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# The Multifocal Pathway: A Pilot Study of a Trainee-Led Multifocal Intraocular Lens Protocol in a Tertiary Referral Hospital in Australia

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**Purpose:** To develop a selection pathway to facilitate the use of multifocal intraocular lenses (mfIOLs) in cataract surgery in a public hospital setting.

**Methods:** A single-surgeon prospective cohort study in an Australian tertiary referral public hospital was conducted. A mfIOL selection pathway was designed and assessed. Outcomes measured included unaided distance (UDVA), intermediate (UIVA) and near visual acuity (UNVA), dysphotopsia, spectacle dependence and satisfaction. Patient-reported outcome measures (PROMs) were assessed using Catquest-9SF (CQ) and Near Visual Acuity Questionnaire (NAVQ). A cost-analysis was performed.

**Results:** Fifty-four eyes from 27 patients underwent cataract surgery with mfIOL implantation. The monocular UDVA (mean ± standard deviation) was 0.05 ± 0.12 logMAR; UIVA 0.19 ± 0.05 logMAR; UNVA 0.28 ± 0.14 logMAR; 87% and 98% of eyes achieved within 0.5D and 1.0D of target refraction respectively. Spectacle independence was 85% at distance, 81% at intermediate, 59% at near vision. High satisfaction was reported with CQ (>85%) and NAVQ (100%). The cost difference between bilateral monofocal and mfIOLs is comparable to a pair of spectacles. Projected annual cost to the health system for a 5%–10% eligibility rate is 1.1–2.3 million Australian dollars.

**Conclusion:** The selection pathway presented overcomes the challenges in patient selection inherent to a public hospital setting and was implemented by a senior trainee with excellent vision and PROMs. The pathway ensures the cost-effectiveness of mfOL implantation. There are several funding models that can be applied to support equitable access and improved visual outcomes with mfIOLs within the government funded health system.

**Plain Language Summary:** Cataract surgery is a safe and effective procedure that is performed in both the private and public sectors. Traditional intraocular lenses offer clear vision at one distance, meaning that spectacles are required post-surgery. Advances in lens technology now offer the possibility of multifocality, that is, clear vision at two or more distances and the possibility to remain spectacle free. These multifocal intraocular lenses (mfIOLs) are not readily available in the public sector, due to the complexity of patient selection and of trainee experience with the mfIOLs.

In this study, conducted at Westmead Hospital in Sydney, Australia, researchers aimed to develop a pathway for patient selection for mfIOLs. The study evaluated outcomes including the resultant visual acuity, the experience of visual disturbances, dependence on glasses and patient satisfaction. They also performed a cost analysis.

The results showed that the pathway was successful and that most patients achieved excellent visual outcomes with mfIOLs, with high satisfaction rates reported. Around 85% were able to see well without glasses at a distance, 81% at intermediate distances, and 59% at near distances. The additional cost of mfIOLs was found to be comparable to the cost of glasses over time, making them a cost-effective option.

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In conclusion, the study demonstrated that the selection pathway effectively addressed challenges in choosing patients for mfIOLs in public hospitals, which can facilitate access to mfIOLs for public patients.

**Keywords:** multifocal IOL, selection pathway, visual outcomes, satisfaction, cost analysis

## Introduction

Cataract surgery is one of the most common elective procedures performed internationally[1–3] and is a safe procedure with only a 0.8%–6.3% rate of any intraoperative complication.[4–6] Advancements in intraocular lens (IOL) technology over the past 35 years has led to a wide selection of IOLs that offer more than the standard monofocal distance vision correction. Bi- and tri-focal IOLs offer the possibility of spectacle independence following surgery, thereby improving quality of life and convenience for patients.[7,8] This has led to an increased use of mfIOLs, particularly as technological advances have resulted in satisfactory and perhaps more importantly, reliable visual outcomes.[9]

To achieve the visual outcomes promised by mfIOLs, refractive accuracy is critical, as even small deviations from the emmetropic target are associated with a rapid deterioration in vision.[8,10] For this reason, among many others, mfIOLs are not routinely used in training hospitals. Limitations that increase variability include shared care by a team of trainees through the pre-operative, operative and post-operative appointments, variations in the quality of biometry acquisition, limitations on consult time in a high-volume setting, and trainee inexperience from patient selection and counselling through to implantation of the IOLs. Despite these limitations, if good outcomes can be achieved, the introduction of mfIOLs in a public hospital setting is advantageous to both patient and trainee. From a patient perspective, it allows access to technology and visual outcomes that can improve their quality of vision and quality of life.[11–13] From a trainee perspective, it allows an opportunity to develop the knowledge and technical skills in an area that is increasingly expected by patients. However, it is critical that good outcomes be demonstrated first to justify the increased cost associated with these premium IOLs.

This study aimed to determine if mfIOLs can be successfully implanted in the highly variable training environment of a tertiary referral public hospital by a trainee surgeon. A protocol was created for trainees who had no prior experience with mfIOLs to aid their decision-making in selecting appropriate patients for mfIOL implantation. Beyond clinical outcomes across distance, intermediate and near, we collected patient reported outcome measures (PROMs) to determine the patient experience and conducted a cost analysis to determine the value in using these premium IOLs. The overarching goal was to determine if it is feasible to use mfIOLs in a teaching hospital with trainee-led assessments, and to develop a protocolised system to overcome the limitations inherent in a large teaching hospital setting.

## Method

This study was conducted at Westmead Hospital, Sydney, Australia. The project was approved by the Western Sydney Local Health District Human Research Ethics Committee (HREC 2019–10) and followed the tenets of the Declaration of Helsinki.

### Clinical Setting

The study was conducted in the Outpatient Ophthalmology Department of Westmead Hospital. The department is staffed by 5–6 trainees with varying levels of clinical knowledge and skills. Every three months, a new allocation of trainees is provided. The cataract assessment clinic typically accommodates 25–35 new referrals per 4-hour session and are overseen by a consultant surgeon or senior trainee alongside a junior trainee. Patient flow through the clinic includes sign-in, screening by nursing staff including visual acuity and intraocular pressure. The patient is then assessed for cataract surgery by the trainee or surgeon. Additional scans including OCT, A-scan or Pentacam are ordered at subsequent allied health appointments and are not typically overseen by medical staff. The high-volume nature and flow of the clinic, the lack of screening protocols and the variability in trainee experience with the mfIOLs are all limitations to their use in this setting.

## Participant Selection

Eligible participants over 18 years of age with visually significant bilateral cataracts, an expected postoperative visual outcome of logMAR <0.1, and a strong desire for spectacle independence were selected. Exclusion criteria for the study included previous intraocular or corneal surgery, irregular corneal astigmatism, axial length less than 23 mm or greater than 25 mm, or comorbid ocular pathology that could affect visual acuity (eg maculopathy, glaucoma, diabetic retinopathy).

Participants were recruited from the general cataract assessment clinics and internally referred directly to the senior operating trainee surgeon (CG). During the consultation with the trainee, information describing the IOL technology was given to patients, and they were counselled on the risks, benefits and side effect profile of mfIOLs. Participants were given the opportunity to seek additional counselling before consenting and were able to withdraw at any time. Multifocal IOLs available for implantation were the Tecnis Synergy (Johnson & Johnson Vision, California, USA), Lentis Mplus MF30 (Teleon, Berlin, Germany) and AT LISA Tri (Carl Zeiss Meditec, Jena, Germany), and a random number generator was used to allocate patients. Outcomes from all mfIOL were pooled for analysis as the aim of the study was to determine outcomes for the class as a whole.

## IOLs

The IOLs used and their characteristics are listed in Table 1. The study size was limited by the number of mfIOLs donated: twenty mfIOLs from each manufacturer were available and used. An additional Synergy mfIOL was requested due to suboptimal patient selection and is discussed in the Results section below.

## IOL Calculation

Biometry was performed with IOLMaster 700 (Carl Zeiss Meditec, Jena, Germany) and corneal tomography measured with Pentacam (Oculus Optikgeräte GmbH, Wetzlar, Germany). Multifocal IOLs were implanted where there was agreement between IOLMaster 700 and Pentacam for the axis of astigmatism (within 30°) and the total corneal power (within 0.5 D). Power calculations were made using the inbuilt Barrett TK Universal formula from the IOLMaster 700 for Mplus and Synergy IOLs, and using the online Zcalc calculator (https://zcalc.meditec.zeiss.com/) for the AT LISA IOL, as suggested by the IOL manufacturer. Target refraction was emmetropia in the MF30 and AT LISA IOL groups and the first plus target in the Synergy group, also as suggested by the IOL manufacturer. Toric IOLs were assigned to eyes with any astigmatism where calculations indicated benefit (including T2 toric IOLs) for the Synergy and AT LISA groups. In the MF30 group, toric IOLs were assigned to eyes with astigmatism of ≥0.75, as toric MF30 IOLs were custom made to the individual eye.

**Table 1** Characteristics of IOLs Used

| | AT LISA Tri | Tecnis Synergy | Lentis Mplus MF30 |
|---|---|---|---|
| **Optic Design** | Aspheric<br>Diffractive<br>Trifocal<br>+33.3 D near add (40cm)<br>+1.66 D intermediate add (80cm) | Aspheric<br>Hybrid diffractive - EDOF design<br>Echelette profile with diffractive zones<br>No distinct add power | Aspheric<br>Refractive<br>Inferior segmented sector-shaped near add<br>Bifocal<br>+3.0 D near add |
| **Material** | Hydrophilic acrylic with a hydrophobic surface | Hydrophobic acrylic | Hydrophilic acrylic with hydrophobic surface |
| **Refractive index** | 1.46 | 1.47 | 1.46 |
| **Optic diameter (mm)** | 6.0 | 6.0 | 6.0 |
| **Total diameter (mm)** | 11.0 | 13.0 | 11.0 |

## Surgical Technique

A single surgeon (CG) performed cataract extraction and IOL implantation after informed consent was obtained. Toric alignment was performed with the RoboMarker (Surgilūm, Wilmington, NC) or VERION Image Guided System (Alcon, San Diego, CA). A 2.4 mm temporal clear corneal incision was made and continuous curvilinear capsulorhexis performed. Phacoemulsification using a standard divide and conquer technique was performed and followed by coaxial irrigation and aspiration of the cortex. The IOL was inserted and aligned to the toric marking. After viscoelastic removal, the wounds were hydrated and intracameral cefazolin 2.5 mg in 0.1 mL was given. Patients were instructed to use topical chloramphenicol 0.5% eye drops four times daily for 14 days and dexamethasone 0.1% four times daily for 28 days. The second eye was completed within 1–3 months of the first operation.

## Primary and Secondary Outcome Measures

Primary outcomes measured were uniocular and binocular-uncorrected distance (6 m; UDVA), intermediate (80 cm for AT LISA Tri or 66 cm for all others, as per the suggested distance from the IOL manufacturer; UIVA) and near (33 cm; UNVA) visual acuity. A backlit Snellen chart was used to measure distance acuity and handheld printed charts (Carl Zeiss Meditec, Jena, Germany) were used for intermediate and near acuity. Post-operative subjective refraction was performed, and the spherical equivalent (SE) and its difference from target SE was calculated.

Secondary outcomes included uniocular and binocular best corrected distance visual acuity (6m; CDVA), best corrected intermediate (80 cm or 66 cm as per IOL manufacturer; CIVA) and best corrected near (33 cm; CNVA) visual acuity. Root mean square higher-order aberrations (RMS HOA), and Chang-Wearing Chord (CWC; mm) were recorded. If the binocular CDVA was ≤ logMAR 0.2, defocus curves were measured in both eyes. The vision was best corrected for distance and defocus lenses from +1.00 D to – 4.00 D were applied, in steps of 0.50 D.

Quality of vision was measured at 1-month and 3-months using the self-administered Catquest-9SF (CQ)[14] and Near Visual Acuity Questionnaire (NAVQ).[15] Patients were also asked to rate the presence of dysphotopsias (halos, glare, starburst) and spectacle dependence (see Supplementary Tables 3 and 4).

Ophthalmic examination was performed at baseline and at 1 month post-operatively. Intraocular pressure, slit lamp, fundus examinations, biometry, and optical coherence tomography (OCT) were performed at both visits.

## Data Collection and Statistical Method

Refractive, surgical, dysphotopsia and spectacle use data was entered into the Cataract & Lens Exchange Analysis & Register log (CLEARlog; HOYA Surgical Optics, UK).

Snellen units were converted to logMAR for statistical analysis. Descriptive statistics were calculated for all primary outcomes. The VA outcomes from the mfIOL groups were pooled, as the aim of the study was to examine the outcomes of the class as a whole and not to make comparisons between the mfIOL models.

Statistical analyses were performed on SPSS (SPSS v. 20.0, IBM Corp). The larger RMS HOA and CWC was selected for each patient and used to calculate the mean HOA RMS and mean CWC for each IOL group. Normality of data was assessed using the Shapiro–Wilk test. Normally distributed data was analysed using one-way analysis of variance, and data that was not normally distributed were analysed using the Kruskal–Wallis test. Statistical significance was set to a P value of 0.05.

## Cost Analysis

A cost-analysis comparing the cost of bilateral cataract surgery with monofocal and mfIOLs, in addition to the projected cost of spectacles was conducted.[16] Medical costs were determined using official Australian figures.[17] IOL prostheses costs were taken from the current Australian Government Department of Health Prostheses List.[18] The prosthesis cost for the mfIOLs ranged from $619 - $651 Australian Dollars (AUD) with a mean of $635 AUD, which was used as the mfIOL cost in this analysis. The cost of spectacles can vary considerably and there are no official recommendations for pricing, therefore the price for a pair of varifocal spectacles was sourced from a well-recognised Australian optometry chain and listed as $939 AUD.[19] The spectacle price included an anti-reflective coating but no additional lens features

were included. An analysis was conducted for glasses replacement every 1, 2 and 3 years to reflect the potential preferences of the patient[20–23] for a total of 17 years, based on an average age at the time of cataract surgery of 68 years and a life expectancy of 85 years.[24] Prices were adjusted for inflation where appropriate using the Reserve Bank of Australia Inflation Calculator.[25] To facilitate comparison with other studies, the costs were converted to United States dollars (USD) using the exchange rate listed on 17th October 2023 (AUD1.00 = USD0.63).

# Results

## Optimised Surgical Pathway for mfIOLs

A total of 61 eyes from 31 patients were implanted with mfIOLs as part of the study. During the iterative process of protocol creation, mfIOLs were used in sentinel patients to determine if the protocol implemented to overcome the limitations of a public hospital to accommodate mfIOL use were effective. During this period, 2 patients had suboptimal mfIOL implantation: one patient was found to have vitelliform lesions after surgery, one had unexplained vision loss with the principal abnormality of ganglion cell layer thinning on OCT subsequently detected. These experiences led to refinement of the mfIOL protocol to include OCT as part of the pre-operative assessment, which is presented in Figure 1. With the protocol finalised, 58 eyes from 29 patients were implanted using the final pathway presented in Figure 1. Intra- and post-operative complications included 1 case of posterior capsule tear and 1 case of persistent cystoid macular oedema; both cases were excluded from the analysis. Fifty-four eyes from 27 patients were included in the analysis (Table 2). Over the study period, a total of 372 phacoemulsification procedures were performed at the hospital; mfIOL accounted for 7.3% of procedures performed.

## Visual Acuity

Visual acuity outcomes are displayed in Table 2. All IOLs performed better for distance followed by intermediate and near foci, with binocular vision being superior to monocular vision. Overall, accuracy was excellent with 87% of eyes within 0.5D of target refraction and mean deviation from target refraction of only 0.2D.

## Patient-Reported Outcomes

Patient reported dysphotopsias by group are displayed in Figure 2. Individual disturbances had a prevalence from 33% to 67%, with a mean prevalence of 56% for halos, 41% for glare and 52% for starburst.

Complete spectacle independence (defined as a PROM rating of "never") at distance, intermediate and near vision is displayed in Figure 3. Of note, no patients listed "mostly" or "always" for spectacle requirement for any visual distance, indicating the overall utility of the mfIOL. Satisfaction with overall vision (measured with CQ) and near vision specifically (measured with NAVQ) were rated highly in all IOL groups; all patients were either "completely" or "very" satisfied, see Figure 4. A complete summary of responses to PROMs is reported in supplementary tables 1–4.

## Aberrations

In our sample, higher-order aberrations (RMS HOA) and the Chang-Warring Chord (CWC) were not associated with an increased risk of dysphotopsias (RMS HOA of 0.249 μm ± 0.085 μm vs 0.230 μm ± 0.064 μm for dysphotopsias vs no dysphotopsias; p = 0.664; CWC of 0.289 mm ± 0.156 mm vs 0.225 mm ± 0.128 mm, respectively; p = 0.612).

## Cost-Analysis

Table 3 presents the economic costs of bilateral cataract surgery. The difference in price between multifocal and monofocal IOL conservatively equates to the price of a single pair of varifocal glasses. Assuming glasses are updated every year, mfIOL represents a saving to the patient of at least $15,185 AUD over 17 years, depending on the frames and lens options bought and excluding intangible costs such as the improvement in quality of life. However, these cost savings to the patient represent an increased cost to the health system that must pay for the

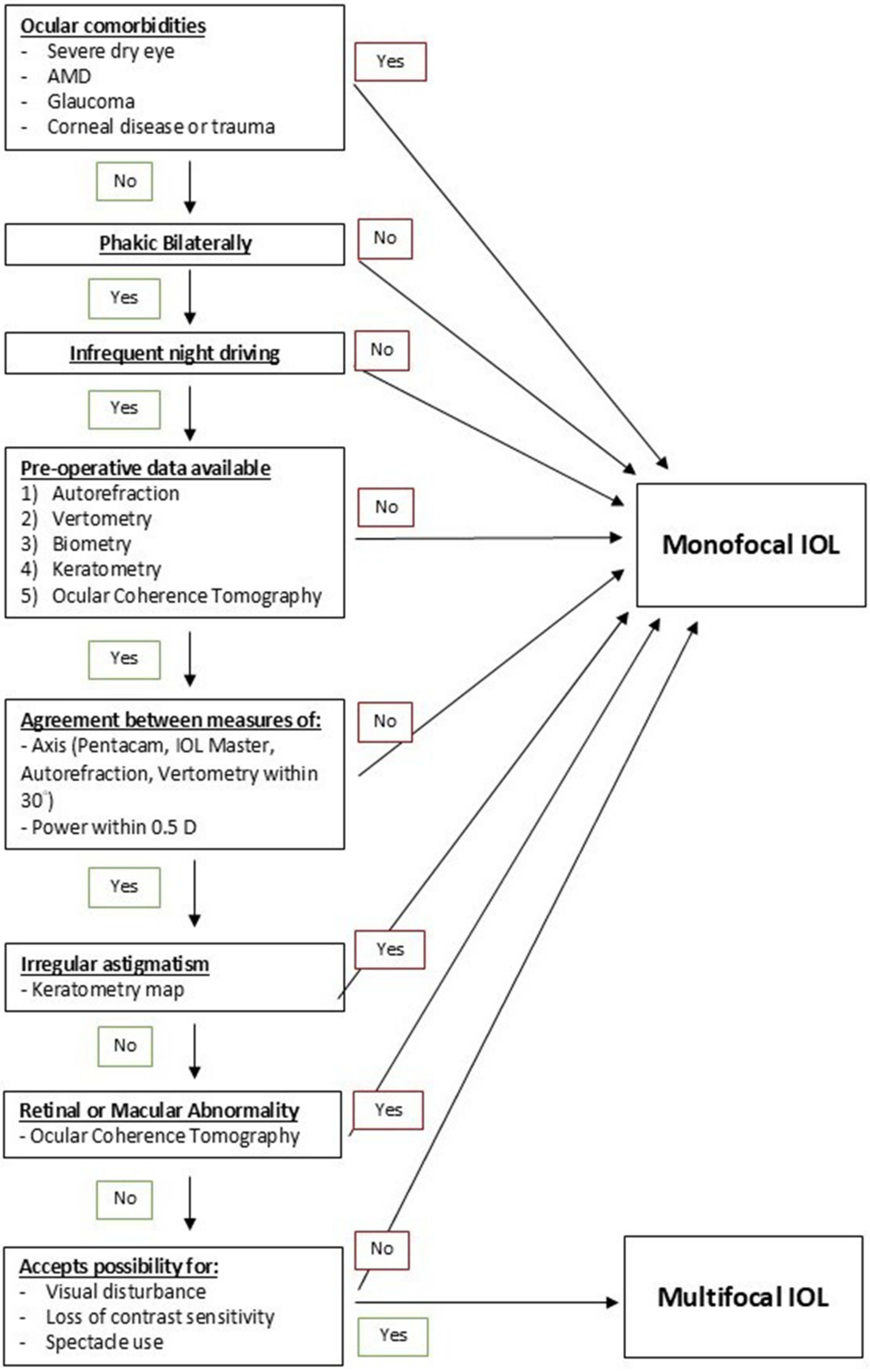


**Figure 1** Optimised mfIOL selection pathway used by the trainee surgeon.

**Table 2** Preoperative Characteristics and 1-Month Postoperative Monocular and Binocular Refractive Outcomes (Presented as Mean ± Standard Deviation Unless Otherwise Specified)

| | Lentis Mplus MF30 | AT LISA tri | Tecnis Synergy | MF Combined |
|---|---|---|---|---|
| **Preoperative characteristi** | | | | |
| **N patients (eyes)** | 9 (18) | 9 (18) | 9 (18) | 27 (54) |
| **N female (%)** | 6 (67) | 5 (56) | 6 (67) | 17 (63) |
| **Age (years)** | 66.9 ± 11.1 | 68.0 ± 10.0 | 70.3 ± 8.4 | 67.9 ± 9.4 |
| **Pre-op Monocular UDVA (logMAR)** | 0.5 ± 0.5 | 0.6 ± 0.5 | 0.4 ± 0.3 | 0.5 ± 0.4 |
| **Astigmatism (ΔTK)** | 0.6 ± 0.3 | 0.9 ± 0.5 | 1.0 ± 0.5 | 0.8 ± 0.5 |
| **RMS HOA** | 0.2 ± 0.1 | 0.2 ± 0.1 | 0.3 ± 0.1 | 0.2 ± 0.1 |
| **Chang-Wearing Chord** | 0.3 ± 0.2 | 0.3 ± 0.1 | 0.3 ± 0.1 | 0.3 ± 0.2 |
| **Toric IOL ‡** | 4 | 14 | 13 | 31 |
| **Postoperative outcomes** | | | | |
| **UDVA**<br>**Monocular**<br>**Binocular** | 0.01 ± 0.11<br>–0.08 ± 0.05 | 0.08 ± 0.11<br>0.01 ± 0.12 | 0.04 ± 0.13<br>0.03 ± 0.13 | 0.05 ± 0.12<br>–0.02 ± 0.11 |
| **UIVA**<br>**monocular**<br>**Binocular** | 0.20 ± 0.03<br>0.17 ± 0.08 | 0.20 ± 0.00<br>0.21 ± 0.04 | 0.20 ± 0.00<br>0.20 ± 0.00 | 0.19 ± 0.05<br>0.18 ± 0.06 |
| **UNVA**<br>**monocular**<br>**Binocular** | 0.19 ± 0.13<br>0.20 ± 0.13 | 0.33 ± 0.11<br>0.30 ± 0.13 | 0.31 ± 0.15<br>0.29 ± 0.15 | 0.28 ± 0.14<br>0.26 ± 0.13 |
| **CDVA**<br>**monocular**<br>**Binocular** | −0.06 ± 0.08<br>–0.09 ± 0.04 | 0.02 ± 0.10<br>–0.04 ± 0.07 | 0.00 ± 0.12<br>–0.01 ± 0.14 | −0.01 ± 0.10<br>–0.05 ± 0.10 |
| **CIVA**<br>**monocular**<br>**Binocular** | 0.23 ± 0.15<br>0.16 ± 0.13 | 0.25 ± 0.10<br>0.19 ± 0.04 | 0.26 ± 0.15<br>0.16 ± 0.12 | 0.25 ± 0.13<br>0.17 ± 0.10 |
| **CNVA**<br>**monocular**<br>**Binocular** | 0.21 ± 0.16<br>0.19 ± 0.11 | 0.32 ± 0.12<br>0.26 ± 0.13 | 0.31 ± 0.15<br>0.28 ± 0.14 | 0.28 ± 0.15<br>0.24 ± 0.13 |
| **Target refraction (SE)** | 0.00 ±0.08 | 0.02 ± 0.11 | 0.18 ±0.11 | |
| **Difference between target and post-op refraction (SE)** | −0.21 ±0.34 | −0.16 ± 0.33 | −0.14 ± 0.28 | −0.17 ± 0.31 |
| **Within 0.50 D target †**<br>**Within 1.00 D target †** | 83.3%<br>94.4% | 84.2%<br>100% | 88.9%<br>100% | 87.0%<br>98.0% |
| **Spherical equivalent (D)**<br>**Post-op refractive Sphere (D)**<br>**Post-op refractive cylinder (D)** | −0.21 ± 0.34<br>–0.11 ± 0.31<br>–0.19 ± 0.36 | −0.15 ± 0.32<br>0.06 ± 0.41<br>–0.40 ± 0.40 | 0.04 ± 0.29<br>0.10 ± 0.33<br>–0.08 ± 0.34 | −0.10 ± 0.33<br>–0.08 ± 0.36<br>–0.23 ± 0.39 |
| **Toric angle: degrees from target ‡**<br>**≤ 5**<br>**6–15**<br>**16-20**<br>**Unknown** | <br>1<br>1<br>-<br>2 | <br>7<br>6<br>1<br>- | <br>7<br>3<br>1<br>2 | |

**Note**: Values are presented as mean ± standard deviation unless otherwise indicated. † Values are percentages, ‡ values are presented as number of eyes.
**Abbreviations**: CDVA, Best-corrected distance visual acuity; CIVA, Best corrected intermediate visual acuity; CNVA, Best corrected near visual acuity; D, Dioptres; RMS HOA, Root mean square higher order aberrations; ΔTK, Total keratometric astigmatism, UDVA, Uncorrected distance visual acuity; UIVA, Uncorrected intermediate visual acuity; UNVA, Uncorrected near visual acuity.

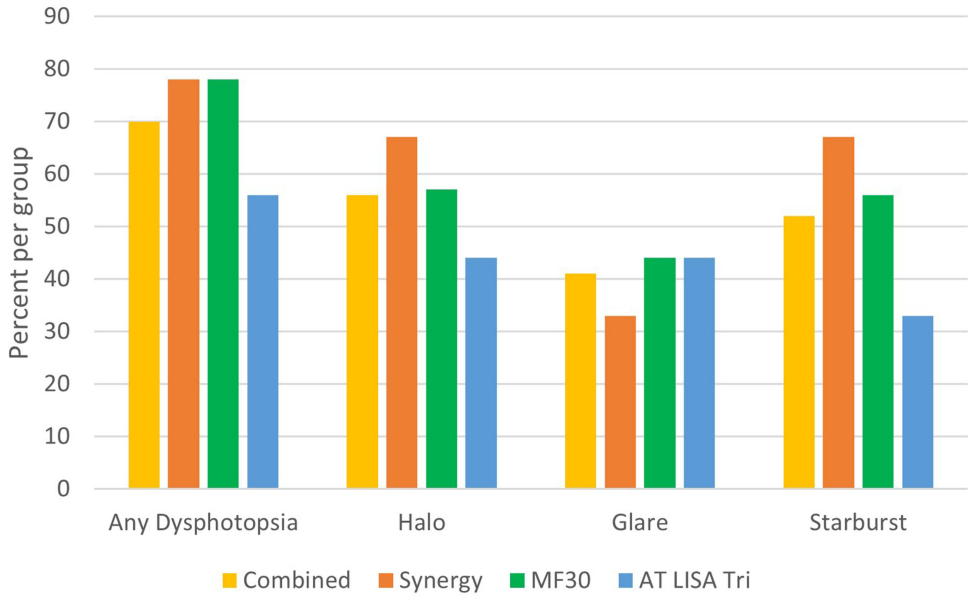


**Figure 2** Any dysphotopsia, halos, glare or starburst in each IOL group (% participants per group).

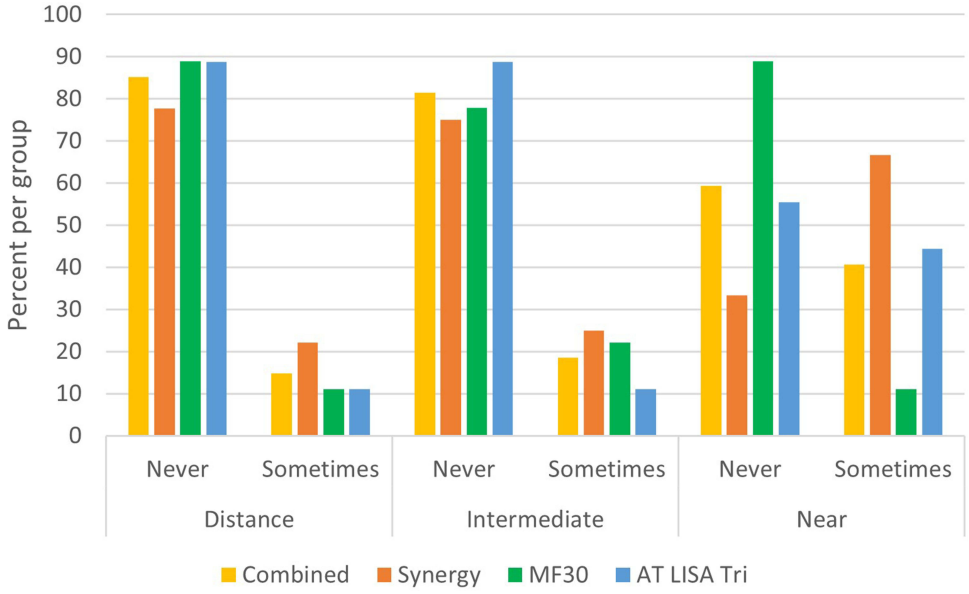


**Figure 3** Self-rated spectacle dependence at distance, intermediate and near vision (% of participants per group).

advanced technology of a mfIOL. Our mfIOL cohort represented 7.3% of all cataract operations at Westmead during the study period; assuming between 5% and 10% of all public cataract patients were eligible for mfIOL implantation, this represents an increased cost of $1.1 to $2.3 million AUD per annum.

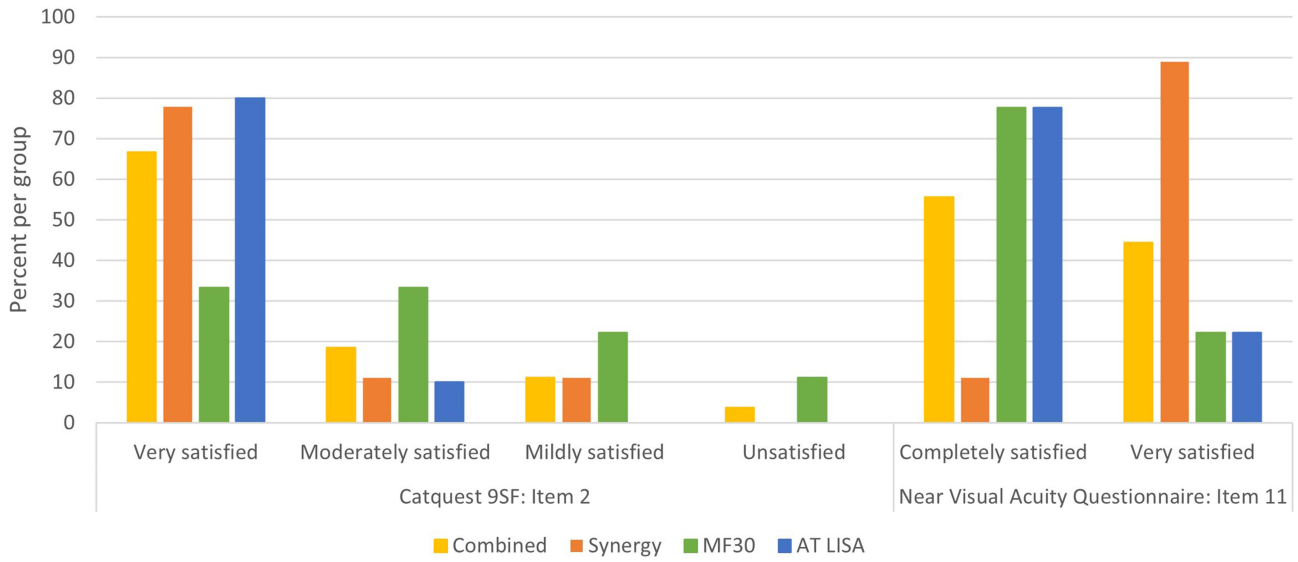


**Figure 4** Self-rated satisfaction with vision using the Catquest-9SF and Near Visual Acuity Questionnaire.

## Discussion

In the correct patient, mfIOLs deliver improved intermediate and near visual acuity and greater spectacle independence when compared with monofocal IOLs.[26] The challenge in the public sector, with variable measurement quality, significant time pressures that impact patient counselling, and multiple surgeons of various expertise influencing patient

**Table 3** Economic Cost Analysis for Bilateral Cataract Surgery

| **Parameter** | **Cost per Patient (Bilateral Surgery) AUD (USD)** |
|---|---|
| Phacoemulsification day-surgery in public hospital<br>*2x procedures* | $7,054 (4,444) |
| Outpatient appointments in public hospital<br>*6x appointments* | $2,064 (1,300) |
| Intraocular lens (*2x IOLs*) | |
| *i) Monofocal IOL*† | $480 (302) |
| *ii) Trifocal IOL*‡ | $1,270 (800) |
| *Difference in prosthesis cost (i–ii)* | -$790 (498) |
| Spectacles | |
| 1x *Pair*[19] | $939 (592) |
| *Cost over 17 years, replacing pair every:* | |
| *1 year* | $15,963 (10,056) |
| *2 years* | $ 8,451 (5,324) |
| *3 years* | $ 5,634 (3,549) |
| **Australian National Health Figures** | **Annual Cost (million)** |
| 2021–2022: 58,186 unilateral procedures | $205.2 (129.3) |
| Corresponding outpatient clinic appointments | $60.0 (37.8) |
| Additional cost for mfIOL<br>*(Difference in IOL cost x* n *procedures)* | |
| *5% eligibility rate*, n=*2,909* | $1.1 (0.7) |
| *10% eligibility rate*, n=*5,819* | $2.3 (1.5) |

**Note:** † Based on the price of the standard monofocal IOL used, the Tecnis ZCB00, ‡ Based on the mean price of the three non-toric mfIOLs used in this study: MF30 $619 AUD; AT LISA Tri $635 AUD; Synergy $651 AUD.

selection, is to implement a pathway that optimises patient outcomes while minimizing the potential risks and hazards inherent with such a mutable system. This pilot study proposes a pathway that overcomes many of these challenges. By empowering a senior trainee with adequate training and support, and utilising a stringent pathway that minimises the potential pitfalls inherent in mfIOL implantation,[27] we were able to demonstrate favourable visual acuity outcomes with mean post-operative subjective refraction above benchmark standards observed in large-scale mfIOL or monofocal audits,[28–30] high levels of spectacle independence and very high levels of patient satisfaction demonstrated through validated PROMs. This decision pathway can be adapted for use across a variety of settings and can aid ophthalmology departments in implementing mfIOL use in select patients.

There is value in considering mfIOL implantation in a public setting. The visual benefits afforded by mfIOLs are desirable as they improve the ease with which patients participate in near-vision related activities, social activities and overall activities, ultimately leading to improved quality of life.[13] There are societal benefits of mfIOL use for patients who desire to return to work[31] and a reduction in indirect costs of salary loss and unemployment.[32] In older cohorts and aged care residents, cataract surgery has been shown to improve self-rated emotional wellbeing, mobility, independence[33] and social interaction, in addition to visual function.[34] Improvements in these domains can facilitate social connectedness with family, friends and community and potentially slow the progression of cognitive decline.[35] Additionally, there is a reduced incidence of falls in the elderly[36–38] which are associated with significant morbidity and mortality,[39] and mfIOLs are associated with fewer falls than monofocal IOLs after first eye surgery.[40] The findings highlight that the benefits of mfIOLs extend far beyond their visual outcomes and can have significant impacts on the quality of life and the everyday functioning of patients and their primary carers.

The challenge of funding innovative technologies and ensuring equitable access to health care within a resource-limited health system is universal,[41–43] and has led to various price setting and funding models.[44] This cost-analysis is one of the first to consider what the projected annual cost of mfIOLs would be to the Australian Health System. A prominent payment model that is used in European countries including Germany, Ireland and France[45] utilises patient co-payments, where the health system funds the cost of the basic procedure and the patient funds the upgrade from a standard monofocal IOL to a mfIOL. This model is patient-centred, focused on patient outcomes and increases access and equity in health care delivery.[46,47] A second model would see the additional prosthesis cost born by the health system and proposes allocating a fixed quota of mfIOLs for use per year. These outcomes could then be assessed to provide a larger evidence base to justify the investment, a practice that is emphasised in value-based healthcare models[48,49] and is necessary for creating benchmarks for care.[50] A third alternative would see mfIOLs tendered at a similar price to monofocal IOLs, with the cost absorbed by the IOL manufacturer, similar to strategies that have been described in orthopaedic surgery.[51–53] There is benefit to the IOL manufacturer as surgeons become familiar with the brand and comfortable with the prosthesis, which can influence surgeon preferences for surgical devices[54] and translate to increased usage outside the government funded health system. The three models presented are not mutually exclusive; elements of two or more can be combined to suit the individual hospital and health jurisdiction. The goal is to maintain cost neutrality while increasing access to newer technologies for patients and trainees and thus improving the standard of care.

Once the aforementioned barriers are addressed, it is necessary to allocate these valuable prostheses to patients who are most likely to benefit, which ensures their cost-effectiveness. This is where the selection pathway presented in Figure 1 is of value. Clinical selection pathways are an integral tool in helping standardise decision-making,[55] reduce treatment error,[56] ensure a high quality of care for all patients.[57,58] They are effectively utilised in glaucoma and ocular hypertension management[59] and can reduce the length of hospital admission for cataract patients.[60] The surgical pathway proposed in Figure 1 is intentionally more stringent than is strictly necessary for mfIOL use to ensure each step in the pre-operative assessment is addressed to reduce error and optimise outcomes for every patient irrespective of the trainee's prior experience, evidenced by the high visual acuity and PROMs achieved in our study. Further, our pathway can be used as a teaching guide for trainees to educate and expose them to the mfIOL process. Although experience in implanting presbyopia-correcting IOLs is not yet a necessary part of surgical training, they have become an increasing part of modern cataract surgery.[8,9,61–63] It is likely that newly graduated surgeons will encounter these IOLs in their private practice, where expectations for optimal results are highest and there is limited or no senior supervision. Hands-on experience with presbyopia correcting IOLs can prepare trainees to identify patients who would benefit from them and

to build technical skills and confidence in implanting them, with visual outcomes comparable to those of more experienced surgeons.[64]

This study had several limitations. The sample size was limited due to the availability of the mfIOL. Dysphotopsias were rated on a self-administered questionnaire, which is an inherently subjective. To improve the objectivity of this measure, dysphotopsias could be quantified using a visual simulator, which would also quantify their severity. We aimed to determine if mfIOLs could be effectively utilised in a public health system and with that in mind did not significantly alter the existing cataract assessment and follow-up protocols. This created limitations such as a short follow-up period where neuroadaptation for dysphotopsias was not assessed, and the use of an a-constant that was not optimised to the biometer[65] or surgeon. Despite these limitations, our refractive outcomes were excellent implying that the pathway created can overcome the inherent limitations of a large tertiary referral public hospital.

To our knowledge, this is the first study to propose a selection pathway for mfIOLs that can be used by trainees in a public hospital setting. The development of the optimised mfIOL pathway was instrumental to the success of the trial demonstrating strong visual outcomes and PROMs. The additional cost for bilateral surgery is similar to the price of a single pair of glasses and their use should be considered in a government health system. The benefits to patients include improved visual acuity in the intermediate and near range, decreased spectacle dependence and high satisfaction, which is commonly linked to an improvement in quality of life.[9,66] The benefit to surgical trainees is hands-on practice in the clinical assessment and management of mfIOL patients, including the nuances in selection, counselling and the management of patients with visual disturbances. Our pathway can be adapted to other training hospitals to suit the individual institutions equipment and needs and helped overcome the inherent limitations of a large, tertiary referral training hospital.

## Abbreviations

mfIOL, Multifocal intraocular lens; IOL, Intraocular lens; UDVA, Uncorrected distance visual acuity;

UIVA, Uncorrected intermediate visual acuity; UNVA, Uncorrected near visual acuity; UDVA, Corrected distance visual acuity; UIVA, Corrected intermediate visual acuity; UNVA, Corrected near visual acuity; CQ, Catquest-9SF; NAVQ, Near visual acuity questionnaire; PROM, Patient reported outcome measure; RMS HOA, higher-order aberrations; CWC, Chang-Warring Chord; AUD, Australian Dollars; USD, American Dollars; CLEARlog, Cataract and lens exchange register.

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