Humphrey and Tomey Biometry for Cataract Surgery: Is there a difference in visual outcome?

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Abstract

This retrospective study compares the refractive outcomes of cataract surgery when two different biometric techniques are used to calculate axial length. One, the slit lamp mounted Humphrey A- Scan and the other the hand held Tomey A- Scan. The medical histories of 344 patients who underwent cataract surgery during 1998-1999 at the Royal Victorian Eye & Ear Hospital were studied. In 179 cases the A-Scan measurement was done using the Tomey, while in 165 cases the Humphrey was used. Results show the refractive outcomes were within +/-1.00D of the expected refractive outcome in 87% of cases with the Tomey and 84% with the Humphrey ($p = 0.36$), indicating no difference between these groups. Mean error, as defined as expected refraction minus achieved refraction, was less with the Humphrey (-0.08D) than with the Tomey (0.11D), ($T=2.4$, $p=0.017$). Despite this small statistically significant difference in mean error, a difference of 0.19D is not clinically significant. Refractive outcomes were similar between the groups showing both instruments give similar results.

Introduction

Cataract surgery with intraocular lens implantation (IOL) has led to dramatic improvement in the rehabilitation of the patient with cataract. Advances in the techniques used to calculate the power of intraocular lenses, have led to the capacity to tailor post-operative refraction to individual needs. This can result in good post-operative visual acuity without the need for distance glasses, to balance the refraction of the fellow eye or to give some reading ability. To achieve this desired outcome the lens power must be both calculated and selected carefully. However the actual final refractive outcome may differ from the selected outcome. Errors may occur from many sources.

One potential source of error is the position of the intraocular lens within the eye. If the lens moves closer to the retina the eye becomes increasingly hypermetropic and as the lens moves further away from the retina the eye becomes myopic. Erickson (1990)[1] calculated that 1mm of longitudinal change was equal to 1D of refractive error. Autopsy studies demonstrate that the lens does move within the eye and haptics can move into the sulcus.[2,3] Modern techniques for cataract surgery are more likely to result in both haptics being 'in the bag', however even within the capsular bag IOL position can vary.[4]

Another potential source of error is the formula used to calculate the IOL power. A study by Olsen (1992)[5] showed 38% of the post-operative refractive error was caused by an error of the formula in estimating anterior chamber depth when a fixed anterior chamber depth was used, and 22% when a predicted anterior chamber depth was used. Both theoretical and regression formulas have been found to be inaccurate for long eyes giving a higher error of refractive outcome in this group.[6,7,8]

Yet another source of error could be found in the lens itself. Error in lens labelling can occur and would only be suspected if the post-operative refraction differed markedly from the expected refraction. However smaller errors in lens mislabelling or manufacture can lead to apparently unaccounted for disappointing results.[9,10]

Keratometry could also be another source of error and in 1992 Olsen[5] attributed 8% of post-operative refractive error to error in keratometry measurements.

However, the largest source of potential error is the measurement of axial length. A 0.33mm error in measuring axial length will result in a 1.00D refractive error variation post-operatively.[11] In 1992, Olsen[5] calculated that errors in measuring axial length would account for 54% of the post-operative refractive error. Olsen compared pre and post-operative axial lengths in 584 patients and found the post-operative axial length to be more myopic. Likewise Kalogeropoulos (1994)[12] found the measured post-operative axial lengths to be longer than the pre-operative axial length. The difference arises from the uncertainty of the exact velocity of ultrasound through a cataractous lens, especially given the varying degrees of cataract density. Errors in the A-Scan biometry can also be the result of different operators and differences in individual models of instruments. The manufacturers of both the Humphrey and Tomey instruments claim an error of 0.1mm between repeated measures with the same operator, which already equates to a 0.3D refractive variation post-operatively. Ultrasound biometry can utilise either the immersion or contact techniques. The contact technique is less time consuming and has the obvious benefit of greater patient comfort. However, the immersion method gives a longer axial length due to the lack of indentation of the cornea.[13,14,15] Indenting the cornea with an A-Scan

probe shortens the measured axial length resulting in a too strong IOL being used and therefore resulting myopia post-operatively. Another variable of biometry techniques is the hand held probe compared with a slit lamp mounted probe. Although both methods indent the cornea, hand held probes might result in further indentation of the cornea, difficulties with correct alignment and unsteady fixation. However, a study by Whelehan et al (1996)[16] comparing the Humphrey biometer in both the hand held and slit lamp mounted techniques, showed no significant difference between the two methods in measuring axial length, although the sample size in this study was small with only 32 patients.

The aim of this study is to compare the actual final post-operative refractive state of the eye with the predicted result in two groups of patients using two different A-Scan machines, the hand held Tomey, Bio & Pach Meter AL1000 and the slit lamp mounted Allergan Humphrey Model 820.

Method

Subjects

The medical records department produced a list of 344 patients who underwent cataract surgery by phacoemulsification and intra-ocular lens implantation at the Royal Victorian Eye & Ear Hospital between 1998 and 1999. Of these patients, 165 had their A-Scan done using the Humphrey A-Scan and 179 patients had their A-Scan done using the Tomey A-Scan.

Apparatus

A Tomey, Bio & Pach Meter AL 1000 and an Allergan Humphrey biometer, model 820, both utilising the SRK/T formula and a Topcon keratometer.

Procedure

Patients' notes were examined. The data collected from each history was as follows:

Patient identification number; Operative eye; Pre-operative visual acuity; Axial length; Surgical date; Procedure performed; Complications; Intraocular lens power, model and A constant; Post-operative refraction and vision including date; Post-operative spherical equivalent; Desired refraction.

The desired refraction was determined by examining the IOL calculation printout and the power of the IOL used (ensuring adjustment for A constant). Spherical equivalents were used as the measure of refractive outcome and error was calculated by subtracting the real final refractive outcome from the expected outcome. For example, patient No. 13 had a 25D IOL inserted. By looking at the IOL calculation printout and adjusting for A constant it was seen that the aimed for refractive outcome was -0.39D. The actual post-operative refraction was -0.63D. Therefore the resultant error from expected to actual was -0.24D.

Data Analysis

SPSS for Windows was used for statistical analysis. Statistics employed included chi square test for proportions and T-test for comparing continuous data.

Results

Pre-operative data can be seen in Table 1. Statistical analysis shows no difference between the groups for visual acuity (Chi-sq = 7.93, p = 0.16) or axial length (T = 0.407, p = 0.685). It can be seen that most surgeons aimed for a slightly myopic, rather than emmetropic, final refractive state, although the range of refractive outcomes indicates that some cases were aimed at balancing the refraction of the fellow eye.

Table 1. Pre-operative data by biometer group

	Humphrey A-Scan N=165	Tomey A-Scan N=179	Test Statistic	P Value
Visual Acuity Range 6/12 or better (%)	6/480 - 6/6 58	6/480 - 6/6 48	Chi-sq = 7.93	0.16
Axial Length (mm) Range Mean (SD)	20.97 - 29.86 23.34 (1.33)	21.11 - 26.67 23.28 (0.92)	T = 0.407	0.685
IOL Power Inserted (D) Range	1.0 - 28.0	13.0 - 29.0		
Desired Refraction (D) Range Mean (SD)	-2.19 - +2.91 -0.29 (0.49)	-4.9 - +0.47 -0.33 (0.42)	T = -0.95	0.34

Post-operative data are shown in Table 2 & 3. There was no statistical difference in error between the groups (Chi-sq = 1.43, p = 0.697) in the percentage of cases between +/-0.5, +/-0.5 to 1.0, +/-1.0 to 2.0 or +/-2.0 or more (Table 3). However, a statistically significant difference was found between the mean error in each group (T = 2.4, p = 0.02) (Table 2). Although a statistically significant difference was found between these two means (Humphrey = -0.08D, Tomey = 0.11D), a difference of 0.19D is not of clinical significance. Figures 1 and 2 show the deviation from the expected outcome in both the Humphrey and Tomey groups. The two outliers seen in the Humphrey group(Figure 1) were both the results of difficult surgical procedures with complication.

Table 2. Post-operative data by biometer groups.

Visual Outcome	Humphrey A-Scan N=165	Tomey A-Scan N =179	Test Statistic	P Value
Visual Acuity Range 6/12 or better (%)	6/60 - 6/6 99	6/60 - 6/6 95	Fishers Exact Test	0.11
Final Refraction (D) Range Mean (SD)	-3.75 - +2.25 -0.38 (0.90)	-7.0 - +1.75 -0.22 (0.89)	Chi-sq 4.19	0.24
Error (D) Range Mean (SD)	-3.49 - +1.54 -0.08 (0.77)	-2.1 - +2.33 +0.11 (0.70)	T = 2.4	0.02

Table 3. Refractive Results

(% of cases) within	Humphrey A-Scan N=165	Tomey A-Scan N=179	Test Statistic	P Value
+/- 0.50 D	57 (n=94)	58 (n=103)		
+/- 0.50-1.00 D	27 (n=44)	30 (n=53)	Chi-sq 1.43	0.697
+/- 1.00-2.00 D	15 (n=25)	11 (n=20)		
Over +/- 2.00 D	1.2 (n=2)	1.7 (n=3)		
+/- 1.00 D	84 (n=138)	87 (n=156)	Chi-sq 0.85	0.36

Discussion

As the outcomes of cataract surgery continue to improve with improving technology, patients' expectations of their surgical procedure continue to increase. Many patients now expect good vision without the use of distance glasses. To achieve good vision without the need for glasses, the appropriately powered intraocular lens must be selected. The final refractive state is important for the patients' comfort and satisfaction. If the axial length is measured incorrectly the patient will have an unexpected post-operative refractive error. A too short axial length will result in too strong an IOL being used that will in turn induce a more myopic error, and a too long axial length will result in too weak an IOL being used, inducing a hypermetropic error. In 1990, Sanders et al[17] found 81% of eyes were within 1.00D of the expected refraction. In 1995, the authors of the SRK/T formulae, Sanders, Retzlaff and Kraff stated that 'even under ideal circumstances, actual post-operative refraction will differ by more than 1.00D from the calculated expected refraction in about 15% of cases'.[11] . This is consistent with our study, which showed 13% of cases with a difference of more than 1.00D using the Tomey A-Scan and 16% using the Humphrey A-Scan.

This study shows mean error from the expected outcome was -0.08D in the Humphrey group and 0.11D in the Tomey group. Looking at the Scattergrams, Figures 1 and 2, show an almost even distribution of over and under corrections with the Humphrey A-Scan, and a more hypermetropic distribution of error with the Tomey A-Scan. The mean errors we found were less than others have reported, with mean errors ranging from 0.45 to 0.64 in other studies.[17,18,19]

Our study showed a statistical difference in mean errors between the Humphrey and Tomey groups. However, visual outcomes were similar between the groups suggesting that the statistical difference in mean error may not be clinically significant.

This study is in agreement with Whelehan et al[16] in showing no difference between hand held and slit lamp mounted biometry. Hand held biometry probes have obvious advantages with difficult patients who are unable to co-operate with fixation, or due to physical difficulties are unable to be positioned on the slit lamp, or even simply when a slit lamp is unavailable. Although a true comparison between biometry instruments would involve a randomised clinical trial using both A-Scanners on each patient, this was not possible in this retrospective study design. In addition, an ideal study design would use one biometry operator and one surgeon. The Royal Victorian Eye & Ear Hospital has over 80 visiting Ophthalmologists and Ophthalmic registrars performing cataract surgery and 20 Orthoptists performing biometry. Adjusting A-constants for individual surgical techniques is therefore not possible and there will be variation within individual practitioners. These methodological limitations should be kept in mind when interpreting these results.

Both the Humphrey and Tomey A-Scanners use ultrasound to measure axial length. Carl Zeiss has recently introduced a laser biometer to measure axial length. This new technology is fully automated eliminating operator error, comfortable for the patient, and being a non-contact instrument reportedly gives axial length results comparable to immersion A-Scan. However light does not travel easily through cataracts and the usefulness of this technology needs to be determined.

With continually improving surgical techniques, developing biometric technology and increasing patient expectations, cataract surgery is increasingly becoming refractive surgery. Routine monitoring of the refractive outcomes of cataract surgery is a highly recommended quality measure that can detect any systematic introduction of error.

References

1. Erickson P. Effects of intraocular lens position errors on postoperative refractive error. J. Cataract Refract Surg 1990; 16: 305-310.

2. Apple D, Park S, Merkley K, Brems R, Richards S, Langley K, Piest K, Isenberg R. J. Posterior chamber intraocular lenses in a series of 75 autopsy eyes. J Cataract Refract Surg 1986; 12: 358-362.

3. Setala K, Ruusuvaara P, Mianovicz J, Tarkkanen. Anterior Chamber Depth after Sulcus vs Capsular-bag Fixation of Posterior Chamber Intraocular Lenses. Eur J Implant Ref Surg 1992; 4: 29-32.

4. Armstrong T. Refractive effect of capsular bag lens placement with the capsulorhexis technique. J Cataract Refract Surg 1992; 18: 121-124.

5. Olsen T. Sources of error in intraocular lens power calculation. J Cataract Ref Surg 1992; 18: 125-129.

6. Nurozler A, Unlu N, Yalvac I, Kasim R, Duman S. The SRK11 formula in the Calculation of Intraocular Lens Power. Ophthalmolgica 1998; 212: 153-156.

7. Olsen T, Thim K, Corydon L. Accuracy of the newer generation intraocular lens power calculation formulas in long and short eyes. J Cataract Ref Surg 1991; 17: 187-193.

8. Brandser R, Haaskjold E, Drolsum L. Accuracy of IOL calculation in cataract surgery. Acta Ophthalmol Scand 1997; 75: 162-165.

9. Olsen T, Olesen H. IOL power mislabelling. Acta Ophthalmol 1993; 71: 99-102.

10. Courtright P, Paton K, McCarthy M, Sibley L, Holland S. An epidemiologic investigation of unexpected refractive errors following cataract surgery. Can J Ophthalmol 1998; 33: 210-215.

11. American Academy of Ophthalmology Focal Points. Vol X111. No. 10. 1995.

12. Kalogeropoulos C, Aspiotis M, Stefaniotou M, Psilas K. Factors influencing the accuracy of the SRK formula in the intraocular lens power calculation. Documenta Ophthalmologica 1994; 85: 223-242.

13. Olsen T, Nielsen P. Immersion versus contact technique in the measurement of axial length by ultrasound. Acta Ophthalmologica 1989; 67: 101-102.

14. Schelenz J, Kammann J. Comparison of contact and immersion techniques for axial length measurement and implant power calculation. J Cataract Refract Surg 1989; 15:425-428.

15. Snead P, Rubinstein S, Haworth S. Calculated Versus A-Scan Result for Axial Length Using Different Types of Ultrasound Probe Tip. Eye 1990; 4: 718-722.

16. Whelehan I, Heyworth P, Tabandeh H, McGuigan S, Foss A. A comparison of Slit Lamp Supported Versus Hand-Held Biometry. Eye 1996; 10: 514-516.

17. Sanders D, Retzlaff J, Kraff M, Gimbel H, Raanan M. Comparison of the SRK/T formula and other theoretical and regression formulas. J Cataract Refract Surg 1990; 16: 341-346.

18. Retzlaff J, Sanders D, Kraff M. Development of the SRK/T intraocular lens implant power calculation formula. J Cataract Ref Surg 1990; 16: 333-339.

19. Hoffer K. The Hoffer Q formula: a comparison of theoretic and regression formulas. J Cataract Refract Surg 1993; 19: 700-712.