Photodiagnosis and Photodynamic Therapy 59 (2026) 105521

Contents lists available at ScienceDirect

Photodiagnosis and Photodynamic Therapy

journal homepage: www.elsevier.com/locate/pdpdt

Research Paper

Agreement of anterior segment parameters measured by Scheimpflug-based Scansys and Pentacam HR: A prospective, cross-sectional comparative study

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ARTICLE INFO

Keywords:
Scheimpflug imaging
Anterior segment parameters
Agreement
Interchangeability
Repeatability

ABSTRACT

Objective: This study aimed to systematically evaluate the repeatability, differences, and agreement between Scansys and Pentacam HR for measuring anterior segment parameters.
Methods: This prospective consistency evaluation study evaluated 222 patients' right eyes at our hospital from October to December 2025, analyzing anterior segment parameters with Scansys and Pentacam HR through three scans per eye. Measurement repeatability for both devices was assessed. Differences between devices were analyzed, and agreement was evaluated.
Results: Both Scansys and Pentacam HR demonstrated excellent measurement repeatability (ICC >0.9). No significant differences were observed in corneal curvature between the two devices. Although significant differences in corneal thickness, horizontal white-to-white (HWTW), anterior chamber depth (ACD), anterior chamber angle, and corneal volume were noted, these were clinically insignificant. Meanwhile, Q value, pupil diameter (PD), and anterior chamber volume (ACV) were significantly different. Agreement analysis showed that key parameters (corneal curvature, corneal astigmatism, corneal thickness, and corneal volume) demonstrated excellent agreement between devices (ICC >0.9; narrow 95% limits of agreement). However, agreement was poor for corneal asphericity, ACV, and PD (ICC <0.75). HWTW and ACD showed good agreement, but their 95% limits of agreement were wide.
Conclusion: Scansys has good stability, and its measurements of corneal curvature and thickness align well with Pentacam HR, allowing safe interchange. However, parameters like corneal asphericity, ACV, and PD show poor consistency and should not be used interchangeably. Caution is warranted when using HWTW and ACD interchangeably in high-precision applications. Taken together, this study supports rational device selection in clinical practice.

1. Introduction

Accurate measurement of anterior segment parameters is a critical foundation for modern ophthalmic clinical practice, essential in refractive surgery, cataract preoperative planning, glaucoma screening, and corneal disease diagnosis [1]. Key anatomical and optical parameters, such as corneal curvature, corneal thickness, and anterior chamber depth (ACD) are critical for determining surgical strategies, calculating intraocular lens power, and assessing disease risk. Thus, rigorous validation of anterior segment imaging technologies is paramount to ensure accurate clinical decision-making and patient safety.

With advancing ophthalmic technology, various devices are available for anterior segment analysis.Among these, rotational tomography based on Scheimpflug imaging principles has become a mainstream method for anterior segment assessment owing to its advantages such as non-contact imaging, high resolution, and three-dimensional reconstruction capabilities compared with other techniques [2]. The Pentacam HR (Oculus, Wetzlar, Germany) is widely regarded as the reference

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https://doi.org/10.1016/j.pdpdt.2026.105521
Received 20 March 2026; Received in revised form 1 May 2026; Accepted 20 May 2026
Available online 21 May 2026
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standard in this field, supported by extensive validation and clinical application [1,3,4], with well-established measurement accuracy and repeatability [5,6]. While other Scheimpflug-based devices, such as Galilei and Sirius are also used, their higher cost may limit accessibility in primary or resource-limited settings.The Scansys three-dimensional anterior segment analyzer (MediWorks, Shanghai, China) is a newly developed Scheimpflug system that has emerged as a promising alternative, offering potential advantages such as lower cost, multifunctionality, and rapid data acquisition in a single scan. It also incorporates advanced features like artificial intelligence-assisted keratoconus detection and prediction of implantable collamer lens (ICL) size and vault [7]. Although Scheimpflug-based devices share similar imaging principles, differences in image acquisition algorithms, three-dimensional reconstruction models, and parameter definitions across manufacturers may lead to systematic differences in measurement results.Failure to account for these differences may introduce bias into clinical decisions and potentially affect surgical outcomes and safety [8]. Preliminary studies have begun evaluating Scansys against other devices [9–11]; however, comprehensive, head-to-head comparisons with the Pentacam HR across a broad spectrum of anterior segment parameters remain scarce, and existing findings show heterogeneity, particularly regarding the agreement for specific parameters.

This study aimed to systematically assess the intra-device repeatability, inter-device variability, and agreement between the new Scheimpflug anterior segment analysis system Scansys and the gold standard device Pentacam HR in measuring multiple anterior segment parameters in healthy eyes. Through a rigorous methodological design, we sought to determine whether the measurements obtained from the two devices are interchangeable in clinical practice, thereby providing objective evidence to support the clinical application of Scansys. Our findings are intended to offer practical guidance for data interpretation and to contribute to the standardized clinical use of high-performance ophthalmic diagnostic devices.

2. Methods

2.1. Study design and participants

This prospective cross-sectional consistency evaluation study included 222 healthy individuals who visited the Refractive Department of our hospital from October to December 2025. Both eyes were examined;however, only data from the right eye of each participant were included in the final analysis (n = 222 eyes) to avoid potential statistical bias arising from interocular correlation within subjects, a common approach in ophthalmic device comparison studies [12].

The inclusion criteria were as follows: age 18–45 years; absence of organic ocular diseases (such as keratoconus, glaucoma, corneal scarring, or active ocular surface inflammation); no history of ocular surgery or trauma; discontinuation of soft contact lenses for at least 1 week, rigid contact lenses for at least 3 weeks, and orthokeratology lenses for at least 3 months prior to examination; and ability to cooperate and complete various examinations. The exclusion criteria were as follows: presence of the aforementioned ocular diseases or surgical history, systemic diseases that may affect ocular measurements (such as uncontrolled diabetes or autoimmune diseases), poor cooperation during examination, or unsatisfactory image quality. This study was performed in accordance with the Declaration of Helsinki and was approved by the hospital's ethics committee (approval number: XXXX). All participants were informed of the study purpose and provided written informed consent.

2.2. Examination devices

Scansys Three-Dimensional Anterior Segment Analyzer (MediWorks): This device utilizes Scheimpflug imaging technology. A single scan acquires 28/60 high-definition tomographic images, collecting 107,520 or 230,400 data points to generate clinical data such as corneal topography, corneal thickness map, and elevation map through analysis and calculation.

Pentacam HR Anterior Segment Analysis System (Oculus): This system, based on Scheimpflug optical principles, uses 475 nm blue light for rotational imaging, capturing 25 or 50 slit images per scan. It measures up to 25,000 corneal data points for three-dimensional reconstruction and analysis, producing clinical data including corneal topography, corneal thickness map, and elevation map.

2.3. Examination protocol and measurement parameters

All examinations were performed in the same dark room environment under natural pupil conditions by the same experienced technician. Both devices operate on similar principles, and the examination order was randomized. Participants were instructed to blink adequately before measurement.Each participant placed their chin and forehead firmly on the chin rest and forehead support. The height of the chin rest was adjusted to align the outer canthus with the instrument's horizontal reference line. Participants were instructed to keep their eyes open and fixate on the blue-light target. Upon proper alignment, image acquisition was automatically initiated. The Scansys and Pentacam HR captured 28 and 25 images, respectively, within approximately 2 s. For each eye, one randomly assigned device first performed three consecutive valid scans,with an interval of approximately 1 min between scans, during which the participant briefly moved away from the device. After a 5-minute interval, the second device repeated the same three-scan procedure. Only measurements with satisfactory image quality were included in the analysis.

The following parameters were recorded and analyzed:

- Corneal shape and optical parameters: flat keratometry (Kf, D), steep keratometry (Ks, D), mean keratometry (Km, D), corneal astigmatism (AST, D), and corneal asphericity (Q value).
- Corneal structural parameters: pupil-center corneal thickness (PCT, μm), central corneal thickness (CCT, μm), thinnest corneal thickness (TCT, μm), and corneal volume (CV, mm^3).
- Anterior chamber parameters: ACD (mm), defined as the vertical distance from the corneal endothelium vertex to the central anterior surface of the lens), anterior chamber angle (ACA, °), anterior chamber volume (ACV, mm^3), and horizontal white-to-white (HWTW, mm).
- Pupil parameter: pupil diameter (PD, mm).

2.4. Statistical analysis

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

Repeatability Assessment: The within-device repeatability of the Scansys and Pentacam HR was evaluated using three consecutive measurements. The following metrics were calculated to assess the consistency of repeated measures within each device:intraclass correlation coefficient (ICC) for intra-device measurements, coefficient of variation (CoV), within-group standard deviation (Sw), and repeatability limit (2.77Sw). ICC values were interpreted as follows: ≥0.90, excellent; 0.75–0.89, acceptable; <0.75, poor. Smaller Sw and CoV values indicate better repeatability.

Variability Assessment: The mean of the three measurements from each device was used for comparison to evaluate differences in measurements between the two devices. The Shapiro–Wilk test was used to check the normality of the data. Normally distributed measurement data are expressed as mean ± standard deviation(SD). For parameters with normal distribution and equal variances, paired-sample *t*-tests were used to compare differences in measurements between devices. Otherwise, the non-parametric Wilcoxon signed-rank test was applied.A P-value < 0.05 was considered statistically significant.

Agreement and Interchangeability Analysis: The agreement

between the two devices was assessed using two complementary methods.to determine whether it met clinically acceptable standards. First, the inter-device ICC was calculated to evaluate the reliability and concordance of measurements between the Scansys and Pentacam HR, where ICC > 0.9 indicated excellent agreement, 0.75–0.9 indicated good agreement, and ICC < 0.75 indicated moderate or poor agreement. The clinical interchangeability of parameters was assessed in conjunction with clinically acceptable limits. Second, Bland–Altman plots were generated using MedCalc® software (version 19.0.4; MedCalc, Ostend, Belgium). Bland–Altman analysis was performed to evaluate the limits of agreement (LoA). The mean difference (bias) and 95% LoA,defined as bias ± 1.96 SD of the differences) were calculated and visualized. The clinical interchangeability for each parameter was judged by determining whether the 95% LoA fell within a predefined clinically acceptable range. A systematic pattern in the Bland-Altman plots was also assessed.

3. Results

A total of 222 patients (222 eyes) were included in this study. The mean age was 28.03 ± 6.74 years (range, 17–46). Among the participants, 67 were male (30.2%), and 155 were female (69.8%).

3.1. Device repeatability

Table 1 summarizes the repeatability metrics for the Pentacam HR and Scansys devices across multiple anterior segment parameters.For both devices, all ICC values exceeded 0.9, indicating excellent intra-device repeatability. The Sw values were small and within clinically acceptable range.Furthermore, no statistically significant differences were found among the three repeated measurements for any parameter (P > 0.05 for all), confirming the high measurement stability of both systems.

3.2. Measurement differences between devices

The paired comparison results are presented in Table 2. No

Table 2
Difference and correlation of the anterior segment parameters measured by Scansys and Pentacam HR.

Parameters	N	Difference			Relevance	
		(Difference, mean ±SD)	t/Z	P	r	P
Kf (D)	222	−0.01±0.13	−1	0.32	0.995	0
Ks (D)	222	0.01±0.14	0.54	0.588	0.996	0
Km (D)	222	−0.01±0.12	−1.09	0.278	0.996	0
AST (D)	222	0.01±0.13	−9.599	0	0.981	0
Q value	222	0.15±0.2	−13.048	0	0.475	0
PCT (mm)	222	−1.93±3.82	−7.53	0	0.994	0
CCT (mm)	222	−1.93±3.88	−7.4	0	0.994	0
TCT (mm)	222	−2.58±4.24	−9.08	0	0.992	0
HWTW (mm)	222	0.07±0.15	−5.935	0	0.922	0
Corneal volume (mm^3)	222	1.91±1.89	15.02	0	0.825	0
ACD (mm)	222	0.09±0.16	8.67	0	0.829	0
Chamber volume (mm^3)	222	25.89±18.49	−12.092	0	0.847	0
ACA (degree)	222	2.05±3.35	9.12	0	0.926	0
Pupil diameter (mm)	222	−0.54±0.39	−20.59	0	0.797	0

Kf, flat keratometry; Ks, steep keratometry; Km, mean keratometry; SD, standard deviation; Q, corneal asphericity; AST, astigmatism magnitude; PCT, pupil-center corneal thickness; CCT, central corneal thickness; TCT, thinnest corneal thickness; HWTW, horizontal white-to-white; ACD, anterior chamber depth; ACA, anterior chamber angle.

Table 1
Comparison of repeatability of the anterior segment parameters measured by Scansys and Pentacam HR.

Parameters	Device	N	Mean±SD	ICC(95%CI)	Sw	2.77Sw	CoV(%)	RMANOVA	
								F	P
Kf (D)	Pentacam	222	42.71±1.4	0.995	0.265	0.73	0.62%	0.466	0.629
	Scansys	222	42.72±1.41	0.995	0.095	0.26	0.22%	0.035	0.966
Ks (D)	Pentacam	222	43.82±1.5	0.996	0.100	0.28	0.23%	0.229	0.796
	Scansys	222	43.79±1.49	0.994	0.122	0.34	0.28%	0.224	0.8
Km (D)	Pentacam	222	43.25±1.41	0.997	0.084	0.23	0.19%	0.988	0.377
	Scansys	222	43.24±1.41	0.996	0.084	0.23	0.19%	0.078	0.925
AST (D)	Pentacam	222	1.11±0.69	0.972	0.095	0.26	8.55%	0.337	0.725
	Scansys	222	1.07±0.68	0.943	0.089	0.36	8.32%	0.251	0.779
Q value	Pentacam	222	−0.3 ± 0.14	0.952	0.025	0.09	8.33%	0.09	0.914
	Scansys	222	−0.45±0.22	0.868	0.037	0.30	−8.00%	0.22	0.803
PCT (mm)	Pentacam	222	541.25±32.01	0.996	1.794	4.97	0.33%	1.623	0.204
	Scansys	222	543.17±30.37	0.993	2.192	6.07	0.40%	0.181	0.835
CCT (mm)	Pentacam	222	541.16±32.1	0.991	1.708	4.73	0.32%	1.817	0.169
	Scansys	222	543.08±30.47	0.993	2.136	5.92	0.39%	0.099	0.906
TCT (mm)	Pentacam	222	537.28±32.26	0.996	1.817	5.03	0.34%	2.712	0.072
	Scansys	222	539.86±30.67	0.998	2.183	6.05	0.40%	0.015	0.985
HWTW (mm)	Pentacam	222	11.63±0.38	0.984	0.055	0.15	0.47%	2.689	0.505
	Scansys	222	11.56±0.38	0.927	0.118	0.33	1.02%	0.017	0.983
Corneal volume (mm^3)	Pentacam	222	60.76±3.35	0.984	0.055	0.15	0.09%	1.927	0.152
	Scansys	222	58.84±2.85	0.984	0.272	0.75	0.46%	0.854	0.43
ACD (mm)	Pentacam	222	3.12±0.26	0.996	0.230	0.92	7.37%	0.125	0.883
	Scansys	222	3.03±0.27	0.991	0.032	0.09	1.04%	1.833	0.167
Chamber volume (mm^3)	Pentacam	222	191.56±34.5	0.987	3.476	9.63	1.81%	0.087	0.917
	Scansys	222	165.65±31.4	0.974	4.415	12.23	2.67%	5.108	0.08
ACA (degree)	Pentacam	222	38.15±4.82	0.952	1.134	3.14	2.97%	1.211	0.303
	Scansys	222	36.1 ± 3.99	0.965	0.749	2.07	2.07%	0.521	0.596
Pupil diameter (mm)	Pentacam	222	3.12±0.57	0.906	0.158	0.44	5.07%	1.056	0.353
	Scansys	222	3.66±0.64	0.902	0.315	0.87	8.60%	0.927	0.4

Kf, flat keratometry; Ks, steep keratometry; Km, mean keratometry; SD, standard deviation; Q value, corneal asphericity; AST, astigmatism magnitude; PCT, pupil-center corneal thickness; CCT, central corneal thickness; TCT, thinnest corneal thickness; HWTW, horizontal white-to-white; ACD, anterior chamber depth; ACA, anterior chamber angle; ICC, intraclass correlation coefficient; CI, confidence interval; Sw, within-group standard deviation; 2.77Sw, repeatability limit; CoV, coefficient of variation; RMANOVA, repeated-measures analysis of variance.

significant differences were observed for Kf, Ks, and Km between Scansys and Pentacam HR ($P > 0.05$).For several other parameters—including PCT, CCT, TCT, HWTW, ACD, ACA, and CV—the measured differences were statistically significant ($P \leq 0.05$). However, the magnitudes of these differences were minimal (e.g., −1.93 μm for CCT, 0.09 mm for ACD) and are therefore considered clinically negligible.In contrast, statistically significant differences were observed for the Q value, ACV, and PD ($P \leq 0.05$), indicating clinically significant differences.

3.3. Consistency between devices

The agreement analysis results are detailed in Table 3 and Fig. 1.

- Parameters with Excellent Agreement: The inter-device ICC values for Kf, Ks, Km, AST, PCT, CCT, and TCT were all >0.9, indicating excellent agreement. The Bland–Altman plots showed that the data points were clustered around the zero line with narrow 95% limits of agreement (95% LoA), which fell entirely within pre-defined clinically acceptable limits (Fig. 1A–D, F–H).
- Parameters with Good to Moderate Agreement: The ACD showed good agreement (ICC = 0.784), but its Bland–Altman plot revealed a 95% LoA ranging from −0.214 to 0.395 mm (Fig. 1K). Although HWTW had an excellent ICC (>0.9), its 95% LoA was relatively wide (−0.228 to 0.361 mm) (Fig. 1I). The width of the LoA for these two parameters suggests that their interchangeability in clinical practice should be approached with caution, particularly in applications demanding high precision.
- Parameters with Poor Agreement: The Q-value, ACA, ACV, and PD all demonstrated poor agreement, with ICC values <0.75;their Bland–Altman plots showed mean biases notably deviating from zero, with widely dispersed data points and very broad 95% LoA (Fig. 1E, M, L, N). These results indicate that measurements of these parameters are not interchangeable between the Scansys and Pentacam HR, and the potential causes for these discrepancies are explored in the “Discussion”.

4. Discussion

This prospective study provides a comprehensive evaluation of the novel Scansys system against the established Pentacam HR, systematically assessing the measurement repeatability, inter-device agreement, and clinical interchangeability of key anterior segment parameters. The significance of this work is twofold:on one hand, it offers a rigorous validation of the cost-effective Scansys, moving beyond preliminary repeatability reports to directly test its clinical interchangeability with the gold standard;on the other hand, it delivers immediate, evidence-based guidance by supporting the rational adoption of Scansys for fundamental biometrics, while clearly delineating parameters that require device-specific interpretation to safeguard clinical accuracy and decision-making.

The central findings delineate a clear, tripartite spectrum of agreement, which forms the practical core of this study. Excellent intrinsic repeatability was established for both devices, providing a reliable methodological foundation. Building on this foundation, the inter-device analysis revealed parameter-specific outcomes. Corneal curvature showed no significant inter-device difference, while parameters such as corneal thickness and ACA exhibited statistically significant yet clinically negligible differences. In contrast, Q-value, PD, and ACV demonstrated differences that were both statistically and clinically significant. Consequently, the key practical outcome is a parameter-specific guide for clinicians: core corneal parameters (corneal curvature, astigmatism, and thickness) are interchangeable; ACD and HWTW require cautious interpretation due to clinically wide LoA; and Q-value, ACV, and PD should not be used interchangeably between devices.

A robust comparison first requires establishing the intrinsic measurement stability of each device. In the present study, we employed a comprehensive evaluation using both ICC and Sw to strengthen the assessment of repeatability. Our analysis confirmed outstanding intra-device repeatability for both Scansys and Pentacam HR (ICC >0.9 for all parameters, coupled with small Sw values), with no significant difference in repeatability performance between the two devices themselves. This high degree of repeatability underscores the inherent stability of rotating Scheimpflug imaging technology, a finding consistent with prior studies [2,13], and thereby establishes a reliable foundation for the subsequent inter-device agreement analysis.

For corneal curvature parameters (Kf, Ks, Km), no significant inter-device differences were observed, with excellent agreement (ICC > 0.9) supporting their clinical interchangeability. This finding is consistent with the fundamental principles of Scheimpflug imaging for direct anterior corneal surface reconstruction. Our results align with and are corroborated by prior comparative studies. For instance, Wang et al. reported minimal differences and narrow 95% LoA ranging from −0.48 to 0.55 D, −0.52 to 0.69 D, and −0.45 to 0.57 D for K1, K2, and Km between Scansys and Pentacam [14]. Similarly, Xu et al. concluded that Scansys can be used interchangeably with Pentacam HR for corneal curvature data [10]. Collectively, these findings confirm the reliability of our measurements and underscore the robust clinical utility of this

Table 3
Agreement between Scansys and Pentacam HR in measuring anterior segment parameters.

Parameters	N	ICC (Two-Way Mixed Model)			Bland–Altman		
		ICC	95%LoA	P	Mean Difference	95%CI	P
Kf (D)	222	0.995	0.996 to 0.994	0.32	−0.009	−0.273 to 0.255	0.32
Ks (D)	222	0.996	0.997 to 0.995	0.588	0.005	−0.262 to 0.271	0.588
Km (D)	222	0.996	0.997 to 0.995	0.278	−0.005	−0.249 to 0.238	0.518
AST (D)	222	0.981	0.985 to 0.975	0.131	0.014	−0.247 to 0.274	0.131
Q value	222	0.325	0.526 to 0.051	0	0.152	−0.241 to 0.546	0
PCT (mm)	222	0.991	0.995 to 0.981	0	−1.928	−9.406 to 5.550	0
CCT (mm)	222	0.99	0.994 to 0.981	0	−1.928	−9.537 to 5.681	0
TCT (mm)	222	0.988	0.994 to 0.968	0	−2.581	−10.886 to 5.724	0
HWTW (mm)	222	0.908	0.941 to 0.846	0	0.066	−0.228 to 0.361	0
Corneal volume (mm^3)	222	0.686	0.861 to 0.12	0	1.909	−1.802 to 5.619	0
ACD (mm)	222	0.784	0.873 to 0.588	0	0.09	−0.214 to 0.395	0
Chamber volume (mm^3)	222	0.645	0.865 to −0.058	0	25.892	−10.352 to 62.135	0
ACA (degree)	222	0.645	0.781 to 0.383	0	2.05	−4.511 to 8.611	0
Pupil diameter (mm)	222	0.568	0.821 to −0.074	0	−0.541	−1.307 to 0.226	0

Kf, flat keratometry; Ks, steep keratometry; Km, mean keratometry; SD, standard deviation; Q, corneal asphericity; AST, astigmatism magnitude; PCT, pupil-center corneal thickness; CCT, central corneal thickness; TCT, thinnest corneal thickness; HWTW, horizontal white-to-white; ACD, anterior chamber depth; ACA, anterior chamber angle.

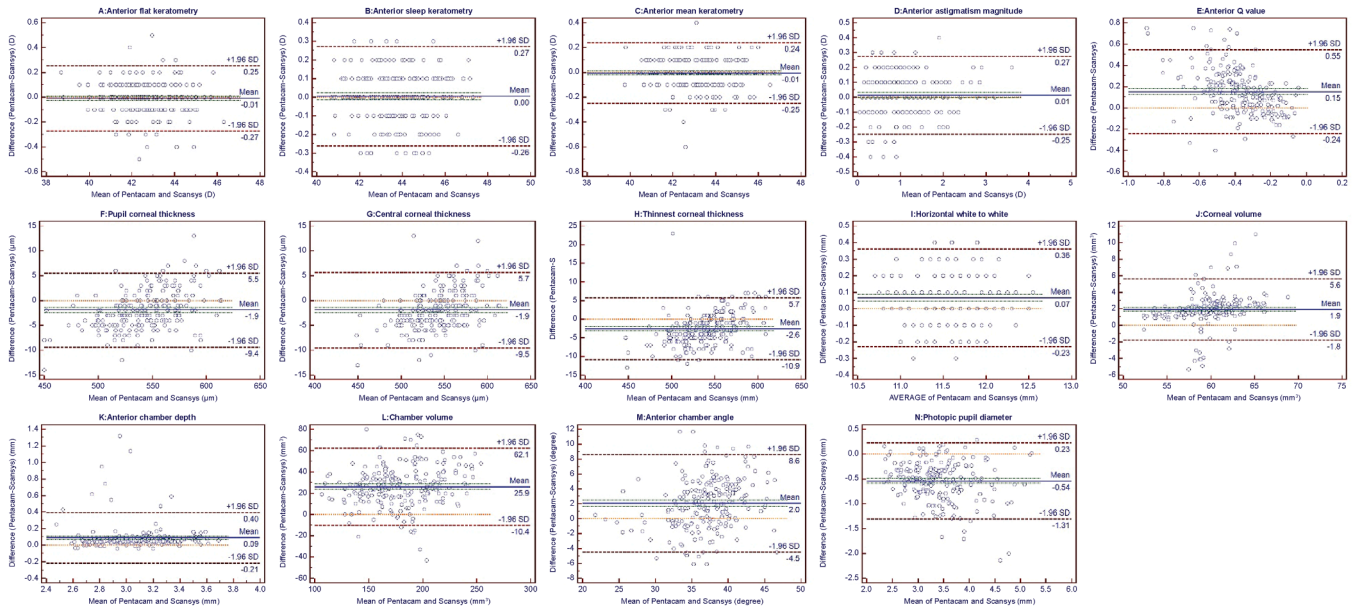


Fig. 1. Bland–Altman plots with limits of agreement (LoAs) for the biometric parameters measured using Scansys and Pentacam HR.
(A:Anterior flat keratometry(Kf); B: Anterior steep keratometry(Ks); C: Anterior mean keratometry(Km); D: Anterior astigmatism magnitude(AST);E:Anterior Q value; F:Pupil-center corneal thickness(PCT);G:Central corneal thickness(CCT);H:Thinnest corneal thickness(TCT);I:Horizontal white-to-white(HWTW);J:Corneal volume;K: Anterior chamber depth(ACD);L:Chamber volume;M:Anterior chamber angle(ACA);N:Photopic pupil diameter(PD).SD, standard deviation.The mean difference and 95% LoA are indicated by the blue solid line and brown dash-dotted lines, respectively.).

imaging technology for applications such as refractive surgery planning and keratoconus screening.

Regarding corneal thickness and anterior chamber angle (ACA), our data demonstrated excellent inter-device agreement between Scansys and Pentacam HR. For corneal thickness parameters (PCT, CCT, TCT), Scansys yielded slightly higher values, but the mean differences were small (-1.93 ± 3.82, -1.93 ± 3.88, and -2.58 ± 4.24 μm, respectively), aligning with prior reports that Pentacam may systematically underestimate corneal thickness [15,16]. Wang et al. found no statistically significant difference in CCT between the devices (mean difference: 3.50 ± 2.80 μm) with good correlation [14]. Another study reported Scansys-measured CCT lower than Pentacam by -17 ± 7.0 μm, but the narrow 95% LoA of −31 to −3.5 μm confirmed good consistency [17]. Similarly, Yu et al. concluded that Scansys could be used interchangeably with Pentacam HR for corneal thickness assessment [18]. A comparable pattern emerged for ACA. The mean ACA was $36.1° \pm 3.99°$ for Scansys and $38.15° \pm 4.82°$ for Pentacam HR, yielding a statistically significant mean difference of 2.05° with 95% LoA of $-4.51°$ to $8.61°$ These findings are consistent with previous work: Dai et al. [19] reported Pentacam-measured ACA values in normal and highly myopic subjects comparable to ours, and Y. Liu et al. [17] observed a mean difference of $3.5° \pm 4.8°$ (95% LoA: −6° to 13°) between the two devices, concluding they are interchangeable for ACA assessment.Critically, when interpreted within the Shaffer angle classification system—where the minimum interval between grades is 10°—the observed inter-device variability falls well within clinically acceptable limits. Although potential measurement variations (e.g., scanning time, fixation light intensity, tear film thickness) can influence Scheimpflug acquisitions, statistical significance does not necessarily equate to clinical relevance. Therefore, the minimal absolute differences and narrow LoA support the clinical interchangeability of Scansys and Pentacam HR for assessing both corneal thickness and ACA.

The clinical picture is more nuanced for parameters such as anterior chamber depth (ACD) and horizontal white-to-white distance (HWTW). While both demonstrated good statistical agreement between devices, each exhibited clinically wide 95% LoA,necessitating context-dependent caution.For ACD, agreement was good (ICC = 0.784). However, Bland–Altman analysis revealed 95% LoA from −0.214 to 0.395 mm, indicating that inter-device differences for an individual could exceed 0.4 mm. This variability is clinically significant because a 0.10 mm change in ACD can alter refractive outcomes by 0.10–0.15 D in intraocular lens (IOL) power calculation [20]. The literature on the interchangeability of Scheimpflug-derived ACD measurements presents a mixed picture. Liu et al. [17] reported a minimal mean difference (approximately 0.04 mm) and 95% LoA of −0.38 to 0.30 mm between Scansys and Pentacam but still advised corroboration with ultrasound biomicroscopy. In contrast, Mustafa et al. [21] found significant differences and wide LoA across several devices, concluding against interchangeability. A similar pattern was observed for HWTW. Pentacam HR yielded significantly higher values than Scansys ($P < 0.05$). Despite excellent agreement (ICC = 0.908), the 95% LoA ranged from −0.228 to 0.361 mm, suggesting that inter-device differences in individual patients could approach 0.6 mm.This aligns with existing literature cautioning against the interchangeable use of HWTW measurements from different Scheimpflug-based devices [17,22]. For instance, Domínguez-Vicent et al. [22] reported wide 95% LoA between Pentacam HR and Galilei G2, advising against direct interchangeability. Similarly, Liu et al. [17], in a direct comparison, observed a mean difference of -0.36 ± 0.14 mm with 95% LoA of −0.64 to −0.08 mm between Scansys and Pentacam, further corroborating the systematic bias and variability noted in our study. Consequently, although overall agreement for ACD and HWTW is statistically good, the clinically wide LoA preclude direct substitution of measurements between devices for individual patients in high-precision scenarios, such as ICL sizing or premium IOL calculations. Therefore, we recommend using the same device system for both preoperative planning and postoperative follow-up in such cases.

In contrast, parameters such as the corneal asphericity (Q-value), anterior chamber volume (ACV), and pupil diameter (PD) exhibited differences that were both statistically significant and clinically substantial, with poor inter-device agreement (ICC < 0.75), thereby precluding their clinical interchangeability. This conclusion is supported by previous studies. Y. Liu et al. [17] reported a mean difference of (-21 ± 20) mm^3 for ACV and (0.36 ± 0.45) mm for PD, with wide 95% LoA, concluding against their interchangeable use. Similarly, Xu et al. [10]

found statistically significant differences and poor agreement for all three parameters, advising against their interchangeability. These discrepancies likely stem from two principal sources: (1) algorithmic differences, as Q-value and ACV are derived parameters highly dependent on proprietary corneal shape-fitting and three-dimensional reconstruction algorithms; and (2) variations in measurement conditions, particularly for PD, which is notoriously sensitive to ambient lighting and the specific properties of the device's fixation target.

This study has some limitations. First, the cohort comprised healthy individuals and myopic patients planning refractive surgery,and did not include individuals with corneal pathologies, prior ocular surgeries, or systemic diseases affecting anterior segment structures; therefore, the generalizability to pathological conditions is limited. Additionally, due to sample constraints, device-specific functions of Scansys (e.g., ICL sizing recommendations) were not evaluated, and their clinical performance requires further investigation.

5. Conclusions

This study confirms that the novel Scheimpflug device Scansys demonstrates excellent repeatability and high agreement with the gold-standard Pentacam HR for key parameters including corneal curvature, corneal thickness, and ACA, supporting their clinical interchangeability. However, for ACD and HWTW, good agreement was accompanied by relatively wide LoA, indicating that caution is warranted in high-precision applications such as ICL implantation, and recommending consistent use of the same device. In contrast, for Q -value, ACV, and PD, significant systematic differences preclude interchangeable use. These findings provide differentiated, evidence-based guidance for the clinical application of Scansys.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

All data generated or analysed during this study are included in this published article [and its supplementary information files].

Ethics approval

This study was performed in accordance with the principles of the Declaration of Helsinki and was approved by the Ethics Committee of Hubei Bright Eye Hospital, Wuhan, China (approval number: MR-42-26-011141). All participants were informed of the study purpose and provided written informed consent.

CRediT authorship contribution statement

Yanfen Liao: Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Pengfei Li:** Investigation, Data curation. **Lei Si:** Formal analysis, Data curation. **Zhengwei Shen:** Resources, Methodology, Conceptualization. **Suli Yang:** Investigation. **Zhongling Yuan:** Investigation. **Bin Zhang:** Project administration. **Liang Xie:** Writing – review & editing, Supervision, Methodology.

Declaration of competing interest

The authors have nothing to declare.

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