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ORIGINAL ARTICLE

Predictive accuracy of intraocular lens power calculation using applanation ultrasound biometry: can we still rely on ultrasound biometry?

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Abstract

Introduction: Ultrasound biometric measurements have long been the gold standard in cataract surgery. In the course of time, optical biometry replaced ultrasonography as the standard technique for axial length measurements of the eyes. However, optical biometry is not accessible in some centers; therefore, the present study was carried out to evaluate the predictability of refractive outcomes following phacoemulsification using applanation ultrasound biometry.

Methods: In this prospective study, ocular biometry was performed using applanation ultrasound. Thereafter, mean absolute error (MAE) and the percentage of eyes achieving postoperative refraction within 0.5, 1.0, 1.5, and 2.0 D of the predicted spherical equivalent were calculated for SRK/T IOL formulas through a temporal clear corneal incision 1 month after phacoemulsification.

Results: A number of 299 adult cataract patients (323 eyes in total) were enrolled. Absolute refractive mean error was obtained as 0.51±29 D 1 month after the surgery. In addition, 59.4% of the eyes achieved postoperative refraction of ±.5 D of the predicted value. Furthermore, 95.7 % of the eyes were found to be within ± 1.00 D.

Conclusions: Based on the results of the present study, refractive outcomes after phacoemulsification using applanation ultrasound biometry are comparable with international standards for good practice and outcomes. It is worthy to note that this method offers considerable advantages, such as a few measurement limitations, cost-effectiveness, and accessibility.

Key words: Biometry, Refractive Errors, Ultrasound

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Introduction

Phacoemulsification and foldable intraocular lens (IOL) implantation have led to improved success rates and quicker visual rehabilitation in patients undergoing cataract surgery (1). However, the precise calculation of the IOL power required for the attainment of the intended postoperative refraction is still an unresolved issue. The refractive outcome following cataract surgery depends on several factors, including axial length, keratometry, anterior chamber depth, and lens formulas (2). Ultrasound biometric measurements have long been the gold standards in cataract surgery (3). In the course of time, optical biometry has substituted ultrasonography as the standard technique for axial length measurements of the eyes (4). The device has non-contact nature and

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can measure axial length (AL), anterior chamber depth (ACD), and lens thickness (LT) in a single scan (5). A common belief is that optical biometry provides high-precision AL measurement and the IOL implant power calculation, compared to ultrasound. Although ultrasound requires topical anesthesia and corneal applanation, it can measure AL in all eyes except those with intravitreous silicone oil (2). Nonetheless, in certain centers, such as ours, optical biometry is not accessible owing to high cost which may be a matter of concern for ophthalmologists and patients. Accordingly, this prospective study was conducted to reemphasize the prediction accuracy of IOL power calculation using applanation ultrasound biometry.

Methods

The current study was carried out at the Ophthalmology Department of Valiasr Hospital in Birjand, Iran between July 2017 and September 2018. The protocol of the study was approved by the Institutional Ethics Committee under the identifier IR.BUMS.REC.1398.184. Patients planned for cataract surgery were prospectively enrolled. Exclusion criteria entailed: 1) ocular abnormalities, such as keratoconus, 2) previous ocular injury or surgery, 3) obvious opacity in refracting media except for cataract, and 4) posterior capsule rupture during surgery. The same examiner performed all the measurements on the same patient. All the examinations, including AL and keratometry were routine preoperative considerations and patients underwent the usual course of cataract treatment and no additional study-related measure was implemented. AL measurements were carried out via Sonomed direct contact MV4500 Master- Vu A-scan (Optimetric, INC, USA) ultrasound unit. The A-scan unit was equipped with a 12 MHz transducer frequency probe and velocities were set by device per medium, e.g. 1640 m/s for cornea and lens, 1530 for aqueous and vitreous for axial length measurements. Applanation ultrasound was performed following the instillation of one drop of topical anesthetic (Anestocain 0.5%) on the lower conjunctiva. A number of 10 measurements were performed for each eye, and the mean value was recorded. Keratometry was obtained with the automated keratometry (NIDEK ARK-530A; NIDEK Co. Ltd., Gamagori, Japan). All measurements were obtained based on the manufacturer's recommendations. Eyes were categorized according to AL as short (<22 mm), normal (22 to <24.50 mm), and long (>24.50 mm). The IOL power was calculated using the SRK/T formulas intended for postoperative emmetropia in all eyes.

Phacoemulsification was carried out through a temporal clear corneal incision (3.2 mm). A foldable posterior chamber monofocal IOL was implanted in the capsular bag. In addition, all surgeries were performed by one surgeon (MN). As already stated, patients were excluded from the study if posterior capsule rupture occurred. All patients were examined by an ophthalmologist 1, 7, and 30 days after surgery. The best corrected visual acuity, postoperative refraction, and keratometry were monitored in each examination. Patients were scheduled for refraction by autorefractometer in the last postoperative visit.

The refractive outcome was determined 1 month after surgery when the significant difference was calculated between the target spherical equivalent (SE) and the post-operative SE value. The obtained data were analyzed in SPSS software (version 19). Moreover, the percentage of cases achieving postoperative refraction within 0.5, 1.0, 1.5, and 2.0 D of the predicted spherical equivalent was further calculated. The mean error (ME) and the mean absolute error (MAE) were obtained based on the difference between the anticipated and achieved postoperative refraction.

Results

The present study involved the analysis of 323 eyes of 299 adult cataract patients. The AL measurement failure rate was reported as 0.00% for A–scan ultrasound (US). The study population included 147 men (49.2%) and 152 women (50.8%). The postoperative data of 255 eyes were accessible. The mean age of the patients was measured at 67.3 years, and the postoperative mean error was obtained as .51 ±29 D. In addition, 78.2% of eyes had an AL of 22.0 to 24.5 mm (Table 1) and 36.3 % of the eyes were within .50- 1.00 D, 3.1% were reported to be within 1-1.5, and 1.2% were within 1.5-2.00 D (Table 1). Moreover, 59.4% of the eyes achieved postoperative refraction of 0-0.5 D of the predicted value which was significantly higher than 0.55 (P-value=0.006). Postoperative refraction in subgroups was evaluated and most of the patients in short eye and normal eye subgroups achieved statistically significant postoperative refraction of <0.5 (P-value short eye=0.013, P-value normal eye=0.02); however, there was no significant difference between postoperative refraction in long eyes (Table 2).

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Table 1: Results of axial length and absolute refractive error

variable	Percent
Axial Length	
Short eye (<22 mm)	10.9
Normal eye (22-24.5 mm)	78.2
Long eye (>24.5 mm)	10.9
Absolute refraction error	
0-0.5 D	59.4
0.5-1 D	36.3
1.0-1.5 D	3.1
1.5-2 D	1.2

Table 2: Results of subgroups refractive error

Axial length	Postoperative refraction	N(percent)	p-value
<22	<0.5	21(0.75)	.013
	>0.5	7(0.25)	
22-24.5	<0.5	118(0.58)	.020
	>0.5	84(0.42)	
>24.5	<0.5	12(0.48)	1.000
	>0.5	13(0.52)	

Bold numbers show significant difference at 0.05 level

Discussion

The recent developments in phacoemulsification and IOL implantation in cataract and refractive lens surgery led to the promotion of accurate ocular biometry for the achievement of the predicted postoperative refractive outcomes (6). In this study, 59.4% of the eyes attained postoperative refraction within .5 D of refractive aim, which was statistically significant and above the 55% value established as the benchmark standard set by the National Health Service of the United Kingdom. In addition, 95.7% of patients achieved postoperative refraction within 1 D of refractive aim in 1 month, which is comparable to the suggested standard of above 85% (7).

The results of the study conducted by Norrby et al. on recognizing the sources of error in the refractive outcome of cataract surgery indicated that preoperative estimation of postoperative IOL position, postoperative refraction determination, and preoperative AL measurement were the largest contributors of error (35%, 27%, and 17%, respectively) (8). Since the predictability of refractive outcome is mainly based on the accuracy of preoperative AL measurement, the methods used in biometry are developing (1). Optical coherence biometry and ultrasound biometry are both important and popular means of biometry (9). It is widely accepted that optical biometry provides high-precision AL measurement and IOL implant power calculation, when compared to ultrasound (2). However, the ultrasound method is less affected by refractive medium, in comparison with optics method (10). In present study, AL measurement success rate was obtained as 100% despite the presence of patients with dense cataracts. The AL measurement failure rates with IOL Master have been reported as 10%–20% in previous studies (7). Swept-source optical coherence tomography (SS-OCT) technology dramatically improves the rate of attainable AL measurements (8). The higher success rate of SS-OCT technology can be attributed to the higher wavelength (1055 nm), in comparison with partial coherence interferometry (PCI) technology (780 nm, IOL Master) since a shorter wavelength results in a reduced penetration depth due to scattering (9).

The pitfall of the ultrasound method is its potential for corneal compression which may result in shorter AL measurements. The accuracy of AL with ultrasound is approximately 0.10–0.12 mm, as compared to 0.012 mm obtained using optical AL. Ultrasound measures AL from the anterior surface of the corneal apex to the internal limiting membrane (ILM) of the fovea, whereas optical biometry measures AL from the second principal plane of the cornea (0.05 mm deeper than the corneal apex) to photoreceptor layer (0.25 mm deeper than ILM) of the fovea. Theoretically, optical biometry reads longer than ultrasonic AL (4), generating the true optical AL of the eye since the measurements are carried out while the patient

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is fixating measuring the true optical axis extending from the fovea out through the nasal side of the cornea (3).

The results of a study performed by Cech et al. signified that the results of both methods concur significantly if ultrasound probe measurement is carried out correctly pinpointing the fact that the methods are mutually replaceable. Therefore, the application of ultrasound biometry is sufficient when optical biometry is not feasible (11).

The findings of another study performed by Nemeth et al. which compared these two modalities indicated that optical biometry provides only slightly better outcomes, as compared to those of immersion ultrasound with no optimized formulas. However, in the case of new generation formulas with both methods, the optimization of IOL-constants gives significantly better results (12). Naicker et al., in a similar study, revealed no significant difference in the predicted post-operative refractive outcome between immersion A-scan US biometry and optical Lenstar. Based on the obtained results, the immersion A-scan US technique is as accurate as optical methods in the hands of an experienced operator (13). One limitation of the present study was the absence of optical biometry tool to compare the results of ultrasound; therefore, we relied on postoperative refraction and indicated that ultrasound biometry results were consistent with the gold standard.

Conclusions

As a conclusion, refractive outcomes following phacoemulsification using applanation ultrasound biometry are comparable with international standards for good practice and outcomes, with 95.4% of eyes achieving within 1 D of spherical equivalent to the refractive aim. Furthermore, the measurement failure rate was obtained as zero leading to the reemphasis on the prediction accuracy of IOL power calculation using applanation ultrasound biometry with few measurement limitations.

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Conflict of Interest

The authors declared that there is no conflict of interest.

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