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ORIGINAL RESEARCH

Comparing the intraocular pressure values obtained with a rebound tonometer (TONOVET Plus) and an indentation tonometer (IOPvet) in dogs with and without ocular disease

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Abstract

Background: This study aimed to compare the intraocular pressure (IOP) values obtained from two groups of dogs using the IOPvet indentation tonometer to those obtained from the same dogs using an established rebound tonometer (TONOVET Plus).

Methods: Tonometry was performed on 36 dogs with ocular diseases (70 eyes; group A) and 25 healthy dogs (49 eyes; group B). First, the TONOVET Plus rebound tonometer was used. Then, one drop of oxybuprocaine hydrochloride was applied to each eye, and 1 minute later, the IOP was estimated using the IOPvet.

Results: The IOPvet was safe, well tolerated and easy to use. The instrument had a high specificity (98.5%) for identifying IOPs of 20 mmHg or less. A lack of sensitivity (67.9%) was noted when evaluating eyes with an IOP between 20 and 30 mmHg. The sensitivity (33.3%) for identifying canine eyes with an IOP of greater than 30 mmHg ($n = 24$) was low.

Limitations: This study lacks manometric work, which would be hard to justify with client-owned dogs. Quantitative numerical data were compared with qualitative values and the same investigator obtained readings using both tonometers without being masked.

Conclusions: The IOPvet is highly sensitive for assessing normal IOPs, but underestimation of higher IOPs can lead to poor diagnostics. Digital tonometers remain the best way to assess IOP in veterinary clinics.

KEYWORDS
dog, glaucoma, intraocular pressure, tonometer, tonometry

INTRODUCTION

Evaluation of intraocular pressure (IOP) is an important part of ophthalmologic examinations, and the tonometer is an essential tool for diagnosing and managing ocular pathologies such as glaucoma and uveitis.[1] Tonometry is an indirect, non-invasive measurement of IOP via indentation, applanation or rebound techniques.[2–5] The first indentation tonometer was developed approximately 100 years ago by Schiotz (Friedwald, 1937).[6,7] Currently, electronic applanation and rebound devices (including iCare TONOVET and TONOVET Plus [TVP] and the Reichert Tono-Pen and Tono-Vera) are the most commonly used devices, and their accuracy has been studied extensively in dogs and other species.[8–14] These devices remain the best way to assess IOP, but they may be cost-prohibitive for some veterinarians.

Recently, a new single-use indentation tonometer, the IOPvet, a lightweight and affordable handheld device developed by an Australian company (Ingeneus), was introduced for IOP estimation in cats, dogs and horses without having been tested in veterinary species (Figures 1–3). This device is a disposable indentation tonometer that functions similarly to the Schiotz tonometer and has a colour-coded pressure reading scale (green <20 mmHg, yellow 20–30 mmHg and red >30 mmHg) associated with recommendations ('normal', 'elevated, requires further investigation' and 'high, urgent attention required', respectively) and numerical markers of IOP values (10, 15, 20, 25 and 30 mmHg) allowing a semi-quantitative assessment of the IOP. The manufacturer has only validated the device for human use.

To the best of our knowledge, no studies have yet assessed the accuracy of the IOPvet on a canine

FIGURE 1 Measuring the intraocular pressure of a dog using the IOPvet

FIGURE 2 The IOPvet

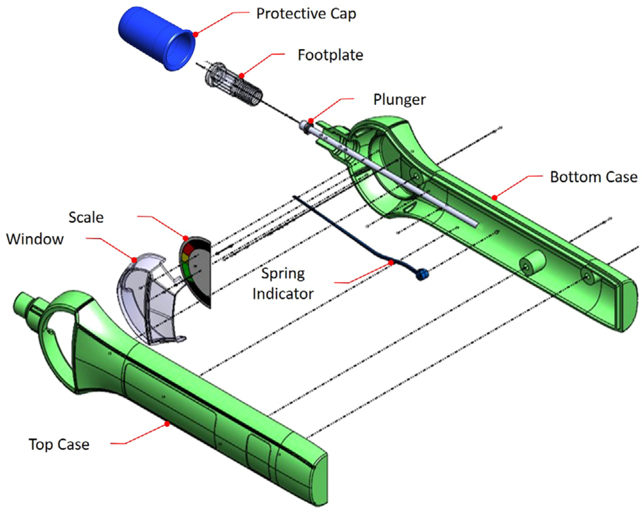

FIGURE 3 Decomposed view of the IOPvet (courtesy of Ingeneus). After applying the footplate in contact with the cornea, the plunger is pushed back to mobilise the spring indicator, which indicates the pressure on the scale. The scale gives an indication of pressure in mmHg as well as a green/yellow/red colour to make it easier to interpret the results

TABLE 1 Demographics of the studied population.

	Group A	Group B
Sample size	36	25
Median age (interquartile range) (years)	10.0 (4.3–15.0)	10.0 (1.2–15.4)
Sex ratio (male/female)	1.3 (20/16)	0.92 (12/13)
Proportion sterilised (male/female)	30.0%/87.5%	25.0%/76.9%

population representative of the usual attendance at veterinary clinics. This study aimed to compare the IOP values obtained using the IOPvet (Ingeneus) and a commonly used electronic rebound tonometer (TVP, iCare) in dogs with and without ocular disease. A secondary aim was to evaluate whether the IOPvet is reusable over time, even though it is marketed as a disposable device.

MATERIALS AND METHODS

Animals

The study population consisted of 61 client-owned dogs of different breeds, sexes and ages whose owners provided informed consent. The cohort was divided into two groups: 36 dogs with ocular disease that presented to the ophthalmology department (70 eyes, group A) and 25 dogs without ocular disease that presented to the preventive medicine department (49 eyes, group B). The demographic profiles of the two groups are presented in Tables 1 and 2. Group A animals presented with different ocular pathologies (Table 3), and all dogs that presented with glaucoma during the study period were included. Patients with deep corneal ulceration were excluded from this study because indentation tonometry with IOPvet may lead to corneal perforation. Dogs with persistent blepharospasm despite the use of topical anaesthetics or any ocular diseases leading to a change in corneal resistance, such as melting corneal ulceration or corneal fibrosis, were excluded from the study because these conditions prevent sufficiently reliable measurement of IOP with the IOPvet.

The animals included were presented to the AnimaVet Veterinary Clinic in Saint-Genis-Pouilly, either to the ophthalmology or preventive medicine departments. Complete slit-lamp biomicroscopic examination (Kowa SL-17, Kowa Company) and indirect ophthalmoscopy (Aurora, Optomed USA) were performed on both eyes of each dog. Fluorescein staining was used, if needed, after IOP measurements with each device to avoid interference with the results.

Tonometry

All measurements were performed for both eyes of each dog, in accordance with the manufacturer's recommendations, by a single investigator. The TVP was calibrated by the manufacturer less than 1 year before the study and was used with the 'dog' setting. Computer-generated randomisation was used to

TABLE 2 Breeds represented inthe two groups and in the study population overall.

Group A			Group B			Overall		
Breed	***N***	**Percent**	**Breed**	***N***	**Percent**	**Breed**	***N***	**Percent**
Jack Russell Terrier	5	13.9%	Boston Terrier	3	12.0%	Jack Russell Terrier	7	11.5%
French Bulldog	3	8.3%	Chihuahua	2	8.0%	Boston Terrier	4	6.6%
American Bully	2	5.6%	Golden Retriever	2	8.0%	Chihuahua	4	6.6%
Chihuahua	2	5.6%	Jack Russell Terrier	2	8.0%	French Bulldog	4	6.6%
Dachshund	2	5.6%	Maltese	2	8.0%	American Bully	3	4.9%
English Springer Spaniel	2	5.6%	Siberian Husky	2	8.0%	English Springer Spaniel	3	4.9%
Pinscher	2	5.6%	American Bully	1	4.0%	Golden Retriever	3	4.9%
Shih Tzu	2	5.6%	Belgian Shepherd	1	4.0%	Maltese	3	4.9%
Whippet	2	5.6%	English Springer Spaniel	1	4.0%	Belgian Shepherd	2	3.3%
Belgian Shepherd	1	2.8%	French Bulldog	1	4.0%	Dachshund	2	3.3%
Boston Terrier	1	2.8%				Pinscher	2	3.3%
Golden Retriever	1	2.8%				Shih Tzu	2	3.3%
Maltese	1	2.8%				Siberian Husky	2	3.3%
						Whippet	2	3.3%
Other	10	27.8%	Other	8	32.0%	Other	18	29.5%
Total	36	100%	Total	25	100%	Total	61	100%

TABLE 3 Ocular pathologies of dogs in group A.

Reason for consultation	***N***	**Percent**
Glaucoma	22	61.1%
Superficial corneal ulcer	5	13.9%
Cataract	3	8.3%
Keratitis	2	5.6%
SARD	1	2.8%
Uveitis	1	2.8%
Progressive retinal atrophy	1	2.8%
Trauma	1	2.8%
Total	36	100%

Abbreviation: SARD, sudden acquired retinal degeneration syndrome.

select the order of the eyes (right vs. left). The dogs sat as calmly as possible with appropriate restraint, and we avoided applying pressure to the jugular veins or eyeballs. Rebound tonometry was first performed with the handheld TVP near the dog's eye at an estimated distance of approximately 5–8 mm from the central cornea. A drop of topical anaesthetic (oxybuprocaine hydrochloride, 0.4% ophthalmic solution; Cébesine Collyre Laboratoire Chauvun) was applied to each eye. One minute later, IOP was assessed using the IOPvet by placing the device perpendicularly in contact with the central cornea and applying sufficient pressure, but without pushing the eye back into the orbit (Video 1). IOP readings were recorded with each method. The IOPvet is graduated with both colours and numeric values, as shown in Figure 1. During estimates, the user watched the needle and noted the interval over which it stabilised.

The TVP probe was changed between the patients. The TVP-recorded IOP is an average of four measurements, with the highest and lowest readings discarded before the average calculation. The footplate and plunger of the IOPvet were cleaned between dogs by spraying them with sterile saline solution and more thorough cleaning was carried out after every 10 patients by immersing the probe of the device in 100 mL of lukewarm water supplemented with a drop of dishwashing product, as recommended by the

VIDEO 1 Measuring pressure with the IOPvet in an 11-year-old Jack Russell with corneal scaring following lens luxation surgery 1 month beforehand. The spring indicator moved from 15 to 19 mmHg (green area). The TONOVET Plus value was 17 mmHg. A slight movement of the eye in the orbit can be appreciated when estimating the pressure with the IOPvet (https://youtu.be/hHnuOa_HXNY)

TABLE 4 IOPvet sensitivity.

	Group A	No. of eyes	Group B	No. of eyes
All ranges	65.7%	70	93.9%	49
<20 mmHg	96.8%	31	100%	36
20–30 mmHg	60.0%	15	76.9%	13
>30 mmHg	33.3%	24	–	0
Details of the critical zone				
20–25 mmHg	55.6%	9	72.7%	11
25–30 mmHg	50.0%	6	100%	2

TABLE 5 Confusion matrix.

	IOPVet			
TONOVET	Green	Yellow	Red	Total
Green	66	1	0	67
Yellow	7	21	0	28
Red	0	16	8	24
Total	73	38	8	119

manufacturer. This was performed to lubricate the piston and disinfect the device. The device was stored in a portable container. All instrument-generated averages were discarded if an erroneous IOP reading resulted from the movement of the dog's head or if the tip of the tonometer did not encounter the central cornea. Both eyes were recorded, and the first eye was randomly selected. The same IOPvet was used for the entire study.

Statistical analysis

TVP data are numerical, whereas IOPvet data are expressed as a range: green (normal, ≤20 mmHg according to the manufacturer), yellow (elevated, 21–30 mmHg) or red (high, >30 mmHg). The sensitivity, specificity and positive and negative predictive values were calculated to determine the accuracy of the IOPvet. A graphical representation of the equivalence zones and confidence intervals was also made to visually validate these parameters.

One bilateral Student's *t*-test was used for statistical analysis to compare the right-eye IOP to the left-eye IOP (TVP measurements). An analysis of variance test was used to compare the period effects. A *p*-value of less than 0.05 was considered significant. The data were considered in pairs in the statistical tests (a pair of measurements was compared for the same eye), but each eye was considered independent of the other.

RESULTS

No statistically significant difference was noted between the left and right eyes for the measurements obtained using TVP (p = 0.6889). The sensitivity of the IOPvet for both groups is presented in Table 4, which was completed using a confusion matrix (Table 5). The median IOP value was 29.5 mmHg for group A and 16.9 mmHg for group B. Both groups were studied separately to compare the two tonometers.

Healthy controls

The IOP data from the right (range: TVP, 11–26 mmHg) and left (range: TVP, 9–26 mmHg) eyes showed no significant differences ($p = 0.0716$). The mean IOP values ± standard deviation (SD) measured with the TVP was 16.9 ± 4.1 mmHg.

Measurements for IOPs of less than 20 mmHg were equivalent between the two devices, with the IOPvet having 100% sensitivity in this interval. However, IOPs of 20–30 mmHg were often underestimated with the IOPvet, with a sensitivity of approximately 80% ($n = 13$ cases).

Dogs with ocular disease

The IOP data from the right (range: TVP, 7–97 mmHg) and left (range: TVP, 6–80 mmHg) eyes showed no significant differences ($p = 0.6004$).

Measurements in the 20 mmHg or less interval were reliable and repeatable between the two devices, with a the IOPvet having a sensitivity of 96.8%. Nevertheless, the sensitivity drastically reduced at the 21–30 mmHg (73.3%) and more than 30 mmHg (33.3%) intervals. In contrast to the TVP 'standard', all the estimations of the IOPvet were systematically underestimated. The IOP estimations with the IOPvet and correlations with the TVP measurements are presented in Table 4 and Figure 4. This allowed us to appreciate the low level of sensitivity of the IOPvet (sensitivity = 33.3%) for eyes with a pressure greater than 30 mmHg and the high prevalence of underestimated values with the IOPvet in dogs with ocular disease.

Comparing different groups

A comparison of the results obtained from the two tonometers for the eyes of the control group ($n = 49$) and the non-glaucomatous eyes (whose IOP was ≤29 mmHg) of group A ($n = 46$) led to the same conclusion: the agreement between the two devices up to 20 mmHg was good. However, the sensitivity dropped when IOP increased from 21 to 30 mmHg. The condition of the examined eye (except for glaucoma) did not affect the results with IOPvet. Figure 5 gives an overview of the frequency and dispersion of the whole population, split into a control group ($n = 49$; SD = 4.13), non-glaucomatous eyes from group A ($n = 46$; SD = 5.99) and glaucomatous eyes ($n = 24$; SD = 17.21). Isolating the glaucomatous eyes in group A ($n = 24$) in Figure 5 allowed us to appreciate a significant number of glaucomatous eyes falsely assessed as having a pressure less than 30 mmHg with the IOPvet.

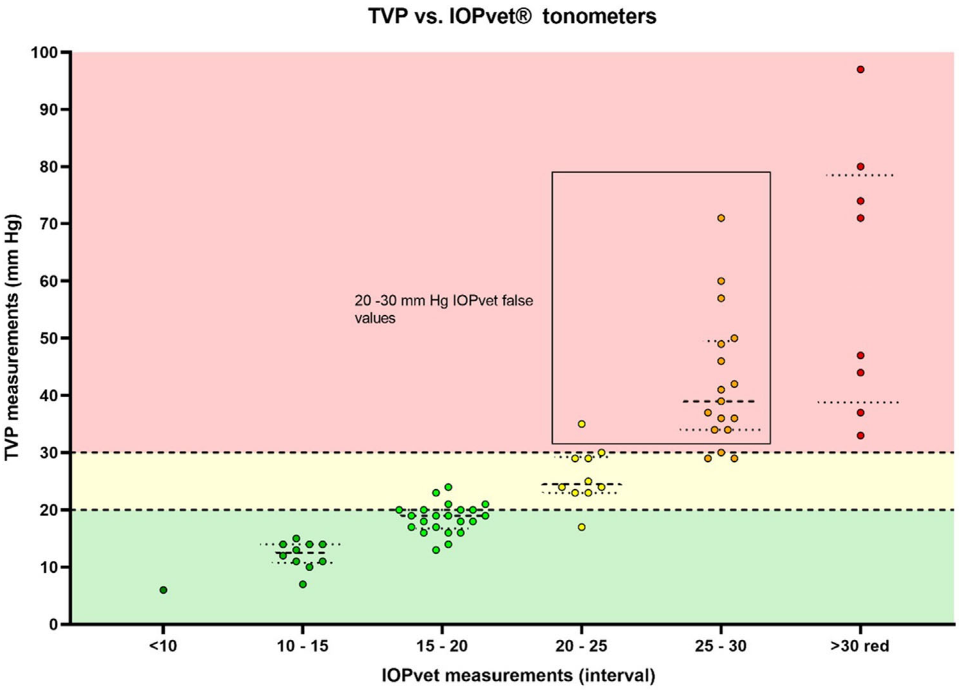

FIGURE 4 Comparison of TONOVET Plus (TVP) (y-axis) measurements and IOPvet (x-axis) estimates in dogs with ocular disease. The framed part specifies all the values underestimated by the IOPvet: in these cases, the IOPvet estimated intraocular pressure values under 30 mmHg while the TVP values measured were higher than 30 mmHg in more than 55% of cases

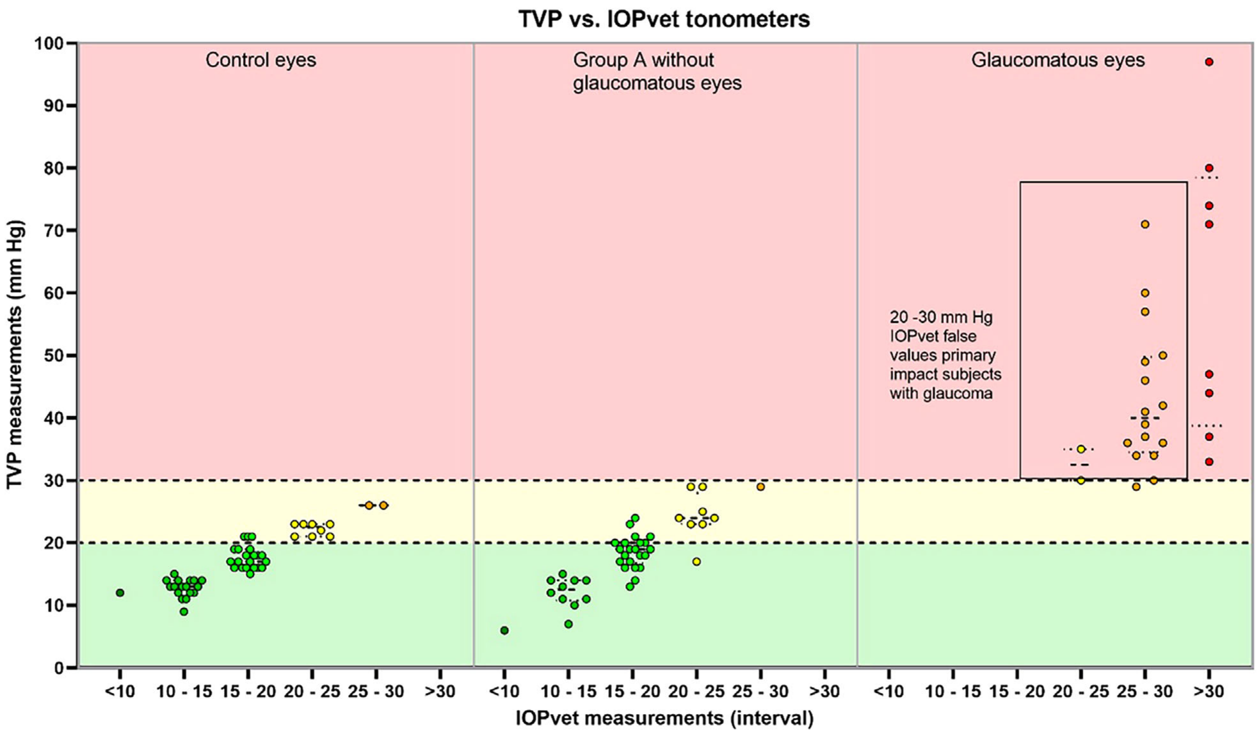

FIGURE 5 Distribution of TONOVET Plus (TVP) and IOPvet measurements for 'control eyes' ($n = 49$; standard deviation [SD] = 4.13), 'group A without glaucomatous eyes' ($n = 46$; SD = 4.13) and 'group A with glaucomatous eyes' ($n = 24$; SD = 17.21). Agreement between the two devices up to 20 mmHg was good. A significant number of glaucomatous eyes were falsely assessed as having a pressure below 30 mmHg with the IOPvet

Repeatability of values over time with the IOPvet

To assess the repeatability of the estimates obtained with the IOPvet over time, group A was divided into three periods and the differences in clinical classes given by the two devices were compared. A t-test comparing periods 1–3 yfound that period did not affect the data (p = 0.1005), thus demonstrating the possibility of reusing the IOPvet for at least 100 estimations, provided that the maintenance instructions are followed.

DISCUSSION

The evaluation and monitoring of IOP are essential for the diagnosis and management of various ocular pathologies.[15–17] Interpretation of the estimated IOP is impossible without information on the reference IOP values obtained for a given tonometer and species.[9,10] In addition, the lack of information on the concordance of values obtained between different tonometers can represent a real clinical challenge, as many factors can influence the measurements (practitioner, time of day, stress state of the animal, etc.).[2,3,7,10,11,13] In this study, we compared the tonometry values obtained in two populations of different breeds of dogs whose eyes were healthy or diseased using a new measuring device, the IOPvet. The estimates were compared to the measurements obtained using an established rebound tonometer, the TONOVET Plus, which was previously shown to underestimate true IOP in canine eyes but is more accurate than applanation tonometers.[4,13,14] To the best of our knowledge, this is the first comparison of tonometric values obtained using these two tonometers under actual clinical conditions and in various dog breeds.

The IOPvet values obtained are repeatable over time (i.e., no periodic effect was observed). It appears that the device has quite high sensitivity for assessing normal IOPs. However, there is a significant risk of incorrectly assessing normal IOP values with the IOPvet as an underestimation zone was present for the 20–30 mmHg interval for the two groups, and especially for IOPs over 30 mmHg, for which the IOPvet showed its limits. As such, confirmation by a reference device such as the TVP is required. This allows us to conclude that the IOPvet is not a useful device and can never replace digital tonometers. Moreover, it can only create doubt for the practitioner.

This study had several limitations. First, it lacks manometric work, which would allow the two instruments to be properly compared, but this would be difficult to justify with client-owned dogs. Second, we compared quantitative numerical data from the TVP with values considered qualitative from the IOPvet. Third, the same investigator obtained readings using both tonometers and used the TVP first without being masked. This can limit the objectivity of the second measurement, which can be influenced by knowledge of the value obtained with the digital tonometer. Finally, corneal thickness was not measured by pachymetry, which may have influenced the IOPvet evaluations of the various breeds of dogs included in the present study. The ocular muscles' resistance may also be a factor affecting the values obtained with the IOPvet, but we were unable to assess it.

A study evaluating the reliability of the IOPvet was carried out in 2024 by Kapeller et al., who compared the IOPvet to the Tono-vera in a population of experimental Beagles with open-angle glaucoma.[18] It was concluded that the instrument had a high specificity (99%) and positive predictive value (94%) when identifying IOPs of 30 mmHg or less, whereas high-pressure estimates were underestimated with the IOPvet. This study referred to the first generation of the IOPvet, whose scale was different from that of the second version of IOPvet used for our study. In our study, all tonometry measurements and estimates were performed by the same operator to minimise interoperator error. We also chose to have a larger cohort with several canine breeds and ages with no or various eye conditions to ensure that conditions were closer to those encountered when using the IOPvet in general practice.

An indentation tonometer traditionally uses weights, whereas the IOPvet uses a spring mechanism (Figure 3). The strength of the examiner may also influence the IOP readings, which is why we recommend applying a slight pressure at the limit at which the eyeball recedes in the orbit.

The low cost of this device and the possibility of reuse make it interesting to evaluate normal IOPs; however, the significant risk of underestimation of IOPs for high pressure may be detrimental for veterinarians or owners because they may miss an IOP spike due to a falsely low reading. Given the risk of causing corneal damage and the consequences associated with the misuse of topical anaesthetics, it seems imprudent to recommend at-home use of the IOPvet by dog owners. Overall, the results of this study indicate that applanation and rebound tonometers (in veterinary clinics) remain the best way to assess IOP.

It would be interesting to extend this study to a larger cohort of dogs with intraocular hypertension as well as feline and equine species to fully evaluate the practical use of the IOPvet. It would also be interesting to assess the performance of the IOPvet in hypotensive eyes.

Following the completion of our study, the manufacturer agreed that a new version of the IOPvet with a different scale allowing greater accuracy will be developed and will require field validation.

AUTHOR CONTRIBUTIONS

Conceptualisation, data curation, formal analysis, investigation, methodology, project administration, resources, supervision, validation, visualisation, writing—original draft and writing—review and editing: Bertrand Michaud. *Conceptualisation, data curation, formal analysis, investigation, methodology, supervision and writing—review and editing*: Fabien Lesne.

CONFLICT OF INTEREST STATEMENT

Fabien Lesne declares no conflict of interest. Bertrand Michaud was in contact with Ingeneus to obtain a detailed diagram of the device and is now working to develop a more accurate version of IOPvet (without any financial compensation).

FUNDING INFORMATION

The authors received no specific funding for this work.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Figshare at https://www.doi.org/10.6084/m9.figshare.25656534.

ETHICS STATEMENT

This study adhered to the Association for Research in Vision and Ophthalmology Statement for the Use of Animals in Ophthalmic and was approved by the Ethics Committee on the Use of Animals of the School of Veterinary Medicine and Agronomy (VetAgroSup). The owners provided informed consent for this study.

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