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Original article

Optical Biometry *versus* Ultrasound A-scan in Measuring Anterior Chamber Depth, Axial Length, and Lens Thickness in Patients Undergoing Cataract Surgery

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ABSTRACT

Ocular biometry measurements use ultrasonography and optical biometry, offering high precision for noninvasive intraocular distance measurement in cataract surgery. This study aims to Compare agreement values between an optical biometry machine and an ocular ultrasound-based biometry device for axial length, anterior chamber depth, and lens thickness measurements. A study enrolled 64 eyes of 42 patients scheduled for cataract surgery at Benghazi Teaching Eye Hospital, Libya, from January 1st to February 1st, 2024. Patients' medical and ocular histories were taken, and slit lamp examinations were conducted. All eyes with visual impairment and good fixation were included. Axial length, anterior chamber depth, and lens thickness were measured using Aladdin optical biometer and an ellex eye-cubed ultrasonic contact biometer. The study involved 64 eyes with a mean age of 64.36 years, The most common type of cataract was posterior subcapsular cataract [46.9%], nuclear cataract [14.1%], and cortical cataract [14.1%]. Combined cataracts were also present in 31.3% of the participants. The ICC analysis showed a strong agreement [0.976] between the two measurement devices in assessing axial length. difference in measurements of the mean anterior chamber depth. ICC showed a high level of agreement between the two methods [0.545]. There was no significant difference in lens thickness as measured by optical biometry and A-scan ultrasound, with a medium positive correlation between lens thickness measurement by the two devices [P<0.001]. The interclass correlation further supported these findings, with a strong correlation between lens thickness and cataract development [r = 0.753]. The study reveals consistency in the measurements between optical and ultrasound biometry, highlighting the need for future research, to address limitations like small sample size and potential biases.

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INTRODUCTION

Cataracts are opacifications of the eye's lens, affecting infants, adults, and older people. They can be bilateral and vary in severity. The disease progresses gradually, but after the fourth- or fifth-decade cataracts become opaque, interfering with daily activities. Treatment options include refractive glasses and surgery if necessary [1–3].

Cataract onset is more common in older adults and women, with a male-to-female ratio of 1 to 1.3. A study in Libya of people aged 50+ found a prevalence of blindness of 3.25%, with cataracts, glaucoma, and corneal scars being the major causes. Avoidable causes accounted for 60.6% of blindness. Major causes of visual impairment were cataracts, diabetic retinopathy, and posterior segment diseases. Cataract surgical coverage was 95.4%, but poor outcomes were reported in 38% of cataract-operated eyes. Libya needs to improve cataract surgery quality and coverage [4].

There are two distinct technologies used to conduct ocular biometry measurements, ultrasonography and optical biometry [5,6]. Ophthalmic ultrasound is a readily accessible, economical, and dependable imaging technique for quantifying oculometric parameters [7]. A-mode applanation ultrasound is a biometric technique that involves placing the probe of the device directly on the surface of the cornea [5]. The main issue with the contact approach is the excessive force exerted on the cornea during the test, which can lead to an underestimation of the measured axial length (AL) and anterior chamber depth (ACD) [8].

The applanation ultrasound (US) A-scan technique is the most common method for biometry in cataract surgery, used by 95% of surgeons in the US. It measures axial length with a resolution of 150-200 mm and an accuracy of 100-150 mm. A new optical biometric technique, the IOL master, has been developed, allowing noninvasive measurement of intraocular distances with high precision and resolution [9]. This study compared the agreement values between an optical biometry machine and an ocular ultrasound-based biometry device for axial length (AL), anterior chamber depth (ACD), and lens thickness (LT) measurements.

METHODS

Study design and setting

A cross-sectional study included 64 eyes of 42 consecutive patients scheduled for cataract surgery at Benghazi Teaching Eye Hospital, Libya was prospectively enrolled in the period between January 1st to February 1st, 2024. All of the cataractous eyes with visual impairment and good fixation were included. Any patient with corneal or retinal disease or ocular trauma, previous ocular surgery, or any ocular disease that could affect the axial length measurements had been excluded.

Data collection and ophthalmic examination

All of the patients' medical and ocular history were taken and went under slit lamp examination with detailed anterior and posterior segment examination. visual acuity and intra-ocular pressure measurements have been recorded. The axial length, anterior chamber depth, and lens thickness were measured for each patient without using cycloplegia on two devices, first, the Aladdin optical biometer (Topcon, Tokyo, Japan) with three readings had been taken for each eye by the same trained ophthalmologist. Then with the ellex eye cubed ultrasonic contact biometer after the instillation of one drop of benoxinate hydrochloride 0.4 % again by the same trained ophthalmologist.

Data analysis

Descriptive statistics were applied using Microsoft Excell.

RESULTS

The study population consisted of a total of 64 participants with a mean age of 64.36 years. The majority of the participants were male (54.7%), (54.7%) right eye, (45.3%) left eye, and had chronic illnesses such as diabetes mellitus (29.7%) and hypertension (31.3%). Overall, the baseline characteristics of the study population were diverse and representative of a range of demographic and health factors in Table 1.

The results showed that the most common type of cataract among the study sample was posterior subcapsular cataracts (46.9%), nuclear cataracts, followed by cortical cataracts (14.1%). Interestingly, a percentage of participants also had combined cataracts (31.3%) (figure 1).

The study also found a correlation between axial length measured through optical biometry and a-scan ultrasound, with a statistically significant difference in measurements ($P<0.01$). The data collected also revealed that the axial length measured through optical biometry had a mean of 23.7 mm (SD 0.9) with a minimum of (21.36 mm) and a maximum of (26.81 mm). The difference in axial length among participants was 0.08 mm (SD 0.3). The ICC analysis showed a strong agreement (0.976) between the two measurement devices in assessing axial length. The Bland-Altman plot visually represents the agreement in axial length measurements between the applanation ultrasound A-scan and optical biometry. The plot shows a narrow range of differences between the two methods, suggesting good agreement overall (Table 2 & Figure 2(a)).

There was a slight negative difference in the measurement of the mean anterior chamber depth (-0.03), with a standard deviation of 0.5 mm. The correlation analysis revealed a significant relationship between the measurements, with a p-value of <0.001. The correlation coefficient (r) was 0.49, indicating a moderate positive correlation between the variables. The regression analysis and interclass correlation showed a high level of agreement between the two methods (0.545). values in anterior chamber depth measurements between the two methods are within a small range, indicating a strong agreement (Table 2 & Figure 2(b)).

There was no significant difference in the lens thickness as measured by optical biometry, and A-scan ultrasound (P=0.181). The analysis showed a medium positive correlation between the lens thickness measurement by the two devices as (P<0.001) r=0.42. The interclass correlation further supported these findings, with a strong correlation between lens thickness and cataract development (r = 0.753) (Table 2). In Figure 2 (c). The plot shows that the majority of data points fall within the limits of agreement, indicating good agreement between the two methods. Figure 3 showed a consistent trend of slightly longer measurements compared to ultrasound across all axial lengths.

Table 1. Baseline characteristics of the study population

Character	n(%)
Mean Age [SD]	64.36 (10.5)
Gender	
Male	35(54.7%)
Female	29(45.3%)
Chronic illness	
DM	19(29.7%)
HTN	20(31.3%)
Glaucoma	4(6.3%)
Rheumatoid	4(6.3%)
Side	
Left eye	29(45.3%)
Right eye	35(54.7%)

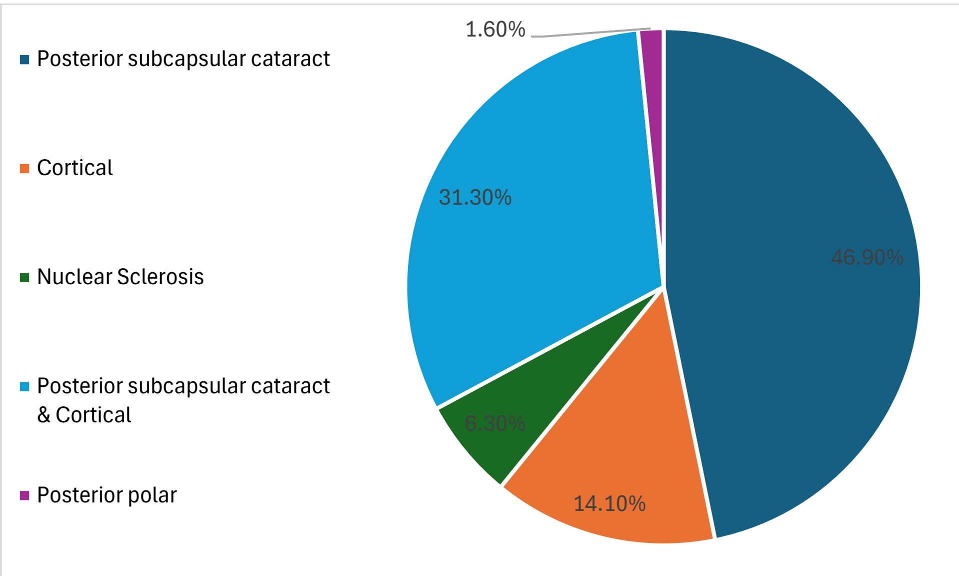
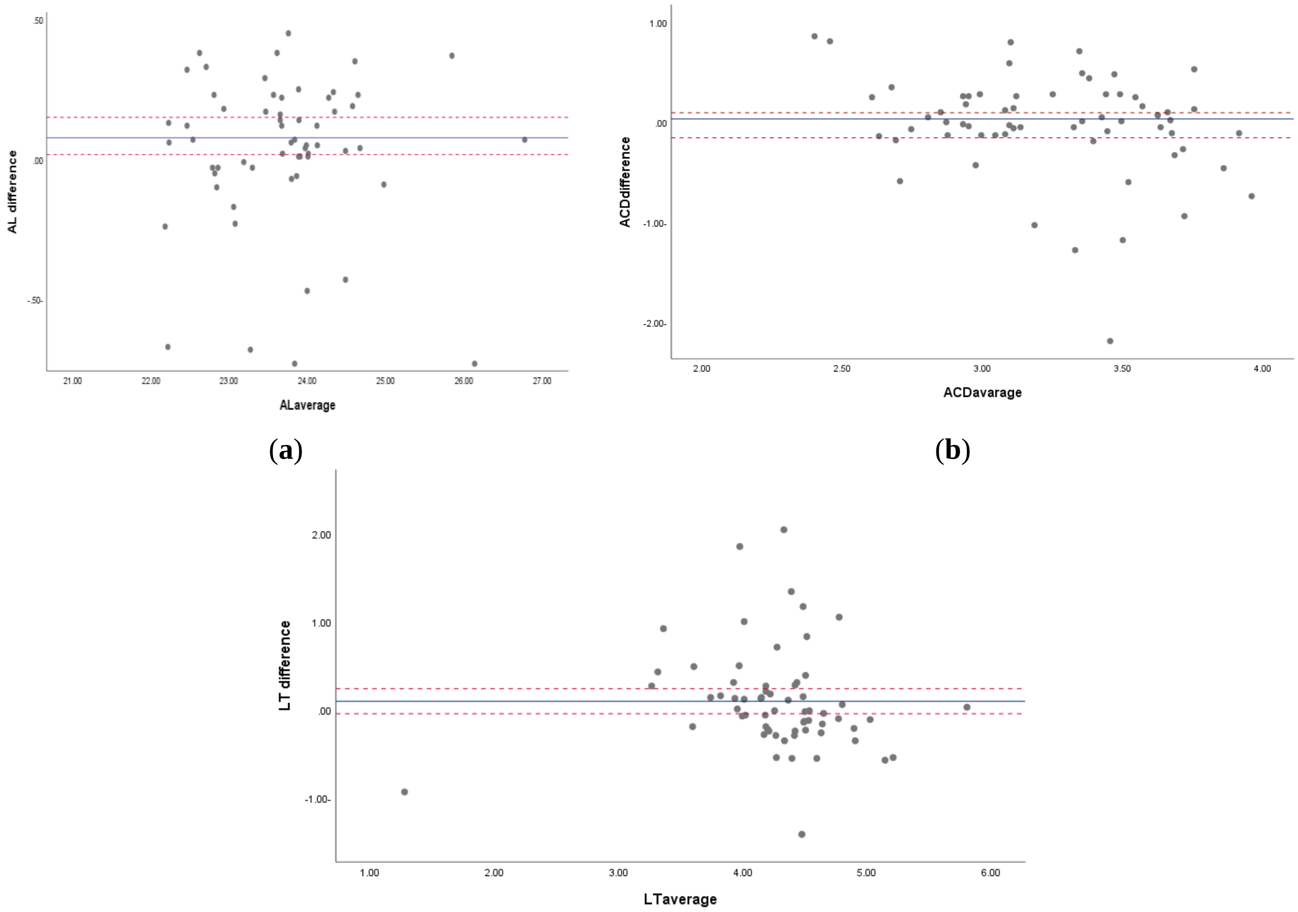


Figure 1. The prevalence of cataract types in the study sample

Table 2. Axial length, anterior chamber depth, and lens thickness data comparison between optical biometry and A-scan ultrasound.

Measurement	Device	Mean (SD)	Minimum	Maximum	Difference [SD]	Regression		ICC	P value
						r	P value		
Axial length	Optical biometry	23.7 (0.9)	21.36	26.81	0.08 (0.3)	0.93	<0.001	0.976	0.045*
Axial length	Ultrasound	23.6 (2.8)	20.78	26.74					
ACD	Optical biometry	3.2 (0.4)	2.36	4.02	-0.03 (0.5)	0.49	<0.001	0.545	0.615
ACD	Ultrasound A-scan	3.2 (0.5)	1.97	4.55					
Lens thickness	Optical biometry	4.3 (0.6)	.81	5.82	0.09 (0.6)	0.42	<0.001	0.753	0.181
Lens thickness	Ultrasound A-scan	4.1 (0.8)	1.74	5.79					



(c)

Figure 2. Bland–Altman plot of the agreement in measurements, Y-axis difference, and axis average, with applanation ultrasound A-scan versus optical biometry: (a) axial length (AXL); (b) anterior chamber depth (ACD); (c)Lens thickness (LT).

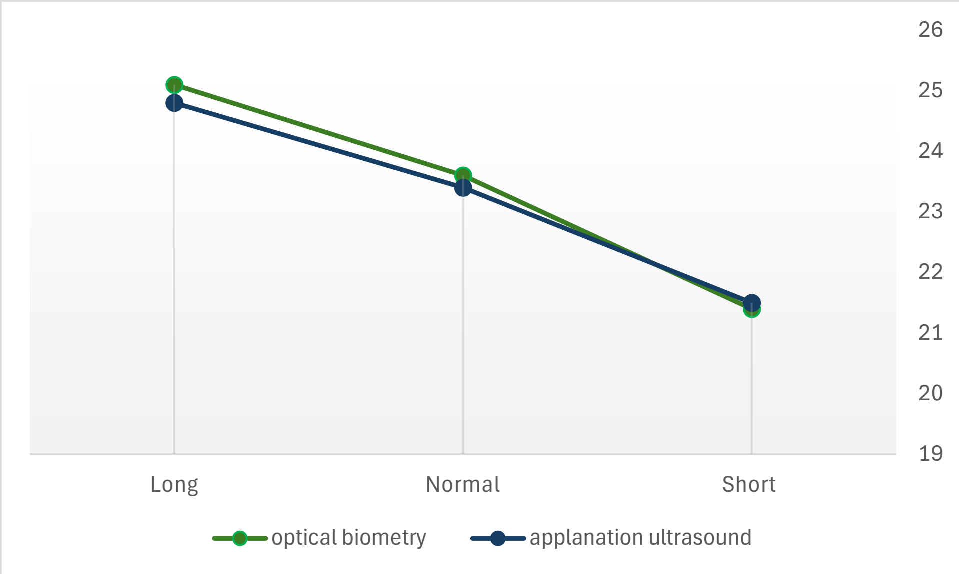


Figure 3. Comparison of axial length measurements with applanation ultrasound versus optical biometry stratified according to length. Green line: Optical length. Blue line: ultrasound length.

DISCUSSION

Assessing oculometric parameters is crucial in preoperative assessments before cataract surgery for determining the power of the intraocular lens (IOL) [2,10–13]. The primary objective of this study was to assess the consistency and concordance between two different devices used for measuring axial length (AL), anterior chamber depth (ACD), and lens thickness (LT). The devices compared were an advanced optical-based biometry machine and an ocular ultrasound-based biometry device known as A-scan.

In this study, there was significant agreement in the quality of ACD measurement when assessed using two different biometric devices. ICC analysis revealed that AL and ACD measurements showed high reliability across different quality metrics when comparing optical biometry with ultrasound A-scan. The order of ICC values for the measured parameters were as follows: AL had the highest value, followed by LT, then ACD.

Optical biometry devices provide higher accuracy compared to ocular ultrasound. However, these devices are costly and may have limits in measuring ocular biometric data in individuals with extensive cataracts [14,15]. On the other hand, ultrasound biometry has better resolution due to shorter wavelengths, resulting in a lower accuracy of 0.10–0.12 mm compared to optical AL, but measurement accuracy is limited by retinal thickness variation [16]. Ultrasound and optical biometry measurements differ in starting points, with ultrasound measuring AL from the corneal apex to the internal limiting membrane, and optical biometry measuring AL from the second principal plane to the photoreceptor layer. Optical biometry reads longer than ultrasound, and the visual axis is shorter than the anatomic axis [17].

However, ocular ultrasound biometry remains a commonly employed approach in many developing nations for measuring AL and calculating IOL power. This is mostly because it is more affordable and familiar compared to optical biometry instruments [18]. Nakhli et al., conducted study examining the correlation between AL measured using optical biometry and ultrasonography in 55 cataract surgery patients and found high reproducibility and agreement between the two technologies, indicating a strong correlation between AL values obtained using optical biometry and ultrasonography [18]. That finding highlights our results.

In this investigation, we obtained results for AL measures with less agreement compared to the other device. Rose et al conducted a study comparing anterior chamber depth measurements using applanation A-mode applanation ultrasound and the Zeiss IOL Master biometer optical system [19].

This study utilized a cross-sectional design and included 64 eyes who were referred for cataract surgery. The optical biometry estimated the AL to be, on average, 0.08 mm greater (p=0.045) than the ultrasonic biometry. Our findings indicate that the average values of AL, using optical biometry offer precise measurement of the AL of the eye. It is characterized by its efficiency and simplicity, since it does not require any physical contact and eliminates the possibility of infection or injury to the cornea [20].

Tao Ming et al., [21]. conducted A retrospective chart review comparing optical and ultrasonic biometric measurements in patients with a borderline signal-to-noise ratio (SNR) and found no significant disparity between the two. The study involved sixty patients with cataracts who underwent IOL Master biometry. The analysis showed strong concurrence between the two techniques. However, the study used outdated biometry tools, so the authors suggest that optical biometry remains valuable in surgical planning for patients with borderline-quality data. The analysis of the Bland-Altman plots revealed that the AL bias line was near zero, precisely measuring 0.077 mm. Based on our research findings, as depicted in figure 2, the 95% confidence interval for the disparity in AL is presented. The primary cause responsible for most disparities in AL, if any, is the restricted reproducibility of ultrasound measurements. Another vital component pertains to the cooperation of the patient. Patients who have an AL difference beyond 0.2 mm may exhibit less cooperation as a result of being older. In addition to the inherent limitations of ultrasound in accurately measuring AL, a difference of over 0.2 mm can also be ascribed to the level of compliance exhibited by patients [5].

The Bland-Altman plot for ACD shows a moderate positive correlation between differences and means, indicating that as the value of ACD increases, the difference between the measurements of the two instruments similarly increases. Based on the results in Figure 4. However, for ACD values below or above the average, the difference increases. In individuals with a shallow anterior chamber (AC), possible reasons for these differences include the effect of pressure on the ultrasound measurement of anterior chamber depth (ACD). Conversely, in individuals with profound AC, the ACD measurement tends to have a larger standard deviation (SD), leading to lower measurement accuracy [5]. Nevertheless, additional investigation is required to ascertain the precise underlying factor responsible for these disparities.

The Bland-Altmann plot for LT again shows a good relationship between differences and means, but a thicker LT may lead to increased variability between the two devices. Since the ultrasound approach does not affect LT, any differences, if any, can be attributed to the effect of refractive indices or uncertainties in optical measurements [5]. Fouad et al., compared axial length measurements in the study with optical and ultrasound biometry for clinical purposes, and a Bland-Altman plot found good agreement between devices. The mean difference of -0.117 mm was statistically significant but not clinically significant. Differences were only present for short eyes and were not normal for long eyes, requiring a comparison based on equation [17].

The readings we obtained using Aladdin ocular biometer are quite comparable to those obtained in the previous research, which was conducted on a group of Libyans in the same geographical area as the current study [22]. This consistency in results indicates that our findings can be dependable and can be applied to the broader population of Libyans in the region. The validity of our study is further bolstered by the fact that our data is in close alignment with previous research. This study is subject to certain constraints, particularly regarding conducting the research using only two biometry devices. Furthermore, the present study focused on two widely used biometric devices, its findings may not be generalizable to other types of biometric devices. We suggest that researchers develop a mathematical correlation between the optical and ultrasound biometers for AL, ACD, and LT in various AL groups, including short, normal, and long eyes. Furthermore, future studies should assess the potential interchangeability of AL, ACD, and LT measurements obtained using optical and ultrasound biometers across different AL groups. Mature cataracts, old people with poor comprehension and poor fixation, and the small number of the sample due to the narrow period and smaller number of patients who met all of the inclusion criteria all of these can be considered as limitations of this study.

CONCLUSION

Overall, the findings of this study suggest that there are good agreements in AL, ACD, and LT measurements between Optical biometry and ultrasound A-scan. It is important for future research to explore the potential interchangeability of these measurements to improve the accuracy and reliability of biometric measurements in cataract surgery planning. Additionally, addressing the limitations of this study, such as the small sample size and potential biases in patient selection, will be crucial for ensuring the validity of future research in this area.

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Conflicts of Interest

The authors declare no conflicts of interest.

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القياس الحيوي البصري مقابل المسح بالموجات فوق الصوتية في قياس عمق الغرفة الأمامية والطول المحوري وسمك العدسة لدى المرضى الذين يخضعون لجراحة إعتام عدسية العين

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المستخلص

تستخدم القياسات الحيوية للعين عن طريق التصوير بالموجات فوق الصوتية والقياسات الحيوية البصرية، مما يوفر دقة عالية لقياس المسافة داخل العين غير الباضعة في جراحة إعتام عدسية العين. الهدف من هذه الدراسة هو مقارنة قيم الاتفاق بين جهاز القياس الحيوي البصري وجهاز القياس الحيوي المعتمد على الموجات فوق الصوتية للعين لقياسات الطول المحوري، وعمق الغرفة الأمامية، وسمك العدسة. سجلت الدراسة 64 عينًا لـ 42 مريضًا من المقرر لهم إجراء جراحة إزالة المياه البيضاء في مستشفى بنغازي التعليمي للعيون، ليبيا، في الفترة من 1 يناير إلى 1 فبراير 2024. تم أخذ التاريخ الطبي والعيني للمرضى، وتم إجراء فحوصات المصباح الشقي. تم تضمين جميع العيون ذات الإعاقة البصرية والتثبيت الجيد. تم قياس طول المحور وعمق الغرفة الأمامية وسمك العدسة باستخدام مقياس علاء الدين البصري ومقياس الاتصال الحيوي بالموجات فوق الصوتية. شملت الدراسة 64 عينًا بمتوسط عمر 64.36 عامًا، وكان النوع الأكثر شيوعًا لإعتام عدسة العين هو إعتام عدسة العين الخلفي تحت المحفظة (46.9٪)، وإعتام عدسة العين النووي (14.1٪)، وإعتام عدسة العين القشري (14.1٪). كان إعتام عدسة العين المختلط موجودًا أيضًا في 31.3٪ من المشاركين. أظهر تحليل الارتباط داخل الطبقة الاحصائي اتفاقًا قويًا [0.976] بين جهازي القياس في تقييم الطول المحوري. اما بالنسبة لقياسات متوسط عمق الغرفة الأمامية اظهر الارتباط داخل الطبقة مستوى عال من الاتفاق بين الطريقتين (0.545). لم يكن هناك فرق كبير في سمك العدسة كما تم قياسه بواسطة القياسات الحيوية البصرية والموجات فوق الصوتية المسح ، مع وجود علاقة إيجابية متوسطة بين قياس سمك العدسة بواسطة الجهازين .[P < 0.001] دعم الارتباط بين الطبقات هذه النتائج أيضًا، مع وجود علاقة قوية بين سماكة العدسة وتطور إعتام عدسة العين (r = 0.753) تكشف الدراسة عن اتساق في القياسات بين القياسات البصرية والموجات فوق الصوتية، مما يسلط الضوء على الحاجة إلى البحوث المستقبلية ومعالجة القيود مثل حجم العينة الصغير والتحيزات المحتملة.

الكلمات المفتاحية. القياسات الحيوية، المسح ، البصري، المحوري، الغرفة الأمامية، سمك العدسة.