Agreement of Rebound Tonometer in Measuring Intraocular Pressure With Three Types of Applanation Tonometers

Nakamura, Makoto ; Darhad, Urtogta ; Tatsumi, Yasuko ; Fujioka, Miyuki ; Kusuhara, Azusa ; Maeda, Hidetaka ; Negi, Akira

(Citation)
American Journal of Ophthalmology,142(2):332-334

(Issue Date)
2006-08

(Resource Type)
journal article

(Version)
Accepted Manuscript

(URL)
https://hdl.handle.net/20.500.14094/90000358

Title: Agreement of rebound tonometer in measuring intraocular pressure with three types of applanation tonometers.

Authors: Makoto Nakamura, MD, PhD, Urtogtah Darhad, MD, Yasuko Tatsumi, MD, Miyuki Fujioka, MD, Azusa Kusuhara, MD, Hidetaka Maeda, MD, PhD, Akira Negi, MD, PhD.

Affiliation: Division of Ophthalmology, Department of Organs Therapeutics, Kobe University Graduate School of Medicine. 7-5-2 Kusunoki-cho, Chuo-ku, Kobe 650-0017, Japan.

Correspondence: Makoto Nakamura, MD, PhD. Division of Ophthalmology, Department of Organs Therapeutics, Kobe University Graduate School of Medicine. 7-5-2 Kusunoki-cho, Chuo-ku, Kobe 650-0017, Japan.
Phone: 81-78-382-6048
e-mail: manakamu@med.kobe-u.ac.jp

There is no proprietary commercial interest in this study.

This study is partly supported by Grant-in-Aid No. 16390499 (AN, MN) and No. 17591835 (MN) from the Ministry of Education, Culture, Sports, Science and Technology of the Japanese Government and by Suda Memorial Foundation for Glaucoma Research (MN).

Purpose: To evaluate the agreement of ICARE rebound tonometer in measuring intraocular pressure (IOP) with Goldmann applanation tonometer (GAT), Tonopen XL, and non-contact tonometer (NCT) and the influence of the central corneal thickness (CCT) on IOP measurements made with these four tonometers in 45 (12 control and 33 glaucomatous or ocular hypertensive) eyes.

Design: Clinically relevant experimental study.

Methods: Tonometer inter-method agreement was assessed by the Bland-Altman method. The relations of CCT with absolute IOP values and inter-tonometer differences were analyzed by linear regression.

Results: The mean differences (95% limits of agreement) in IOP readings between ICARE and GAT, Tonopen XL, and NCT were 1.40 (±4.29), 0.00 (±4.78), and 2.22 (±4.19) mmHg, respectively. All tonometries had a significant association with CCT. The thicker the cornea, ICARE significantly overestimated GAT and Tonopen XL.

Conclusions: Although influenced by CCT, ICARE agrees well with applanation tonometers

A newly developed, hand-held, anesthetic-free rebound tonometer (ICRAE TA01; Tiolat, Helsinki, Finland) is a solenoid mechanism, which launches a magnetized probe and detects its motion parameters during impacting on the cornea[1-4]. However, the interchangeability of the ICARE with applanation tonometers and the effect of CCT on ICRAE in measuring intraocular pressure (IOP) remain investigated.

The purposes of this study were to evaluate whether ICARE agrees with three types of applanation tonometers in measuring IOP and to assess the influence of CCT on the IOP measurements made with these four tonometers.

The study was approved by the Institutional Review Board of the Kobe University Graduate School of Medicine. Written informed consent was obtained from each participant.

Enrolled were right eyes of 45 persons (15 males, 30 females) aged from 26 to 86 (mean±S.D., 52.0 ± 20.0) years, which included 12 healthy volunteers and 33 patients with ocular hypertension or glaucoma. They had no histories of contact lens wear, anti-glaucoma hypotensive use, corneal surface diseases or intraocular surgeries.

The CCT was measured with a specular-type CCT measurement apparatus (NONCON ROBO; Konan Mecial, Nishinomiya, Japan). IOP measurements were made sequentially in an order of the Canon TX-10 non-contact tonometer (NCT), ICARE, Tonopen XL (Medtronic Solan, Jacksonville, FL, USA), and Goldmann applanation tonometer (GAT; Haag-Streit AG, Bern, Switzerland) to avoid possible reduction in IOP induced by contact applanation tonometry. The median of three readings per instrument was used for comparison among tonometers[5]. Orthoptists performed the NCT. Tonopen XL performance was made by MN with only measurements with a

standard error smaller than 5% being accepted. MN also conducted on six consecutive measurements per patient with ICARE. When the P blinked or an error sign '-' was displayed, data were discarded and measurements were repeated until such error signs were not displayed. At GAT measurements, UD randomly set the dial around 10 mmHg and recorded the pressure, whereas MN applanated the cornea and turned the dial without looking.

The mean IOP with ICARE, GAT, NCT, and Tonopen XL was 15.6 ± 4.8, 14.1 ± 4.2, 13.4, and 15.5 mmHg, respectively. Mean difference between ICARE and GAT, between ICARE and NCT, and between ICARE and Tonopen XL was 1.40 ± 2.19, 2.22 ± 2.14, and 0.00 ± 2.44 mmHg, respectively, with 95% limits of agreement[6] being bias ± 4.29, ± 4.19, and ± 4.78 mmHg, respectively. The difference between the former two pairs was statistically significant (paired t-test, $p<0.0001$). As shown in Bland-Altman plots[6] with linear regression, ICARE constantly overestimated GAT over the range of measured IOP (Fig.1), whereas ICARE overestimated NCT and Tonopen XL at higher IOP and underestimated them at lower IOP (Figs. 2 and 3).

The mean CCT was 530.4 ± 44.1, raging from 422 to 636 μm. The associations between CCT and IOP measured with ICARE ($r^2=0.352$, $p<0.0001$), GAT ($r^2=0.206$, $p=0.001$), NCT ($r^2=0.424$, $p<0.0001$), and Tonopen XL ($r^2=0.315$, $p<0.0001$) were all significant. Linear regression analyses also disclosed that ICARE overestimated GAT and Tonopen XL at higher CCT and underestimated them at lower CCT, whereas there was no significant association between the CCT and the ICARE to NCT difference (Figs. 1 through 3).

The mean difference and 95% limits of agreement between ICARE and GAT in two recent studies[3,4] (1.34 and ± 3.98 mmHg, and 1.8 and ± 5.5 mmHg, respectively) fit the

present ones. ICARE also showed a good agreement in the IOP measurement with NCT and Tonopen XL. Thus, ICRAE overall seems to be interchangeable with these applanation tonometers.

On the other hand, CCT affected ICARE measurements as well as the applanation tonometries[7]. Deceleration of the ICARE probe is claimed to be inversely proportional to IOP[1,2]. The present study demonstrated that the probe deceleration could be also influenced by corneal parameters; that is, the thicker or stiffer the cornea, the shorter the duration of the impact, which would cause ICARE to overestimate IOP.

Acknowledgement

The authors wish to thank M.E. Technica (Tokyo, Japan) for a restricted trial period with the ICARE tonometer.

References

1. Kontiola AI. A new induction-based impact method for measuring intraocular pressure. Acta Ophthalmol Scand 2000; 78: 142-145.
2. Kontiola AI, Goldblum D, Mittag T, Danias J. The induction / impact tonometer: a new instrument to measure intraocular pressure in rat. Exp Eye Res 2001; 73: 781-785.
3. Fernandes P, Diaz-Rey JA, Queiros A, Gonzalez-Meijome JM, Jorge J. Comparison of the ICare® rebound tonometer with the Goldmann tonometer in a normal population. Ophthal Physiol Opt 2005; 25: 436-440.

4. Martinez-de-la-Casa JM, Garcia-Feijoo J, Castillo A, Garcia-Sanchez J. Reproducibility and clinical evaluation of rebound tonometry. Invets Ophthalmol Vis Sci 46: 4578-4580, 2005.

Dielemans I, Vingerling JR, Hofman A, Grobbee DE, de Jong PTVM. Reliability of intraocular pressure measurement with the Goldmann applanation tonometer in epidemiological studies. Graefe's Arch Clin Exp Ophthalmol 1994; 232: 141-144.

5. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986; 1: 307-310.
6. Tonnu P-A, Ho T, Newson T, et al. The influence of central corneal thickness and age on intraocular pressure measured by pneumatonometry, noncontact tonometry, the Tono-Pen XL, and Goldmann applanation tonometry. Br J Ophthalmol 2005; 89: 851-854.

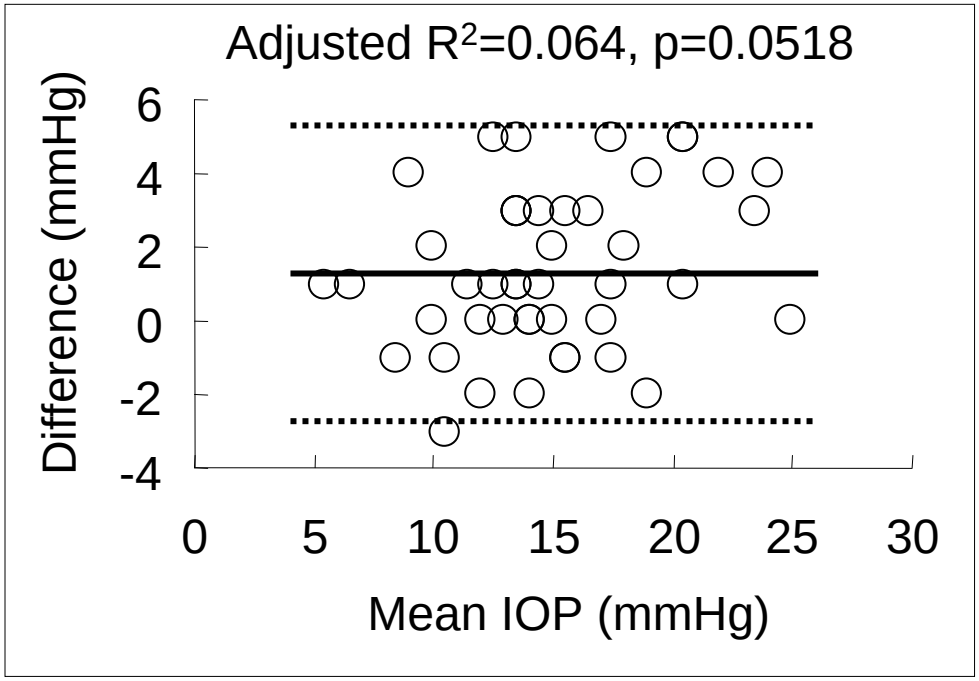
Figure legends

Figure 1. The agreement of ICARE with Goldmann applanation tonometry (GAT) in measuring intraocular pressure (IOP) and the effect of central corneal thickness (CCT) on the inter-tonometry difference. Top. A Bland-Altman plot of agreement on IOP taken with ICARE against GAT. Solid line denotes mean difference (bias), whereas dotted lines 95% of limits of agreement. Bottom. A scattered plot of the ICARE to GAT difference against CCT.

Figure 2. . The agreement of ICARE with non-contact tonometer (NCT) in measuring intraocular pressure (IOP) and the effect of central corneal thickness (CCT) on the inter-tonometry difference. Top. A Bland-Altman plot of agreement on IOP taken with ICARE against NCT. Solid line denotes mean difference (bias), whereas dotted lines 95% of limits of agreement. Bottom. A scattered plot of the ICARE to NCT difference against CCT.

Figure 3. The agreement of ICARE with Tonopen XL in measuring intraocular pressure (IOP) and the effect of central corneal thickness (CCT) on the inter-tonometry difference. Top. A Bland-Altman plot of agreement on IOP taken with ICARE against Tonopen XL. Solid line denotes mean difference (bias), whereas dotted lines 95% of limits of agreement. Bottom. A scattered plot of the ICARE to Tonopen XL difference against CCT.

Fig.1


Adjusted R²=0.064, p=0.0518
Difference (mmHg)
6
4
2
0
-2
-4
0
5
10
15
20
25
30
Mean IOP (mmHg)

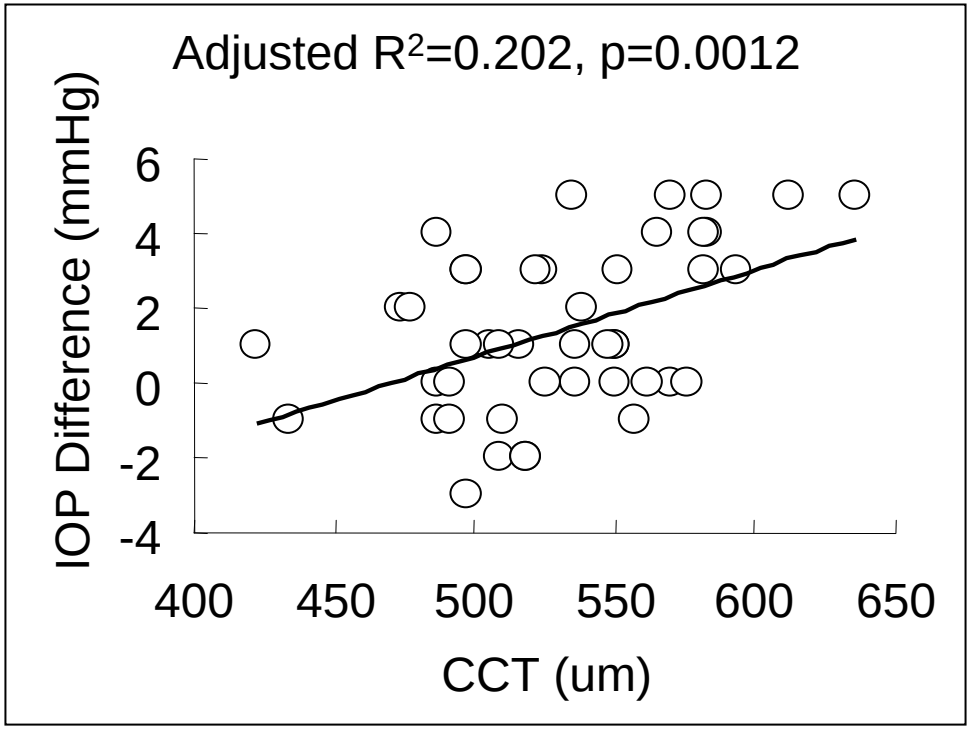
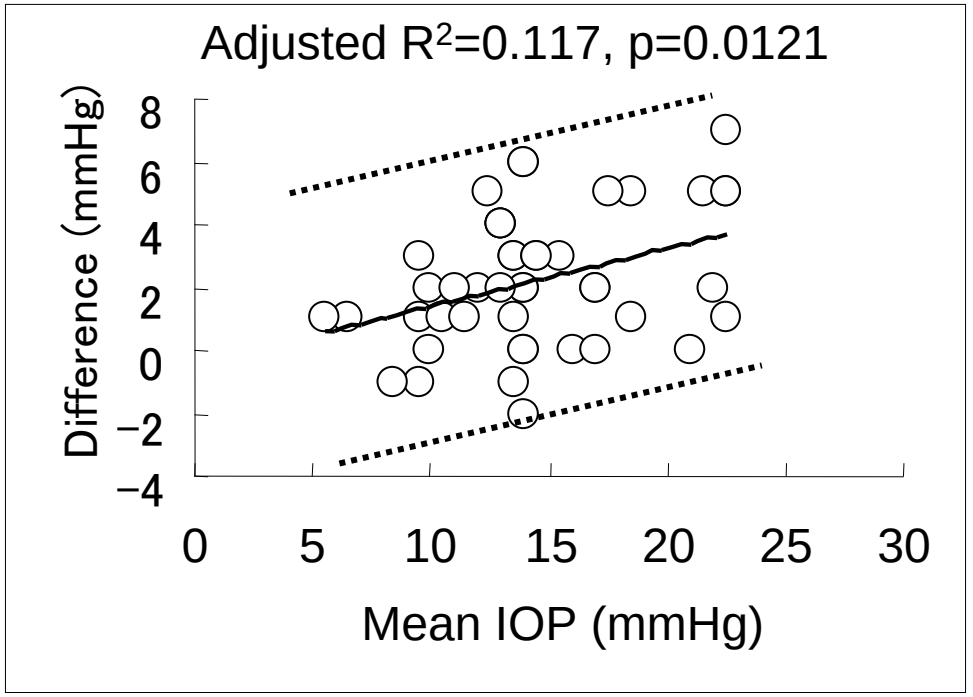

Adjusted R²=0.202, p=0.0012
IOP Difference (mmHg)
6
4
2
0
-2
-4
400
450
500
550
600
650
CCT (um)

Fig. 2


Adjusted R2=0.117, p=0.0121
Difference (mmHg)
8
6
4
2
0
−2
−4
0
5
10
15
20
25
30
Mean IOP (mmHg)

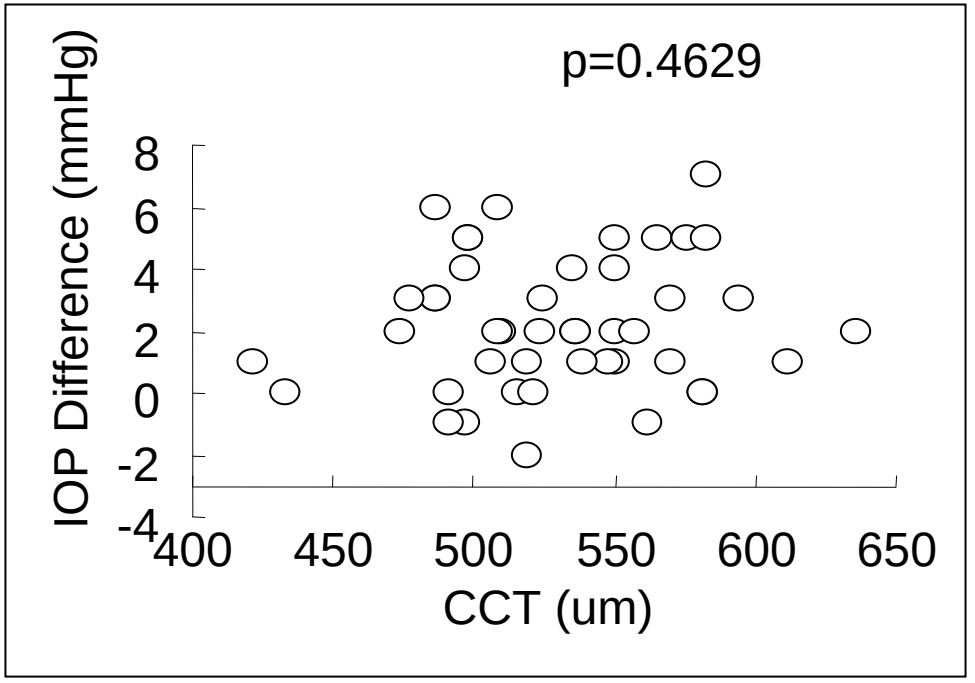
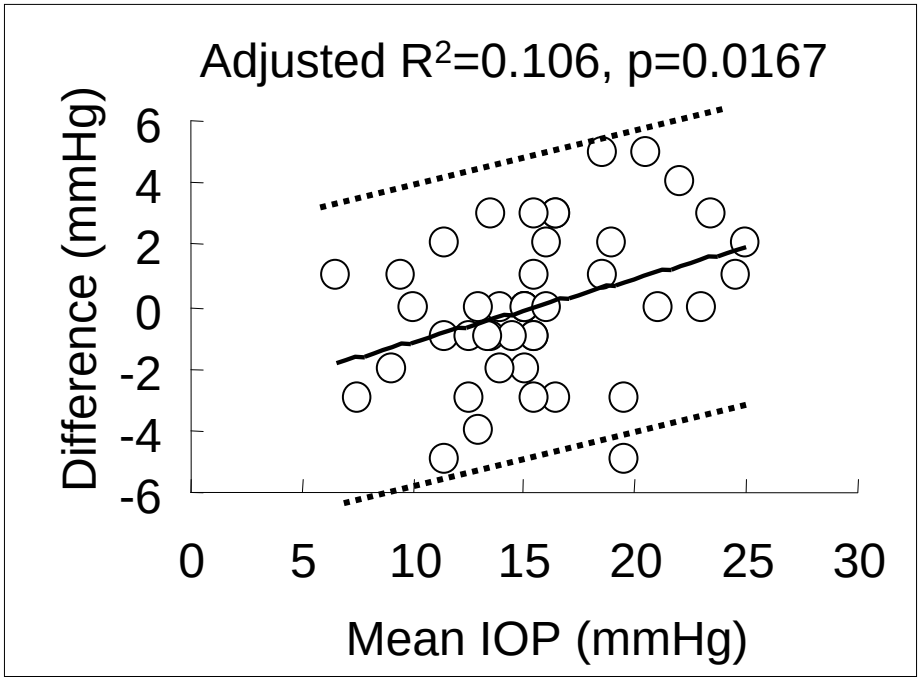
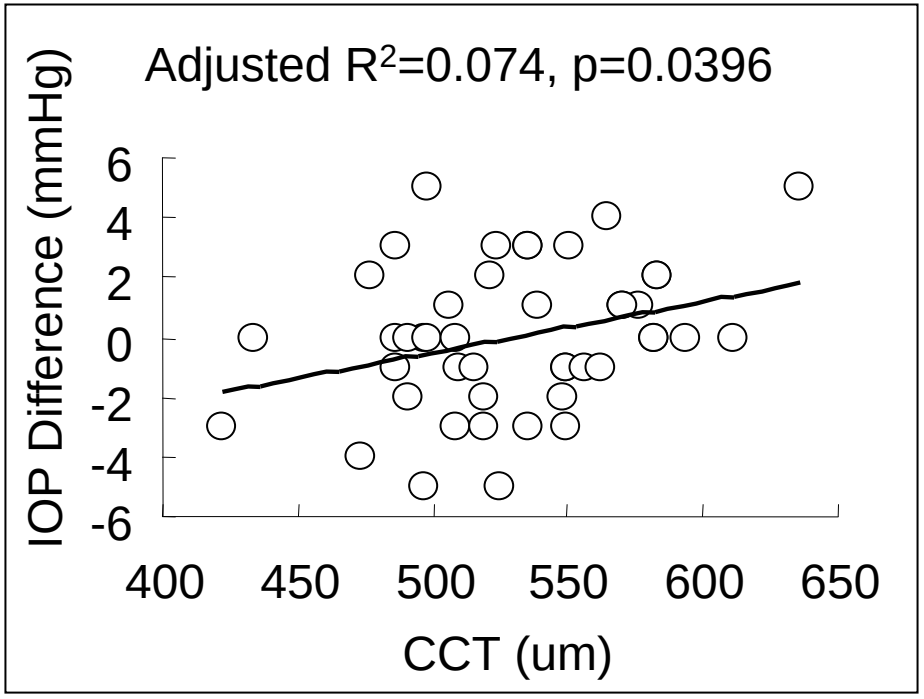

p=0.4629
IOP Difference (mmHg)
8
6
4
2
0
-2
-4
400
450
500
550
600
650
CCT (um)

Fig. 3


Adjusted R2=0.106, p=0.0167
Difference (mmHg)
6
4
2
0
-2
-4
-6
0
5
10
15
20
25
30
Mean IOP (mmHg)


Adjusted R2=0.074, p=0.0396
IOP Difference (mmHg)
6
4
2
0
-2
-4
-6
400
450
500
550
600
650
CCT (um)