28.5	-0.52
28.0	-0.12
27.5	+0.35
27.0	+0.72
26.5	+1.1

The suspicion is that the left eye is amblyopic. If so, it should have a shorter axial length, which is confirmed. As outlined above, the risk of proceeding to cataract surgery in the left eye first would be intractable double vision. This is less of a problem if the eyes are aligned with binocular functions. Any manifest deviation would be a contraindication to proceeding to cataract surgery in the left eye first. This is because cataract surgery might improve the acuity in the left eye to a level superior to the right eye and could anti-suppress the left eye leading to intractable double vision, i.e. double vision that persists even after subsequent cataract surgery to the right eye.

The right eye has reduced vision. If we assume this is due to cataract, the recommendation would be to proceed to cataract surgery for the right eye first.

Refractive planning

The right eye is planned first, as outlined above, and the aim would be emmetropia. The K readings are not presented, but the spectacle astigmatism power is low so let us assume that the K readings reveal less than 1 dioptre of corneal astigmatism. As the patient is likely to have been hypermetropic until the onset of cataract, a lens choice of 22.5 might be reasonable. For planning the left eye, the pre-existing anisometropia should be respected and the fact that the left eye is probably amblyopic makes the choice less critical. A 27.5 or 27 power lens could be chosen to maintain the direction of the pre-existing anisometropia, if not its magnitude.

Although it is tempting to push up the myopic end result if patients wish for a reading vision outcome, it is sometimes not tolerated well in patients who have always been hypermetropic.

Case 7

A 54-year-old female presents with worsening vision in the left eye. She has worn single vision glasses for driving since early adulthood, and more recently changed to full time varifocal glasses wear. She wishes to have uncorrected distance vision.

Refraction and best corrected acuity:
-2.00/+2.00x85 6/6
-1.75/+2.00x95 6/12
K1 42.00 D K2 44.00 @95 left eye
Calculated lens implant choices:

LEFT EYE	
22.5	-1.20
22.0	-0.81
21.5	-0.45
21.0	-0.1

Refractive planning

This case is similar to Case 2, although there is more astigmatism which is reflected in the K readings, and the history of requiring distance correction. The patient's preference is for good uncorrected distance vision but this is unlikely to be achieved with 2 D of corneal astigmatism. While on-axis incisions or toric lens implants are options, let us assume that these are unavailable.

This patient's most positive meridian is +0.25 D in the left eye, zero in the right eye. The initial lens to choose might appear to be 21.5 D for a postoperative spherical equivalent of -0.45 D. However, given her degree of astigmatism, this would create a hypermetropic meridian. Therefore, selecting a 22.0 D lens would be more logical.

This same principle applies if the overall myopia is greater. See next case.

Case 8

A 60-year-old patient presents with reducing vision as a result of cataract. He has worn contact lenses for many years and reading glasses over the top. He requests good unaided visual acuity at distance in the operated eye and understands that he will need reading glasses, which he will use while continuing with his contact lens in the un-operated eye.

Refraction and best corrected acuity:
Right -10.00/+2.00x90 6/18
Left -10.00/+2.00x90 6/9
K1 42.00 D K2 44.00 @90 each eye

Refractive planning

Aim for a myopic spherical equivalent of half the corneal astigmatism power which, in this case, is -(+2.00/2) = -1.00. Remember that biometry is

"Patients are often under the impression that they will be glasses independent after routine cataract surgery. This may be the case, but is not guaranteed."

less accurate in higher axial lengths so it is wise to leave more room for error and counsel the patient accordingly.

This case is uncommon as most myopes have a degree of anisometropia. By reflecting this in the refractive planning, a useful all round uncorrected acuity can be achieved, assuming the degree of astigmatism is not large. Some patients prefer to continue in glasses and have used their myopia on occasion to see close up (perhaps unlikely if minus 10 but always worth asking). If this is the case aiming for a spherical equivalent of between -1.0 and -2.0 (depending on corneal astigmatism and anisometropia) may be a better option. A set of varifocals is usually well tolerated.

Some moderately myopic presbyopic patients (around -4.00 D), have adapted to enjoy the unaided near magnification that their refractive error enables. It is worth checking that they would not miss this magnified near vision if given an emmetropic outcome with cataract surgery. A clue to this pitfall is to observe whether they look over the top of their glasses when they are given fine detail to examine (for example the consent form).

Case 9

A 64-year-old man presents with reduced vision as a result of cataracts. He has worn glasses since age seven years and currently wears varifocals. He has no strong preference about glasses postoperatively.

Refraction and best corrected acuity:

-10.00/+1.00x180 6/12

-6.00/+1.50x160 6/9

RIGHT EYE	
Axial Length	26.5mm
17.0	-3.19
16.5	-2.84
16.0	-2.51
15.5	-2.22
15.0	-1.9
14.5	-1.58
14.0	-1.23
13.5	-0.81
13.0	-0.52
12.5	-0.12

Refractive planning

The pre-existing refraction is reflected in the different axial lengths of the two eyes. An option is to aim to preserve this difference in the planning and aim for approximately -2.5 in the right eye and -0.3 in the left eye. With these measurements a 15.5 D lens in each eye would probably be ideal. Note the symmetry in the intraocular lens choice.

In this case, one danger is in doing the right eye first and leaving the spherical equivalent at zero or minimally myopic. This leaves no

LEFT EYE	
Axial length	24.50mm
19.5	-3.19
19.0	-2.84
18.5	-2.51
18.0	-2.22
17.5	-1.9
17.0	-1.58
16.5	-1.23
16.0	-0.81
15.5	-0.52
15.0	-0.12

room for manoeuvre for the left eye as a hypermetropic error on the left is undesirable, and leaving the same degree of low myopia or emmetropia as on the right may lead to binocular intolerance, as the pre-existing anisometropia is eliminated.

Case 10

A 55-year-old lady presents with symptomatic early cataract. She does not wear glasses or contact lenses at all and prior to the cataract developing was happy with her unaided vision.

Refraction and best corrected acuity:

-0.5/+0.25x90 6/9

-0.75DS 6/12

Left eye K1 38.0 D K2 39.0 D@90

24.5	-2.0
24.0	-1.9
23.5	-1.58
23.0	-1.23
22.5	-0.81
22.0	-0.52
21.5	-0.12
21.0	+0.23
13.0	-0.52
12.5	-0.12

Refractive planning

This case is fraught because the patient is young and very symptomatic and expects not to be needing any refractive aids. She has not told you that she had laser refractive surgery for low myopia 10 years ago. A clue is present in that the K readings (presented in dioptres) are low. Her presbyopia has developed coincident with the small and asymmetric index myopic change that has been preserving her unaided near vision in the left and distance vision in the right remains well preserved. Her left eye now has sufficient nuclear cataract to interfere with her reading and interfere with the clarity of vision in the right eye for distance.

The assumptions in the lens implant calculations are invalidated with prior refractive surgery and adjustments must be made (which are not within the remit of this article) [2]. Following the calculations without adjusting for the prior surgery is likely to lead to a hypermetropic outcome and an unhappy patient. Counselling the patient about the increased chance of a refractive surprise is crucial prior to surgery. The patient should be prepared for the possibility that a second procedure might be needed to correct any postoperative refractive error once the refraction has stabilised, i.e. may need to wear glasses or contact lenses. Multiple postoperative visits may also be necessary. Lastly the patient needs to have her presbyopia explained, as glasses will be required for near, if she requests distance vision. Leaving her slightly myopic in the left eye maybe an option, particularly because of the difficulty with biometry calculations following refractive laser, but again the patient needs to understand that unaided distance acuity will remain reduced.

Conclusion

This article has aimed to point out some of the common scenarios that lead to a patient unhappy with the refractive outcome after cataract surgery. The cases are not exhaustive, and sometimes multiple factors are present in one patient. We have chosen not to discuss toric lens implants or multifocals, as it would overcomplicate the discussion and there are many circumstances where such premium lenses are unavailable. We aim to assist surgeons in their early careers rather than experienced refractive cataract surgeons. In any cataract surgical plan, always consider the patient and their preferences as a whole, and the way in which both eyes function together. Recognise for each individual their needs and desired outcome. Often small adjustments to lens power choices, combined with the multifocality of low astigmatism and preservation of small amounts of anisometropia, can lead to very happy patients free from refractive aids. Managing expectations is extremely important as even the best plan may not produce the desired outcome.

Follow the acronym PHAKO:

Plan:	Plan IOL choice, patient preferences
History:	Myope, hypemetropia, astig, presbypia, contacts, laser
Anisometropia:	Old refractions / axial lengths
K Readings (k's):	Corneal astigmatism power, axis
Overview:	Loss of near sight in myopes, amblyopia, tropia, myopic astigmatism.

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"The patient should be prepared for the possibility that a second procedure might be needed to correct any postoperative refractive error once the refraction has stabilised."

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