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The PASCAL Dynamic Contour Tonometer – a «Must Have» for all Ophthalmologists

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For the last half a century, since its introduction by Goldmann in 1950's, the Goldmann Applanation Tonometer (GAT) has been regarded by clinicians as the "gold standard" in routine measurement of intraocular pressure (IOP)[1]. However, the GAT has its limitations[2]. Goldmann and Schmidt (1957)2, in their original paper, had mentioned some possible sources of error in the GAT which included variations in central corneal thickness (CCT). Subsequently, the accuracy of GAT has been found to depend on many factors including CCT, corneal curvature, corneal structure, and axial length[3]. Various studies have reported thicker corneas in patients with higher IOPs compared with thinner corneas in patients with lower IOPs[4-7]. Recently, the Ocular Hypertension Study results relating to the effect of CCT on outcome has lead to a quest for more accurate measurement of IOP[8,9]. It has been recommended by many that GAT readings should be complemented with CCT readings[10,11]. Several nomograms for adjusting GAT readings in normal eyes for varying CCT have been suggested[3,12,13], but so far none seems to be satisfactory as the relationship is non-linear and variable[14-15].

The PASCAL® Dynamic Contour Tonometer (DCT), named after Blaise Pascal, a seventeenth century mathematician and physicist, has been developed by SMT Swiss Microtechnology AG, part of the Ziemer Group. It is a new digital tonometer that provides a direct trans-corneal measurement of IOP and also detects the Ocular Pulse Amplitude. The DCT measures IOP using the principle of contour matching instead of applanation. This has been claimed to eliminate the physiological errors by the GAT, for example, the influence of CCT and ocular rigidity. The built-in "SensorTip" utilises a solid-state "Pressure Sensor," which matches corneal curvature. The contour surface has been calculated to generate minimum distortion of the cornea and to direct all forces acting within the cornea to the pressure sensor surface[16].

The PASCAL DCT is mounted on a slit lamp and operated in a similar fashion as the GAT. It gathers one hundred IOP values per second and records the dynamics of IOP rather than a pseudo-static figure and hence furnishes information on the entire range of short-term pressure fluctuations to which the eye is subjected. The digital panel, on the DCT displays the average IOP and the mean Ocular Pulse Amplitude.

Several studies have been performed to examine the influence of CCT on IOP using GAT and DCT[17-20]. Boehm et al (2006)[21] examined the influence of CCT, corneal curvature and axial length on IOP measured by the DCT. The IOP was measured in 49 eyes undergoing cataract operation using an intracameral manometer, set at 15, 20 and 35 mmHg by a manometric water column. The DCT and manometric IOP compared well at all manometric levels, the difference was 0.7 mmHg,

-0.2 and -0.8 mmHg at 15, 20 and 35mmHg respectively. There was no correlation between CCT and corneal curvature at any level of IOP. They found a good concordance with GAT in this small group.

Various studies have been performed to compare IOP using GAT, non-contact tonometry (NCT) and DCT before and after corneal refractive surgery. Pre-operatively, there was a correlation between CCT & GAT, and also CCT & NCT but not with CCT & DCT[22-24]. A drop in IOP readings after LASIK by both GAT and NCT was noted but the IOP was not significantly different from pre-op by DCT[22-24]. This is in keeping with the manufacturers claims about the mode of action of the DCT.

As part of a series of ongoing studies, we examined keratoconic eyes and ocular hypertension (OHT) eyes (because of the known extremes of CCT in the two conditions). The IOP by GAT and DCT was measured and it was found that the mean IOP obtained by GAT in keratoconic eyes was 13.2 ± 2.9 mmHg and by DCT it was 15.1 ± 3.3 mmHg. The IOP in OHT eyes was 23.1 ± 3.7 mmHg and 20.7 ± 3.8 mmHg by GAT and DCT respectively. The result showed that the GAT measured a higher value of IOP in OHT eyes than DCT, whereas it measured lower values in keratoconus eyes in relation to DCT. The higher IOP values by GAT in OHT patients may be due to the thicker cornea and lower readings may be due to the thinner cornea in keratoconus patients, whilst DCT, as reported by various studies, is not influenced by CCT and was showing truer IOP values i.e. lower in OHT and higher in keratoconus eyes.

CCT, corneal curvature and other factors seem to have no significant effect on the IOP values obtained by DCT. DCT measurements closely compare to manometric values in both in-vitro and in-vivo eyes and reveal no significant change in IOP pre and post LASIK. It is likely that the Pascal DCT seems to reflect truer IOP measurements than the other available tonometers in these studies. The DCT is set to become one of the 'must have' instrument for all ophthalmologists.

References

1. Shah S. Accurate intraocular pressure measurement - the myth of modern ophthalmology? Ophthalmology 2000; 107: 1805-18.7
2. Goldmann H, Schmidt Th: Über Applanationstonometrie. Ophthalmologica 1957; 134: 21-242.
3. Whitacre MM, Stein R. Sources of error with use of Goldmann-type tonometers. Surv Ophthalmol. 1993; 38: 1-30.
4. Hansen F, Ehlers N. Elevated tonometer readings caused by a thick cornea. Acta Ophthalmol. 1971; 9: 775-778.
5. Johnson M, Kass MA, Moses RA, et al. Increased corneal thickness simulating elevated intraocular pressure. Arch Ophthalmol 1978;96:664-665
6. Argus WA. Ocular hypertension and central corneal thickness. Ophthalmology 1995;102:1810-1812
7. Herndon LW, Choudhri SA, Cox T, et al. Central corneal thickness in normal, glaucomatous, and ocular hypertensive eyes. Arch Ophthalmol 1997; 115: 1137-1141
8. Brandt JD, Beiser JA, Kass MA, Gordon MO. Central corneal thickness in the Ocular Hypertension Treatment Study (OHTS). Ophthalmology. 2001; 108: 1779–1788.
9. Kass MA, Heuer DK, Higginbotham EJ, Johnson CA, Keltner JL, Miller JP, Parrish RK 2nd, Wilson MR, Gordon MO. The Ocular Hypertension Treatment Study. Arch Ophthalmol. 2002; 120: 701-713.
10. Whitacre MM, Stein RA, Hassanein K: The effect of corneal thickness on applanation tonometry. Am J Ophthalmol. 1993; 11: 592-596
11. Ventura AC, Bohnke M, Mojon DS. Central corneal thickness measurements in patients with normal tension glaucoma, primary open angle glaucoma, pseudoexfoliation glaucoma, or ocular hypertension. Br J Ophthalmol. 2001; 85: 792–795.
12. Ehlers N, Bramsen T, Sperling S. Applanation tonometry and central corneal thickness. Acta Ophthalmol (Copenh). 1975; 53: 34–43
13. Stodtmeister R. Applanation tonometry and correction according to corneal thickness. Acta Ophthalmol Scand. 1998; 76: 319–324.
14. Lewis RA. Refractive surgery and the glaucoma patient: customized corneas under pressure. Ophthalmology. 2000; 107: 1621–1622.
15. Kniestedt C, Lin S, Choe J, Bostrom A, Nee M, Stamper R L. Clinical comparison of contour and applanation tonometry and their relationship to pachymetry. 2005. Arch Ophthalmol; 123: 1532-1537
16. Kirstein E M, Husler A. Evalution of the Orssengo-Pye IOP corrective algorithm in LASIK patients with thick cornea. Optometry. 2005; 76: 536-543
17. Kaufmann C, Bachmann LM, Thiel MA: Intraocular Pressure Measurements Using Dynamic Contour Tonometry after Laser In Situ Keratomileusis. Invest. Ophthalmol. Vis. Sci., 2003; 44: 3790-3794.
18. Kaufmann C, Bachmann L M, Thiel M A. Comparison of Dynamic Contour Tonometry with Goldmann Applanation Tonometry Invest Ophthalmol Vis Sci. 2004; 45: 3118–3121
19. Kotecha A, White E T, Shewry J M, Garway-Heath D F. The relative effects of corneal thickness and age on Goldmann applanation tonometry and Dynamic Contour Tonometry. B J Ophthalmol. 2005; 89: 1572-1575
20. Pache M, Wilmsneyer S, Lautebach S, Funk J. Dynamic Contour Tonometry versus Goldmann applanation tonometry: a comparative study. Graefes Arch Clin Exp Ophthalmol. 2005; 243: 763-767
21. Boehm A G, Weber A, Sporei E. In-vivo direct manometric IOP measurement: the ultimate reference for tomometry. 2006 ASCRS seminar.
22. Duba I, Wirthlin A C. Dynamic Contour Tonometry for post-LASIK intraocular pressure measurements. Klin Monatsbl Augenheilkd. 2004; 221: 347-350
23. Burvenich H, Burvenich E, Vincent C. Dynamic Contour Tonometry versus non contact tomomery (NCT) a comparison study. Bull Sco Belge Ophthalmol. 2005; 298: 63-69
24. Siganos D S, Papastergiou G I, Moedas C. Assessment of Pascal Dynamic Contour Tonometer in monitoring intraocular pressure in in-operated eyes and eyes after LASIK. J Cataract Refract Surg. 2004; 30: 746-751