Measurement of axial length in the calculation of intraocular lens power

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Abstract

Purpose Accurate measurement of ocular axial length is essential for accurate intraocular lens (IOL) power calculation. Although it is common practice to average several axial length measurements to improve accuracy, it has been suggested that a single high-quality A-scan ultrasonographic measurement is adequately accurate owing to the high test-retest reliability of A-scan biometry. The aim of this study was to compare the accuracy of a single high-quality A-scan measurement with that of the average of three acceptable measurements in the calculation of IOL power.

Method We studied 103 eyes of 103 patients who underwent cataract-IOL surgery. All these patients underwent pre-operative ocular biometry, a standardised extracapsular cataract extraction with posterior chamber IOL implantation, and clinical refraction between 10 and 14 weeks post-operatively.

Results There was no statistically significant difference between the two study groups in measured axial length ($p > 0.01$), calculated emmetropic IOL power ($p > 0.05$) or the prediction of post-operative refraction ($p > 0.99$).

Conclusion The use of a single high-quality axial length measurement was as accurate as the mean of three acceptable axial length measurements in the calculation of IOL power.

Key words Axial length, Biometry, Cataract surgery, Intraocular lens, Power calculation

The power of the intraocular lens (IOL) to be implanted during cataract surgery to achieve a desired amount of post-operative refraction is routinely calculated pre-operatively. The two ocular parameters that need to be measured are axial length and corneal curvature, of which the former is measured with A-scan ultrasonography. Some authors¹⁻³ recommend using the average (mean) of several successive axial length measurements to increase accuracy, while others⁴ suggest taking six to eight axial length measurements until consecutive readings differ by less than 0.1 mm. These

views have been questioned by Giers and Epple,⁵ who suggested that single high-quality A-scans are as accurate as the means of several successive measurements owing to the high test-retest reliability of A-scan biometry in measuring ocular axial length. As our clinical impression was consistent with the above suggestion, we performed this study to compare the accuracy of a single high-quality A-scan measurement with that of the mean of three acceptable measurements in the calculation of IOL power.

Patient and methods

The operative eye of 121 consecutive patients admitted for routine cataract-IOL surgery was studied. Patients were excluded if one eye had already been included in the study. Keratometry was first performed using the Topcon OM-4 (Bausch and Lomb type) Ophthalmometer. Axial length was then measured in the autofreeze mode with the Cooper Vision Ultrascan Digital B 2000 system. The applanation-type ultrasound probe was mounted on a slit-lamp using a special adapter to minimise the variability in corneal indentation that may be associated with hand-held A-scan biometry. Only A-scans with strong lens and retinal echoes at low amplification were accepted; traces with echoes indicating off-axis alignment were excluded. Axial length measurements were performed until three acceptable A-scan traces were obtained for each eye studied. All axial length measurements were performed by the same investigator (P.S.R.).

The power of the IOL to be implanted for obtaining a desired amount of post-operative refraction was calculated using the mean of the three acceptable axial length measurements, the SRK II formula⁶ and an 'A' constant of 118. The Cooper Vision ultrasonography system used for this purpose has built-in software for IOL power calculations and prints out the IOL power for obtaining a desired amount of post-operative refraction as well as the predicted emmetropic IOP power. All surgeries, extracapsular cataract extraction and posterior

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Table 1. Differences in measured axial length (mm)

Eyes grouped according to axial length	H ^a –M ^b for axial length	
	Mean (SD)	<i>p</i> value
Short	0.08 (0.12)	> 0.3
Long	0.14 (0.12)	> 0.4
Average	0.10 (0.11)	> 0.3
All	0.10 (0.11)	> 0.1

^aH, a single high-quality A-scan.

^bM, mean of three acceptable A-scans.

chamber IOL implantation in the capsular bag were performed by a single surgeon (A.W.) using the same technique. Post-operative refraction was recorded by the same investigator (P.S.R.) at the time of prescription of spectacles, usually between 10 and 14 weeks post-operatively.

The three acceptable A-scan traces were assessed and the most accurate chosen by an independent investigator (B.I.) who was masked as to the actual axial length on the print-out. The choice was based on strong lens and retinal echoes at low amplification, absence of irregular echoes that indicate off-axis alignment, and assessment of anterior chamber depth to rule out accidental corneal indentation with the ultrasound probe. The accuracy of this chosen single high-quality (H) axial length measurement was compared with that of the mean (M) of the three acceptable measurements using the following parameters: (i) absolute differences between H and M in the measured axial length, statistical significance being tested with the paired *t*-test; (ii) absolute differences between H and M in calculated emmetropic IOL power, statistical significance being tested with the paired *t*-test, and (iii) use of the axial lengths measured by H and M in the SRK II formula to predict post-operative refraction for the IOL power implanted. The distribution of predictive errors that would have been obtained had H axial length been used (calculated) was compared with that actually obtained following use of M axial length (measured); statistical significance of the difference between the two groups was tested with the chi-squared test.

Results

One hundred and fifteen consecutive patients (115 eyes) were enrolled in the study, of whom 12 were excluded from analysis because at least three acceptable A-scan traces could not be obtained in 4, keratometry was not possible in 3, surgery was complicated in 1, and post-operative refraction was not possible in 4 due to failure to

Table 2. Differences in calculated emmetropic IOL power (in dioptres)

Eyes grouped according to axial length	H ^a –M ^b for emmetropic IOL power	
	Mean (SD)	<i>p</i> value
Short	0.3 (0.5)	> 0.05
Long	0.4 (0.3)	> 0.40
Average	0.2 (0.3)	> 0.40
All	0.3 (0.4)	> 0.05

^aH, a single high-quality A-scan.

^bM, mean of three acceptable A-scans.

follow the appointment schedule. Of the 103 eyes (103 patients) available for various analyses, 26 were short (axial length < 22 mm), 63 were of average axial length and 14 were long (≥ 24.5 mm).

The results of the comparison of accuracy in the measurement of ocular axial length between H (the single, high-quality axial length measurement) and M (the mean of three acceptable axial length measurements) are shown in Tables 1 (measured axial length in millimetres), 2 (emmetropic IOL power in dioptres calculated with the SRK II formula) and 3 (distribution of actual predictive errors for M and calculated predictive errors for H). Of the 103 patients (103 eyes) available for various analyses, 11 were excluded from the analysis of the distribution of predictive errors as their best corrected vision was less than 6/12 due to posterior segment pathology. There was no statistically significant difference between the two study groups in any of the three ocular parameters compared (Tables 1–3).

Discussion

Accurate measurement of ocular axial length is extremely important for accurate IOL power calculation since axial length measurement is the major identifiable source of error in IOL power calculation.^{7–9} It is commonly recommended that multiple A-scan readings be averaged to obtain an accurate estimate of ocular axial length.^{1–3} In this study, there was no significant difference in measured axial length, calculated emmetropic IOL power or, more importantly, the prediction of post-operative refraction between a single high-quality measurement of axial length and the mean of three acceptable axial length measurements. Our observations confirm the suggestion of Giers and Epple⁵ regarding the accuracy of single high-quality A-scans. Hence, to save time, we select a single high-quality axial length measurement from a series of acceptable A-scan readings and use it in the calculation of IOL power. We

Table 3. Differences in the distribution of predictive errors

Eyes grouped according to axial length	Total no.	No. of eyes (%)		<i>p</i> value
		H ^a	M ^b	
Short	23	18 (78%)	17 (74%)	> 0.98
Long	11	8 (73%)	8 (73%)	1.00
Average	58	44 (75%)	46 (79%)	> 0.98
All	92	70 (76%)	71 (77%)	> 0.995

^aH, a single high-quality A-scan.

^bM, mean of three acceptable A-scans.

continue this practice despite having moved from routine extracapsular cataract surgery to routine phacoemulsification, since the conclusions of this study are unlikely to be influenced by the technique of cataract surgery employed. We agree, however, that acceptable A-scan traces cannot be obtained in all eyes undergoing cataract surgery. In such patients and in the rare event of consecutive and acceptable axial length measurements varying widely, it would be reasonable to use the mean of several A-scan measurements in IOL power calculation.

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