Original Article

# Comparison of Post-Operative Outcomes Predicted By Ultrasonic and Optic Biometry after Phacoemulsification

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## ABSTRACT

**Purpose:** To compare postoperative refractive outcomes predicted by ultrasonic and optical biometry after phacoemulsification.

**Study Design:** Descriptive observational.

**Place and Duration of Study:** WAPDA Teaching Hospital and Acuity Eye Center in Lahore Pakistan from January 2022 to May 2022.

**Methods:** The study included 59 eyes with cataracts and required phacoemulsification and implantation of a foldable intraocular lens. They were divided into two groups; (29 in the ultrasonic biometry group and 30 in the optical biometry group). The first group was subjected to ultrasound biometry, whereas the second was subjected to optical biometry. We compared ocular refractions following cataract surgery in two groups. The Mann-Whitney U test was used to compare the mean absolute refractive error (MAE). The operating surgeon was the same in both the groups.

**Results:** All the participants were between 40 and 70 years of age. The preoperative mean target refraction in the ultrasonic group was 0.05 ± 0.13D (range: -0.01 to + 0.17D) and 0.12 ± 0.33D in the optical group (range: -0.01 to +0.49D). Thus, there was a non-significant difference between both groups regarding target refraction (P = 0.58, U = 398.5). The MAE measured for the first group was 0.14 ± 0.46D and for the second group was 0.60 ± 0.53D. The comparison between both the biometry procedures showed that the difference was non-significant between the biometry methods (P = 0.430).

**Conclusion:** The difference between Post-Operative MAE of patients undergoing two different biometry procedures (Optical and Ultrasonic) after cataract surgery was non-significant at P > 0.05.

**Key Words:** Cataract, Optical Biometry, Ultrasonic Biometry, Phacoemulsification, Mean Absolute Refractive Error (MAE).

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## INTRODUCTION

Every year, more than 11 million eyes undergo IOL implantation worldwide.[1] In the majority of patients, functional postoperative vision is easily regained. The success and safety of this procedure is due to continuous advances in surgical technique and measurement methods.

On November 29, 1949, at St. Thomas Hospital in London, Harold Ridley became the first person to skillfully and effectively insert an intraocular lens.[2] The Rayner organization of Brighton, East Sussex, England created the first intraocular lens from ICI's (Imperial Chemical Industry) Perspex CQ polymethylmethacrylate (PMMA). Before 1980s, IOL power calculations were mainly based on the patient's

refractive status before cataract surgery.[3] An inaccuracy of 1 mm in the axial length leads to a post-operative error of 2.88D or 3.00 – 3.50D. similarly, inaccuracy of 1D in Keratometry (K) reading results in an IOL power calculation error of 0.9 – 1.00D.[4] The IOL power prediction methods were developed to ensure higher precision and accuracy in predicting the power of IOL that contributed to ideal postoperative spherical equivalents. Many generations of IOL calculation formulae have been developed. These are either theoretical formulae (based on mathematical principles) or regression formulae (based on post-operative outcomes).

The most commonly used 3rd and 4th generation formulas. SRK/T (T for hypotheses) methodology is a 3rd generation equation that calculates the depth of the anterior chamber (ACD) making use of retinal thickness and corneal index of refraction.[5,6] The anterior chamber density consistent for SRK/T is given by the production company or else could be ascertained by evaluating from Sanders-Retzlaff-Kraff II A-constant trying to apply the mathematical equation to calculate the depth of the anterior chamber = (0.62467 × A) – 68.747.[6] This will be used in the current study.

Nowadays, two biometric methods are used: ultrasound biometry and optical biometry.[7] The most commonly used instruments that are based on optical A-Scan, for example, the Zeiss Intraocular lens Master and the Haag-Streit Lenstar, help to calculate the intraocular lens power. The IOL Master (Carl Zeiss, Germany) was recently launched and is centered on the dual flare partial coherence interferometry PCI concept. It measures optical AL with short-coherence infrared energy (λ = 780 nanometer), which is then transformed to geometric axial length using a group index of refraction.[8] It is a non-contact technology. IOL Master Zeiss 5.4 was used in the current study to evaluate axial length.

The ocular AL can be routinely measured with A-scan ultrasound imaging, which has a disclosed longitudinal resolution of about 200 micrometers and a precision of about 100 – 150 micrometers. Ultrasound biometry requires a contact between an eye and the transducer. In our study ultrasonic biometry was performed by Sonomed (PAC Scan 200 A) biometer which uses the contact method to measure axial length after topical anesthesia with proparacaine eye drops.[9] Ultrasonic biometry is still the most commonly used method for determining axial length of the eye in our part of the world.

To gain adequate refractive outcomes in phacoemulsification, accurate preoperative measurements are required. The accuracy of the preoperative prediction of postoperative refraction is limited by systematic and random error.[9] Currently, mean absolute errors of typically0.4 – 0.5 D can be achieved under optimized conditions. In individual cases, errors as low as 0.25 – 0.3 D have been reported.[10]

We are applying these parameters to our study pre-operatively to evaluate outcomes gained post-operatively by using ultrasonic and optical biometry in two tertiary care centers.

## METHODS

A descriptive study was performed from February 2022 to May 2022, at WAPDA Teaching Hospital and Acuity Eye Centre, Lahore. The sample size calculated from the given formula was 59.

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Where,

$$n = sample\ size$$

$$Z = Confidence\ Interval = 95\% = 1.96$$

$$d = error = 5\% = 0.05$$

$$P = Prevalance\ Value = 0.04_{(21)}$$

So,

$$n = \frac{(1.96)^2(0.04)(1-0.04)}{(0.05)^2} = 59.00$$

The total number of patients was grouped into: **Ultrasonic Biometry = 29, Optical Biometry = 30.** All participants were between 40 to 70 years of age.

The study included patients who underwent normal cataract surgery through phacoemulsification along with IOL implantation. Apart from age-related cataracts, all eyes had no other ocular pathology and no history of ocular surgery or corneal scar. All procedures were performed by a single surgeon. The first group (29 patients) underwent ultrasound biometry, whereas the second group underwent optical biometry (30 patients). In the first group, biometry was performed using non-invasive ultrasonography contact method, after performing Keratometry reading through

a Topcon auto-refractokeratometer. While in the second group, IOL Master was used. Tests were performed by an optometrist or resident medical officer under supervision of a consultant ophthalmologist. Routine phacoemulsification was performed on all patients using a two-step 2.75 mm temporal clear corneal incision and a sub-optical 5.5mm rhexis. A foldable IOL was implanted. Visual acuity assessments and auto-refractions were performed at follow-up visits roughly 1 week and 4 weeks after the surgery. The final assessments were performed at least 6 months after the surgery. In this research, spherical powers were used as a measuring tool; astigmatic errors themselves were not taken into account. The Mann-Whitney U test was used to compare the post-operative refractive outcomes predicted by ultrasonic and optic biometry after phacoemulsification. A p-value of ($P < 0.05$) was considered statistically significant.

## RESULTS

The current study included 59 patients of which 28 (47.5%) were males and 31 (52.5%) were females. All the participants were between the ages of 40 to 70 years. Comparison of IOL power, axial length and target refraction are shown in Table 1.

There was statistically insignificant difference between both groups regarding axial length (P = 0.94, U = 430.0) and target refraction (P = 0.58, U = 398.5). However, the mean IOL power calculated for the ultrasonic group was 19.79 ± 3.04D (range: 14.50 – 28.50D) and 20.80 ± 3.02D for the optical group with a (range: 12.00 – 28.00D). There was a statistically significant difference between both groups regarding obtained IOL powers (P = 0.029, U = 291.5).

Frequency of post-operative refractive error in the ultrasonic group was myopia 20.7% (range: -0.25 to -0.75) and hypermetropia 44.8% (range: 0.25 to 1.50). In the optical group, myopia was 43.3% (range: -0.25 to -2.00) and hypermetropia was 43.3% (range: 0.25 to 1.75). The post-op MAE for the ultrasonic group was 0.40 ± 0.46D and for the optical group was 0.60 ± 0.53D (figure 1). There was no statistically significant difference between the two groups (P = 0.430, U = 373.0).

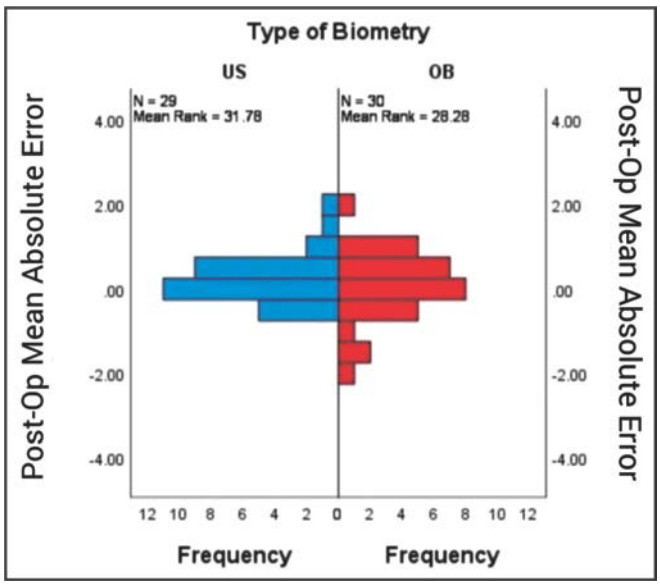


**Figure 1:** Post-Operative Mean Absolute Error.

**Table 1:** *Descriptive Statistics for Axial Length, IOL Power and Target Refraction of Two Biometry Methods.*

| | Ultrasonic Biometry | | Optical Biometry | | Mann-Whitney | |
|---|---|---|---|---|---|---|
| | Range | Mean ± SD | Range | Mean ± SD | U Value | P-Value |
| Axial Length | 20.44 – 25.25mm | 23.25 ± 1.14 | 20.95 – 29.81 mm | 23.47 ± 1.65 | 430.0 | 0.94 |
| IOL Power | 14.50 – 28.50D | 19.79 ± 3.04 | 12.00 – 28.00D | 20.80 ± 3.02 | 291.5 | 0.029 |
| Target Refraction | -0.01 to +0.17D | 0.05 ± 0.13 | -0.01 to +0.49D | 0.12 ± 0.33 | 398.5 | 0.58 |

**Table 2:** *Postoperative Refractions and Types of Cataracts in the Study.*

| Type of Biometry | Refraction Post-operative | | | Type of Cataract | | | |
|---|---|---|---|---|---|---|---|
| | Emmetropia | Myopia | Hypermetropia | Cortical | Nuclear | Posterior Subcapsular | MAE ± SD Post-Operative Refraction |
| Ultrasonic | 10 (34.55%) | 6 (20.7%) | 13 (44.8%) | 6 (20.7%) | 10 (34.5%) | 13 (44.8%) | 0.40 ± 0.46 |
| Optical | 4 (13.3%) | 13 (43.3%) | 13 (43.3%) | 5 (16.7%) | 16 (53.3%) | 9 (30%) | 0.60 ± 0.53 |

## DISCUSSION

Refractive errors, one of the most serious surgical consequences, have been minimized as a result of technological breakthroughs in predicting intraocular lens (IOL) power. The IOL power is currently calculated using two biometric methods: ultrasound biometry and optical biometry. Both procedures have advantages, and it is debatable which should be used before surgery. The current study was done to assess if there was a difference between the two biometry techniques for reducing refractive errors after cataract surgery.[11]

The results of the present study showed that the post-operative MAE obtained for the ultrasonic group was 0.41 ± 0.46D and for the optical group was 0.60 ± 0.53D with a non-significant difference between both groups (P = 0.430, U = 373.0). These findings are comparable to the results of a cohort study done by Heidarali Moeini et al, in 2008, wherein they also found a non-significant difference between the two methods with a post-operative MAE of 0.67 ± 0.70D for the first group and 0.79 ± 0.76D for the second group.[12] Similarly Chia TMT et al, showed that optical biometry IOL and AL measurements were not significantly different from the Ultrasonic measurements. Analysis also demonstrated good agreement between the two methods.[13] Contrary to this another study showed that Optical biometry yielded a significantly larger percentage of cases within ± 0.50D of refractive error compared to ultrasound biometry. However, this study used Barrett Universal II IOL power formula.[14]

Literature shows that one of the advantages of optical biometer is that it is highly reliable for AL measurement, offering observer-independent measurement results.[15]

The use of optical biometry has greatly simplified the procedure of ocular biometry. It is non-invasive technology that does not need the use of topical anesthesia, allowing the patient to be more comfortable while also preventing rubbing of cornea and risk of infection. Theoretically speaking, optical biometry gives more accurate readings than ultrasonic biometry because it helps in measuring both the axial length of the eye as well as the visual axis while maintaining fixation on the measuring beam of light.[16] Ultrasonic biometry requires probe contact with the patient's eye. This is especially important because of the more precise specificity of the fovea in eyes having staphyloma of the posterior pole. The introduction of optical biometry, however, hasn't really deemed ultrasonic biometry outmoded, there is a continuous need of ultrasound biometry, which is still useful in many eye care centers.

Research showed that optical biometer sometimes fail with dense cataracts. The most common reasons for failure of are posterior subcapsular cataract and dense nuclear cataract. Furthermore, because the assessments are not on the visual axis, non-optimal fixation in the eyes, including cases like macular degeneration can lead to imprecise axial length readings.[17] Positioning of patients with limited mobility or problem with focusing can be challenging at times on the optical biometry machine. In one study, posterior subcapsular cataracts including lens opacities and mature cataracts accounted for 16% of failure in measurements with optical biometry.[18]

It was seen in keratoconic eyes that although the difference between the measurements of the two devices might be clinically acceptable, Ultrasound and optical biometer should not be used interchangeably for biometric measurements.[19] Similarly if signal to noise ratio using IOL Master are < 10, postoperative spherical equivalents are more hyperopic than preoperative target refraction by IOL formula.[20]

Limitation of the current study is that we did not take astigmatism into consideration and we did not evaluate each method's accuracy in particular situations such as cataract type (posterior subcapsular, nuclear, or cortical), density of cataract, and refraction before cataract surgery (myopia, hyperopia, and emmetropia). The studies with bigger sample size might help to establish the superiority of optical biometry reported in certain studies.

## CONCLUSION

Based on our findings, the difference between post-operative MAE of patients undergoing two different biometry procedures (Optical and Ultrasonic) after cataract surgery was non-significant at P > 0.05. However, the guarantee of optical biometry to achieve greater precision and consequently considerably better prediction of an individual's post-operative refraction following cataract surgery is still to be achieved.

## Conflict of Interest

Authors declared no conflict of interest.

## Ethical Approval

The study was approved by the Institutional review board/Ethical review board **(OSP-IRB/006-2023).**

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## Authors' Designation and Contribution

Zia-ul-Mazhry; Professor: *Concepts, Design, Data acquisition, Data analysis, Manuscript preparation, Manuscript editing, Manuscript review.*

Faiza Hassan; Optometrist: *Concepts, Design, Literature search, Data acquisition, Data analysis, Statistical analysis, Manuscript preparation, Manuscript editing, Manuscript review.*

Muhammad Abdullah; Medical Officer: *Literature search, Data acquisition, Manuscript preparation, Manuscript editing, Manuscript review.*

Laiba Asif; Medical Officer: *Literature search, Statistical analysis, Manuscript editing, Manuscript review.*