KLİNİK ÇALIŞMA / ORIGINAL ARTICLE

Comparison of Anterior Segment Parameters Obtained with Two Different Scheimpflug Based Devices

Scheimpflug Tabanlı İki Farklı Cihazla Saptanan Ön Segment Parametrelerinin Karşılaştırılması

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ABSTRACT

Purpose: To compare the corneal and anterior segment parameters obtained by Pentacam and Nidek AL-Scan in healthy subjects.

Material and Methods: The right eyes of 156 healthy volunteers were included in the study. Participants did not have a history of drug use and systemic illness and ocular surgery. Patients with 3.0 D or more astigmatism or 4.0 D or more spherical refractive error and history of previous contact lens use (within 4 weeks for rigid contact lenses and within 2 weeks for soft contact lenses) were also excluded. Anterior chamber depth (ACD), central corneal thickness (CCT), keratometry (K) [Flattest K (Kf), steepest K (Ks) and mean K (Km)] measurements obtained with Pentacam and Nidek AL-Scan optical biometer were compaired.

Results: Nidek AL Scan underestimated CCT measurements compared with Pentacam ($p<0,001$ and mean difference was -13.41 micrometers). Pearson correlation analysis determined significant positive correlations between Nidek AL Scan and Pentacam in terms of CCT ($r=0.981$, $p<0.001$), ACD ($r=0.983$, $p<0.001$), Kf ($r=0.990$,$p<0.001$), Ks ($r=0.990$, $p<0.001$) and Km ($r=0.991$, $p<0.001$) The Bland-Altman plots showed narrow limits of agreement for ACD, Kf, Ks and Km parameters. However, the limits of agreement for CCT were broad and moderate agreement was found for this parameter.

Conclusions: Good agreement was found in Ks, Kf, Km and ACD parameters between Nidek AL Scan and Pentacam. On the other hand these devices do not seem to be interchangeable for pachymetric determination.

Key Words: Anterior chamber depth, central corneal thickness; keratometry, nidek AL scan optical biometry, pentacam, scheimpflug.

ÖZ

Amaç: Sağlıklı kişilerde Pentacam ve Nidek AL-Scan ile elde edilen kornea ve ön segment parametrelerini karşılaştırmak.

Gereç ve Yöntemler: 156 sağlıklı gönüllünün 156 sağ gözü çalışmaya dahil edildi. Katılımcıların ilaç kullanımı, sistemik hastalıkları ve oküler cerrahi hikayeleri yoktu. 3.0 D veya daha fazla astigmatizması veya 4.0 D veya daha fazla sferik refraktif kusuru ve kontakt lens kullanım öyküsü (sert kontakt lensler için 4 hafta içinde, yumuşak kontakt lensler için 2 hafta içinde) olan hastalar da çalışma dışı bırakıldı. Pentacam ve Nidek AL-Scan optik biometri ile elde edilen ön kamara derinliği (ÖKD), santral kornea kalınlığı (SKK) ve keratometri (K) [en düz K (Kf), en dik K (Ks) ve ortalama K (Km)] ölçümleri karşılaştırıldı.

Bulgular: Pentacam ile karşılaştırıldığında Nidek AL-Scan ile SKK ölçümleri daha düşüktü ($p<0,001$, ortalama fark -13,41 mikron idi). Pearson korelasyon analizi SKK ($r=0,981$, $p<0,001$), ÖKD ($r=0,983$, $p<0,001$), Kf ($r=0,990$, $p<0,001$), Ks ($r=0,990$, $p<0,001$) ve Km ($r=0,991$, $p<0,001$) için anlamlı pozitif korelasyon gösterdi. Bland-Altman grafikleri ÖKD, Kf, Ks ve Km parametreleri için dar uyum sınırları gösterdi. Ancak uyum sınırları SKK için genişti ve bu parametre için ortalama uyum bulundu.

Sonuç: Pentacam ve Nidek AL-Scan ile ölçülen ÖKD, Ks, Kf ve Km değerleri birbiriyle uyumluydu. Ancak pakimetrik ölçümler açısından iki cihazın birbirlerinin yerine kullanılmasının güvenilir olmayacağı görüldü.

Anahtar Sözcükler: Keratometri, nidek AL scan optik biyometri, ön kamara derinliği, pentacam, santral kornea kalınlığı, scheimpflug.

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INTRODUCTION

Precise assessment of central corneal thickness (CCT) is desirable in planning keratorefractive procedures to avoid complications such as corneal ectasia and to evaluate the physiological condition of the corneal endothelium and to determine intraocular pressure accurately.[1-3] The requirement for precise measurements and assessments of corneal topography is increasing in patients undergoing cataract or refractive surgery to obtain good postoperative uncorrected visual acuity. The keratometry (K) value is entered into any intraocular lens (IOL) power calculation formula, while corneal astigmatism measurements are needed when planning toric IOL implantation.[4] In addition, corneal power is indispensable to analyze the shape of the cornea and for fitting contact lenses. Incorrect or invalid information may result in misdiagnosing the keratoconus or misjudging the appropriate timing of treatment.[5] Anterior chamber depth (ACD) is required by the Haigis, Holladay 2, and Shammas intraocular lens power calculation formulae. ACD can be used to assess the risk for angle closure.[4]

The introduction of Scheimpflug cameras into clinical practice has significantly improved capabilities of imaging the anterior eye segment that was not possible until a few years ago.[6] Scheimpflug imaging systems are based on a principle that allows documentation of an object not parallel to the lens and image planes of a camera. It works with maximally possible depth of focus and minimal image distortion. These systems can image and provide meaningful information from the anterior corneal surface to the posterior lens surface (ie, the dioptric power of the whole cornea, including the anterior and posterior surfaces, corneal pachymetry, the ACD, and volume).[7] Scheimpflug imaging systems are non-contact, fast and easy to use. They do not need topical anesthesia and indentation of the cornea.[8]

Nowadays several different versions of Scheimpflug based systems are available. Previous studies have assessed the agreement of the Pentacam (Oculus Optikgeräte GmbH) measurements with Galilei and Sirius.[7,9] To the best of our knowledge two Scheimpflug based camera systems, Pentacam and Nidek AL-Scan optical biometers (Nidek Co., Gamagori, Japan) have not been compared clearly before. Therefore we aimed to compare the corneal and anterior segment parameters obtained by Pentacam and Nidek AL-Scan in healthy subjects.

MATERIAL AND METHODS

All procedures followed the Declaration of Helsinki rules and informed consent was obtained from the participants. The study was approved by the institutional ethic committee. One hundred and fifty-six eyes of 156 healthy volunteers were included in the study. Only the right eyes of the participants were evaluated for statistical analyses. Participants did not have a history of drug use and systemic illness and ocular surgery. Patients with 3.0 D or more astigmatism or 4.0 D or more spherical refractive error and history of previous contact lens use (within 4 weeks for rigid contact lenses and within 2 weeks for soft contact lenses) were also excluded.[10] The measurements were always taken in the same order with Nidek AL Scan and Pentacam by one experienced examiner.

The Nidek AL Scan automatically measures the corneal curvature radius and the steepest and flattest meridians over 2.4 and 3.3 mm diameters. Flattest K (Kf), steepest K (Ks) and mean K (Km) values at the 2.4 mm zone were analysed in this study. The Scheimpflug imaging technique is applied for CCT and ACD measurements and analysed.[11,12]

The Pentacam system uses a rotating Scheimpflug camera and a monochromatic slit light source (blue LED at 475 nm) that rotate together around the optical axis of the eye. During 2 seconds, the system rotates 180° and acquires 25 images that contain 500 measurement points on the front and back corneal surface to draw a true elevation map. In this study Pentacam's automatic release mode was used to reduce operator-dependent variables. The system determined pachymetry at the apex center of the cornea and provided Kf and Ks values. Km was calculated using the mean of the Kf and the Ks. In this study, the CCT at the apex of the cornea, Kf, Ks, Km and ACD measurements were used for analysis.[13]

Statistical Analyses

Statistical analysis was performed with Statistical Package for the Social Sciences (SPSS ver.17) and P values <0.05 were considered statistically significant. Quantitative variables are expressed as mean values ± SD. The paired samples t test was used to compare the results of Pentacam and Nidek AL Scan measurements. Pearson correlation coefficients were calculated to determine the actual correlation between Pentacam and Nidek AL Scan. In order to achieve precise evaluation agreement between the two methods was also assessed using Bland-Altman plot analysis with Analyse-it for Microsoft Excel program. In this analysis, bias was defined as a significant difference in the means of the 2 methods; 95% limits of agreement (LoA) were calculated as the mean difference ±1.96 SD.[13]

RESULTS

Of 156 participants, 70 were male and 86 were female with a mean age of 30.95±12.22 years (ranging from 18 to 59 years). The mean CCT, Kf, Ks, Km and ACD values measured by the two devices and paired comparison results were listed (Table 1). The mean CCT ($p<0.001$), ACD ($p=0.004$), Kf ($p<0.001$), Ks ($p<0.001$), Km ($p<0.001$) measurements were statistically different between the two groups.

The Pearson correlation and Bland-Altman plots of agreement results between two devices are listed (Table 2). Pear-

Table 1. *The mean CCT,ACD, Kf, Ks and Km values and paired comparison results of two devices.*

PARAMETER	NIDEK-AL SCAN (MEAN±SD)	PENTACAM (MEAN±SD)	MEAN DIFFERENCE	STANDART DEVIATION (±)	p VALUE
CCT (mikrometer)	520.33±28.82 (435-589)	533.74±28.64 (448-599)	-13.41	5.56	<0.001
ACD (milimeter)	3.57±0.39 (2.26-4.43)	3.56±0.38 (2.25-4.40)	0.016	0.07	0.004
K flattest (diopter)	43.33±1.62 (39.85-47.07)	43.21±1.57 (39.80-46.90)	0.14	0.24	<0.001
K steepest (diopter)	44.38±1.65 (40.66-48.77)	44.19±1.58 (40.50-48.00)	0.19	0.24	<0.001
K mean (diopter)	43.84±1.60 (40.32-47.87)	43.70±1.54 (40.30-47.50)	0.15	0.22	<0.001

CCT : central corneal thickness ACD : anterior chamber depth K: keratometry

Table 2. *The Pearson correlation and Bland-Altman plots of agreement results between two devices.*

PARAMETER	95% LoA	r Value	p Value
CCT (mikrometer)	2.5 to 24.3	0.981	<0.001
ACD (milimeter)	-0.155 to 0.122	0.983	<0.001
K Flattest (diopter)	-0.614 to 0.341	0.990	<0.001
K Steepest (diopter)	-0.669 to 0.284	0.990	<0.001
K Mean (diopter)	-0.577 to 0.277	0.991	<0.001

CCT : central corneal thickness ACD : anterior chamber depth K: keratometry

son correlation analysis determined significant positive correlations between Nidek AL Scan and Pentacam in terms of CCT (r=0.981, p<0.001) (Fig. 1A), ACD (r=0.983, p<0.001) (Fig. 1B), Kf (r=0.990, p<0.001), Ks (r=0.990, p<0.001) and Km (r=0.991, p<0.001) (Fig.1C).

The Bland-Altman plots showed that the mean differences between the two devices were not significantly different from zero and had a narrow 95% LoA, which implies good agreement for ACD (Figure 2A), Kf, Ks and Km (Figure 2B) parameters. However, the 95%LoA were broad and different from zero for CCT (Figure 2C) measurements which implies moderate agreement for this parameter.

DISCUSSION

Nidek AL Scan uses an 830 nm super luminescent diode for axial length (AL) measurement with partial coherence interferometry. It uses a light-emitting diode for corneal keratometry readings and white-to-white (WTW) distance and pupil diameter assessment. The device uses the Scheimpflug principle to measure CCT and ACD values. The device is capable of performing IOL power calculation using various pre-programmed formulae.[14] The Pentacam offers evaluation of the entire anterior segment from the anterior corneal surface to the posterior lens surface using a rotating Scheimpflug camera.[15]

A number of studies have been conducted to evaluate the performances of Nidek AL Scan and Pentacam. Kola et al.[14] assessed the repeatability and reproducibility of ocular biometry and IOL power measurements obtained by ophthalmology residents using a Nidek AL-Scan device. They found good repeatability and reproducibility in all biometric measurements (corneal keratometry readings, horizontal iris width, central corneal thickness, anterior chamber depth, pupil size, and axial length) and IOL power calculations, independent of the operator concerned. Shankar et al.[16] assessed the reliability of automated Pentacam and reported that corneal curvature and anterior chamber parameters were highly repeatable, but pupil measurements had poor repeatability.

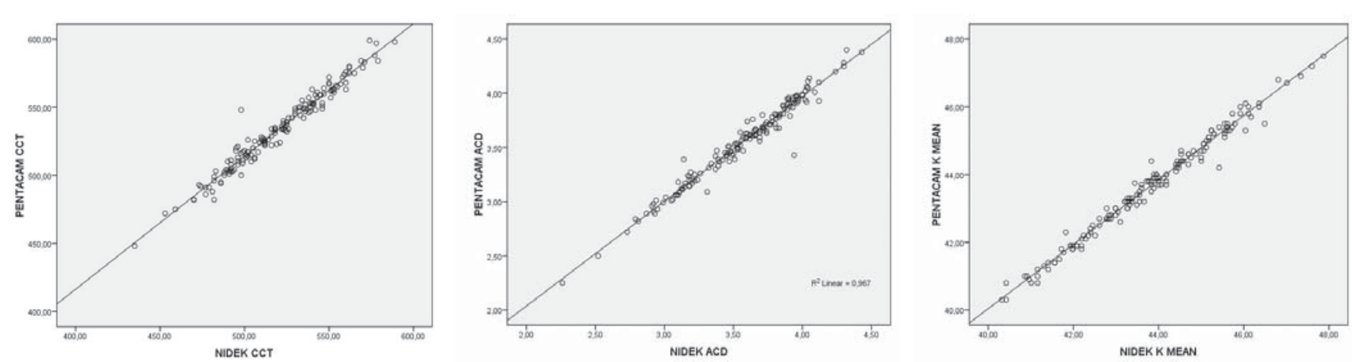

Figure 1. Correlations between Nidek AL Scan and Pentacam measurements. Correlations of CCT (r=0.981, p<0.001) (Fig. 1A), ACD (r=0.983, p<0.001) (Fig. 1B), and Km (r=0.991, p<0.001) (Fig.1C). (CCT: central corneal thickness; ACD: anterior chamber depth; K: keratometry).

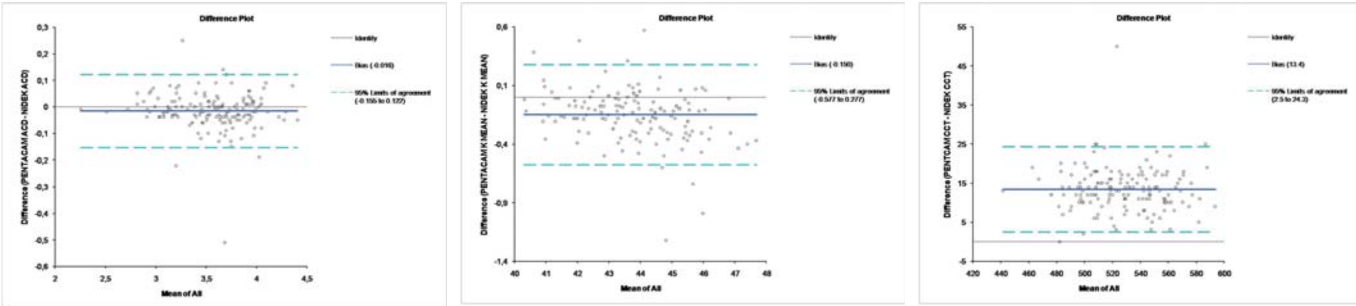

Figure 2. Bland-Altman plots of agreement of ACD (Fig. 2A), K mean (Fig. 2B) and CCT (Fig. 2C) values. The solid line indicates the mean difference (bias). The upper and lower dashed lines represent the 95% limits of agreement. (CCT: central corneal thickness; ACD: anterior chamber depth; K: keratometry).

Rabsilber et al.[15] investigated the mean values and standard deviations according to age, reliability, and correlation between different parameters of anterior chamber measurements using the Pentacam rotating Scheimpflug camera. They concluded that it is possible to examine different parameters of the anterior chamber within a short period and with good reliability with Pentacam.

Various studies in the literature have compared the Nidek AL Scan and IOLMaster which is accepted as reference. Kaswin et al.[17] evaluated the agreement in AL, K, ACD measurements, IOL power calculations beween Nidek AL Scan and IOLMaster. Nidek AL-Scan optical biometer provided precise biometry data and IOL power calculations in cataract patients within an average range of ALs. The measurements were comparable to those obtained with the IOLMaster device. Huang et al.[5] compared K values, AL, ACD, WTW corneal diameter, and IOL power calculated using the Holladay 1 formula obtained with Nidek AL Scan and IOL Master. The mean value of all measurements (except the WTW distance) and calculated IOL power showed good correlation between the two devices.

There are scanty studies about the comparison of Nidek AL Scan and other Scheimpflug imaging systems in the literature. Yağcı et al.[11] evaluated the repeatability and agreement of the anterior segment measurements obtained by using the Galilei dual Scheimpflug analyzer and Nidek AL Scan in keratoconic and normal eyes. In normal eyes, the Galilei DSA and Nidek AL Scan can be used interchangeably for anterior segment measurements. In keratoconic eyes, both devices yielded interchangeable anterior chamber depth and WTW distance measurements, whereas CCT and keratometry measurements showed clinically significant differences. Dervişoğulları et al.[18] compared ACD measurements between the Nidek AL-Scan and the Galilei Dual Scheimpflug Analyzer. The difference in ACD between the measurements of the Nidek AL-Scan and the Galilei Dual Scheimpflug Analyzer was statistically significant but clinically it was negligible. Same authors compared the CCT measurements of Nidek AL-Scan, Galilei G4 Dual Scheimpflug Analyzer and Cirrus HD-OCT. They found that these three devices were in agreement with each other and CCT measurements from these instruments could be used interchangeably.[19]

Many studies have assessed the agreement of the Pentacam with Galiei and Sirius. De la Parra-Colín et al.[20] assessed the repeatability and comparability of mean simulated keratometry (SimK), Kf, Ks, CCT and ACD measurements obtained with Pentacam and Sirius. They found good agreement in three parameters (SimK, Kf and ACD). On the other hand these devices did not seem to be interchangeable for pachymetric determination. Anayol et al.[21] evaluated the agreement of CCT, thinnest corneal thickness (TCT), ACD, and SimK measurements using Pentacam, Galilei, and Sirius Scheimpflug systems in normal eyes. Their study revealed significant differences in CCT, TCT, ACD, and SimK measurements between three devices. Therefore, they suggested that the Pentacam, Galilei, and Sirius Scheimpflug systems should not be accepted as interchangeable for CCT, TCT, ACD, and Sim K in healthy subjects. Shetty et al.[7] assessed the repeatability and agreement of three rotating Scheimpflug cameras, Pentacam, Galilei, and Sirius, in terms of Km, TCT, ACD, and mean posterior keratometry (pKm) measurements in keratoconus patients. In their study Pentacam, Galilei, and Sirius showed repeatable measurements for Km, TCT, ACD, and pKm. Repeatabilities with Pentacam and Sirius were better than those with Galilei. They stated that there were significant differences in the measurements between the three devices; hence they can not be used interchangeably for anterior segment measurements in keratoconus patients.

Our study may have some limitations. Although our sample size is large, the population comprised only healthy persons with normal corneas. Further studies are necessary to determine the accuracy and reliability of anterior segment measurements with the Pentacam system and the Nidek AL Scan biometer in cases of corneal disease, cataract, and pseudophakia etc.

Although the devices yielded significantly different results, the magnitude of the differences are unlikely to be clinically important for ACD, Ks, Kf and Km parameters. Good agreement was found for ACD, Ks, Kf and Km parameters between Nidek AL Scan and Pentacam. On the other hand caution must be used in regard to CCT measurements because the devices had a wide LoA and do not seem to be interchangeable for pachymetric determination.

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