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Kertas Asli/*Original Articles*

Comparison of Refractive Outcomes in Post Cataract Surgery using Measurements from Immersion and Contact A-scan Biometry Techniques

(Perbandingan Hasil Refaksi Pos Surgeri Katarak Menggunakan Pengukuran dari Teknik Imersi dan Biometri A-scan)

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ABSTRACT

It is possible that different techniques used to measure axial length (AL) and anterior chamber depth (ACD) is the cause of discrepancy in refractive outcomes of cataract surgery. This study evaluated the agreement and repeatability of AL and ACD measurements using immersion and contact A-scan biometry techniques and compared the refractive outcomes from both techniques. Twenty four patients were evaluated for agreement and repeatability of AL and ACD measurements using the two different methods. The results were analyzed using Bland and Altman plots. Another 60 patients with age-related cataract were selected to compare the refractive outcomes between both methods. The IOL power was calculated using Sanders- Retzlaff- Kraff- Theoretical (SRK-T) equation. Refraction was determined between four to six weeks postoperatively and the results were analyzed using paired t-test. The results of this study showed good agreement between both techniques was noted with no significant difference detected between measurements ($p > 0.05$). Significant correlation was found in all parameters (AL: $r = 0.99$; $p < 0.01$, $r = 0.99$; $p < 0.01$) ACD: $r = 0.91$; $p < 0.01$, $r = 0.97$; $p < 0.01$). No significant difference in refractive outcomes of post cataract surgery was detected between the two techniques ($p = 0.07$). This study concludes that contact A-scan biometry and immersion techniques provide reliable results and should not be the cause of discrepancy in the refractive planned and outcome of cataract surgery.

Keywords: Cataract, refractive outcomes, immersion, A-scan biometry

ABSTRAK

Terdapat kemungkinan satu daripada perbezaan hasil refraksi surgeri pos katarak adalah disebabkan oleh penggunaan teknik yang berbeza untuk pengukuran paksi aksial (AL) dan kedalaman kamar anterior (ACD). Kajian ini menilai persetujuan dan kebolehulangan pengukuran AL dan ACD menggunakan teknik imersi dan biometri A-scan serta membandingkan hasil refraksi surgeri pos katarak menggunakan kedua-dua teknik tersebut. Seramai 24 orang pesakit katarak digunakan untuk menilai persetujuan dan kebolehulangan kedua-dua teknik dan hasil kajian dianalisa menggunakan plot Bland dan Altman. Enam puluh (60) orang pesakit katarak pula digunakan untuk perbandingan hasil refraksi. Pengiraan kuasa IOL dilakukan menggunakan rumus Sanders- Retzlaff- Kraff- Theoretical (SRK-T). Hasil refraksi ditentukan 4 hingga 6 minggu pos surgeri dan keputusan dianalisa menggunakan ujian t berpasangan. Keputusan kajian menunjukkan persetujuan yang bagus antara kedua-dua teknik dan tiada perbezaan yang signifikan ($p > 0.05$) diperolehi antara pengukuran. Korelasi yang signifikan diperolehi untuk semua parameter yang diukur (AL: $r = 0.99$; $p < 0.01$, $r = 0.99$; $p < 0.01$) ACD: $r = 0.91$; $p < 0.01$, $r = 0.97$; $p < 0.01$). Tiada perbezaan yang signifikan dikesan untuk hasil refrkasi ($p = 0.07$) menggunakan pengukuran dari kedua-dua teknik. Kajian ini merumuskan bahawa teknik imersi dan biometri A-scan memberikan keputusan yang boleh dipercayai. Pengukuran dari kedua-dua teknik ini tidak menyebabkan perbezaan dalam hasil refraksi surgeri pos katarak.

Kata kunci: Katarak, hasil refraksi, imersi, biometri A-scan

INTRODUCTION

Cataract surgery with intraocular lens (IOL) implantation is the most frequent ophthalmic surgical procedure today. The critical step in attaining the desired postoperative refractive outcome is measurement of the axial length (AL). Studies based on ultrasound showed that 54% of the error in predicted refraction after IOL implantation is attributed to errors in AL measurement (Olsen 1992). A measurement error of 100 µm in AL is estimated to result in a corresponding postoperative error of approximately 0.28 Diopter (D) (Olsen 1987).

It is generally accepted that the mean absolute predicted error in children is less accurate than that obtained in adult surgeries. Ben-Zion et al. (2008) found no significant difference in prediction error accuracy between immersion and contact ultrasound biometry techniques among children. Lens prediction error for the contact A-scan subgroup was 1.11± 0.90D, whereas the immersion A-scan subgroup was 1.03 ± 0.98D (p = 0.6442). Tromans et al (2001) measured 52 pediatric eyes using contact A-scan biometry and reported a mean prediction error of 1.40D.

In a study on adult patients, the authors reported that the mean error of difference found between the predicted and achieved postoperative refraction was -0.32D ± 1.05D; with 72.3% of eyes within ±1.00D of the planned refraction (Murphy et al. 2002). Langrasta et al. (2009) measured the AL of 33 adult eyes with nuclear cataract using contact ultrasound biometry and reported that mean predicted refraction was -0.43D ± 0.18D and the mean achieved postoperative refractive outcome was -0.22D ± 0.73D. However, no comparison was made between immersion and contact techniques in both studies.

At present there are two types of A-scan ultrasound biometry that are commonly used in Malaysia. The first is contact or applanation A-scan biometry. This technique requires placing an ultrasound probe on the central cornea. The second type is immersion A-scan biometry, which requires placing a saline filled scleral shell between the probe and the eye. According to the first report of the Malaysia National Eye Database (NED) (Zainal et al 2002), for patients who has had cataract surgery with phacoemulsification, the mean difference between planned and final refractive power was -0.38D ± 1.15D, which is a signifying a myopic shift. In 2007, most of the hospitals involved in the Cataract Surgery Registry in Malaysia were using contact A-scan biometry to measure the AL. Range of difference between planned and final refractive power (D) in spherical equivalent showed that only 23.6% of eyes had differences within 0D to -1.00D, which is considered ideal outcome while 71.1% had differences between -1.00D to +1.00D, 1.5% had differences of more than +2.00D and 6.6% with difference of higher than -2.00D.

It is possible that the significant difference between planned and final refractive power was due to the technique used in measuring AL and ACD. We undertook this cross sectional clinical study to compare the difference between planned and final refractive power outcome post cataract surgery with phacoemulsification using measurements from immersion and contact A-scan biometry techniques. The agreement and repeatability of measurements from both techniques were evaluated at the initial stage of the study. Results from this investigation will improve the standard of cataract surgery in this country.

MATERIALS AND METHODS

This is a prospective study where subjects were recruited from patients who were undergoing cataract surgery with posterior intraocular lens implanted in the Eye Clinic, Hospital Umum Sarawak, Kuching, Malaysia. The number of subjects included in this study was calculated based on the prevalence of cataract in Malaysia which is 2.58 in every 100 population (Zainal et al. 2002). Following Kish's (1965) formula for sample size calculation and using the precision of 5%, the number of subjects required per treatment group is 40.

The inclusion criteria were as follows: (1) patients presenting with age related cataract (2) patients planned for phacoemulsification (PC) with PC IOL implant. (3) age of more than 40 years old and (4) axial length between 22 mm to 27 mm. Patients undergoing the cataract surgery under extra capsular cataract extraction (ECCE) with anterior or posterior lens implanted were excluded from this study because more time was needed for the suture to dissolve and stable for the post-operation refraction The axial length of eye ball between 22 mm to 27 mm was chosen in this study because previous study showed high accuracy between the two measurements of AL (Sanders et al. 1981). Informed consent was obtained from each subjects and this study was approved by the Medical Ethics Committee of UKM. The research followed the tenets of the Declaration of Helsinki.

Refractive error was determined with Handheld Autorefract Keratometer (Retinomax Kplus 3 from Righton, Japan) and refined using cross-cylinder technique. For post-operation refraction, refractive error was determined at between four to six weeks after cataract surgery, that is after the surgical sutures had dissolved and stable refraction can be obtained. The spherical equivalent was determined from the final prescription. Clear Chart Digital Acuity System, (Reichert, United States of America) was used to measure VA at 3 meters during pre and post-operation assessment. Keratometer reading was measured using Handheld Keratometer (Nidek KM 500, Japan). Three readings were taken for every subjects and the mean was recorded.

Measurements of axial length (AL) and anterior chamber depth (ACD) were determined with Sonomed A-scan, (PACSCAN 300A, USA). Local anesthetic (0.5% Alcaine, Alcon Lab. Inc, USA) was instilled in the subject's eye prior to measurements. Measurements were taken using the immersion A-scan biometry first followed by contact A-scan biometry by the same examiner. For immersion A-scan; a Prager scleral immersion shell was used and chamber was filled with normal saline connected by the silicone tube. Prior to measurement, patient was seated partially reclined in the examination chair and was asked to fixate on the target light of the probe. Automated sequences of five reliable readings were taken according to the preset amplitude and timing criteria for the ultrasound reflections with one application of the shell and probe. For contact A-scan; the probe was placed gently over the cornea and an automated sequence of five reliable readings with characteristic peaks was taken, according to the preset amplitude and timing criteria for ultrasound reflections. Unreliable readings were discarded and the mean was recorded.

The intra ocular lens power (IOL) calculations were determined by the surgeons using Sanders-Retzlaff-Kraff (SRK) equation. The equation was the first regression formula designed for calculation of IOL power (Ray et al. 1985) and is commonly used in the eye clinics in Malaysia. Biometry prediction error was determined for each case by the measuring the difference between the actual postoperative refraction and the preoperative predicted refractive outcome, in spherical equivalent. Predicted postoperative refraction was determined during pre-operation assessment while actual postoperative refraction was determined during refraction after cataract surgery. All subjects were implanted with acrylic intra ocular lens from different manufacturers (Acrysof SN 60AT, Acrysoft IQ SN 60WF from ALCON Laboratories Inc, VA60BB from HOYA, AR40e from AMO, Akreos-Adapt, MI60 from Bausch & Lomb Surgical Inc) depending on the patient's requirement and economical status.

REPEATABILITY AND AGREEMENT STUDY

Twenty four (24) patients were evaluated to compare the repeatability and agreement between 2 qualified Optometrists (O1, O2). Both Optometrists have more than five years experience in handling the equipments in public hospitals. Data for the right eye only was measured to avoid the confounding effect of using non-independent data from both eyes (Bland & Altman 1986). This was a double blind study where the researchers and surgeons did not know which technique was used to measure the axial length and anterior chamber depth. Data were collected from patients undergoing cataract surgery under two consultant Ophthalmologists between May and September 2010. All patients must undergo pre-operation assessment where measurements of ocular parameters and IOL calculation were conducted.

REFRACTIVE OUTCOMES

Sixty subjects (including 24 from the initial phase of study) were recruited for the second part of the study. The subjects were divided into 2 groups, that is Group A and Group B. Patients in Group A (N = 30) were implanted with IOL power calculated using immersion A-scan biometry measurement while Group B patients (N = 30) were implanted with IOL power calculated using measurements from contact A-scan biometry. All the measurements were conducted by one independent Optometrist.

Two equally trained and experienced surgeons performed 30 surgeries each, on subjects of both groups (15 patients with IOL power calculated using measurements from contact technique and another 15 patients using measurements from immersion technique). The spherical equivalent of the actual post operative refraction was recorded in Diopters (D) and the biometry prediction errors were then calculated.

STATISTICAL ANALYSIS

Data forms were reviewed for accuracy before data entry. Normalization was done against baseline data for the pre-operation and post operation cataract surgery data. The threshold of statistical significance for this study was taken as the p = 0.05 level. Nonparametric (Mann-Whitney U test and Wolcoxon Signed Rank Test) and parametric techniques (Paired t-test and Independent t-test analysis) were used to compare the parameter results using the two different techniques pre and post surgery. This was dependent on whether the distributions of the parameters measured were normal or not according to the Shapiro-Wilk test. Regression and Bland & Altman (1986) analyses were used to for analysis of correlation and agreement of the two operators and two techniques.

RESULTS

Around 116 patients were screened and 92 of them fitted the inclusion criteria and agreed to participate in this study. However, 11 of them cancelled their surgery due to medical problems such as hypertension and diabetes while another 7 of them refused surgery because of various reasons like financial problems, difficulties in traveling and others. Three of the patients who underwent cataract surgery had intra complications and another 11 did not turn up for post operation refraction due to difficulties in travelling. Most of patients live in rural areas and require several days to travel to the hospital. The final number of patients that completed the study was 60.

The range of age of for all subjects was from 43 to 88 years (mean 67.37 ± 8.44 years). Sarawak's population consists of multi ethnic groups. The subjects group race composition was 9 (15%) Malays, 27 (45%) Chinese, 11(18%) Bidayuh, 12 (20%) Iban and 1 (2%) others. Their gender composition was 32 (53%) male and 28 (47%) females. Operated eye composition was 27 (45%) right eye and 33 (55%) left eye. Their unaided VA preoperatively ranged from hand movement to 0.5 (6/19). The range of corneal dioptric power for all subjects preoperatively was from 40.75 to 46.50 D in the vertical meridian (mean 43.73 ± 1.22 D) and from 41.75 to 48.25 D (mean 44.71 ± 1.17 D) in the horizontal meridian. Their unaided VA postoperatively ranged from 6/60 to 6/6 while range of corrected VA was from 6/15 to 6/6. Type of IOL composition implanted into subjects eye was 22 (37%) from ALCON, 20 (33%) from Baush and Lomb, 10 (17%) from AMO and 8 (13%) from HOYA.

REPEATABILITY AND AGREEMENT STUDY

The range of age for 24 subjects in this study was from 56 to 81 years (mean 68.04 ± 7.14 years). The subjects group race composition was 5 Malays, 14 Chinese, 4 Bidayuh, and 1 other. Their gender composition was 12 (50%) male and 12 (50%) females. The analysis showed that the intra-operator standard deviation for O1 was 0.08 and 0.07 for O2 in AL measurement. For O1, the respective repeatability coefficient using the same analyses of the contact and immersion technique was 0.22 and 0.30

while the respective repeatability coefficient of contact and immersion technique was 0.26 and 0.27 for O2 (Table 1). In measurement of ACD, the intra-operator standard deviation was 0.24 for O1 and 0.18 for O2. The respective repeatability coefficient of the contact and immersion technique for O1 was 0.13 and 0.11, respectively and was 0.18 and 0.14 for O2. The analysis showed similar repeatability between both techniques for AL and ACD measurements by both Optometrists.

TABLE 1. Repeatability coefficient of contact and immersion techniques for measurements of axial length and anterior chamber depth

Axial length	Intra-Operator Standard Deviation	Repeatability coefficient Contact	Immersion
Operator 1	0.08	0.22	0.30
Operator 2	0.07	0.26	0.27
Anterior chamber depth			
Operator 1	0.24	0.13	0.11
Operator 2	0.18	0.18	0.14

Using Bland – Altman analyses, the mean difference (bias) between both techniques in AL measurement by O1 was -0.01 mm (-0.04, 0.02, 95% CI) and 0.000 mm (-0.03, 0.03, 95% CI) by O2 (Table 2). In measurement of ACD, the mean difference (bias) between both techniques measured by O1 was -0.092 mm (-0.19, 0.01, 95% CI) and -0.075 mm (-0.15, 0.003, 95% CI) by O2 (Table 2). Good agreement was noted between both techniques in axial length and anterior chamber depth measurement by both operators.

REFRACTIVE OUTCOME POST CATARACT SURGERY

In this study biometry prediction errors (PE) and absolute biometry prediction errors (APE) were calculated to represent the refractive outcome after cataract surgery. Mean APE was considered to represent the main refractive

TABLE 2. Mean difference between both technique and 95% limit of agreement for axial length and anterior chamber depth

Axial length	Mean difference (mm)	95% CI of mean difference	95% limit agreement Lower	Upper
Operator 1	-0.01	-0.04, 0.02	-0.16	0.14
Operator 2	0.00	-0.03, 0.03	-0.13	0.13
Anterior chamber depth				
Operator 1	-0.09	-0.19, 0.01	-0.56	0.38
Operator 2	-0.07	-0.15, 0.003	-0.43	0.28

outcome because it was already corrected the "canceling out" effect of overcorrection versus undercorrections (Nihalani & VanderVeen 2010). Comparison of PE and APE in this study was tabulated with their appropriate parametric analyses in Table 3. Analysis using independent samples t-test (difference in mean) indicated insignificant difference of PE ($p = 0.07$) and APE ($p = 0.61$) between both techniques.

DISCUSSION

Results of this study showed that there was good repeatability and agreement between contact and immersion techniques in ultrasound A-scan biometry for AL measurement. In AL measurement, the 95% limit of agreement between the two techniques was satisfactory and clinically acceptable by both operators. Kitthaweesin and Mungsing (2009) reported similar results of repeatability and agreement of the two techniques for the measurement of AL. Their results showed that for operator 1, the respective repeatability coefficient of the contact and immersion technique was 0.24 and 0.21 while for operator 2 was 0.43 and 0.22, which are similar to the present study.

TABLE 3. Comparison of biometry prediction errors and absolute prediction errors between immersion and contact biometry A-scan technique

	Method Immersion	Contact	Significance of difference between 2 techniques
Mean Biometry Prediction Errors ± SD (D)	0.63 ± 0.73	0.28 ± 0.73	p = 0.07 Independent Sample t Test
Mean Absolute Biometry Prediction Errors ± SD (D)	0.74 ± 0.61	0.65 ± 0.43	Z = -0.52 p = 0.61 Mann-Whitney U Test

The present results also showed good repeatability and agreement between both techniques for measurements of ACD. Recent study by Zhang et al. (2010) showed similar results using ultrasound biometry (immersion technique) and anterior segment optical coherence tomography (AS-OCT) in ACD measurements of phakics eyes. However, other authors reported significantly lower ACD values using immersion ultrasound biometry than AS-OCT using similar subjects (Kiss et al. 2002). The results of this study indicate the importance of having experience operators to perform the preoperative measurements. According to Kitthaweesin and Mungsing (2009) the repeatability coefficient of the contact technique when performed by the less-experienced operator was approximately two-fold that of the experienced operator. However, there was no significant difference in the repeatability coefficient of the immersion techniques by either operator.

Minimizing the refractive prediction error (PE) is a primary goal in cataract surgery. Results from this study showed that mean absolute PE was not significantly different between contact and immersion techniques (p=0.61). It is possible that the various designs of IOL used in this study may have influenced the refractive outcomes post cataract surgery. We were unable to control this variable as the selection of IOL design was dependent on evaluation of the surgeons, the type of IOL implanted on the other eye (prior to this study) and the economical status of the patient. In Malaysia, the cost of IOL is paid by the patients themselves. Thus, their economical status influences the selection of IOL.

However, the mean absolute PE of this study was consistent with previous study in adult cataract patients where the mean absolute PE was found to be within ± 0.5 D or ± 1.0 D (Lagrasta et al. 2009). Kiss et al. (2002) showed similar results when they compared refractive outcomes using measurements from optical biometry (IOL Master) and ultrasound biometry. Their results did not differ significantly (p = 0.28) with mean absolute PE of 0.48D and 0.46D, respectively. The authors concluded that refractive outcome in cataract patients using optical biometry was as good as that achieved with ultrasound using immersion technique.

CONCLUSION

This study shows that both immersion and Contact A-scan provide reliable pre operative measurements for cataract surgeries. The measurements, if performed by experienced Optometrists should not be the cause of discrepancy between the refractive planned and outcome of cataract surgery. Other factors such as patient selection and precision of IOL manufacturing should also be examined to ensure that ideal refractive outcomes can be achieved at the end of the surgery.

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