# A Comparative Analytical Study on Intra Ocular Lens Power Calculation with IOL Master and Applanation A Scan Ultrasound Biometry and its Refractive Outcome after Cataract Surgery

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**ABSTRACT**

**BACKGROUND**

Cataract is the leading cause of blindness and visual impairment throughout the world and the commonest cause of visual impairment in older adults. Surgery is the only definitive treatment currently available for visually significant lenticular opacity. Cataract extraction with the implantation of an artificial intraocular lens (IOL) is the most commonly performed ophthalmic surgical procedure. Accurate calculation of IOL power is necessary for attaining the desired postoperative refraction. Aim of this study is to compare the accuracy of Intra Ocular Lens (IOL) power calculation by two different methods, with partial coherence interferometry in Carl Zeiss IOL master and applanation ultrasound biometry, by analysing the post-operative refractive status.

**METHODS**

It is a prospective study, 150 eyes, cataract extraction by single surgeon during March 2013-2014 at Little Flower Institute of Ophthalmology. Before surgery axial length and IOL power measured by both IOL master and contact Amplitude scan (A scan) ultrasound biometry. Surgery was uneventful temporal phacoemulsification, clear-corneal incision with posterior chamber IOL implantation. IOL power calculated with IOL master was implanted for all patients.

**RESULTS**

150 eyes analysed. Mean axial length: IOL Master calculated axial length was 0.02 mm longer compared to ultrasound (p value <.001). Mean spherical equivalent on 2 weeks and 6 week follow up shows no significant difference. Post-operative mean Best Corrected Visual Acuity (BCVA) was 6/6 in 94% patients and 6/9 or better in 99.3% patients.

**CONCLUSIONS**

Though there is no significant difference in mean prediction error and final spherical equivalent with these two machines, the patients who attained refractive accuracy within 0.25 D was considerably more with PCI calculated IOL power compared to A scan. Mean spherical equivalent in patients at 1-2 weeks and 4-6 weeks showed no significant difference, demonstrated the early stability of refractive status after phacoemulsification.

**KEYWORDS**

Cataract, Intra Ocular Lens, Phacoemulsification, IOL Master, Applanation Ultrasound Biometry

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## BACKGROUND

Cataract is the leading cause of blindness and visual impairment throughout the world and the commonest cause of visual impairment in older adults.[1] World Health Organisation estimated that cataract caused reversible visual impairment and blindness in more than 62.5 million individuals world wide.[2] Surgery is the only definitive treatment currently available for visually significant lenticular opacity. Cataract extraction with the implantation of an artificial intraocular lens (IOL) is the most commonly performed ophthalmic surgical procedure. Accurate calculation of IOL power is necessary for attaining the desired postoperative refraction.[3] Refractive outcome after cataract surgery is dependent on several factors including axial length, keratometry, anterior chamber depth, IOL power calculation formulas & method of cataract extraction.[4] One the greatest challenge is the restoration of normal or near normal vision after surgery. The development of better instruments for measuring the axial length (AL) of the eye and pre-operative ocular biometry, the use of more precise mathematical formulas to perform the appropriate calculation of IOL power, and newer techniques of cataract extraction with newer types of intra ocular lenses, have considerably improved the refractive outcomes of cataract surgery.[4] Of these factors the preoperative measurement of axial length is considered to be a key determinant in calculating the IOL power to be implanted.[4,5]

2 methods are commonly available for measurement of axial length, Ultrasound method and Optical method. Ultrasound A scan measures the echoes of eye's tissue interfaces with an ultrasound beam and measures the distance between corneal vertex to Internal Limiting membrane as axial length.[6] Ultrasound biometry requires a skilled operator, good corneal surface contact of a transducer with the eye either directly or through an immersion bath of normal saline.[6] The introduction of non-contact optical biometry has revolutionized preoperative biometry and IOL power calculation by eliminating the obstacles met in conventional A scan biometry. A dual beam version of the optical coherence tomography (OCT) partial coherence interferometry (PCI), which is insensitive to longitudinal eye movements, uses the cornea as reference surface. It measures the distance from corneal vertex to retinal pigment epithelium.[7,8]

Expectations following cataract surgery today are not limited to just restoration of vision alone but wanting vision close to what a young normal patient has, in other words qualitative emmetropia. Both methods have their own advantages and the preoperative choice regarding the method is often controversial. In this study we compared the refractive outcome in cataract surgery following biometry with the applanation A-scan ultrasound and partial coherence laser interferometry.

We wanted to compare the accuracy of IOL power calculation for cataract surgery by partial coherence interferometry (PCI) in IOL master (Carl Zeiss 500) and applanation ultrasound biometry (Sonomed AB 5500+ model) by comparing post-operative refraction, where cataract surgery was done by phacoemulsification with IOL implantation. We also wanted to determine as to whether partial coherence interferometry technology increases the accuracy of post-operative refractive outcomes compared with applanation ultrasound &evaluate the refractive outcome after cataract surgery in the selected group.

## METHODS

This is a prospective observational study. Patients undergoing cataract extraction by an experienced single surgeon in Little Flower Institute of Ophthalmology Angamaly, during the period of March 2013 – 2014. Pre-operative ophthalmic examination including best corrected visual acuity, subjective refraction, anterior segment slit lamp examination, type and grades of cataract and retinal evaluation done for all patients. Pre-operative refractive status has been noted. Written informed consent was obtained from all patients. Consent for cataract surgery taken after explaining all the benefits, procedure and complications of surgery.

### Inclusion Criteria

Age: 40-70 yrs. with Immature cataract,
Axial length 21-24.5 mm

### Exclusion Criteria

Dense cataract, Complicated cataract, Corneal scar, Macular pathology, History of ocular disease such as glaucoma, optic atrophy, retinal diseases, Dense Posterior Sub capsular opacity, Pre-operative astigmatic refractive errors >1.5 D.

### Technique

Axial length and IOL power calculation for designated surgical eye of all patients was measured by both partial coherence interferometry (IOL master 500, Carl Zeiss) and contact A scan ultrasound biometry (Sonomed AB 5500+ model). Axial length as well as IOL power calculated kept blind with each machine. To eliminate the confounding variable introduced by keratometry performed with different techniques, autokeratometry with IOL Master is performed for all patients in which when the patient fixates a cross hair, a circle in the middle will appear in the display. Measurements taken when the six peripheral points appear optimally focused on the display. Axial length with IOL Master conducted before AUS for all patients to avoid alterations in reading due to contact biometry.

With IOL master, axial length is measured by asking the patient is to look at fixation light. On the display a cross hair with a circle in the middle appears and axial length measurements will be made to the centre of the macula, giving the refractive axial length, rather than the anatomic axial length. Axial length protocol, repeated 4 scans within

0.02 mm of ideal wave form, >10 SNR (signal noise ratio) which indicates the quality of measurements. Average of these reading is taken as final axial length reading. The ACD measurement is based on the optical cross-sectional image of the anterior chamber by means of a slit lamp with subsequent image analysis. IOL power calculation in IOL master done using SRK II, SRK T, Holladay and Hoffer Q formula. A constant is decided depending on the type of intra ocular lens used.

A scan Ultrasonography axial length is taken by single examiner who is unaware of the axial length measurement obtained with IOL master. Patient seated in comfortable upright position and asked to look straight, axial length measurement taken by hand held direct contact probe. Move the probe forward until contact with cornea is achieved and once contact is made, a live A scan pattern will be displayed, and no further movement is made. Axial Length measurement accuracy ± 0.10 mm, repeated measurements until 4 scans consistent with in ± 0.10 are obtained. IOL power calculation is done by regression II formula. Targeted refraction is emmetropia in all patients. Cataract removal and IOL implantation done by single experienced surgeon, uneventful temporal phacoemulsification with self-sealing clear corneal incision, 3.2 mm, within the bag fixated foldable posterior chamber IOL. IOL power calculated with IOL master, SRK 2 formula was implanted for all patients.

Patients are reviewed at 2 weeks and 6 weeks. All patients underwent uncorrected visual acuity & best corrected visual acuity using Snellen's visual acuity chart, subjective refraction, auto refraction in each visit and the values are recorded. No incidence of post-operative complications were noted. Refractive errors in each post op visits converted to spherical equivalents by adding spherical power and half of the cylindrical power. For all patients from the present spherical equivalent value obtained, we predicted what will be the spherical equivalent if we were implanting A Scan calculated IOL power. This is recorded as the presumed spherical equivalent with A scan. If there is difference in calculated IOL power with two biometry methods, we get a different spherical equivalent value as presumed A scan spherical equivalent. Thus, retrospective analysis of A scan Ultrasound values also done. The postoperative refractive accuracy is determined for both methods.

### Data Analysis

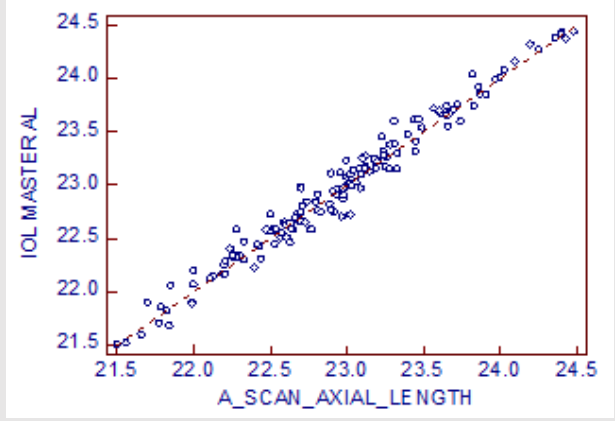
Statistical analyses were performed using MedCalc v12.5.0. Axial length measurement and the IOL power calculated by IOL master and Ultrasound A scan compared. The visual results are expressed as the percentage of eyes that achieved uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA) 6/9 or better. Postoperative refractive error is determined and compared with the predictions made by these two types of biometry. Refractive errors converted in to spherical equivalents. Mean prediction error for IOL calculation with both instruments noted. Stability of refraction in 2nd post-operative week as well as 6th post-operative week also compared.

## RESULTS

150 eyes of 150 patients analysed. The mean age was 65.07±8.19 yrs. 49.3% were Males and 50.7% were Females.

### Axial Length Measurements

Pre-operative Mean AL: With IOL master: 22.95 ± 66 mm, and with contact A Scan ultrasound biometry: 22.93 0.65 mm. Comparing the axial length measurements, mean Axial length measured by IOL master was longer by 0.02 mm and on Paired T test, this difference is significant (P value 0.0248) On calculating concordance correlation coefficient, showed an accuracy of 0.9995 between both the machines in axial length measurements, which denotes substantial agreement between the axial length measurement by two methods. Bland Altman analysis, done to find out the agreement between these two machines showed that most of the values are within SD ± 1.96. But some values are beyond SD ± 1.96, these methods cannot be used interchangeably with full agreement for axial length measurements.




***Graph 1. Concordance Coefficient of Axial Length Measurement with the Two Machines***

### Keratometry

Preoperative corneal curvature: Mean K1 44.05 ± 1.49 D, Mean K2 44.80 ± 1.53 D. Corneal astigmatism: 0.7 ± 0.48 D.

### IOL Power Calculation

Mean IOL Power calculated with IOL master by SRK2 Formula 21.20± 1.34 D. Mean IOL power calculated with A scan ultrasound biometry: 21.12 ± 1.37 D Comparing IOL Master Power with SRK 2 and A Scan Power, these two with concordance correlation coefficient, showed moderate strength of agreement (concordance correlation coefficient 0.943) between these two values. Bland altman analysis also showed good agreement between the two with a mean of 0.0066 D with all values within the limit of agreement.

**Post-Operative Results**

Post-operative Uncorrected visual acuity (UCVA) was 6/9 or better in 133 (88.6%) patients. Post-operative mean Best corrected visual acuity (BCVA) was 6/6 in 141 (94%) patients and 6/9 or better in 149 patients (99.3%).

**Stability of Refraction**

To assess stability of refraction, refraction at 2 weeks and 6 weeks were compared. Mean spherical equivalent at: 1-2 weeks 0.10 ± 0.38 D, 5 - 6 weeks 0.10±0.37 D Paired T test showed no significant difference between these two values. (p value 0.9758)

**Post-Operative Refractive Error**

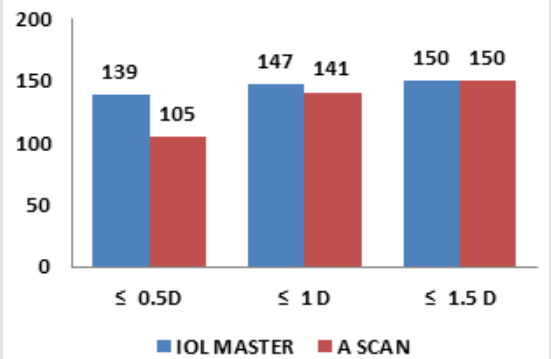
Mean prediction error with IOL master: 0.10±0.37 D Mean prediction error with A scan: 0.12±0.57 D Unpaired T test shows no significant difference in the mean prediction error in IOL power calculation with IOL master and Ultrasound (P value 0.7188)

| Spherical Equivalent (±) | ≤ 0.5 D | ≤ 1.00 D | ≤ 1.5.00 D |
|---|---|---|---|
| IOL MASTER | 139 (93%) | 147 (98%) | 150 |
| A SCAN (PRESUMED) | 105 (70%) | 141 (94%) | 150 |

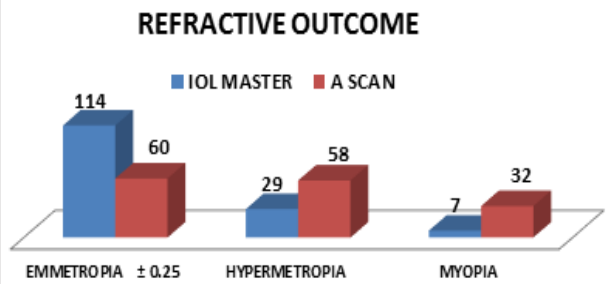
***Table 1. Final Refractive Outcome at 4-6 Weeks***

| | Emmetropia | Hypermetropia | Myopia |
|---|---|---|---|
| IOL MASTER | 114 (76%) | 29 (19.3%) | 7 (4.7%) |
| AUS | 60 (40%) | 58 (38.7%) | 32(21.3%) |

***Table 2. Percentage of Patients Obtained Emmetropia, Hypermetropia and Myopia Postoperatively***




***Graph 2. Spherical Equivalent at 6 Weeks***




***Graph 3. post-Operative Refractive Error***

Graph shows that with IOL master calculated power 93% patients had spherical equivalent ± 0.5 D and 98% of patients had spherical equivalent ± 1.00 D. If we are using ultrasound calculated IOL power, it has been calculated that 70% patients will have spherical equivalent ± 0.5 D and 94% of the eyes will have postoperative refraction of ±1 D of the predicted value. On Chi- square test for comparison of these two proportion, showed that there is a significant difference between the two, for ± 0.5 D prediction error in spherical equivalent with p value <0.0001, and within ± 1 D no significant difference in the prediction error. (p value 0.1504).

**Refractive Outcome**

Emmetropia is calculated with those with spherical equivalent within 0.25 D. Hypermetropia included spherical equivalent with positive value. Myopia with spherical equivalent with negative value. On comparison of post-operative refractive error in terms of spherical equivalent we could see that even though there is no statistically significant difference between the final spherical equivalent obtained by these two machines, the number of patients who attained emmetropia was high with IOL master, compared to Ultrasound, on comparing with chi-square test, for the comparison of these two proportion which is significant with, p value <0.0001. Within 1 D there is no significant difference between the two calculation.

## DISCUSSION

Cataract surgery has become a refractive procedure, it requires precision in each step, in order to meet patients expectations. In order to obtain this goal, main step is the accurate calculation of IOL power and for which preoperative axial length measurement is the key step.[4,5,9] Of the techniques available for axial length measurement PCI based prototypes have been demonstrated to measure very accurately the AL with precision comparable to or even better than that ultrasound biometry.[10,11] But the mixed conclusions from various trials render this topic debatable.

In our study we evaluated the axial length calculated with IOL master and contact applanation ultrasound method. Refractive outcome for those patients who are undergoing cataract extraction with foldable IOL implantation surgery done by phacoemulsification. In our study it has been found that the axial length measured with IOL master was longer by 0.02 mm and on paired T test this difference was found to be significant with (P= 0.012).Some of the other studies also showed an increased axial length measurement with IOL master ranging from 0.18 mm to 0.47 mm.[4,12,13,14] This difference may be attributed to possible corneal indentation and shortening of the AL during applanation and the ultrasound is reflected mainly at the internal limiting membrane whereas the light of the IOL Master measures from the retinal pigment epithelium, thus resulting in a difference that corresponds to the retinal thickness of the fovea.[14]

Of the recruited patients, who fit in to inclusion criteria after primary ophthalmic evaluation, axial length could not be assessed by IOL master because of more density of cataract in 6 patients and thick posterior sub capsular cataract in 12 patients, so they had to be excluded from the study (10.7%).Other studies also had excluded up to 15-20% of patients who were not measurable by PCI.[3,4] Causes were mainly inattention, corneal scarring, and dense cataracts Failure rate is less compared to other studies may be because we already excluded dense cataract corneal scar in the patient selection itself.[3,4,12,15] In such circumstances measurements could be taken only by ultrasound method. This indicate that at present PCI cannot supersede AUS for all routine biometry. This situation may change if cataracts are removed before they become too dense for the PCI measurement. Backup ultrasonic biometry is still necessary, even with this new technology because advanced cataracts are still common in our set up.[16]

Mean spherical equivalent in patients at 1-2 weeks and 4-6 weeks showed no significant difference demonstrated the early stability of refractive status after phacoemulsification, as evidenced by similar studies.[17,18,19] This help us in confidently prescribing spectacles early,[20] within 1-2 weeks, in order obtain early visual recovery.[20]

## CONCLUSIONS

IOL master biometry is non-contact method and its rapidity in measuring multiple variables in one sitting, has simplified considerably the process of ocular biometry compared to the contact ultrasound biometry. The employment of the optical biometry has improved significantly the refractive results of cataract surgery. Though there is no significant difference in mean prediction error and final spherical equivalent with these two machines, the patients who attained refractive accuracy within 0.25 D was considerably more (p value <0.001) with PCI calculated IOL power compared to A scan i.e., final refractive accuracy is more with IOL master. AUS is still essential in every ophthalmic practice due to inability of PCI technology to measure axial length is typically due to posterior sub capsular cataract and dense nuclear cataract. Mean spherical equivalent in patients at 1-2 weeks and 4-6 weeks showed no significant difference, demonstrated the early stability of refractive status after phacoemulsification. This helps us in confidently prescribing spectacles within 1-2 weeks in order obtain early visual recovery.

## REFERENCES


[1] Murthy GVS, John N, Shamanna BR, et al. Elimination of avoidable blindness due to cataract: where do we prioritize and how should we monitor this decade. Indian J Ophthalmol 2012;60(5):438-445.

[2] Bourne RRA, Flaxman SR, Braithwaite T, et al. Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. Lancet Glob Health 2017;5(9):e888-e897.

[3] Watson A, Armstrong R. Contact or immersion technique for axial length measurement. Aust NZ J Ophthalmol 1999;27(1):49-51.

[4] Eleftheriadis H. IOL Master Biometry: refractive results of 100 consecutive cases. Br J Ophthalmol 2003;87(8):960-963.

[5] Olsen T. Sources of error in intraocular lens power calculation. J Cataract Refract Surg 1992;18(2):125-129.

[6] Oslen T. The accuracy of ultrasonic determination of axial length in pseudophakic eyes. Acta Ophthalmol (Copenh) 1989;67(2):141-144.

[7] Drexler W, Findl O, Menapace R, et al. Partial coherence interferometry: a novel approach to biometry in cataract surgery. Am J Ophthalmol 1998;126(4):524-534.

[8] Findl O, Drexler W, Menapace R, et al. Improved prediction of intraocular lens power using partial coherence interferometry. J Cataract Refract Surg 2001;27(6):861-867.

[9] Holladay JT, Prager TC, Ruiz RS et al. Improving the predictability of intraocular lens power calculations. Arch Ophthalmol 1986;104(4):539-541.

[10] Kiss B, Findl O, Menapace R, et al. Biometry of cataractous eyes using partial coherence interferometry: clinical feasibility study of a commercial prototype I. J Cataract Refract Surg 2002;28(2):224-229.

[11] Packer M, Fine IH, Hoffman RS, et al. Immersion A-scan compared with partial coherence interferometry: outcomes analysis. J Cataract Refract Surg 2002;28(2):239-242.

[12] Hitzenberger CK. Optical measurement of the axial eye length by laser Doppler interferometry. Invest Ophthalmol Vis Sci 1991;32(3):616-624.

[13] Drexler W, Findl O, Menapace R, et al. Partial coherence interferometry: a novel approach to biometry in cataract surgery. Am J Ophthalmol 1998;126(4):524-534.

[14] Findl O, Drexler W, Menapace R, et al. Improved prediction of intraocular lens power using partial coherence interferometry. J Cataract Refract Surg 2001;27(6):861-867.

[15] Freeman G, Pesudovs K. The impact of cataract severity on measurement acquisition with the IOL Master. Acta Ophthalmol 2005;83(4):439-442.

[16] Connors R; Boseman P, Olson RJ. Accuracy and reproducibility of biometry using partial coherence interferometry. J Cataract Refract Surg 2002;28(2):235-238.

[17] Lyle WA, Jin GJ. Prospective evaluation of early visual and refractive effects with small clear corneal incision for cataract surgery. J Cataract Refract Surg 1996;22(10):1456-1460.

[18] Masket S, Tennen DG. Astigmatic stabilization of 3.0 mm temporal clear corneal cataract incisions. JCRS 1996;22(10):1451-1455.

[19] Naeser K. Incision size and corneal shape changes in sutureless cataract surgery. Ophthalmology 1995;102(11):1579-1580.

[20] Sugar A, Sadri E, Dawson DG et al. Refractive stabilization after temporal phacoemulsification with foldable acrylic intraocular lens implantation. J Cataract Refract Surg 2001;27(11):1741-1745.