Investigation of correlation between corneal thickness and intraocular pressure in New Zealand Albino Rabbits

Research Article

Büşra Kibar Kurt

Department of Surgery, Faculty of Veterinary Medicine, Aydın Adnan Menderes University, Aydın, Turkey

ORCİD-
0000-0002-1490-8832

ABSTRACT

The aim of this study was to determine intraocular pressure (IOP) and central corneal thickness (CCT) measurements in healthy rabbits to establish clinical reference values and to investigate the possible relationship between these measurements. The study included 40 eyes of 20 New Zealand albino rabbits, aged 1.5-2 years. All the eyes were healthy with no abnormalities, corneal disease, or evidence of glaucoma. An ultrasonographic pachymeter was used to measure CCT and TonoVet® was used to measure IOP. Correlations between IOP and CCT measurements were examined. The mean CCT was 388.2 ± 38.22 µm in the right eye and 391.8± 59.18 µm in the left eye. IOP was measured as 16 ± 3.76 mmHg in the right eye and 16 ± 2.73 mmHg in the left eye. No correlation was determined between the IOP and CCT, and this indicated that the TonoVet® readings of CCT and IOP did not cause a deviation that could be determined. There is a need for further studies of different animals to investigate the effect of corneal thickness on the IOP measurements made with TonoVet®.

Keywords: Central corneal thickness, pachymeter, rebound tonometer, tonovet**.**

INTRODUCTION

Glaucoma is the most important cause of permanent blindness in humans and domestic animals. Degeneration in the optic nerve head and retina forms with an increase in intraocular pressure (IOP) (Garway-Heath et al., 2015; Gelatt & MacKay, 2004a, 2004b; Tham et al., 2014). IOP is accepted as one of the greatest risk factors for the development of glaucoma, and is the most consistent predictor of glaucoma damage in both humans and animals. Accurate measurement and follow up of IOP is important for the diagnosis of glaucoma and treatment follow-up. Therefore, the available treatments for this disease focus on first reducing IOP (Gloe et al., 2019). Rabbits have been used for many years in glaucoma studies, and these studies have contributed to the development of drugs designed to reduce IOP, and to surgical procedures and medical devices. Rabbits are relatively inexpensive, and the care and study of large numbers is simple. Moreover, their clinical importance has increased in recent years as they are preferred as domestic pets (Millar & Pang, 2014; Hong Zhang et al., 2014).

Other types of tonoometry used in rabbits include Schiøtz (Becker, 1960; Behar-Cohen et al., 1996), MacKay-Marg (Wind & Irvine, 1969), Perkins (Acosta et al., 2007), Draeger (Kass et al., 1972), GAT (Jin et al., 2014), the Tono-Pen® ve TonoPen-XL® (Gerometta et al., 2012; Ito et al., 2013) and airpuff (Gupta et al., 2007).

Correspondence
Buşra KIBAR KURT
busrakibar@yandex.com

Article info
Submission: 10-08-2021
Accepted: 27-01-2022
Online First: 27-04-2022
Publication: 30-04-2022

e-ISSN: 2548-1150
doi prefix: 10.31797/vetbio
• http://dergipark.org.tr/vetbio

How to cite this article
Kurt BK. (2022). Investigation of correlation between corneal thickness and intraocular pressure in New Zealand Albino Rabbits. *Journal of Advances in VetBio Science and Techniques*, *7*(1), 54-61. https://doi.org/10.31797/vetbio.980971

It is known that biomechanical properties such as central corneal thickness (CCT) and fluid content affect IOP, and correct measurement of IOP is important to understand how it is affected by these factors. There is evidence that there is a relationship between glaucoma and properties related to the cornea such as CCT (Belovay & Goldberg, 2018; Brandt et al., 2004; Brown & Congdon, 2006).

As there are variations in CCT between individuals, a great variation in CCT can cause an incorrect estimation of IOP and may cause incorrect diagnosis in the classification of glaucoma (Mansoori & Balakrishna, 2018). Therefore, it is important to determine how various tonometers are affected by CCT.

The estimated IOP values will likely be dependent upon corneal surface conditions, such as the central corneal thickness (CCT), the corneal curvature, and the precorneal tear film. Nearly all human studies have shown that the CCT is positively correlated with IOP (Broman et al., 2007; Harada et al., 2008; Zeng et al., 2008). However, the effects of other corneal factors are still in dispute. The degree that the CCT affects IOP nevertheless varies between each study and tonometer (Bhan et al., 2002; Iliev et al., 2006). In the literature reviews, it was determined that the applanation tonometer was mostly used in the studies (Cairns et al., 2019; Moussa et al., 2021; Sethi et al., 2021; Hui Zhang et al., 2020). In the present study, it is also among the aims to investigate the effect of measurement with rebound tonometry. The aim of this study was to measure IOP and CCT in healthy rabbits and to determine whether or not there was any correlation between these measurements.

MATERIAL and METHOD

The study sample comprised 20 adult albino rabbits (10 males, 10 females), aged 1.5-2 years. In the physical and ophthalmoscopic examinations, the whole eye was evaluated with additional organs. All the eyes of all the rabbits were healthy with no disorder in the cornea and anterior/posterior chamber, or findings of glaucoma.

An ultrasonographic pachymeter (Pocket II, Quantel) was used in the measurement of both cornea thicknesses in all the rabbits. When taking the measurement, the probe was placed vertical to the cornea and gentle contact was made. The measurement result was obtained as the mean of 5 measurements taken by the device. The corneal thickness was recorded as µm separately for each eye. In all the rabbits, IOP was measured using a TonoVet® (icare) rebound tonometry device, which provides the average of 5 measurements displayed on a digital screen. The measurements obtained were recorded separately for each eye (Figure 1). No anesthetic agents were used during the examination and measurements. All the measurements were gathered between 02:00 pm and 04:00 pm by the same veterinary surgeon.

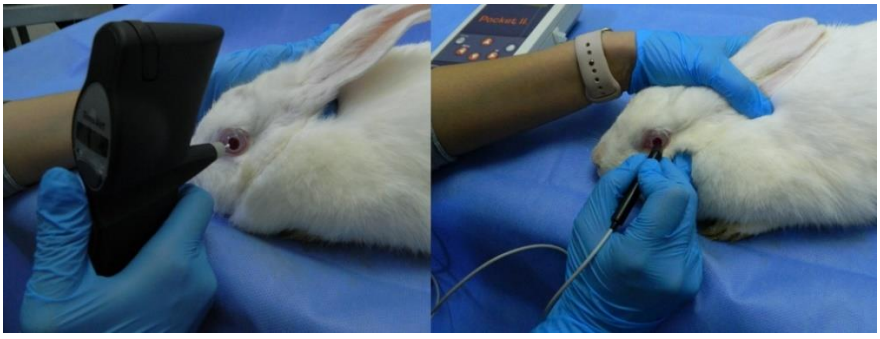

Figure 1. IOP and CCT measurements.

Statistical Analysis

Data obtained in the study were analyzed statistically using SPSS vn. 14.01 software (SPSS Inc, USA). Descriptive analyses were used to summarize data and to check if assumptions were met. The results were evaluated using the Shapiro Wilk Test for normality, and the Levene Test for homogeneity of variances. Differences in the IOP and CCT measurements between the right and left eyes were assessed with Independent Samples T-Test. The Pearson correlation coefficient was computed to evaluate relationships. A value of $p<0.05$ was considered statistically significant for all analyses.

RESULTS

The mean CCT was 388.2 ± 38.22 µm in the right eye and 391.8± 59.18 µm in the left eye. IOP was measured as 16 ± 3.76 mmHg in the right eye and 16 ± 2.73 mmHg in the left eye (Table 1).

Table 1. Mean value of IOP and CCT in right and left eyes.

		N	Mean	SD	P
IOP	Right	20	16	3,76	1
	Left	20	16	2,73	
CCT	Right	20	388,2	38,22	0,818
	Left	20	391,8	59,18	

The IOP and CCT values of the right and left eyes were examined separately with the Paired Samples t-test. No significant difference was determined.

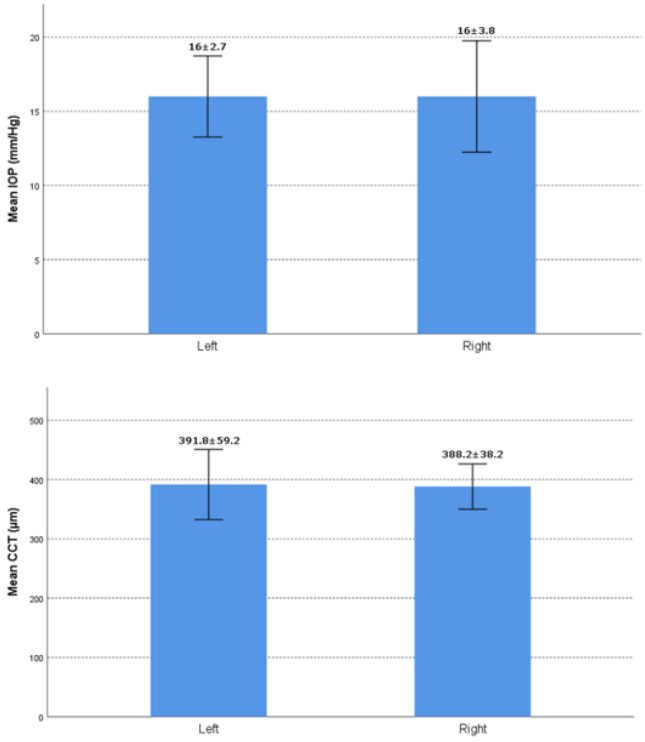

Figure 2. The bar graphs show the IOP and CCT values of the left and right eye.

Correlations between IOP and CCT were examined in the right eye (p=0.961, r=0.012), the left eye (p=0.435, r=0.185) and both eyes together (p=0.097, r=0.553) and no significant correlation was determined (Figures 3, 4).

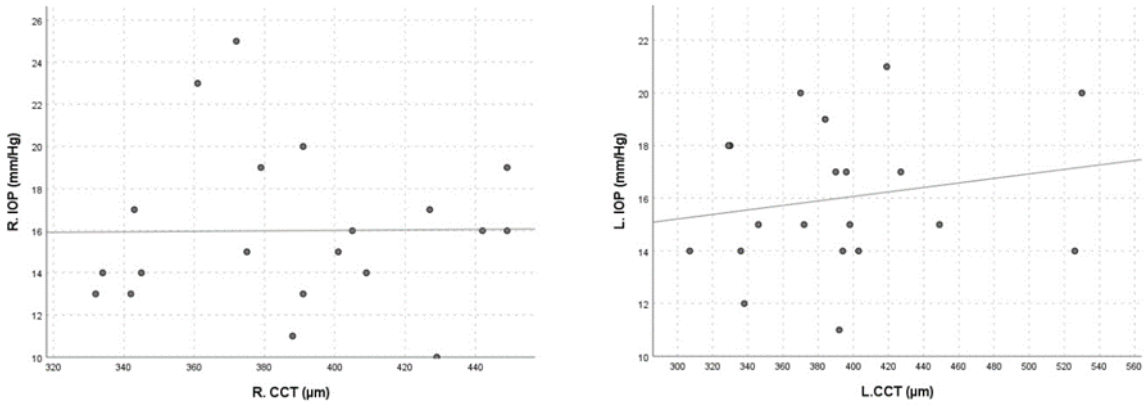

Figure 3. Scatter Dot Plot of IOP and CCT, right and left eyes (R: Right eye, L: Left eye, CCT: Central corneal thickness, IOP: intraocular pressure)

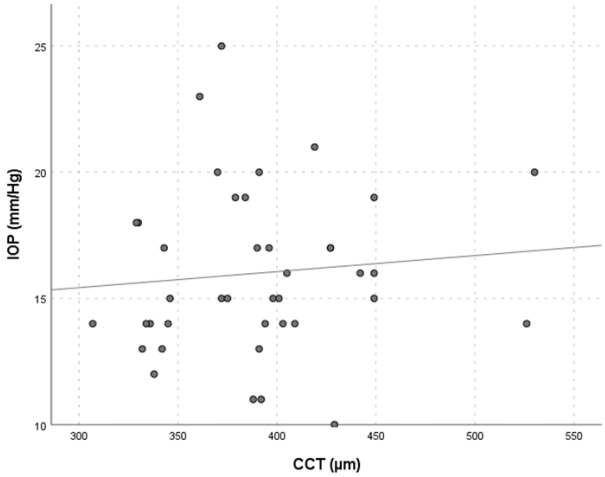

Figure 4. Scatter Dot Plot of IOP and CCT, both eyes (CCT: Central corneal thickness, IOP: intraocular pressure.

DISCUSSION

Rabbits are widely used as animal models in pharmacological tests for the examination of glaucoma and ocular diseases, and have recently been increasingly owned as domestic pets (A. Bouhenni et al., 2012; Hong Zhang et al., 2014).

An accurate, repeatable method for the measurement of IOP in rabbits is of vital importance. IOP is known to be affected by many types of sedative and general anaesthetic agents. In a previous study it was stated that if sedation or general anaesthesia is applied, attention must be paid not only to the effects of the agents used but also to how the effect changes in the time following application. Overall, general anaesthetics (injectable or gas) significantly reduce basic IOP (Millar & Pang, 2014). Therefore, in the current study, no anaesthetic or sedative agent was used.

During an ophthalmic examination, clinicians measure and record values in the patient file such as the amount of tears, IOP, and corneal thickness. This is necessary for individual follow-up of the patient and for the formation of type-specific data records. It is clear that studies to determine reference values are important in the fields of both experimental and clinical studies. Species-specific studies can be considered to contribute to literature to be able to

clearly establish reference values. In the current study, the mean values of IOP were determined with TonoVet® and mean CCT values with pachymetry in healthy New Zealand albino rabbits.

From a literature scan (Table 2) it was seen that IOP values ranged between 3mmHg and 80 mmHG, and when studies are examined in detail, the values can be seen to be mostly in the range of 9-15mmHg. The IOP values obtained in the current study were found to be similar to the findings of studies by Williams et al, Doğan and Kıbar, and Pereira et al(Doğan & Kibar, 2015; Pereira et al., 2011; Williams, 2012). Studies that have aimed to determine CCT values in rabbits have reported (Table 3) values ranging from 356µm to 407µm (Abrams et al., 1996; Charisis et al., 2008; Doğan & Kibar, 2015; Lim et al., 2005b; Ma et al., 2016; Mermoud et al., 1995; Pereira et al., 2011; Wang et al., 2013; Williams, 2012). The CCT values recorded in the current study were determined to be within this range. Consistent with the findings of previous studies, no significant difference was determined between the right and left eyes in respect of the IOP (Abrams et al., 1996; Charisis et al., 2008; Doğan & Kibar, 2015; Lim et al., 2005b; Ma et al., 2016; Mermoud et al., 1995; Pereira et al., 2011; Wang et al., 2013; Williams, 2012) and CCT (T. Chan et al., 1983; Herse & Yao, 2009; Khan, 2019; H. F. Li et al., 1997; Schulz et al., 2003; Wang & Wu, 2013) values.

Table 2. IOP values in literatures.

IOP	
16 ± 3,76 mmHg Right 16 ± 2.73 mmHg Left	Present study
3-30 mmHg	(Abrams et al., 1996) Abrams ve ark, 1996
0-50 mmHg	(Lim et al., 2005a)Lim ve ark, 2005
11.06 ± 1.62 mmHg	(Ma et al., 2016)Ma ve ark, 2016
9.51 ± 2.62 mmHg TonoVet® 15.44 ± 2.16 mmHg Tono-Pen Avia	(Pigatto et al., 2011)Pereira ve ark, 2011
12.99±2.67 mm/Hg	(Doğan & Kibar, 2015)Doğan ve Kibar, 2015
10.25 ± 2.3 mmHg Right 9.07 ± 2.47 mmHg Left	(Wang et al., 2013)Wang ve ark, 2013
15-23 mm Hg Yenidoğan 25 -50 mm Hg 1- 3 aylık	(Williams, 2012)
5-80 mmHg (Tono-Pen XL)	(Mermoud et al., 1995) Mermoud ve ark, 1995
10-70 mmHg (Tono-Pen XL)	(Charisis et al., 2008) Charisis ve ark, 2008

Table 3. CCT values in literatures.

CCT	
388,2 ± 38,22 µm Right 391,8± 59,18 µm Left	Present Study
381.6 ± 27,3 µm	(H. F. Li et al., 1997) Li ve ark, 1997
407 ± 20 µm	(Toiloi Chan et al., 1983) Chan ve Holden, 1983
356.11 ± 14.34 µm	(Schulz et al., 2003) Schulz ve ark, 2003
540 ± 25 µm	(Herse & Yao, 2009) Herse ve Yao, 1993
387 ± 19.8 µm Right 384 ± 20.2 µm Left	(Wang & Wu, 2013) Wang ve Wu, 2013
Pachymeter 372.47±20.11µm Right 373.20±20.32 µm Left spectral-domain anterior segment optical coherence tomography 375.40±20.12 µm Right 376.09±20.45 µm Left	(Khan, 2019) Khan, 2019

CONCLUSION

Previous studies in literature have reported that Goldmann applanation tonometry is effective in the measurement of CCT values (J. Li, 2004; Nejabat et al., 2016; Ozbek et al., 2006). That there was no correlation between IOP and CCT in the current study shows that there was no deviation that could be determined in the TonoVet® readings of CCT and IOP. The determination that there was no effect of corneal thickness in the IOP measurements made with TonoVet® is extremely important information in both clinical terms and in respect of experimental studies. Nevertheless, there is a need for further similar studies of different animal species to support these results.

ACKNOWLEDGMENT

The author would like to thank Prof. Dr. Ali Belge for constructive criticism of the manuscript.

Ethical approval: Ethical approval: The ethics committee report of this study was obtained from Aydın Adnan Menderes University Animal Experimental Local Ethics Committee (Authorization number: ADU-HADYEK-64583101/2021/099).

Conflict of interest: Authors have no conflicts of interest to declare.

REFERENCES

A. Bouhenni, R., Dunmire, J., Sewell, A., & Edward, D. P. (**2012**). Animal Models of Glaucoma. *Journal of Biomedicine and Biotechnology*, *2012*, 1–11. https://doi.org/10.1155/2012/692609

Abrams, L. S., Vitale, S., & Jampel, H. D. (**1996**). Comparison of three tonometers for measuring intraocular pressure in rabbits. *Investigative Ophthalmology & Visual Science*, *37*(5), 940–944. http://www.ncbi.nlm.nih.gov/pubmed/8603880

Acosta, A. C., Espana, E. M., Nose, I., Orozco, M., Yamamoto, H., Venkatraman, A. S., Fantes, F., & Parel, J.-M. (**2007**). Estimation of Intraocular Pressure in Rabbits With Commonly Used Tonometers. *Ophthalmic Surgery, Lasers and Imaging Retina*, *38*(1), 43–49. https://doi.org/10.3928/15428877-20070101-06

Becker, B. (**1960**). Hypothermia and aqueous humor dynamics of the rabbit eye. *Transactions of the American Ophthalmological Society*, *58*, 337–363. http://www.ncbi.nlm.nih.gov/pubmed/13688428

Behar-Cohen, F. F., Goureau, O., D'Hermies, F., & Courtois, Y. (**1996**). Decreased intraocular pressure induced by nitric oxide donors is correlated to nitrite production in the rabbit eye. *Investigative Ophthalmology & Visual Science*, *37*(8), 1711–1715. http://www.ncbi.nlm.nih.gov/pubmed/8675417

Belovay, G. W., & Goldberg, I. (**2018**). The thick and thin of the central corneal thickness in glaucoma. *Eye*, *32*(5), 915–923. https://doi.org/10.1038/s41433-018-0033-3

Bhan, A., Browning, A. C., Shah, S., Hamilton, R., Dave, D., & Dua, H. S. (**2002**). Effect of corneal thickness on intraocular pressure measurements with the pneumotonometer, Goldmann applanation tonometer, and Tono-Pen. *Investigative Ophthalmology and Visual Science*.

Brandt, J. D., Beiser, J. A., Gordon, M. O., & Kass, M. A. (**2004**). Central corneal thickness and measured IOP response to topical ocular hypotensive medication in the Ocular Hypertension Treatment Study. *American Journal of Ophthalmology*, *138*(5), 717–722. https://doi.org/10.1016/j.ajo.2004.07.036

Broman, A. T., Congdon, N. G., Bandeen-Roche, K., & Quigley, H. A. (**2007**). Influence of Corneal Structure, Corneal Responsiveness, and Other Ocular Parameters on Tonometric Measurement of Intraocular Pressure. *Journal of Glaucoma*, *16*(7), 581–588. https://doi.org/10.1097/IJG.0b013e3180640f40

Brown, K. E., & Congdon, N. G. (**2006**). Corneal structure and biomechanics: Impact on the diagnosis and management of glaucoma. *Current Opinion in Ophthalmology*, *17*(4), 338–343. https://doi.org/10.1097/01.icu.0000233951.01971.5b

Cairns, R., Graham, K., O'Gallagher, M., & Jackson, A. J. (**2019**). Intraocular pressure (IOP) measurements in keratoconic patients: Do variations in IOP respect variations in corneal thickness and corneal curvature? *Contact Lens and Anterior Eye*. https://doi.org/10.1016/j.clae.2018.11.007

Chan, T., Payor, S., & Holden, B. A. (**1983**). Corneal thickness profiles in rabbits using an ultrasonic pachometer. *Investigative Ophthalmology & Visual Science*, *24*(10), 1408–1410. http://www.ncbi.nlm.nih.gov/pubmed/6618800

Chan, Toiloi, Payor, S., & Holden, B. a. (**1983**). Corned Thickness Profiles in Robbits Using on Ultrosonic Pochometer. *Investigative Ophthalmology and Visual Sciences*, *24*, 1408–1410.

Charisis, S. K., Ginis, H. S., Kounis, G. A., & Tsilimbaris, M. K. (**2008**). Tono-Pen XL tonometry during application of a suction ring in rabbits. *BMC Ophthalmology*, *8*(1), 14. https://doi.org/10.1186/1471-2415-8-14

Doğan, Z., & Kibar, M. (**2015**). Tavşanlarda Bazı Antiglokomatöz İlaçların Göz İçi Basıncı Üzerine Etkileri*. *Erciyes Üniversitesi Veteriner Fakültesi Dergisi*, *12*(2), 99–107.

Garway-Heath, D. F., Crabb, D. P., Bunce, C., Lascaratos, G., Amalfitano, F., Anand, N., Azuara-Blanco, A., Bourne, R. R., Broadway, D. C., Cunliffe, I. A., Diamond, J. P., Fraser, S. G., Ho, T. A., Martin, K. R., McNaught, A. I., Negi, A., Patel, K., Russell, R. A., Shah, A., … Zeyen, T. G. (2015). Latanoprost for open-angle glaucoma (UKGTS): a randomised, multicentre, placebo-controlled trial. *The Lancet*, *385*(9975), 1295–1304. https://doi.org/10.1016/S0140-6736(14)62111-5

Gelatt, K. N., & MacKay, E. O. (2004a). Prevalence of the breed-related glaucomas in pure-bred dogs in North America. *Veterinary Ophthalmology*, *7*(2), 97–111. https://doi.org/10.1111/j.1463-5224.2004.04006.x

Gelatt, K. N., & MacKay, E. O. (2004b). Secondary glaucomas in the dog in North America. *Veterinary Ophthalmology*, *7*(4), 245–259. https://doi.org/10.1111/j.1463-5224.2004.04034.x

Gerometta, R., Alvarez, L. J., & Candia, O. A. (2012). Sildenafil Accelerates Anterior Chamber Refilling after Paracentesis in Sheep and Rabbits. *Investigative Opthalmology & Visual Science*, *53*(2), 565. https://doi.org/10.1167/iovs.11-8275

Gloe, S., Rothering, A., Kiland, J. A., & McLellan, G. J. (2019). Validation of the Icare® TONOVET plus rebound tonometer in normal rabbit eyes. *Experimental Eye Research*, *185*(June), 107698. https://doi.org/10.1016/j.exer.2019.107698

Gupta, S. K., Saxena, R., Agarwal, R., Galpalli, N. D., Srivastava, S., & Agrawal, S. S. (2007). Estimation of intraocular pressure in rabbits using Non Contact Tonometer: A comparative evaluation with Schiotz Tonometer. *Methods and Findings in Experimental and Clinical Pharmacology*, *29*(6), 405. https://doi.org/10.1358/mf.2007.29.6.1119161

Harada, Y., Hirose, N., Kubota, T., & Tawara, A. (2008). The Influence of Central Corneal Thickness and Corneal Curvature Radius on The Intraocular Pressure as Measured By Different Tonometers: Noncontact and Goldmann Applanation Tonometers. *Journal of Glaucoma*, *17*(8), 619–625. https://doi.org/10.1097/IJG.0b013e3181634f0f

Herse, P., & Yao, W. (2009). Variation of corneal thickness with age in young New Zealanders. *Acta Ophthalmologica*, *71*(3), 360–364. https://doi.org/10.1111/j.1755-3768.1993.tb07148.x

Iliev, M. E., Goldblum, D., Katsoulis, K., Amstutz, C., & Frueh, B. (2006). Comparison of rebound tonometry with Goldmann applanation tonometry and correlation with central corneal thickness. *British Journal of Ophthalmology*. https://doi.org/10.1136/bjo.2005.089870

Ito, Y., Nagai, N., Okamoto, N., Shimomura, Y., Nakanishi, K., & Tanaka, R. (2013). Reduction of Enhanced Rabbit Intraocular Pressure by Instillation of Pyroglutamic Acid Eye Drops. *Biological and Pharmaceutical Bulletin*, *36*(6), 1017–1023. https://doi.org/10.1248/bpb.b13-00159

Jin, J., Xu, G., & Yuan, Z. (2014). Influence of the Hypothalamic Arcuate Nucleus on Intraocular Pressure and the Role of Opioid Peptides. *PLoS ONE*, *9*(4), e82315. https://doi.org/10.1371/journal. pone.0082315

Kass, M. A., Podos, S. M., Moses, R. A., & Becker, B. (1972). Prostaglandin E 1 and aqueous humor dynamics. *Investigative Ophthalmology*, *11*(12), 1022–1027. http://www.ncbi.nlm.nih.gov/pubmed/4638977

Khan, M. A. (2019). Distribution and measurement of corneal thickness in rabbits. *Investigative Ophthalmology & Visual Science*, 6805. https://iovs.arvojournals.org/article.aspx?articleid=2746137

Li, H. F., Petroll, W. M., Møller-Pedersen, T., Maurer, J. K., Cavanagh, H. D., & Jester, J. V. (1997). Epithelial and corneal thickness measurements by in vivo confocal microscopy through focusing (CMTF). *Current Eye Research*, *16*(3), 214–221. https://doi.org/10.1076/ceyr.16.3.214.15412

Li, J. (2004). Clinical Comparison of the Proview Eye Pressure Monitor With the GoldmannApplanation Tonometer and the TonoPen. *Archives of Ophthalmology*, *122*(8), 1117. https://doi.org/10.1001/archopht.122.8.1117

Lim, K. S., Wickremasinghe, S. S., Cordeiro, M. F., Bunce, C., & Khaw, P. T. (2005a). Accuracy of intraocular pressure measurements in New Zealand white rabbits. *Investigative Ophthalmology and Visual Science*, *46*(7), 2419–2423. https://doi.org/10.1167/iovs.04-0610

Lim, K. S., Wickremasinghe, S. S., Cordeiro, M. F., Bunce, C., & Khaw, P. T. (2005b). Accuracy of Intraocular Pressure Measurements in New Zealand White Rabbits. *Investigative Opthalmology & Visual Science*, *46*(7), 2419. https://doi.org/10.1167/iovs.04-0610

Ma, D., Chen, C.-B., Liang, J., Lu, Z., Chen, H., & Zhang, M. (2016). Repeatability, reproducibility and agreement of intraocular pressure measurement in rabbits by the TonoVet and Tono-Pen. *Scientific Reports*, *6*(1), 35187. https://doi.org/10.1038/srep35187

Mansoori, T., & Balakrishna, N. (2018). Effect of central corneal thickness on intraocular pressure and comparison of Topcon CT-80 non-contact tonometry with Goldmann applanation tonometry. *Clinical and Experimental Optometry*, *101*(2), 206–212. https://doi.org/10.1111/cxo.12620

Mermoud, A., Baerveldf, G., Minckler, D. S., Lee, M. B., & Rao, N. A. (1995). Measurement of Rabbit Intraocular Pressure with the Tono-Pen. *Ophthalmologica*, *209*(5), 275–277. https://doi.org/10.1159/000310630

Millar, J. C., & Pang, I. H. (2014). Non-continuous measurement of intraocular pressure in laboratory animals. *Experimental Eye Research*, *141*, 74–90. https://doi.org/10.1016/j.exer.2015.04.018

Moussa, I. R., Kassem, R. R., Edris, N. A., & Khalil, D. H. (2021). Normal intraocular pressure in Egyptian children and meta-analysis. *Eye*. https://doi.org/10.1038/s41433-021-01633-8

Nejabat, M., Heidary, F., Talebnejad, M. R., Salouti, R., Nowroozzadeh, M. H., Masoumpour, M., Mahdaviazad, H., Tajbakhsh, Z., Keshtkar, M., Jamali, H., Khalili, M. R., Movahedan, H.,

Roustaei, N., & Gharebaghi, R. (**2016**). Correlation Between Intraocular Pressure and Central Corneal Thickness in Persian Children. *Ophthalmology and Therapy*, *5*(2), 235–243. https://doi.org/10.1007/s40123-016-0063-5

Ozbek, Z., Cohen, E. J., Hammersmith, K. M., & Rapuano, C. J. (**2006**). Dynamic Contour Tonometry. *Cornea*, *25*(8), 890–894. https://doi.org/10.1097/01.ico.0000224649.12214.33

Pereira, F. Q., Bercht, B. S., Soares, M. G., da Mota, M. G. B., & Pigatto, J. A. T. (**2011**). Comparison of a rebound and an applanation tonometer for measuring intraocular pressure in normal rabbits. *Veterinary Ophthalmology*, *14*(5), 321–326. https://doi.org/10.1111/j.1463-5224.2011.00879.x

Pigatto, J. A. T., Pereira, F. Q., Albuquerque, L., Corrêa, L. F. D., Bercht, B. S., Hünning, P. S., Silva, A. A. R., & Freitas, L. V. R. P. de. (**2011**). Intraocular pressure measurement in sheep using an applanation tonometer. *Revista Ceres*, *58*(6), 685–689. https://doi.org/10.1590/S0034-737X2011000600002

Schulz, D., Iliev, M. E., Frueh, B. E., & Goldblum, D. (**2003**). In vivo pachymetry in normal eyes of rats, mice and rabbits with the optical low coherence reflectometer. *Vision Research*, *43*(6), 723–728. https://doi.org/10.1016/S0042-6989(03)00005-1

Sethi, A., Puri, V., & Waikar, S. (**2021**). Correlation of corneal hysteresis and central corneal thickness with intraocular pressure measured by ocular response analyzer and goldmann applanation tonometer. *Journal of Marine Medical Society*. https://doi.org/10.4103/jmms.jmms_94_20

Tham, Y.-C., Li, X., Wong, T. Y., Quigley, H. A., Aung, T., & Cheng, C.-Y. (**2014**). Global Prevalence of Glaucoma and Projections of Glaucoma Burden through 2040. *Ophthalmology*, *121*(11), 2081–2090. https://doi.org/10.1016/j.ophtha.2014.05.013

Wang, X., Dong, J., & Wu, Q. (**2013**). Twenty-four-hour measurement of IOP in rabbits using rebound tonometer. *Veterinary Ophthalmology*, *16*(6), 423–428. https://doi.org/10.1111/vop.12020

Wang, X., & Wu, Q. (**2013**). Normal corneal thickness measurements in pigmented rabbits using spectral-domain anterior segment optical coherence tomography. *Veterinary Ophthalmology*, *16*(2), 130–134. https://doi.org/10.1111/j.1463-5224.2012.01041.x

Williams, D. L. (**2012**). Ophthalmology of Exotic Pets. In *Ophthalmology of Exotic Pets*. John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118709627

Wind, C. A., & Irvine, A. R. (**1969**). Electronic applanation tonometry in corneal edema and keratoplasty. *Investigative Ophthalmology*, *8*(6), 620–624. http://www.ncbi.nlm.nih.gov/pubmed/4902381

Zeng, Y., Guo, X., Lin, J., Zeng, X., Zhong, Y., Cai, X., & Liu, X. (**2008**). [Effect of tear film changes on the intraocular pressure measurement by Goldmann applanation tonometer]. *Yan Ke Xue Bao = Eye Science*, *24*(1), 27–29. http://www.ncbi.nlm.nih.gov/pubmed/18709953

Zhang, Hong, Yang, D., Ross, C. M., Wigg, J. P., Pandav, S., & Crowston, J. G. (**2014**). Validation of rebound tonometry for intraocular pressure measurement in the rabbit. *Experimental Eye Research*, *121*, 86–93. https://doi.org/10.1016/j.exer.2014.02.004

Zhang, Hui, Sun, Z., Li, L., Sun, R., & Zhang, H. (**2020**). Comparison of intraocular pressure measured by ocular response analyzer and Goldmann applanation tonometer after corneal refractive surgery: a systematic review and meta-analysis. *BMC Ophthalmology*, *20*(1), 23. https://doi.org/10.1186/s12886-019-1288-6