

# Intraocular Pressure Measurements Difference between Reusable and Disposable Tonometer in Relation to the Central Corneal Thickness and Effect of Cataract Operation on Corneal Thickness

Saqib Ali Khan Utman<sup>1</sup>, Siobhan M E Wren<sup>2</sup>, Phillip Bloom<sup>2</sup>, Hanna Baig<sup>3</sup>

<sup>1</sup>Department of Ophthalmology, Southampton University Hospital, Southampton, England, <sup>2</sup>Department of Ophthalmology, Hillingdon Hospital, Uxbridge, London, <sup>3</sup>Department of Public Health West Midlands, Senior Registrar General Practice, Coventry and Warwickshire Coventry

## ABSTRACT

**Purpose:** The purpose of this audit was to evaluate the accuracy of the disposable applanation tonometer head as a potential substitute to the standard reusable applanation tonometer head for intraocular pressure (IOP) measurements and to determine the influence of central corneal thickness (CCT) on IOP measurements with these tonometer heads and determine the effect of corneal incision on the post-operative CCT. **Methods:** IOP of 30 post-cataract surgery patients was measured with disposable and the standard reusable tonometer head after informed consent. Corneal thickness was recorded in operated and unoperated eye. **Results:** The mean IOP using the reusable tonometer head in both eyes was  $13.4 \pm 3.11$  mmHg and with the disposable head was  $13.11 \pm 3.18$  mmHg with the mean difference of  $0.29 \pm 0.08$  mmHg. Disposable tonometer recorded higher IOP in patients with thicker cornea ( $0.1 \pm 0.2$  mmHg) than in patients with thinner cornea ( $0.4 \pm 0.3$  mmHg) and lower in the normal CCT patients. **Conclusions:** Disposable tonometer prism provides a reliable, effective, and safe alternative to the reusable tonometer prism with the advantages of eliminating the need for chemical disinfection and the risk of cross infection.

**Key words:** Goldmann versus tonosafe, post-operative central corneal thickness, tonometry relation to pachymetry

## INTRODUCTION

The variability in corneal thickness and rigidity, as well as the tear film surface tension, is responsible for the errors in intraocular pressure (IOP) measurement accuracy by applanation tonometry methods.<sup>[1]</sup> The ideal tonometer should be accurate, reliable, easy to use, and comfortable for the patient and physician. It should provide an IOP reading that is as close to manometric IOP as possible. To date, no such tonometer exists, but the Goldmann applanation tonometer is the gold standard for measurements of IOP and is accurate but unfortunately not precise.<sup>[2]</sup> Disposable prism tonometer (Tonosafe) provides a reliable, effective,

and safe alternative to reusable prism tonometer with the advantage of eliminating the need for chemical disinfection and risk of cross infection.<sup>[3,4]</sup> Phacoemulsification causes the corneal endothelial cell loss, leading to post-cataract surgery corneal edema<sup>[5-7]</sup> and is caused by irrigation and the heat generated by phacoemulsification devices, and is dependent on intraoperative phacoemulsification time and ultrasound power used.<sup>[6,8]</sup> The degree of permanent corneal endothelial damage is related to the degree of early post-operative corneal swelling; therefore, measuring the differences in pachymetry postoperatively seems to be useful in assessing the effects of phacoemulsification on corneal integrity.<sup>[9]</sup>

### Address for correspondence:

Dr. Saqib Ali Khan Utman, Moorfields Eye Hospital, 162 City Road, London, EC1V 2PD.  
E-mail: saqibutman@doctors.net.uk

© 2018 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

### Aims and Objectives

The aim of this audit was to compare the accuracy of the disposable applanation tonometer (Tonosafe) as a potential substitute to the standard reusable applanation tonometer head, to determine the influence of central corneal thickness (CCT) on the measurement of IOP with these devices, and to determine the difference of CCT in operated and non-operated eye 2 weeks postoperatively in patients undergoing temporal corneal incision phacoemulsification cataract extraction.

### METHODS

A prospective audit was performed over 4 weeks and patients were recruited from 2 weeks cataract post-operative clinic. 30 patients (10 men and 20 women) with temporal corneal incision cataract surgery in one eye only were included after informed consent.

IOPs of patients were measured using both the Goldmann applanation tonometer prisms and the single-use Tonosafe disposable tonometer prisms. The trained ophthalmologist checked IOP using both devices for each patient while waiting for at least 3–4 min between measurements to avoid erroneously lower pressure readings from repeated tonometry.<sup>[10]</sup> CCT measurements were recorded with the Alcon OcuScan by an experienced ophthalmologist, 5 min before IOP measurements. Ophthalmologist alternated the testing method used first on each patient for counterbalancing and recorded both measurements and the order in which the testing was performed on the pro forma. Measurements with patient squeezing the eyelids were excluded from the study. After use, the Tonosafe heads were disposed and the Goldmann tonometer heads were disinfected by soaking in 10% bleach for 5–10 min, followed by thorough rinsing with tap water for 60s, then rinsing with sterile water, and finally wiping it dry.

All patients were known to have normal IOP preoperatively and patients with corneal pathology, respiratory diseases such as chronic obstructive pulmonary disease and asthma, shallow AC, glaucoma of any sort, complicated cataract surgery or uncooperative, and anxious were excluded from the study.

### RESULTS

IOPs of 60 eyes of 30 patients were measured by both Tonosafe and Goldmann applanation, with an IOP range of 8–24mmHg.

The average age of patients was 71.4 years (range 54–93 years). We noticed that the mean IOP with the reusable tonometer in both eyes was  $13.40 \pm 3.11$  mmHg and with the Tonosafe disposable tonometer was  $13.11 \pm 3.18$  mmHg. The mean difference was  $0.29 \pm 0.08$  mmHg. The *t*-test analysis revealed the value of 0.51, which is not found to be significant.

Subgroup analysis on operated eyes showed mean IOP measurements of  $13.40 \pm 3.45$  mmHg with reusable tonometer and  $13.40 \pm 3.43$  mmHg with Tonosafe with a difference of  $0 \pm 0.02$  mmHg. The observed *t*-value is 0 and the means are not significantly different.

Subgroup analysis on unoperated eyes showed that the Tonosafe IOP measurements ( $12.83 \pm 2.95$  mmHg) were on average  $0.57 \pm 0.04$  mmHg lower than the reusable tonometer measurements ( $13.4 \pm 2.91$  mmHg). The observed *t* = 0.75.

The Tonosafe IOP measurements were recorded higher in patients with thicker ( $0.1 \pm 0.2$  mmHg) and thinner corneas ( $0.4 \pm 0.3$  mmHg) and lower in patients with normal corneal thickness as compared to reusable tonometer [Table 1]. However, we found no direct correlation of corneal thickness on IOP measurements with both tonometers.

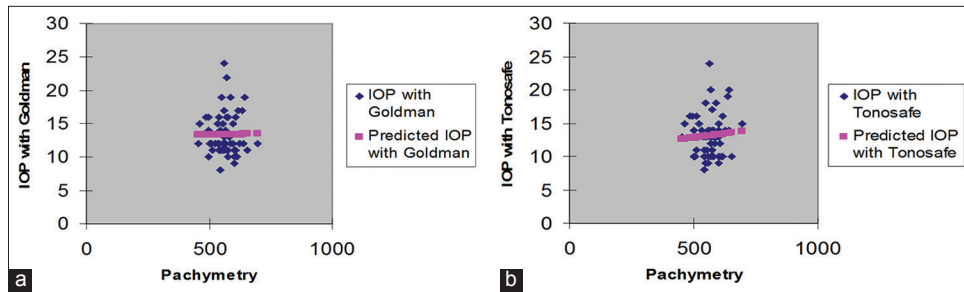
Linear regression analysis was used to determine whether the Tonosafe generates an IOP measurement equivalent to the Goldmann in with difference in CCT such that the devices would be essentially interchangeable. In our audit, IOP measurements with Goldmann were less affected by differences in CCT [Figure 1a], as compared to the Tonosafe [Figure 1b]. Our audit result showed that the corneal thickness varied between two eyes in the same individual [Figure 2]. Phacoemulsification through a temporal corneal incision causes an increase in corneal thickness along the horizontal meridian;<sup>[11]</sup> we noticed in operated eyes; 2 weeks after temporal corneal incision cataract surgery had higher average CCT of  $570.3 \pm 50.5 \mu$  as compared to unoperated eyes of the same patient with the average CCT of  $557.4 \pm 43.2 \mu$ . No adverse event was recorded during the audit.

### DISCUSSION

Despite disparity in IOP measurements, disposable tonometer is better and safer option out of two tonometers.<sup>[12,13,14]</sup>

**Table 1: Effect of Corneal Thickness on the measurement of two tonometers**

Corneal thickness	Average IOP with reusable tonometer	Average IOP with Tonosafe	Difference
610.5±29.0 μ	13.1±3.0 mmHg	13.2±3.2 mmHg	0.1±0.2 mmHg
554.3±13.2 μ	13.8±3.6 mmHg	12.9±3.6 mmHg	0.9±0 mmHg
494.1±20.3 μ	13.1±2.0 mmHg	13.5±2.3 mmHg	0.4±0.3 mmHg



**Figure 1:** (a and b) Linear regression analysis

Goldmann had pointed out that the theoretical model of applanation tonometry, which relied on the Imbert-Fick law,<sup>[15]</sup> concealed errors in clinical practice, 50 years ago. It is well known that the Goldmann applanation tonometry IOP value in thicker corneas is falsely higher, while in thinner corneas, it is falsely lower.<sup>[16-20]</sup> However, few studies showed in normotensive patients; CCT has no significant effect on IOP measurements<sup>[21]</sup> and we also agree with their findings as all our patients were normotensive and we did not find significant correlation between CCT and IOP measurements.

Therefore, we conclude from these findings that the difference between IOP measurement with Tonosafe and reusable tonometer is not significantly affected by CCT in a normotensive patient.

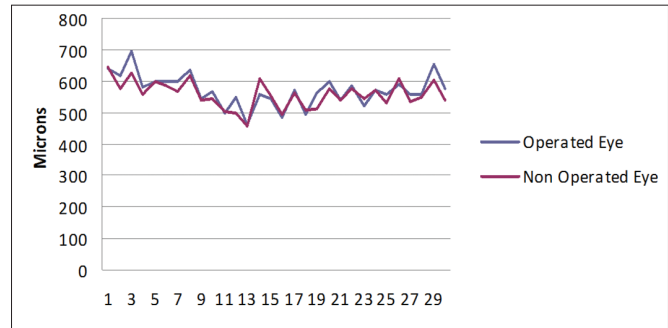
Our audit findings suggested that IOP measurements with Goldmann were higher as compared to Tonosafe, but not so significant to bring the accuracy of disposable tonometer to question which can be more safe to use due to less chances of cross-contamination and spread of potentially life-threatening ocular surface diseases.<sup>[14]</sup>

Although Kim *et al.* reported higher reading with Tonosafe ( $0.14 \pm 1.73$  mmHg)<sup>12</sup> and Goel *et al.* in their study found the mean difference of 0.78 mmHg<sup>13</sup> between two prisms used for tonometry, they agreed that disposable tonometer is the safer option out of two tonometers.

We should not assume that Tonosafe is a valid alternative to reusable tonometer for higher IOP measurements as it had not found to be accurate in patients with raised IOP as compared to reusable tonometer.<sup>[22]</sup>

However, adequate care should be taken while handling the Tonosafe to prevent contamination of the holder and head.<sup>[23]</sup>

Corneal endothelial cells loss during cataract surgery is the known factor for corneal edema and thickness of the cornea after cataract operation and is due to multiple risk factors such as dense cataract, advanced age, long phacoemulsification



**Figure 2:** Difference of central corneal thickness in operated and non-operated eye

time, high ultrasound energy, small pupil diameter, large infusion volume, type of intraocular lens, and short axial length.<sup>[24-28]</sup>

Previous studies recorded higher CCT measurements in the operated eye as compared to non-operated eye and suggested that post-operative CCT following cataract surgery returns to baseline during the 1<sup>st</sup> week.<sup>[11,23]</sup>

CCT in our patients was recorded at 2 weeks postoperatively and average CCT in the operated eye was higher ( $570.3 \pm 50.5 \mu$ ) as compared to non-operated eyes ( $557.4 \pm 43.2 \mu$ ) at 2 weeks.

None of the previous studies measured CCT at 2 weeks. We believe from our findings that minimal corneal edema persists for more than 1 weeks after cataract surgery and CCT takes longer than 1 week to return to pre-operative state.

## CONCLUSIONS

We conclude that disposable prism tonometry provides a reliable, effective, accurate,<sup>[5]</sup> and safe alternative to Goldmann reusable prism tonometry with the advantages of eliminating the need for chemical disinfection and also eliminating the risk of cross infection,<sup>[14,29]</sup> especially in post-operative patients and corneal edema persist for more than 1 weeks post-cataract surgery.

## REFERENCES

1. Liu J, Roberts CJ. Influence of corneal biomechanical properties on intraocular pressure measurement: Quantitative analysis. *J Cataract Refract Surg* 2005;31:146-55.
2. Sarkisian SR. An Update on Tonometry A Look at new Technology and at Many of the Commercially. Devices for Measuring IOP. Available from: <http://www.glaucomatoday.com>. [Last accessed on 2006 Nov 31; Last accessed on Dec 36].
3. Salvi SM, Sivakumar S, Sidiki SS. Use of disposable prism tonometry in routine clinical practice. *Eye (Lond)* 2005;19:743-6.
4. Thomas V, Daly MK, Cakiner-Egilmez T, Baker E. Reliability of tonosafe disposable tonometer prisms: Clinical implications from the veterans affairs Boston healthcare system quality assurance study. *Eye (Lond)* 2011;25:651-6.
5. Zetterström C, Laurell CG. Comparison of endothelial cell loss and phacoemulsification energy during endocapsular phacoemulsification surgery. *J Cataract Refract Surg* 1995;21:55-8.
6. Walkow T, Anders N, Klebe S. Endothelial cell loss after phacoemulsification: Relation to preoperative and intraoperative parameters. *J Cataract Refract Surg* 2000;26:727-32.
7. Dick B, Kohnen T, Jacobi KW. Endothelzellverlust nach phakoemulsifikation und 3, 5 vs. 5 mm hornhauttunnelinzision. *Ophthalmologie* 1995;92:476-83.
8. O'Brien PD, Fitzpatrick P, Kilmartin DJ, Beatty S. Risk factors for endothelial cell loss after phacoemulsification surgery by a junior resident. *J Cataract Refract Surg* 2004;30:839-43.
9. Lundberg B, Jonsson M, Behndig A. Postoperative corneal swelling correlates strongly to corneal endothelial cell loss after phacoemulsification cataract surgery. *Am J Ophthalmol* 2005;139:1035-41.
10. Whitacre MM, Stein R. Sources of error with use of Goldmann-type tonometers. *Surv Ophthalmol* 1993;38:1-30.
11. Bolz M, Sacu S, Drexler W, Findl O. Local corneal thickness changes after small-incision cataract surgery. *J Cataract Refract Surg* 2006;32:1667-71.
12. Kim P, Lertsumitkul S, Clark M, Gardner L, Macken P. Accuracy of the tonosafe disposable tonometer head compared to the Goldmann tonometer alone. *Clin Exp Ophthalmol* 2004;32:364-7.
13. Goel S, Chua C, Dong B, Butcher M, Ahfat F, Hindi SK, *et al.* Comparison between standard Goldmann applanation prism and disposable applanation prism in tonometry. *Eye (Lond)* 2004;18:175-8.
14. Davanipour Z, Alter M, Sobel E, Asher D, Gajdusek DC. Creutzfeldt-jakob disease: Possible medical risk factors. *Neurology* 1985;35:1483-6.
15. Iyamu E, Osuobeni E. Age, gender, corneal diameter, corneal curvature and central corneal thickness in Nigerians with normal intra ocular pressure. *J Optom* 2012;2:87-97.
16. Goldmann H, Schmidt T. Applanation tonometry. *Ophthalmologica* 1957;134:221-42.
17. Ehlers N, Bramsen T, Sperling S. Applanation tonometry and central corneal thickness. *Acta Ophthalmol (Copenh)* 1975;53:34-43.
18. Whitacre MM, Stein RA, Hassanein K. The effect of corneal thickness on applanation tonometry. *Am J Ophthalmol* 1993;115:592-6.
19. Bron AM, Creuzot-Garcher C, Goudeau-Boutillon S, d'Athis P. Falsely elevated intraocular pressure due to increased central corneal thickness. *Graefes Arch Clin Exp Ophthalmol* 1999;237:220-4.
20. Doughty MJ, Zaman ML. Human corneal thickness and its impact on intraocular pressure measures: A review and meta-analysis approach. *Surv Ophthalmol* 2000;44:367-408.
21. Brandt JD, Beiser JA, Kass MA, Gordon MO. Central corneal thickness in the ocular hypertension treatment study (OHTS). *Ophthalmology* 2001;108:1779-88.
22. Maino AP, Morgan LH, Hercules BL, Tullo AB. Are disposable prisms an adequate alternative to standard Goldmann tonometry prisms in glaucoma patients? *Ophthalmology* 2006;113:1837-41.
23. Salvi SM, Soong TK, Kumar BV, Hawksworth NR. Central corneal thickness changes after phacoemulsification cataract surgery. *J Cataract Refract Surg* 2007;33:1426-8.
24. Mencucci R, Ponchiotti C, Virgili G, Giansanti F, Menchini U. Corneal endothelial damage after cataract surgery: Microincision versus standard technique. *J Cataract Refract Surg* 2006;32:1351-4.
25. Hayashi K, Hayashi H, Nakao F, Hayashi F. Risk factors for corneal endothelial injury during phacoemulsification. *J Cataract Refract Surg* 1996;22:1079-84.
26. Pereira AC, Porfirio F Jr, Freitas LL, Belfort R Jr. Ultrasound energy and endothelial cell loss with stop-and-chop and nuclear preslice phacoemulsification. *J Cataract Refract Surg* 2006;32:1661-6.
27. Dosso AA, Cottet L, Burgener ND, Di Nardo S. Outcomes of coaxial microincision cataract surgery versus conventional coaxial cataract surgery. *J Cataract Refract Surg* 2008;34:284-8.
28. Storr-Paulsen A, Norregaard JC, Ahmed S, Storr-Paulsen T, Pedersen TH. Endothelial cell damage after cataract surgery: Divide-and-conquer versus phaco-chop technique. *J Cataract Refract Surg* 2008;34:996-1000.
29. Cillino S, Casuccio A, Giammanco GM, Mammina C, Morreale D, Di Pace F, *et al.* Tonometers and infectious risk: Myth or reality? Efficacy of different disinfection regimens on tonometer tips. *Eye (Lond)* 2007;21:541-6.

**How to cite this article:** Utman SAK, Wren SME, Bloom P, Baig HM. Intraocular Pressure Measurements Difference between Reusable and Disposable Tonometer in Relation to the Central Corneal Thickness and Effect of Cataract Operation on Corneal Thickness. *Clin Res Ophthalmol* 2018;1(2):1-4.