RESEARCH PAPER

Comparative Study of Axial Length Measurement Using A-Scan and B-Scan in Intra Ocular Lens Power Calculation for Cataract Surgery

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ABSTRACT

Background: The precision of intraocular lens (IOL) power estimate is the paramount factor influencing postoperative refractive results following cataract surgery. In contemporary intraocular lens (IOL) formulations, axial length (AL) significantly influences the final IOL power estimation; even minor inaccuracies in AL can result in clinically significant refractive discrepancies post-surgery.

Aims & Objectives: To compare the accuracy of the A-Scan versus B-Scan in measuring the axial length and intraocular lens power in cataract surgery.

Methodology: A prospective comparative study was conducted among 214 patients who were aged more than 40 years and came for cataract surgery at the Department of Ophthalmology, R. L. Jalappa Hospital and Research Centre, Kolar.

Results: The mean axial length assessed by B-scan (23.24 ± 0.93 mm) was marginally but considerably greater than that recorded by A-scan (23.18 ± 0.92 mm) ($p < 0.001$). The A-scan-based IOL power was somewhat greater (20.88 ± 2.49 D) compared to the B-scan-based IOL power (20.73 ± 2.52 D) ($p < 0.001$). On day 1 and day 30, the two groups' post-operative best-corrected visual acuity was similar ($p = 0.67$ and $p = 0.70$, respectively). The mean spherical equivalent at day 30 was nearer to emmetropia in the B-scan group (–0.14 ± 0.43 D) than in the A-scan group (–0.30 ± 0.66 D) ($p = 0.044$). A much greater percentage of patients attained emmetropia (±0.50 D) in the B-scan group (72.0%) compared to the A-scan group (52.3%) ($p = 0.004$).

Conclusion: B-scan yielded slightly longer axial length measurements and correspondingly lower calculated IOL power, resulting in refractive outcomes closer to emmetropia.

Keywords: Axial Length, A Scan, B Scan, Cataract Surgery, Intra Ocular Lens.

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INTRODUCTION:

The precision of intraocular lens (IOL) power estimate is the paramount factor influencing postoperative refractive results following cataract surgery. In contemporary intraocular lens (IOL) formulations, axial length (AL) significantly influences the final IOL power estimation; even minor inaccuracies in AL can result in clinically significant refractive discrepancies post-surgery. As cataract surgery increasingly functions as a refractive treatment, with people anticipating optimal unassisted vision, minimising axial length measurement error is essential to enhance patient happiness, diminish reliance on glasses, and lessen the necessity for postoperative corrective interventions.[1,2]

A-scan biometry is the traditional benchmark for quantifying axial length in ultrasonography. A-scan accuracy may fluctuate based on the method employed—contact/applanation vs immersion—and operator variables, including probe alignment and unintentional corneal compression. Corneal compression during contact A-scan might inaccurately reduce the measured axial length (AL), perhaps resulting in the selection of a higher powered intraocular lens (IOL) and producing postoperative myopia.[3]

B-scan ultrasonography, traditionally employed for posterior segment assessment in opaque medium, also serves a supplementary function in biometry when A-scan results are unsatisfactory or when ocular anatomy heightens the probability of off-axis or erroneous endpoint measurements. High myopia, posterior staphyloma, irregular posterior pole contour, vitreoretinal disease, silicone oil-filled eyes, or inadequate fixation may provide erroneous A-scan findings if the sound beam is not well aligned with the visual axis or if the retinal spike is not properly recognised. In these circumstances, B-scan aids in visualising the posterior pole, enhancing endpoint recognition, and minimising off-axis error.[4]

The comparison of the axial length obtained using A-scan as compared with B-scan in the realm of intraocular lens power calculation for cataract surgery is clinically warranted - especially to recognize subgroups (e.g. elongated eyes/high myopia, suspicious posterior staphyloma, inadequate fixation, dense cataract and ambiguous endpoint of retina) where one method may produce more reliable measurements. A comparative analysis is essential for the standardisation of the preoperative regimens. Numerous institutions do B-scan - mainly as a preliminary assessment of the retinal condition in cases of dense cataract, while axial length (AL) is assessed by using A-scan as an independent procedure. If B-scan-based AL (or B-scan-guided measurement methodologies) demonstrates greater concordance with anticipated postoperative refraction, it may advocate for the incorporation of B-scan into the biometry process for specific patients. If agreement is substantial and discrepancies are clinically insignificant in routine cases, centres may reliably limit B-scan AL assessment to specified reasons, therefore optimising time and minimising needless variability.

Ultimately, evidence customised to local practice patterns is invaluable. Outcomes of ultrasound biometry may vary between centres due to operator proficiency, device calibration, measurement protocols (contact versus immersion), and case mix (percentage of thick cataracts, high myopia, and posterior segment comorbidities). A systematic comparison of A-scan and B-scan AL measures within our cataract population can provide a pragmatic, evidence-based methodology to boost refractive predictability, minimise remakes or enhancements, and ultimately elevate the quality of cataract surgical services.

AIMS & OBJECTIVES:

To compare the accuracy of the A-Scan versus B-Scan in measuring the axial length and intraocular lens power in cataract surgery.

METHODOLOGY:

A prospective comparative study was conducted among 214 patients who were aged more than 40 years and came for cataract surgery at the Department of Ophthalmology, R. L. Jalappa Hospital and Research Centre, Kolar. Using a straightforward randomisation technique, 214 individuals who satisfied the inclusion criteria were enrolled and split into two groups of 107 patients each. Group A – Axial Length Measurement with A-scan and Group B – Axial Length Measurement with Ultrasound B-scan. Visual acuity was evaluated via the Snellen chart for far vision and specialised charts for close vision. Slit lamp biomicroscopy was conducted to assess the anterior portion. The posterior region was assessed using indirect ophthalmoscopy and +90D biomicroscopy. Intraocular pressure was assessed via an applanation tonometer. Both the A-scan and B-scan approaches were used to measure axial length. The SRK formula was used to calculate the intraocular lens's (IOL) power, and the spherical equivalent refraction was recorded. A Goldmann three-mirror lens was used for gonioscopy in order to assess neovascularisation, angle recession, and peripheral anterior synechiae.

Data entry and analysis: Microsoft Excel was used to enter the data, while SPSS version 22 was used for analysis. Pie charts and bar graphs were used to illustrate the proportions of the qualitative data. The mean and standard deviation were used to display quantitative data. For quantitative variables, the significance was assessed using the Student's t-test, and for qualitative variables, the chi-square test. Statistical significance was defined as a p-value of less than 0.05.

RESULTS:

Table 1: Age Distribution (Age Groups) in A-scan and B-scan Groups

Age group (years)	A-scan (n = 107)	B-scan (n = 107)
40–49	8 (7.5%)	8 (7.5%)
50–59	32 (29.9%)	33 (30.8%)
60–69	48 (44.9%)	46 (43.0%)
≥70	19 (17.8%)	20 (18.7%)

The age distribution was comparable between the A-scan and B-scan groups. The majority of participants in both groups belonged to the 60–69 years age category (44.9% in the A-scan group vs 43.0% in the B-scan group), followed by the 50–59 years age group (29.9% vs 30.8%). The distribution across age groups did not differ significantly between the two groups (p = 0.99). [Table 1]

Table 2: Type of Cataract Distribution in A-scan and B-scan Groups

Type of Cataract	A-scan (n = 107)	B-scan (n = 107)
Nuclear	48 (44.9%)	42 (39.3%)
Cortical	28 (26.2%)	23 (21.5%)
Posterior subcapsular (PSC)	15 (14.0%)	21 (19.6%)
Mixed	16 (15.0%)	21 (19.6%)
p-value = 0.46 (Chi-square test)		

Nuclear cataract was the most common type in both study groups, accounting for 44.9% of cases in the A-scan group and 39.3% in the B-scan group. Cortical, posterior subcapsular, and mixed cataracts were distributed in comparable proportions between the two groups. The difference in the distribution of cataract types between the A-scan and B-scan groups was not statistically significant (Chi-square test, p = 0.46). [Table 2]

Table 3: Comparison of Axial Length Measurements Using A-scan and B-scan

Axial Length Measurement	Mean ± SD (mm)
A-scan axial length	23.18 ± 0.92
B-scan axial length	23.24 ± 0.93
p-value < 0.001 (Paired t-test)	

The mean axial length measured using A-scan was 23.18 ± 0.92 mm, while that measured using B-scan was 23.24 ± 0.93 mm. The difference in axial length measurements obtained by the two techniques was statistically significant, with B-scan yielding slightly higher axial length values compared to A-scan (paired t-test, p < 0.001) [Table 3]

Table 4: Comparison of Intraocular Lens (IOL) Power Calculated Using A-scan and B-scan

IOL Power Calculation Method	IOL Power (D) Mean ± SD
A-scan–based IOL power	20.88 ± 2.49
B-scan–based IOL power	20.73 ± 2.52

The mean intraocular lens power calculated using A-scan was 20.88 ± 2.49 diopters, whereas that calculated using B-scan was 20.73 ± 2.52 diopters. The difference in IOL power calculated by the two techniques was statistically significant, with B-scan–based calculations yielding slightly lower IOL power values compared to A-scan–based calculations (paired t-test, p < 0.001). [Table 4]

Table 5: Axial Length Comparison of Postoperative Day 30 Spherical Equivalent Between A-scan and B-scan Groups

Axial Length Subgroup (mm)	A-scan (D)	B-scan (D)	p-value
< 22 (n = 11 each)	−0.27 ± 0.71	−0.25 ± 0.38	0.94

Axial Length Subgroup (mm)	A-scan (D)	B-scan (D)	p-value
22–24 (A: n=76, B: n=81)	−0.31 ± 0.60	−0.15 ± 0.43	0.07
> 24 (A: n=20, B: n=15)	−0.28 ± 0.86	+0.00 ± 0.46	0.26

Across all axial length categories, no statistically significant differences were observed in postoperative spherical equivalent between A-scan and B-scan groups on day 30. The A-scan group exhibited a consistent, slightly more myopic trend, especially in the 22–24 mm range—but the difference did not reach significance, indicating both measurement techniques provide comparable refractive accuracy in cataract surgery biometry across axial lengths. [Table 5]

DISCUSSION:

In the present study, the A-scan and B-scan groups were well matched with respect to age and sex distribution, ensuring baseline comparability between the two cohorts. The majority of patients in both groups belonged to the 60–69-year age group, which is consistent with the known age-related increase in cataract prevalence, and the distribution across all age categories showed no statistically significant difference ($p = 0.99$). The young and old groups have similar ages, minimizing the effect of inappropriate confounding from age-related biological changes such as axial length, lens thickness and corneal curvature, which might affect biometry measurements and postoperative refractive outcome. Similarly, the sex distribution was similar in both groups, with a slight preponderance of males in both the A-scan and B-scan cohort, and no significant difference ($p = 0.67$). This equal balance of gender also further increases the internal validity of the study because anatomical and biometric differences related to sex are unlikely to have influenced the comparison between the two measuring techniques.

Our analysis showed statistically significant difference between paired measurements because B-scan axial length (23.24+-0.93mm) is slightly greater than the A-scan axial length (23.18+-0.92mm) ($p<0.001$). Although the absolute mean difference was small (approximately 0.06 mm) this consistent trend is consistent with well-established principles of biometry. Contact (applanation) A-scan may underestimate axial length due to corneal indentation, whereas B-scan–guided methods, including immersion techniques, minimize this effect and may allow for more accurate alignment with the retinal endpoint in certain cases. Trivedi et al. established that contact A-scan produces shorter axial lengths than immersion A-scan, potentially resulting in the selection of a more powerful intraocular lens and a predisposition to postoperative myopia if not considered. [5]

The group-wise analysis of axial length (AL) by assigned technique revealed no significant difference (A-scan group: 23.25 ± 0.98 mm vs B-scan group: 23.17 ± 0.88 mm; $p = 0.55$), which is consistent with our findings. The paired analysis addresses whether the two approaches provide differing ALs within the same eyes, whereas the group-wise comparison examines the general similarity of AL distribution between the two groups. Under randomisation or balanced allocation, the latter may resemble the former despite the presence of a systematic paired difference between the two procedures.

A-scan–derived IOL power was marginally elevated (20.88 ± 2.49 D) compared to B-scan–derived power (20.73 ± 2.52 D), $p < 0.001$, which is optically consistent with the AL measurement. A reduced axial length estimate often results in an increased intraocular lens power to achieve the same goal refraction, whereas a somewhat elongated axial length estimate leads to a decreased estimated intraocular lens power. Trivedi et al. clinically quantified this notion by demonstrating that contact A-scan-derived axial length can influence lens selection and produce postoperative myopia. [6]

Studies comparing immersion ultrasonography with optical biometry have similarly reported small mean differences, yet have highlighted clinically meaningful variations in the distribution of refractive prediction errors, particularly in specific subgroups or more challenging clinical scenarios.[7] Ademola-Popoola et al performed a comparison of the applanation and immersion methods and showed that immersion methods may be more reliable, especially in environments with varying levels of operator expertise, which is also important in the tertiary care setting and teaching institutions. Similarly, Chia et al. reported good overall agreement of optical and ultrasonic biometry; however, the more important clinical question is which approach makes more consistent and reliable measurements in less than ideal circumstances, such as dense cataracts, poor fixation, limited availability of advanced equipment, etc.[8,9]

Relevant evidence to our findings is that of methodologies that have employed B-scan as a guide. In their research study, El Een et al. reported that B-scan-guided biometry has greater accuracy than contact (applanation) biometry, highlighting the benefits of undertaken guided measurement techniques in practice. Although study settings might be different the general principle is recurrent: Higher degree of alignment and correct identification of the retinal endpoint are related to greater refractive precision. While optical biometry is considered the standard when available, several studies have underlined that ultrasonography has retained an important role and can provide reliable results when performed using sequence of measures to minimize artefacts in the measurement. Landers et al. compared the outcomes of refractive power with immersion ultrasound and measured with IOLMaster and showed that immersion ultrasound can yield clinically comparable results and is a valid alternative when optical biometry is not possible.[10,11]

The classification of subgroups on the axial length (short, medium and long eyes) deserves careful consideration. Despite the insignificance of group (subgroup) p-values, B-scan kept showing greater proportion of subgroup inside +/- 0.50 D within stratified groups. This is consistent with the study performed by Dong et al. which studied ultrasonography and IOLMaster for normal, short and long eyes; with a focus on possible variation of concordance depending on axial length category, namely the portion where slight biometric mismeasurement is amplified into the enormous refractive mismeasurement. Pereira et al. showed the greatest number of eyes hitting +-0.50 D with optical biometry compared to ultrasound with the modern Barrett Universal II formula indirectly reinforcing the principle that is evident in our data; namely the technique that reduces measurement noise the most is usually greatest at the "+-0.50 D" endpoint. Our work is indicative that the B scan route may be closer to the "lower-noise" end of the spectrum according to within ultrasound comparisons.[12,13]

A further interpretation is that b-scan may be an enhanced use if obtaining the axial length is difficult because of extensive cataracts, inadequate fixation or complications of the media. Gonzalez Godinez et al. showed that swept source OCT has a high rate of successful axial length measurement in dense cataracts in comparison to partial coherence interferometry. This finding emphasizes a greater principle: when the measurement conditions are problematic, the capability of a technique to achieve a reliable axial length begins to be quite significant. In such scenarios, ultrasonography may often be the alternative, in which case the choice of ultrasound method that is less susceptible to corneal compression and alignment errors are of great clinical significance. Sheard discussed optimisation of biometry for improved cataract results stressing the importance of accurate measuring techniques in refractive outcome - even small biometric differences can have major consequences for the postoperative refraction.[14,15]

CONCLUSION:

Ultrasound biometry remains an essential tool in cataract surgery, particularly in settings where optical biometry is unavailable or unreliable. A-scan ultrasonography is rapid, cost-effective, and widely accessible, making it especially valuable in resource-limited environments; however, it is technique-sensitive and prone to errors related to corneal compression and off axis alignment, particularly with contact methods. The immersion A-scan technique helps reduce compression-related bias and improves measurement accuracy. B-scan ultrasonography, whether used independently or as a guidance modality, offers the additional advantage of posterior segment evaluation along with improved axial alignment. This is particularly beneficial in challenging clinical scenarios such as dense cataracts, high myopia with posterior staphyloma, silicone oil-filled eyes, or poor fixation. Although B-scan techniques may require greater expertise, time, and specific equipment, comparative evidence suggests that they can enhance measurement reliability and reduce systematic errors in complex cases. In the present study, both A-scan and B-scan demonstrated comparable postoperative visual acuity outcomes, indicating that each method is reliable for axial length measurement and intraocular lens (IOL) power calculation in routine cataract surgery. However, B-scan yielded slightly longer axial length measurements and correspondingly lower calculated IOL power, resulting in refractive outcomes closer to emmetropia. These findings support the selective use of B-scan–based techniques to improve refractive predictability, particularly in situations where measurement accuracy may be compromised.

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