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Evaluation of Refractive Measurements Using a Handheld Autorefractor (Retinomax K+ Screen) Versus Streak Retinoscopy in Dogs

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ABSTRACT

Objective: To evaluate the accuracy and clinical applicability of the handheld autorefractor Retinomax K+ Screen in comparison to manual streak retinoscopy in non-cyclopleged dogs.

Methods: Thirty-four dogs (68 eyes) of 15 different breeds underwent comprehensive ophthalmic examination and refractive assessment using streak retinoscopy and handheld autorefraction. Statistical analyses included the Wilcoxon signed-rank test, Bland–Altman analysis, and Spearman's rank correlation ($\alpha = 0.05$).

Results: Autorefraction was successfully performed in 57 of 68 eyes; 11 eyes were excluded due to insufficient measurement quality. Retinoscopy yielded a mean spherical equivalent of 0.13 ± 1.04 diopters (D), while autorefraction produced significantly more hyperopic values (mean 0.98 ± 1.66 D; $p < 0.001$). Bland–Altman analysis demonstrated wide limits of agreement (−2.52 to +4.10 D), indicating substantial variability. A moderate positive correlation was found between methods ($\rho = 0.49$; $p < 0.001$).

Conclusions: The Retinomax K+ Screen provides rapid, non-invasive refractive measurements but systematically overestimates hyperopia and exhibits considerable variability compared to retinoscopy. Despite fast acquisition, inconsistent results and reduced reliability under suboptimal conditions limit the clinical precision of the autorefractor and its use as a screening tool appears questionable under clinical conditions.

1 | Introduction

Refraction is the process by which light is bent as it passes through the ocular media, primarily the cornea and the crystalline lens, to focus accurately on the retina. Although most dogs are close to emmetropic, breed-specific and individual variations exist, and even mild refractive errors may impact visual performance, particularly in working or performance dogs [1–6].

In human ophthalmology, refractive errors are routinely assessed using either manual retinoscopy or automated refractometers. In particular, handheld automated refractometry is commonly used in pediatric patients, as it allows for quick, non-invasive measurements with minimal cooperation and is less dependent on subjective responses or sustained fixation, which can be challenging in young children. A previous study has shown that handheld autorefractors provide refractive measurements that are comparable to those obtained with table-mounted devices, used in human adults, indicating that the two methods are largely interchangeable in clinical practice [7]. In veterinary ophthalmology manual streak retinoscopy is considered the gold standard for refractive assessment due to its accuracy and applicability across species and it has been extensively used in veterinary medicine to evaluate refractive status in dogs and horses [3, 4, 8–13]. However, streak retinoscopy requires considerable examiner expertise, which limits its widespread application in general practice. Despite this, it demonstrates excellent interobserver reliability, with an average intraclass correlation coefficient (ICC) of 0.91 across four refraction measures [14] and minimal interobserver differences in spherical refraction under both non-cyclopleged and cyclopleged conditions (mean 0.12 diopters (D); median 0 D) [2]. These results confirm the high reproducibility of streak retinoscopy in dogs when performed by experienced observers.

The use of handheld automated refractometers in veterinary patients remains relatively underexplored. To the authors' knowledge, two published studies have assessed the performance of handheld autorefractors in dogs. In 50 healthy dogs (100 eyes) of 20 breeds, non-cyclopleged measurements obtained with the Welch Allyn SureSight autorefractor showed good agreement with streak retinoscopy, with mean spherical equivalents of -0.42 ± 1.13 D and -0.55 ± 1.14 D, respectively, while cycloplegia did not significantly alter retinoscopy results [2] In contrast, the Retinomax K-plus handheld autorefractor, assessed in 46 eyes of 23 healthy Beagles, consistently produced lower and more myopic refractive values compared to retinoscopy, both before and after cycloplegia, with weak correlation in non-cycloplegic eyes and only 46%–52% of readings within ±0.5 D on Bland–Altman analysis [15]. The previously mentioned handheld autorefractors can provide useful refractive data in dogs; differences between devices and limited precision in certain conditions mean they should be interpreted with caution and may not replace conventional retinoscopy for clinical purposes. Two additional studies have investigated the refractive status in dogs using handheld autorefractors, one in Beagles (autorefractor: Welch Allyn SureSight) and the other in a population of mixed-breed dogs (autorefractor: Retinomax 3, Righton) [16, 17]. However, neither study included a comparison with the clinical gold standard of manual streak retinoscopy. As a result, their findings cannot be considered directly applicable to the validation of automated refractometry against established reference methods.

The aim of the study was to assess the accuracy and clinical applicability of the Retinomax K+ Screen by comparing its refractive measurements to those obtained through streak retinoscopy in non-cyclopleged dogs.

2 | Material and Methods

2.1 | Animals

Thirty-four dogs (68 eyes) were enrolled in the study, which was conducted at the ophthalmological service of the University of Veterinary Medicine Vienna. The study was approved by the institutional ethics committee (ETK 176/11/2023) and written informed consent was obtained from all dog owners prior to participation. The dogs had a mean age of 7.2 ± 3.8 years, ranging from 1.5 to 15 years. The study population included various breeds: American Staffordshire Terrier ($n=1$), Australian Shepherd ($n=2$), Beagle ($n=3$), Border Collie ($n=2$), Chihuahua ($n=1$), Collie ($n=4$), German Shorthair ($n=1$), Flat Coated Retriever ($n=1$), Havanese ($n=1$), Podenco ($n=1$), Poodle ($n=2$), Shih Tzu ($n=1$), Staffordshire Bullterrier ($n=1$), Wire Fox Terrier ($n=1$), and mixed-breed dogs ($n=12$). All dogs underwent an ophthalmic examination performed by a diplomate and a resident of the European College of Veterinary Ophthalmologists (ECVO). The examination included slit-lamp biomicroscopy (Kowa SL-17; Kowa, Tokyo, Japan), indirect ophthalmoscopy without pharmacologic mydriasis (Keeler Vantage; Keeler Instruments Inc., Broomall, USA), Schirmer tear test-1 (MSD, Unterschleißheim, Germany), fluorescein staining (Fluoro Touch Ophthalmic Strips, Eickemeyer, Tuttlingen, Germany), and intraocular pressure measurement using rebound tonometry (TonoVet, Icare, Vantaa, Finland). None of the included dogs had a known history of ocular disease, and all were free of clinical signs indicative of ocular surface disorders or any conditions that might compromise the assessment of the fundic reflex.

2.2 | Retinoscopy

Retinoscopy and autorefractometry were performed with each dog in a standing or sitting position under dimmed conditions (24 lx). Streak retinoscopy was performed by the ECVO diplomate and the resident using a streak retinoscope (Heine BETA 200, Heine Optotechnik, Herrsching, Germany) and two skiascope bars (Luneau Ophthamologie, Chartres Cedex, France). Retinoscopy was conducted in both the horizontal and vertical meridians with a working distance of 50 cm (working distance correction of 2.0 D).

2.3 | Autorefraction

A hand-held automatic refracto-keratometer (Retinomax K+ Screen, Visionix) (Figure 1) was used for autorefractometry. Autorefraction was performed by the ECVO resident under the supervision of the ECVO diplomate. Prior to the study, interobserver variability of the Retinomax K+ Screen was evaluated in a subset of 3 dogs (6 eyes). Measurements were obtained independently by two observers. Bland–Altman analysis showed a mean difference of −0.08 D, with 95% limits of agreement from −0.52 to 0.35 D. The ICC was 0.97 (95% CI: 0.68–0.99), indicating excellent agreement between observers. For measurements the distance between the device and the dog's eye was approximately 5 cm. Due to the short distance, some dogs showed defensive behavior, which made the measurement more difficult. The device offers a spherical measuring range from −20 to +23 D. The pupil size is measured automatically. When correctly aligned, the device takes five measurements in auto mode. The mean value was calculated from each of the measurements and analyzed as a single value in this study. In addition, the device provides a confidence value (CV 0–9) for the measurements as a measure of the reliability and quality of the measurement, with a lower number corresponding to a more accurate measurement. Measurements for which the CV displayed an error were excluded from the study, as repeat assessment was not possible due to uncooperative behavior of the dogs. The Retinomax K+ Screen also includes an autokeratometry function; however, the results obtained from this feature were not included in the study.

FIGURE 1 | The handheld autorefractometer Retinomax K+ Screen (Visionix), shown in front view (left) and side view (right), mounted on its charging and printing station.

2.4 | Data Analysis

Data analysis was performed using R statistical language (version 4.1.2; R Core Team, 2020). Normality of the data was assessed indirectly through Spearman's rank correlation. Due to the non-normal distribution of the refractive measurements obtained by autorefractor and retinoscopy, the nonparametric Wilcoxon signed-rank test was applied to evaluate differences between the two methods. The association between measurements was assessed using Spearman's rank correlation coefficient. Agreement between the two methods was further examined using Bland–Altman analysis. Interobserver agreement for streak retinoscopy measurements between the two examiners was assessed using ICC and further evaluated with Bland–Altman analysis to quantify mean differences and limits of agreement. A significance level of $\alpha = 0.05$ was used for all statistical tests.

3 | Results

3.1 | Streak Retinoscopy

Streak retinoscopy was performed on all 34 dogs (68 eyes). The maximum difference between the measurements of the two examiners was 0.5 D. Combining measurements from both examiners, retinoscopy showed a spherical mean of 0.13 ± 1.04 (range: −3.5 to +4.0) D. Interobserver agreement between the two examiners was excellent (ICC = 0.98, 95% CI: 0.96–0.99, $p < 0.001$). Bland–Altman analysis demonstrated a mean difference of 0.06 D, with 95% limits of agreement ranging from −0.37 to +0.50 D.

3.2 | Autorefraction

A total of 57 eyes were included in the data analysis of autorefraction. Eleven eyes were excluded due to error messages caused by a low CV in the measurements. Autorefraction showed a spherical mean of 0.98 ± 1.66 (range: −2.75 to +7.0) D.

3.3 | Streak Retinoscopy Versus Autorefraction

To assess the agreement between autorefraction and retinoscopy in dogs, multiple statistical analyses were conducted. Wilcoxon signed-rank test indicated a statistically significant difference between the two measurement methods ($V = 1097.5$, $p < 0.001$). Bland–Altman analysis was used to evaluate agreement between autorefraction and retinoscopy (Figure 2). The mean difference (bias) between the two methods was +0.79 D, indicating that the autorefractor systematically showed a hyperopic shift compared to retinoscopy. The standard deviation of the differences was 1.69 D, reflecting considerable variability in measurement differences. The 95% limits of agreement ranged from −2.52 to +4.10 D. A histogram illustrating the frequency distribution of the differences in spherical equivalent between autorefraction and retinoscopy is shown in Figure 3. To assess the rank-order correlation between the two methods, a Spearman rank correlation was calculated, yielding a correlation coefficient of $\rho = 0.49$ ($p < 0.001$) (Figure 4).

4 | Discussion

The present study evaluated the accuracy and clinical utility of the Retinomax K+ Screen, a handheld autorefractor in comparison with manual streak retinoscopy in non-cyclopleged dogs. The values obtained by autorefraction using the Retinomax K+ Screen differed significantly from those obtained via streak retinoscopy, with a mean bias of +0.79, a moderate positive monotonic relationship between the two methods and a trend toward increasing disagreement with higher refractive values.

Streak retinoscopy remains the gold standard for objective refraction in veterinary ophthalmology due to its accuracy and

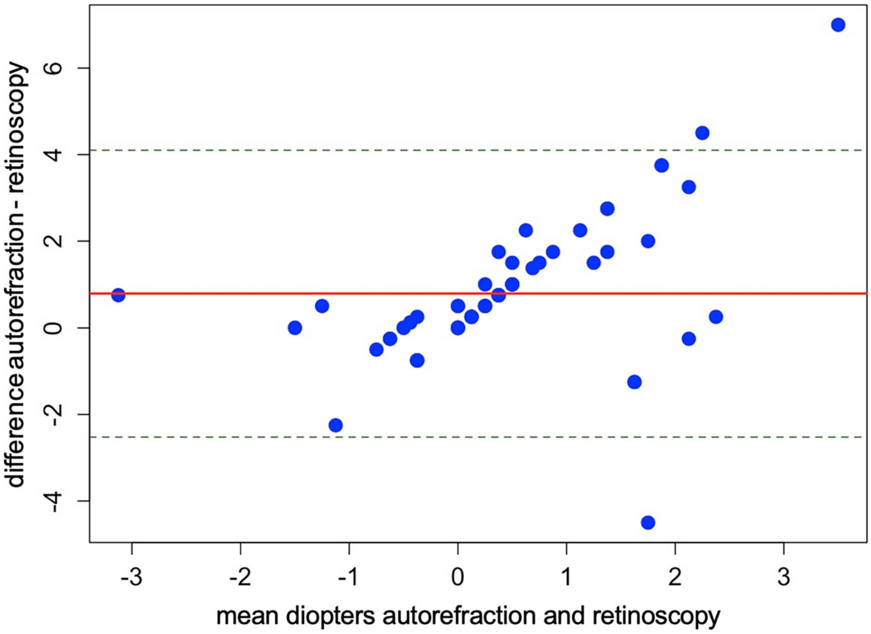

FIGURE 2 | Bland–Altman plot comparing spherical measurements obtained by autorefraction and retinoscopy in 32 dogs (57 eyes). The x-axis shows the mean spherical value of both methods for each eye, while the y-axis represents the difference between autorefraction and retinoscopy. The red line indicates the mean difference (bias), and the dashed green lines represent the 95% limits of agreement. Most values lie within the limits, although a trend toward increasing disagreement with higher refractive values is observable.

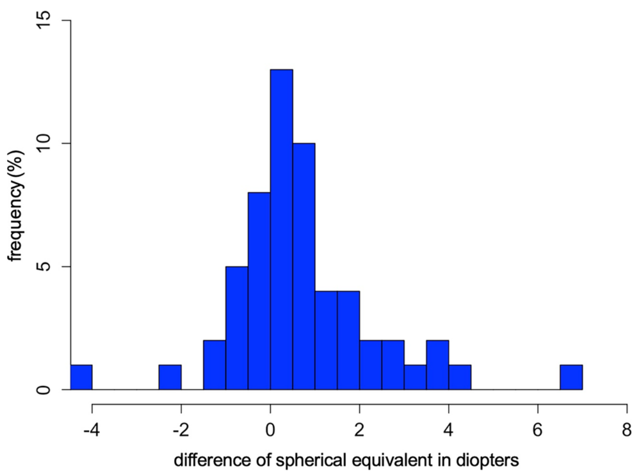

FIGURE 3 | Frequency distribution of the differences in spherical equivalent between autorefraction and streak retinoscopy in 32 dogs (57 eyes). The distribution was skewed to the right, with most values clustering around 0 to +2.0 D. Positive values indicate that the autorefractor tended to measure more hyperopic values compared to streak retinoscopy. The range of differences spanned from approximately −4.0 to +7.0 D, with a noticeable number of outliers showing larger positive deviations.

applicability across species [4, 18]. In the present study, streak retinoscopy showed a maximum interobserver difference of 0.5 D. Interobserver agreement for streak retinoscopy was excellent, with an ICC of 0.98 (95% CI: 0.96–0.99), indicating that measurements obtained by different examiners can be considered interchangeable. In preliminary investigations (unpublished data), measurements obtained with the handheld autorefractometer were compared between two examiners, and no significant inter-examiner differences were observed. The autorefractor is taking measurements only when properly aligned and correctly focused. Autorefraction using the Retinomax K+ Screen systematically produced more hyperopic values. Bland–Altman analysis revealed a mean bias of +0.79 D, indicating consistent overestimation compared to retinoscopy. Cycloplegia has been shown to improve the accuracy of autorefraction in children by eliminating the influence of accommodation [19]. However, excellent agreement between streak retinoscopy measurements in both non-cyclopleged and cyclopleged dogs suggests that accommodation may play a less significant role in refractive assessment in canines [2, 4]. Groth et al. demonstrated a reduction in autorefraction accuracy following cycloplegia. Although the underlying reasons remain unclear, they observed that the device provided measurements more rapidly and required fewer focal adjustments when used on smaller, non-dilated pupils. It is hypothesized that a smaller pupil helps maintain consistent focus on a specific area of the fundic reflex, whereas pupil dilation may increase movement artifacts and result variability [2]. The 95% limits of agreement (−2.52 to +4.10 D) and a standard deviation of 1.69 D reflect substantial variability between the two methods, suggesting that they are not directly interchangeable for precise refractive assessment. The moderate Spearman correlation ($\rho = 0.49$, $p < 0.001$) supports this conclusion, indicating only partial agreement in rank order.

The autorefractor offered several practical advantages. It was easy to use and provided rapid, non-invasive results. However, technical difficulties were noted in some dogs due to the short working distance (~5 cm). In addition, the device emits a high-pitched sound designed to assist the performing person in achieving proper focus. However, this noise appeared to trigger avoidance responses in some dogs, which occasionally provoked defensive behavior. A method to disable the sound was

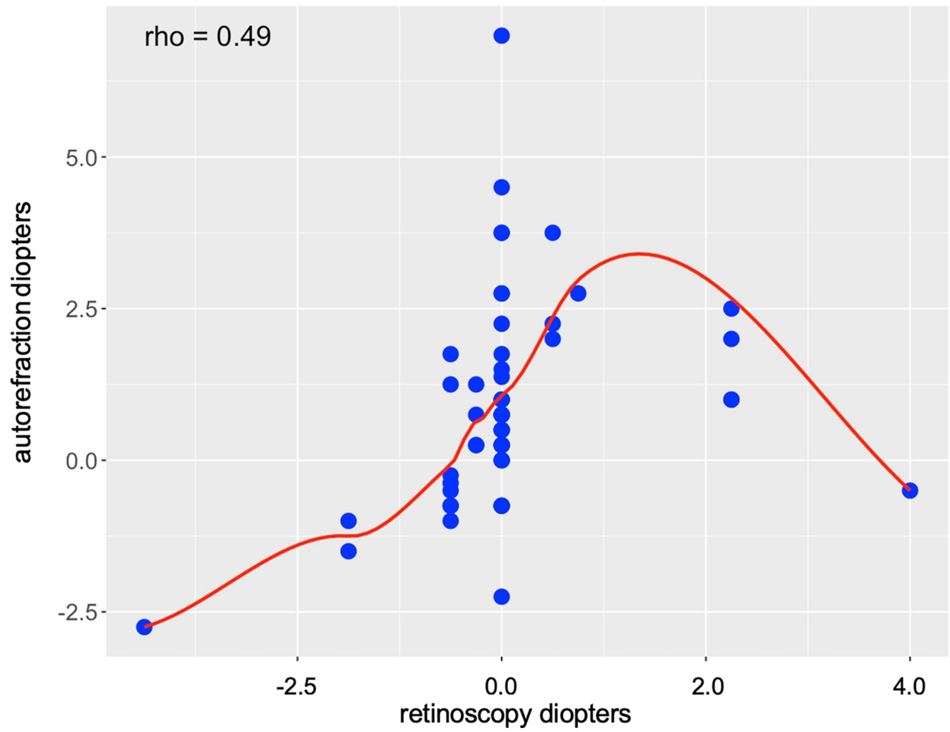

FIGURE 4 | Scatterplot illustrating the Spearman rank correlation between spherical equivalent measurements obtained by autorefraction and retinoscopy ($\rho = 0.49$, $p < 0.001$) in 32 dogs (57 eyes). Each dot represents the mean value of one paired measurement. A non-parametric local regression smoothing curve is overlaid to visualize the trend.

implemented with the manufacturer's assistance. In order to ensure equal study conditions for all dogs, the sound was deactivated after completion of the study. In total, 11 eyes had to be excluded due to low measurement quality, emphasizing a limitation in reliability under suboptimal conditions. This study has several limitations that should be considered when interpreting the results. The sample size of 34 dogs may limit the generalizability of the findings across all canine breeds and age groups. Even though pupillary dilation was not expected to have a positive effect on measurement quality, a comparison of results between non-dilated and dilated pupils could have provided additional insights. The study included dogs of various breeds and refractive profiles but the relatively small cohort may have limited the statistical power and the ability to detect breed-related anatomical or behavioral factors affecting measurement accuracy. Future studies with larger and more uniform subgroups are warranted to further elucidate these effects. Additionally, 11 eyes were excluded from the autorefraction analysis due to low measurement reliability, primarily resulting from uncooperative behavior, which prevented repeat measurements. This exclusion may have introduced bias, particularly if these cases involved dogs with more significant refractive errors. Future studies should aim to mitigate these limitations by optimizing fixation protocols or adjusting device settings.

5 | Conclusion

This study demonstrates that while the handheld Retinomax K+ Screen autorefractor is easy to use and provides rapid measurements, its refractive values significantly differ from those obtained via the gold standard streak retinoscopy in dogs. The observed hyperopic bias and wide limits of agreement, especially in dogs with refractive errors, highlight that autorefraction with this device should be interpreted with caution. Due to inconsistent results and reduced reliability under suboptimal conditions, the Retinomax K+ Screen and its use as a screening tool appear questionable under clinical conditions. Further research is needed to refine automated methods and improve their reliability before they can be widely adopted as alternatives for assessing canine refractive status.

Author Contributions

Juliana Giselbrecht: conceptualization, methodology, formal analysis, data curation, writing – original draft, visualization. **Barbara Nell:** conceptualization, methodology, data curation, writing – review and editing, supervision.

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Disclosure

The authors have not used AI to generate any part of the manuscript.

Ethics Statement

The study was approved by the institutional ethics committee (ETK 176/11/2023) and written informed consent was obtained from all dog owners prior to participation.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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