Contact Lens and Anterior Eye 39 (2016) 160–166

Contents lists available at ScienceDirect

Contact Lens and Anterior Eye

journal homepage: www.elsevier.com/locate/clae

Can the accuracy of multifocal intraocular lens power calculation be improved to make patients spectacle free?

Hasnain Ramji[a], Johnny Moore[a,b], CB Tara Moore[a], Sunil Shah[a,c,d,*]

[a] School of Biomedical Sciences, University of Ulster, Coleraine, NI, UK
[b] Cathedral Eye Clinic, York Street Belfast, NI, UK
[c] Birmingham and Midland Eye Centre, Birmingham, UK
[d] Midland Eye, Solihull, UK

ARTICLE INFO

Article history:
Received 23 March 2015
Received in revised form 9 October 2015
Accepted 20 October 2015

Keywords:
Multifocal
Intraocular
Ray
Tracing
Formula
Optimisation

ABSTRACT

Purpose: To optimise intraocular lens (IOL) power calculation techniques for a segmental multifocal IOL, LENTIS™ MPlus® (Oculentis GmbH, Berlin, Germany) and assess outcomes.
Methods: A retrospective consecutive non-randomised case series of patients receiving the MPlus® IOL following cataract surgery or clear lens extraction was performed at a privately owned ophthalmic hospital, Midland Eye, Solihull, UK. Analysis was undertaken of 116 eyes, with uncomplicated lens replacement surgery using the LENTIS™ MPlus® lenses. Pre-operative biometry data were stratified into short (<22.00 mm) and long axial lengths (ALs) (≥22.00 mm). IOL power predictions were calculated with SRK/T, Holladay I, Hoffer Q, Holladay II and Haigis formulae and compared to the final manifest refraction. These were compared with the OKULIX ray tracing method and the stratification technique suggested by the Royal College of Ophthalmologists (RCOphth).
Results: Using SRK/T for long eyes and Hoffer Q for short eyes, 64% achieved postoperative subjective refractions of ≤±0.25 D, 83% ≤ ±0.50 D and 93% ≤ ±0.75 D, with a maximum predictive error of 1.25 D. No specific calculation method performed best across all ALs; however for ALs under 22 mm Hoffer Q and Holliday I methods performed best.
Conclusions: Excellent but equivalent overall refractive results were found between all biometry methods used in this multifocal IOL study. For eyes with ALs under 22 mm Hoffer Q and Holliday I performed best. Current techniques mean that patients are still likely to need top up glasses for certain situations.

1. Introduction

Lens replacement either as cataract surgery or clear lens extraction is the most commonly performed operation worldwide. Patient expectation (and wish to be glasses free) following such surgery is increasing and complications are relatively uncommon. Hence, there is increasing interest in optimising the refractive outcome, with greater demand for simultaneous far and near vision, whilst minimising the potential of visual disturbances following such surgery [1].

The LENTIS™ MPlus® (Oculentis GmbH, Berlin, Germany) intraocular lens (IOL) is a highly regarded and revolutionary segmental multifocal IOL (MIOL) which has proven success rates over the past 5 years, with more than 200,000 of these IOLs having been implanted worldwide since its introduction about 5 years ago; hence it has been chosen for this study. It was designed to address some of the recognised problems, such as loss of contrast and dysphotopsias, inherent with traditional MIOLs. The LENTIS™ MPlus® lens (hereafter referred to as 'the MPlus®' IOL') addresses these traditional complaints through its design, being rotationally asymmetrical with a large aspheric distance vision zone and an anterior surface-embedded near section which directs light to a near focal point. The shape of the near segment (Fig. 1) allows the lens to be considered as pupil independent and the asymmetric design of the lens is considered to allow for a large depth of focus from intermediate to near. It is a single piece hydrophilic acrylic co-polymer IOL with plate haptics, a hydrophobic surface and a 6.0 mm optic area [2]. The MPlus® IOL is typically positioned with the near vision sector in the inferior position. The steep transition between the distance and the near sections of the IOL are aimed to minimise the reflections and disturbances experienced by directing the light away from the optical axis, with only minimal reduction in light intensity.

* Corresponding author at: Midland Eye, 50 Lode Lane, Solihull, West Midlands B91 2AW, UK. Fax: +44 121 711 4040.
E-mail address: sunilshah@doctors.net.uk (S. Shah).

http://dx.doi.org/10.1016/j.clae.2015.10.005
1367-0484/

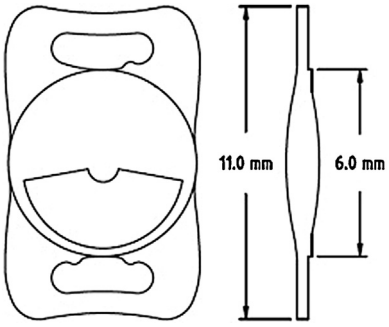

Fig. 1. Diagram of Oculentis MPlus lens demonstrating position and shape of distance and near segments including lens haptics.

The MPlus® IOL has been considered to have a marked improvement on near vision compared with monovision using monofocal implants based upon post-operative acuities achieved and refractive outcomes found in other studies using this lens [3]. The MPlus® IOL is thought to be a significant progression from IOLs previously utilised for pseudophakic multifocal vision by reducing haloes and glare, which normally occur in 25% of patients with other forms of refractive or diffractive MIOL designs [4]. Previous studies have shown that the MPlus® IOL has allows for immediate patient acceptance of the MPlus® IOL [5] with other studies demonstrating both great visual outcomes along with a perceived improvement in quality of life [6,7]. The MPlus® IOL at the time of this study was available with either a +1.50 D or +3.00 D near addition which equates to approximately +1.00 D and +2.50 D equivalent additions in the spectacle plane respectively. Multifocal IOLs are generally bifocal, although some trifocal lenses have been developed recently. The MPlus® IOL, despite being bifocal in essence, due to its' geometry has been found to achieve a large depth of focus incorporating excellent intermediate vision. The availability of the two different power additions also allows the surgeon to use a combination to suit the patient needs resulting in the possibility of distance/near in one eye and distance/intermediate in the other; this would further enhance the depth of focus. The authors wanted to see if the typical mean post-operative refraction, found in several studies conducted with this IOL, of $+0.58 \pm 1.15$D [8] could be improved further.

When using MIOLs, it is vital to maximise the potential outcomes by undertaking accurate biometry and utilising the most appropriate IOL power calculation method. When operating with a new IOL, particularly one with a unique style, it is important to determine whether traditional biometry methods will produce accurate postoperative refractive results and whether significant optimisation of A constant or 'surgeon factor' will be required. Previous studies have demonstrated that all modern power calculation formulae had comparable results [9]; however other recent studies have shown that the Hoffer Q formula should be used for shorter ALs and the SRK/T for longer ALs [10]. This was at the time of the study, and still remains, the current method advocated by the Royal College of Ophthalmologists in Great Britain (RCOphth) guidelines [11]. These guidelines also stipulate that fourth generation formulae such as Haigis, have made some of the older formulae obsolete and may be used for all ALs.

The numerical ray tracing OKULIX program (Tedics, Dortmund, Germany) was generated in an attempt to improve on current IOL power calculation techniques by using ray tracing techniques. The OKULIX method is purported not to rely upon approximations or probability based methods but instead uses complex computer software to map the actual ray paths through each individual eye without the use of A constants [12–14].

Studies have been undertaken on the choice of the most appropriate biometry formula using other IOLs [9]; however no published studies, to our knowledge, have investigated the comparison of third and fourth generation formulae with the recently developed OKULIX ray tracing calculation and the stratification suggested in the guidelines by the RCOphth, specifically when using the MPlus® IOL [11].

This study was conducted to assess postoperative refractive results with the MPlus® IOL, by assessing the postoperative refractive results from a single surgeon to determine whether or not the results could be improved and to see, with present capability, what was the realistic chance of being spectacle independent following surgery. Similar studies have been conducted on monofocal lenses; however this study would be the first of its kind to investigate a MIOL. The information obtained through this study, although predominantly targeted on improving distance correction, it does address and comment on the outcomes achieved for near. This study would prove to be crucial in aiding a surgeon's decision making process when utilising a premium IOL, particularly since this is one of the most commonly used premium MIOLs used in the UK.

1.1. Patients and methods

A retrospective consecutive non-randomised case series of patients receiving the MPlus® IOL following cataract surgery or clear lens extraction was performed at Midland Eye, Solihull, UK, by one surgeon (SS). Full ethical approval was obtained and procedures carried out were in accordance with the ethical standards of the local Research Ethics Committee and with the Declaration of Helsinki. There were no specific inclusion criteria, so all patients who gave consent to the study taking place utilising their data were included.

The biometric data assessed included: the preoperative and postoperative mean spherical equivalent (MSE) refraction, uncorrected (UCVA) and best corrected (BCVA) visual acuities, simulated keratometry, spherical aberration and pupil size results from the Nidek OPD-Scan II (Nidek Co Ltd., Gamagori, Japan); AL and anterior chamber depth (ACD) and horizontal corneal diameter with IOL Master (Carl Zeiss Meditech AG, Jena, Germany), IOL power used and A constant used.

The biometry data for each patient were used to calculate the refractive outcome predictions for the SRK/T, Hoffer Q, Holladay I, Holladay II (partially optimised) and Haigis (partially optimised) formulae. The same was performed using the OKULIX ray tracing method and the stratification method suggested by the RCOphth, i.e., calculating the predicted outcomes using a combination of Hoffer Q for patients with short ALs ($<$22.00 mm) and SRK/T for long ALs ($\geq$22.00 mm). The RCOphth method was the actual technique used by the surgeon.

Various IOL specific constants were used when using this IOL. These values were adjusted at different points in time according to the recommendations from the MPlus® IOL manufacturers who continually reviewed outcomes and adjusted for optimisation; therefore an appropriate constant value was used for the specific formula chosen during the power calculations. This has been accounted for when calculating outcomes with other formulae where each specific constant altered according to that which was used at the time of surgery. The figures of these IOL constants ranged across the following values:: SRK/T-A-constant from 118.0 to 118.4, Hoffer Q-p-ACD from 4.880 to 5.136, Holladay I and II-surgeon factor from 1.098 to 1.354, Haigis-a0 from 0.646 to 0.911,

The actual postoperative MSE outcomes, one month post operatively, were compared with the predicted postoperative MSE and the difference between these was labelled the 'predictive error'. This was used to identify which formula/technique would