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Peter Campbell<sup>1,2</sup>, David F. Edgar<sup>1</sup>, Rakhee Shah<sup>1</sup>

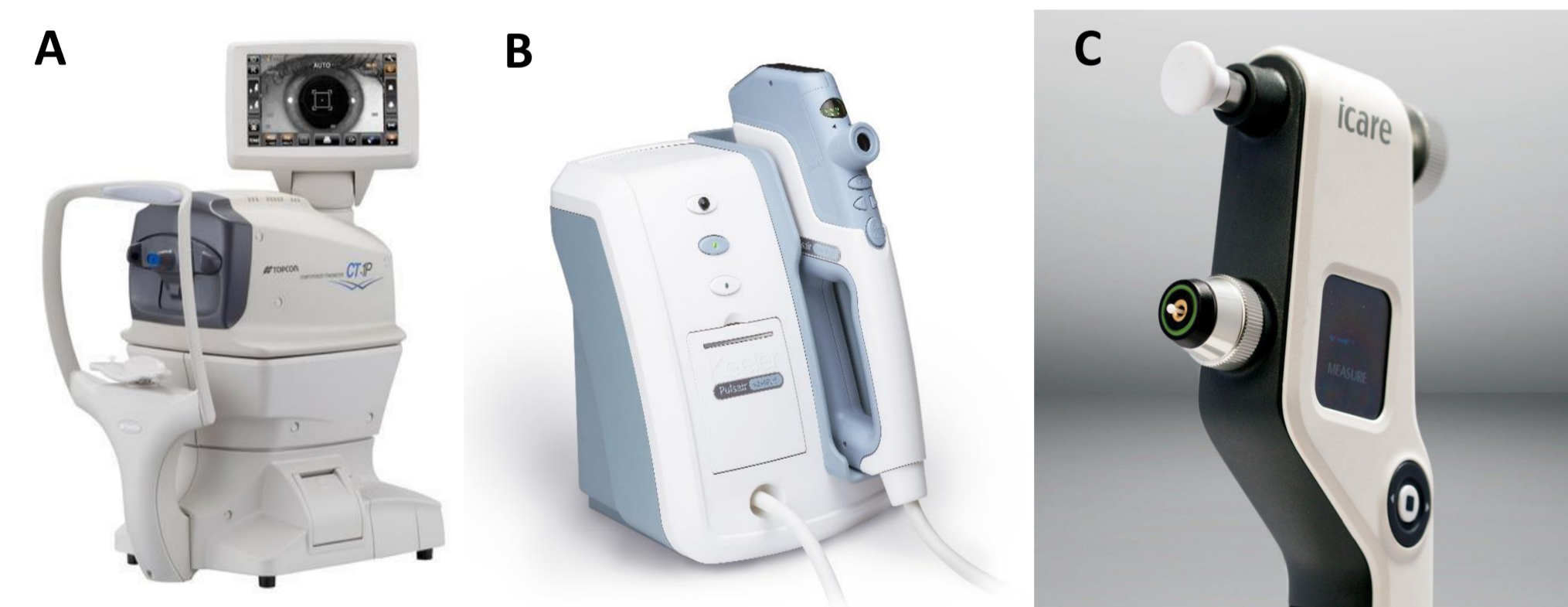
1. Optometry and Visual Science, City, University of London, UK 2. Guy's and St Thomas' NHS Foundation Trust, London, UK

## Introduction

- Cases of glaucoma in the UK are mostly identified through routine examinations by community/primary care optometrists.<sup>1,2</sup>
- Elevated Intraocular Pressure (IOP) is an important risk factor for glaucoma.<sup>3</sup>
- Goldmann Applanation Tonometry (GAT) is regarded as the reference method for IOP measurement.<sup>4</sup>
- UK community optometrists principally use non-contact or rebound tonometry to measure IOP.<sup>5,6</sup> Knowledge of how these devices agree with GAT would help inform their choice of tonometer and potentially reduce the number of false positive referrals.

## Purpose

- To assess the agreement of three tonometers commonly used by UK community optometrists with GAT.



**Figure 1:** Tonometers assessed for their agreement with GAT  
A: CT-1P Non-Contact Tonometer (NCT) (Topcon, Topcon Corporation, Tokyo, Japan).  
B: Pulsair IntelliPuff (Keeler Ltd., Windsor, UK).  
C: Icare rebound tonometer (Icare®, Helsinki, Finland).

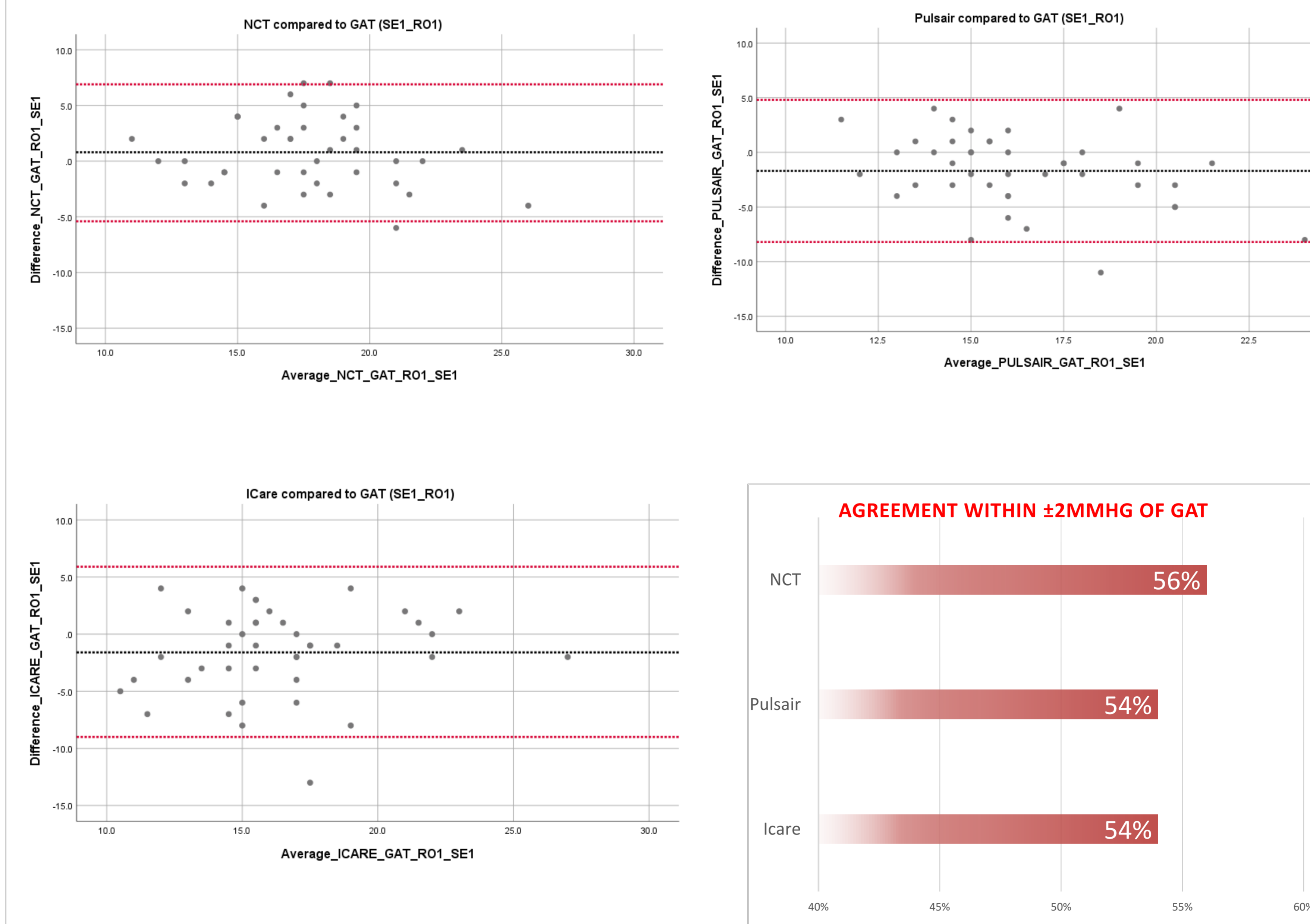
## Methods

- Participants, 18 years and over, were recruited from a university eye clinic.
- IOP was measured by two research optometrists (RO1 and RO2), both experienced in GAT.
- IOP was first measured on the randomly selected study eye (SE1) using the three tonometers, NCT, Pulsair and Icare (Figure 1) by RO1.
- GAT readings were then obtained in a masked manner by RO1. The force on the probe was initially set at a randomly selected value between 1g and 2g by RO2; RO1, masked to the dial reading, adjusted the probe until the end point, and RO2 recorded the measurement.

- Agreement between NCT, Pulsair, Icare and GAT was assessed using Bland–Altman difference analysis, and mean differences and 95% limits of agreement (LoA) of measurements calculated.
- Percentages of IOP readings within  $\pm 2$ mmHg of the GAT reading were obtained.

## Results

- Forty-one participants had their IOP measured by all four tonometers: median age 36 years (IQR: 20, 49), 71% female.
- Figure 2 displays the Bland-Altman plots for each tonometer compared to GAT and the percentage of readings within  $\pm 2$ mmHg of GAT.
- Table 1 outlines the results for each tonometer compared to GAT.



**Figure 2:** Bland–Altman difference plots and % Agreement for NCT, Pulsair and Icare compared to GAT

Tonometer	Mean (SD) IOP (mmHg)	Mean Bias: Tonometer-GAT IOP (mmHg)	95% LoA (mmHg)	P value (F Test)
GAT	17.1 (3.7)	-	-	
NCT	17.9 (3.2)	0.8	-5.4 to 6.9	0.21
Pulsair	15.4 (2.6)	-1.7	-8.2 to 4.8	0.01
Icare	15.6 (4.2)	-1.6	-9.0 to 5.9	0.22

**Table 1** Comparison of each tonometer to GAT (95% LoA: Limits of Agreement)

## Conclusions

- For three tonometers commonly used by UK community/primary care optometrists we found over half of measurements were within  $\pm 2$ mmHg of GAT, with NCT having the greatest percentage of measurements within  $\pm 2$ mmHg. These findings concur with previous studies.<sup>4</sup>
- Pulsair and Icare recorded mean IOP lower than GAT, and there was a statistically significant difference between mean IOPs for Pulsair vs GAT. Both these devices had wider 95% LoA than NCT.
- Our results agreed with other researchers who found Icare to underestimate IOP<sup>7</sup> more so when  $GAT \geq 23$ mmHg.<sup>8</sup>
- Further work is needed to investigate the clinical impact of the choice of tonometer used in the detection of patients at risk of glaucoma, although IOP alone is not a good indicator of glaucoma.<sup>9</sup>

## References

1. NICE. Glaucoma: diagnosis and management | Guidance and guidelines | NICE. (2017). Available at: <https://www.nice.org.uk/Guidance/NG81/evidence>. (Accessed: 15 December 2018)
2. Bowling, B., Chen, S. D. M. & Salmon, J. F. Outcomes of referrals by community optometrists to a hospital glaucoma service. *Br. J. Ophthalmol.* 89, 1102–1104 (2005).
3. Heijl, A. *et al.* Reduction of intraocular pressure and glaucoma progression: results from the Early Manifest Glaucoma Trial. *Arch. Ophthalmol.* 120, 1268–1279 (2002).
4. Cook, J. A. *et al.* Systematic review of the agreement of tonometers with Goldmann applanation tonometry. *Ophthalmology* 119, 1552–1557 (2012).
5. Myint J, Edgar DF, Kotecha A, Murdoch IE, Lawrenson JG. A national survey of diagnostic tests reported by UK community optometrists for the detection of chronic open angle glaucoma. *Ophthalmic and Physiological Optics*. 2011 Jul;31(4):353-9.
6. Dabasia PL, Edgar DF, Garway-Heath DF, Lawrenson JG. A survey of current and anticipated use of standard and specialist equipment by UK optometrists. *Ophthalmic and Physiological Optics*. 2014 Sep;34(5):592-613.
7. Rosentreter, A. *et al.* Rebound, Applanation, and Dynamic Contour Tonometry in Pathologic Corneas. *Cornea* 32, 313 (2013).
8. Gao, F., Liu, X., Zhao, Q. & Pan, Y. Comparison of the iCare rebound tonometer and the Goldmann applanation tonometer. *Exp. Ther. Med.* 13, 1912–1916 (2017).
9. Chan, M. P. Y. *et al.* Glaucoma and intraocular pressure in EPIC-Norfolk Eye Study: cross sectional study. *BMJ* 358, j3889 (2017).