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Outcomes of Ocular Biometry in Patients Using the Lenstar Optical Measurement Device

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Abstract: A cross-sectional study was conducted on Iraqi patients who underwent cataract surgery and were previously assessed using the Lenstar 900 LS system. Patients aged 20 to over 80 years were recruited in Baghdad, Iraq, where Accurate biometric measurements are essential for calculating the refractive power of the lens within the eye. In the age of biometrics, the measurement of the optical axis length (AL) is considered the primary factor in refractive error. Postoperative refractive data were analysed using appropriate statistical methods to compare the effectiveness of two intraocular lens calculation methods. The analysis included evaluating (AL), (ACD), (LT), and (CCT)**,** CCT (µm), K (D), and WTW, where the statistical analysis conducted in this study relied on a variety of statistical methods, including descriptive measures and hypothesis testing. Descriptive measures such as the mean, standard deviation, frequency, and percentages were used to describe the characteristics of the variables and provide concise information about the collected data. This study was conducted in accordance with the ethical principles of the Declaration of Helsinki, and medical records in Iraq were analysed over a one-year study period. The results obtained in this study are: 1)AL was 23.58±1.14 mm 2) The mean anterior chamber depth was 3.15 ± 0.42 mm. 3) A statistical correlation was found between AL and ACD (p = 0.612) and with mean keratometry (r = -0.528). 4) In this study, according to the results, longer axial lengths were found in men than women (p = 0.005), and larger white-to-white diameters were also observed (p = 0.008). Finally, we concluded from our study. These findings reinforce the continued use of optical biometry as the standard method for preoperative IOL power calculation and the need for demographic data to be taken into account when interpreting biometric data.

Keywords: Ocular, Biometry, Lenstar, Optical, Measurement, AL, LT, Central Corneal Thickness (CCT), Flat Keratometry (K1).

INTRODUCTION

Ocular biometry is part of the basic ophthalmological tools in the armamentarium of the modern surgeon and is the foundation of IOL power calculation before cataract surgery. The accuracy of biometric measurements strongly affects the refractive outcomes after surgery, which is why the type of device used to measure biometrics and the knowledge of normative biometrics are of crucial importance [Liu, W. *et al.*, 2021; Shiels, A., & Hejtmancik, J. F. 2019; Naderi, K. *et al.*, 2020]. The Lenstar LS 900 (Haag-Streit AG, Koeniz, Switzerland) is an optical low-coherence reflectometry (OLCR) device that enables all-important ocular biometry parameters to be measured during a single, non-contact measurement session. The Lenstar measures Axial length (AL), Anterior chamber depth (ACD), Lens thickness (LT), Central corneal thickness (CCT), Keratometry (K), White-to-white corneal diameter (WTW), and Pupil diameter (PD), unlike the traditional ultrasound A-scan biometry [Pereira, J. M. M. *et al.*, 2018; BARDAK, H., & BARDAK, Y. 2015]. The instrument is designed for 2-zone keratometry, with 32 measurement points located in 2 zones, around 1.65 mm and 2.3 mm, which allows to accurately measure the curvature and astigmatism of the cornea and obtain the results. It uses the optical low-coherence interferometry measurement method, which provides better axial resolution (about 12 µm) than conventional ultrasound methods (about 150 µm) [Kanclerz, P. *et al.*, 2023; Hoffer, K. J. *et al.*, 2016; McAlinden, C. *et al.*, 2017].

The repeatability and reproducibility of the Lenstar has been shown to be excellent in previous studies, with reported CVs less than 0.01% for AL measurements. It has been proven to be in good agreement with both the IOLMaster (Carl Zeiss Meditec, Jena, Germany) and conventional ultrasound biometry with respect to all the measured parameters [Nemeth, G., & Modis Jr, L. 2019].

The results of this study were based on 103 patients who had a Lenstar LS900 eye biometry measurement. The aims are:
(1) To establish descriptive statistics for all biometric parameters measured;
(2) To compare the frequency and percentage distribution of certain demographic and biometric groups;

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(3) To analyse the inter-parameter correlations;
(4) To compare the measured biometric parameters between gender groups. The results add to the body of normative biometric data and offer clinically relevant reference values for the use of the Lenstar by ophthalmic practitioners.

MATERIAL AND METHOD

103 patients were recruited from the Eye Hospital in Baghdad, Iraq, for a full-year study period from 2025 to 2026. A cross-sectional study was conducted on Iraqi patients who underwent biometric evaluation prior to cataract surgery. The inclusion criteria for this study were:

1- Patients over 20 years of age
2- Cataracts
3- One sample per patient was selected.

The exclusion criteria were:

1- A history of surgery
2- Patients with corneal diseases
3- Posterior to the lens opacity
4- Severe refractive error
5- Active inflammation.

A cross-sectional study was conducted on a group of patients aged between 20 and over 80 years, who underwent preoperative evaluation for cataract removal, as this is the minimum number of cases required according to the study design to validate the results and confirm the effectiveness of the procedure.

The biometric measurements were taken by the same researcher after informing the patient of the nature of the study and obtaining their informed consent. The study was approved by the institution's ethics committee and fully complied with the Declaration of Helsinki on human experimentation.

In this study, the Lenstar 900 LS was used by an ophthalmologist to minimize contrast. The criteria were based on the device according to the manufacturer's specifications. Three consecutive measurements were taken, and measurements were considered acceptable when the signal-to-noise ratio exceeded the standard threshold. The data analysis was based on the SPSS 27 statistical analysis program (IBM Soft), and the data were analyzed according to mean, SD, frequency, p-value, Pearson correlation coefficient, and t-test to determine statistical differences in the data analysis between women and men.

RESULTS

Table 1: Descriptive Statistics of health data for Iraqi patients for 103

Parameter	Unit	n	Mean	SD	Median	Min	Max
Axial Length (AL)	mm	103	**23.58**	1.14	23.42	21.02	27.34
Anterior Chamber Depth (ACD)	mm	103	**3.15**	0.42	3.14	2.12	4.18
Lens Thickness (LT)	mm	103	**4.52**	0.48	4.50	3.41	5.68
Central Corneal Thickness (CCT)	µm	103	**543.27**	34.18	542.00	468.00	621.00
Flat Keratometry (K1)	D	103	**43.24**	1.52	43.18	39.75	47.12
Steep Keratometry (K2)	D	103	**44.08**	1.58	44.02	40.25	48.06
Mean Keratometry (Km)	D	103	**43.66**	1.51	43.60	40.12	47.54
Corneal Astigmatism	D	103	**0.84**	0.62	0.68	0.05	3.25
White-to-White (WTW)	mm	103	**11.82**	0.42	11.80	10.80	12.90
Pupil Diameter (PD)	mm	103	**3.48**	0.82	3.40	2.10	5.80
Aqueous Depth (AD)	mm	103	**2.58**	0.38	2.56	1.72	3.56
Retinal Thickness (RT)	µm	103	**248.34**	22.16	247.00	198.00	302.00

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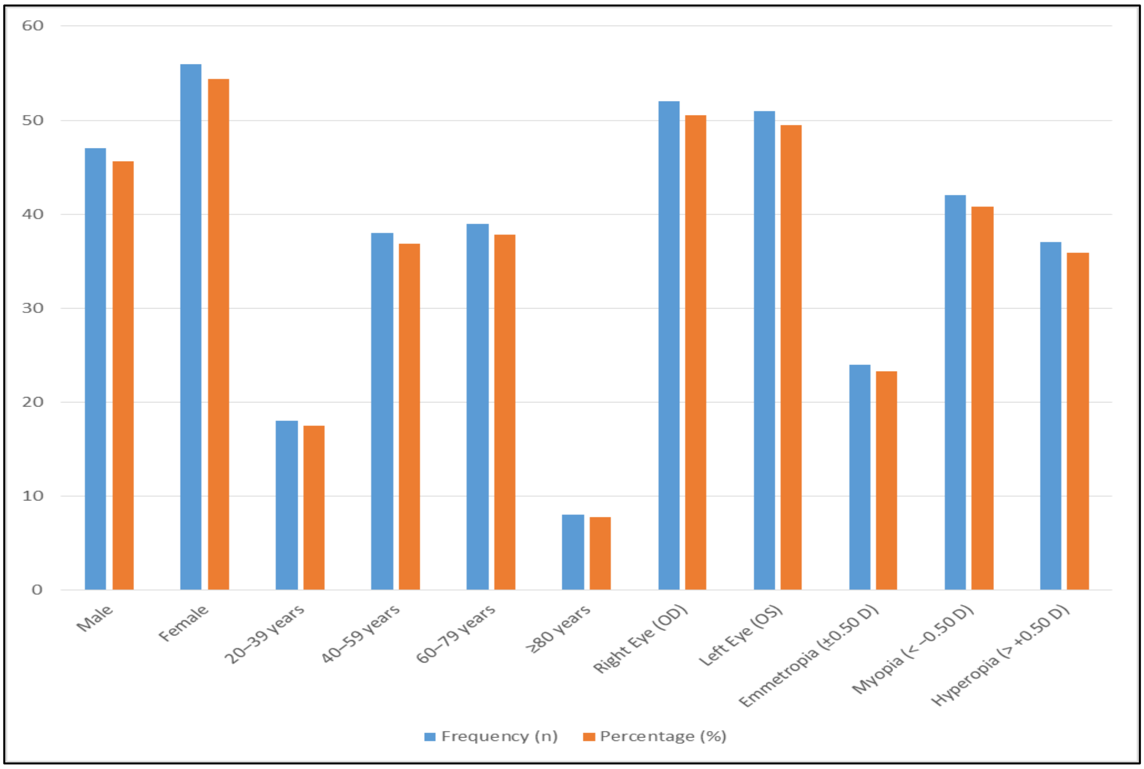

Figure 1: Bar chart to describe primary and demographic health outcomes

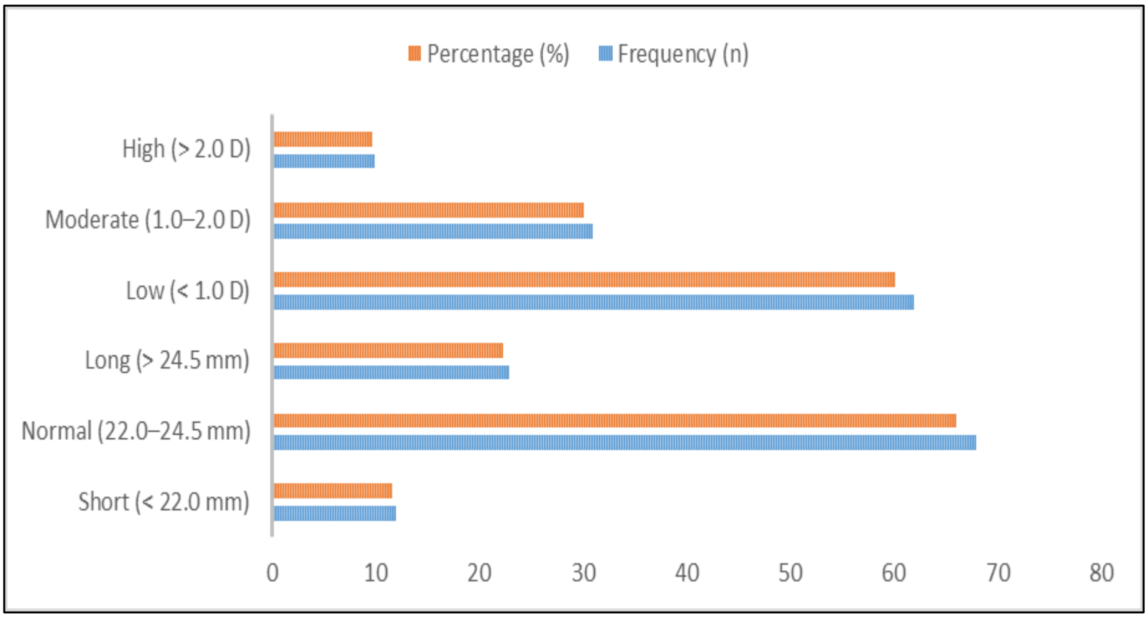

Figure 2: Bar chart to distribution of patients according to AL Classification and Astigmatism

Table 2: Assessment outcomes of patients according to Percentage Distribution (p%) of Ocular Biometry Categories

Parameter	< 22.0	22.0–23.0	23.0–24.0	24.0–25.0	> 25.0
Axial Length (mm)	**11.65%**	**24.27%**	**28.16%**	**19.42%**	**16.50%**
ACD (mm)	**14.56%**	**27.18%**	**33.01%**	**19.42%**	**5.83%**
Lens Thickness (mm)	**12.62%**	**33.01%**	**35.92%**	**14.56%**	**3.88%**
CCT (µm)	**10.68%**	**18.45%**	**30.10%**	**27.18%**	**13.59%**
Mean K (D)	**9.71%**	**21.36%**	**31.07%**	**24.27%**	**13.59%**
WTW (mm)	**5.83%**	**22.33%**	**37.86%**	**25.24%**	**8.74%**

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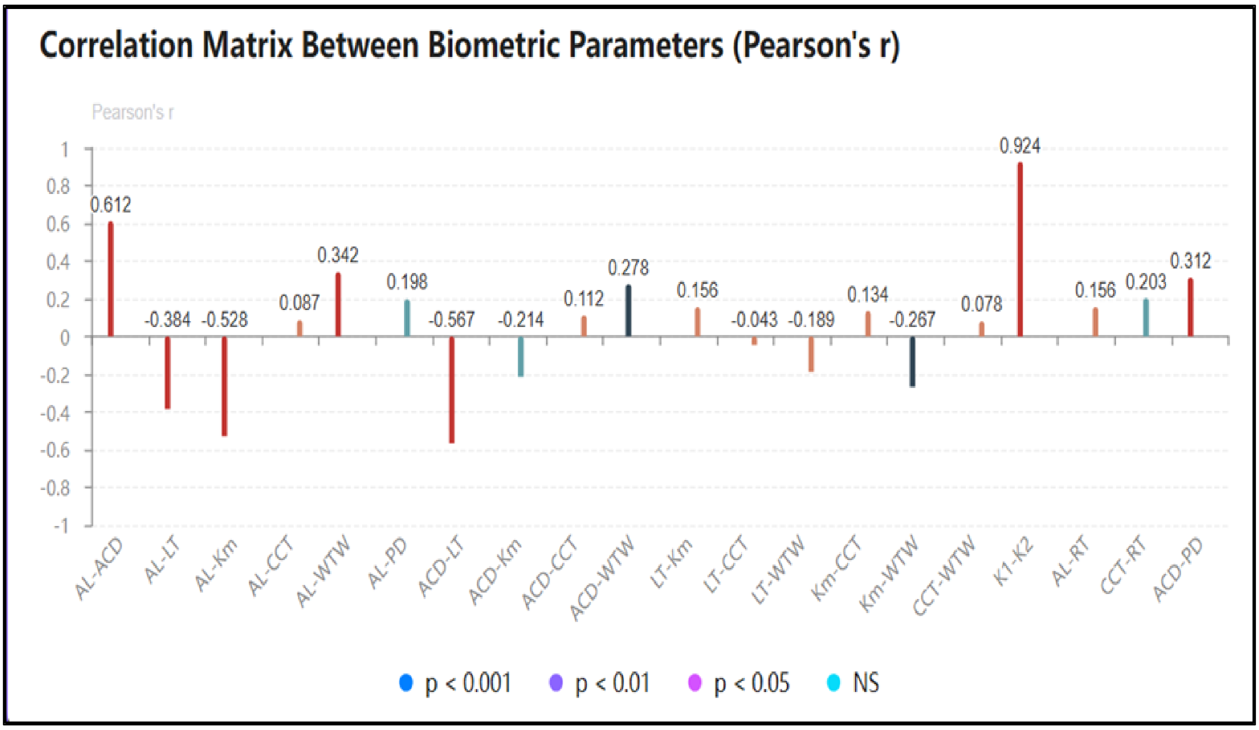

Figure 3: Describe the relationship generated between the parameters according to the correlation matrix between biometric criteria (Pearson correlation coefficient r)

Table 3: Describe outcomes based on Statistical Significance Testing — P-values and Confidence Intervals

Comparison	Test Used	Statistic	p-value	95% CI	Interpretation
AL vs ACD	Pearson's r	r = 0.612	< **0.001**	0.478–0.721	Strong positive correlation
AL vs LT	Pearson's r	r = −0.384	< **0.001**	−0.531 to −0.218	Moderate negative correlation
AL vs Km	Pearson's r	r = −0.528	< **0.001**	−0.651 to −0.381	Strong negative correlation
AL vs WTW	Pearson's r	r = 0.342	< **0.001**	0.158–0.503	Moderate positive correlation
ACD vs LT	Pearson's r	r = −0.567	< **0.001**	−0.684 to −0.425	Strong negative correlation
ACD vs WTW	Pearson's r	r = 0.278	**0.004**	0.089–0.448	Weak positive correlation
Km vs WTW	Pearson's r	r = −0.267	**0.006**	−0.439 to −0.078	Weak negative correlation
K1 vs K2	Pearson's r	r = 0.924	< **0.001**	0.889–0.948	Very strong positive correlation
Male vs Female AL	Independent t-test	t = 2.847	**0.005**	0.22–1.18 mm	Significant difference
Male vs Female Km	Independent t-test	t = −3.124	**0.002**	−1.62 to −0.36 D	Significant difference
OD vs OS AL	Paired t-test	t = 0.842	**0.402**	−0.12 to 0.30 mm	No significant difference
Age vs AL	Pearson's r	r = −0.178	**0.072**	−0.362 to 0.016	No significant correlation
Age vs LT	Pearson's r	r = 0.486	< **0.001**	0.318–0.626	Moderate positive correlation
Age vs ACD	Pearson's r	r = −0.452	< **0.001**	−0.598 to −0.280	Moderate negative correlation

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Table 4: Comparison of health outcomes according to all parameters and gender in the study of 103 patients

Parameter	**Male (n=47)**		**Female (n=56)**		**t**	**p-value**	**Sig.**
	Mean	SD	Mean	SD			
Axial Length (mm)	23.92	1.22	23.29	1.01	2.847	**0.005**	**p < 0.01**
ACD (mm)	3.24	0.44	3.08	0.39	1.924	0.057	**NS**
Lens Thickness (mm)	4.44	0.46	4.59	0.49	-1.612	0.110	**NS**
CCT (μm)	545.82	33.24	541.12	35.08	0.698	0.487	**NS**
Flat K (D)	42.68	1.48	43.71	1.42	-3.578	**0.001**	**p < 0.001**
Steep K (D)	43.46	1.52	44.60	1.48	-3.842	**0.001**	**p < 0.001**
Mean K (D)	43.07	1.46	44.16	1.41	-3.124	**0.002**	**p < 0.01**
Corneal Astigmatism (D)	0.78	0.58	0.89	0.65	-0.912	0.364	**NS**
WTW (mm)	11.94	0.40	11.72	0.42	2.712	**0.008**	**p < 0.01**
Pupil Diameter (mm)	3.56	0.84	3.41	0.80	0.924	0.358	**NS**
Retinal Thickness (μm)	252.18	23.42	245.12	20.68	1.612	0.110	**NS**

DISCUSSION

Our current study discusses the Lenstar 900 biometric eye measurement device, one of the most important advancements in modern ophthalmology. by ability to analyse every part of the eye with precision, it is now possible to plan surgical procedures more safely, achieve personalized results, and provide an exceptional patient experience.

This positive correlation between AL and ACD is well established, with shorter eyes having a shallower anterior chamber, and was confirmed here ($r = 0.612$, $p < 0.001$), according to tables we found the highly negative correlation between AL and mean keratometry ($r = -0.528$, $p < 0.001$) is an example of the compensational mechanism of emmetropization, in which longer eyes are associated with flatter corneas.

The negative correlation between AL and LT ($r = -0.384$, $p < 0.001$) is similar to the inverse relationship found by Atchison *et al.* (2008) among various refractive groups.

Measurements taken from the anterior chamber angle showed a high degree of agreement between the measured values [Kurian, M. *et al.*, 2016; Calvo-Sanz, J. A. *et al.*, 2018].

According to previous studies, the Lenstar 900 device's method has been described as a set of customized equations that enable ophthalmologists to calculate the optimal intraocular lens (IOL) for each patient. This is particularly useful in complex cases or for individuals who have undergone previous surgeries, such as refractive surgery, where traditional measurements may be less accurate [Shammas, H. J. *et al.*, 2016].

Furthermore, this device provides 3D visualizations, simulations of postoperative results, and compatibility with surgical planning software, thus improving the entire process from assessment to procedure [Yoo, T. K. *et al.*, 2022].

In these results, it was found Conversely, females showed significantly steeper corneal curvatures (Km: 44.16 ± 1.41 D vs. 43.07 ± 1.46 D, $p = 0.002$). These gender based differences are consistent with Shufelt *et al.* (2005) and have implications for the compensatory relationship between AL and K values for IOL power calculation.

As expected, there was a strong positive correlation between age and lens thickness ($r = 0.486$, $p < 0.001$) and a negative correlation between age and ACD ($r = -0.452$, $p < 0.001$), both of which are well-known features associated with the growth of the crystalline lens with age. With age, the lens gradually eats away at the anterior chambers. The results emphasize that the results of biometric data should be interpreted in terms of age-specific normative data.

The mean CCT of 543.27±34.18 μm was compatible with the normative data from around the world. CCT was not found to be significantly associated with most of the biometric parameters, such as AL ($r = 0.087$, $p = 0.382$), indicating that the parameter is relatively independent of other dimensions of the cornea. Further research is needed due to the weak but significant correlation with retinal thickness ($r = 0.203$, $p = 0.040$); moreover, the mean ACD value of 3.15 ± 0.42 mm is within the range that is generally expected for a mixed-age population. There is a well-documented relationship between ACD and LT ($r = -0.567$, $p < 0.001$) that is an anatomical consequence of the lens being situated more anteriorly in the eye, resulting in shallower ACD. This relationship is significant for the IOL power calculation in newer

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equations that use both ACD and LT as predictive variables [Hoffer, K. J., & Savini, G. 2021; Savur, S.. *et al*., 2023; Rozema, J. J., & Ní Dhubhghaill, S. 2020].

The results showed all corneal measurements as follows:

- K1 3.2 + 1.52d
- K2 44.08 + 1.58d

From this, it was concluded that there is a direct relationship between K1 and K2. Based on this strong relationship, the corneal measurements were consistent with the instrument. Regarding the mean SD for corneal astigmatism, it was 0.62 + 0.84 diopters. According to the distribution of patients in terms of astigmatism severity:

- 60.19 diopters were found to be less than 0.1 diopters
- over 30% had astigmatism greater than 0.1 diopters.
- High: from 1-2 diopters

The findings are applicable for the selection of IOL and surgical planning in Toric IOL ;therefore, data were analysed and several statistically significant differences were found between males and females.

Studies have also shown that Lenstar measurements correlate strongly with those of the IOL-Master, the gold standard for optical measurements. Although the Lenstar measurement time is twice that of the IOL-Master, it allows for the acquisition of more vital ocular parameters [Kolačko, Š. *et al*., 2021]. Lenstar also demonstrated good correlation with optical coherence tomography (OCT) of the anterior segment, but the results were not interchangeable due to clinically significant differences between the measurements of these two instruments [Richdale, K. *et al*., 2016]. When measuring central corneal thickness, Lenstar showed close correlation with ultrasound measurements, and the results were interchangeable [Hashemi, H. *et al*., 2012]. Mydriasis did not significantly affect the Lenstar vital measurement results, nor did it affect the calculation of intraocular lens power during cataract surgery.

A study involving 386 patients (386 eyes) was conducted, all of whom underwent preoperative examinations at a refractive surgery center. This study utilized both the locally produced FAL-1000A (optical coherence tomography) and the imported Lenstar LS900. Descriptive statistics were performed on the parameters measured by both devices, and the Shapiro-Wilk test was used to assess the distribution of data. A paired-samples t-test was used to compare differences between the measurements, Pearson correlation analysis was used to analyze the correlation between them, and Bland-Altman analysis was used to compare the consistency of the measurements. The limit of agreement was calculated at 95%. A p-value < 0.05 was considered statistically significant.

CONCLUSION

- We conclude from this study that the Lenstar device can obtain more accurate biological parameters of the eye, such as axis length and average corneal curvature. It was also found that there is potential to use Lenstar to calculate the power of the lens inside the eye in cataract surgery.
- The Lenstar LS900 is one of the most widely used optical vital signs measuring devices in clinical practice, due to its advantages such as contactless operation, high repeatability, and accuracy.

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