

Comparison of the iCare with the Perkins tonometer

Tina Romanay compares the performance of two hand-held tonometers

Intraocular pressure (IOP) is determined by the relative production, and drainage of aqueous from the anterior chamber into the trabecular meshwork.¹ Measuring IOP is widely considered an integral part of an eye examination, given its role in the detection and diagnosis of glaucoma.² IOP is measured using a 'tonometer'. Many recent articles have discussed the various types of tonometers currently available in the UK, and their dependability in screening for elevated IOPs. The need for accuracy³ has led to further debate regarding the advantages and disadvantages of these applanation tonometers.⁴

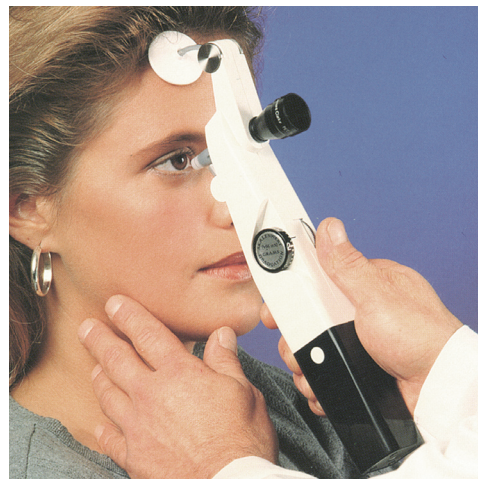
In general optometric practice, measuring IOP using air-pulse tonometers has proven to be a valid and reliable technique,^{5,6} although some studies have shown accuracy to decline above specified readings.^{7,8} It is in these instances that practitioners then revert to the traditional gold standard Goldmann applanation tonometer (GAT) or its portable counterpart the Perkins tonometer.^{9,10}

While GAT is considered accurate as a result of its mechanical design and reduced variability in repeated IOP measurements compared to air-pulse instrumentation,¹¹ it is still associated with its own limitations. Practically, it requires the use of topical anaesthesia which is known to sting and cause patient discomfort. Furthermore, studies have shown lower IOP readings to be attained when using topical anaesthetics.¹²

The combined use of fluorescein also has its disadvantages as the amount instilled to observe the image of the applanated area can affect the accuracy and interpretation of IOP readings.¹³ In addition, using fluorescein on an abraded cornea increases the risk of microbial contamination¹⁴ and continuous use of anaesthesia may lower fluorescein concentration, which may also result in underestimations of IOP readings.¹⁵ Moreover, contact



iCare rebound tonometer



Perkins applanation tonometer

applanation tonometry is an invasive technique where risk of corneal abrasion is increased.

It is with these points in mind that the iCare tonometer has been developed for routine practice. The iCare is a rebound or dynamic tonometer that does not require the use of an anaesthetic or fluorescein to measure IOP. As a portable, lightweight device its use has been recommended in domiciliary work and on patients who have undergone refractive surgery.¹⁶

iCare rebound tonometer

The principle of rebound or dynamic tonometry was considered more than 30 years ago, but limitations of microelectronics meant its principle was only improved by Antti Kontiola in the early 1990s.¹⁷ The basic principle requires a moving target to collide with the ocular surface, impacting with it and rebounding from the eye. This movement is then processed and analysed by the instrument, converting the information into a final IOP reading.

Principle of the iCare

The iCare is a portable, self-calibrating and ultra-light tonometer, housing a round tipped probe of 0.9mm radius,

held in position by an electromagnetic field. The round tip minimises the risk of injury from probe impact and the disposability of the probe means the risk of microbiological contamination is eliminated. The probe collides with the central cornea while the instrument is aligned 4-8mm from the patient's eye. The movement of the probe induces a small induction current, allowing the impact duration to be measured. The probe rebounds faster as the IOP increases and so the higher the IOP, the shorter the duration of the impact. Measurements are taken within 0.1 seconds. The force applied is so minimal that it does not even elicit the blink reflex. This eliminates any need for anaesthetising the cornea.

Six consecutive readings are taken to minimise deviation and to produce an averaged measurement value. An auditory signal alerts the examiner of successful and anomalous readings. The average IOP value is then displayed on an LCD screen along with any variability in measurements that may have occurred.¹⁸

Perkins applanation tonometer

The Perkins tonometer was developed in 1965 as a portable hand-held version of the GAT.

Its internal illumination system

makes it ideal for domiciliary visits and for patients with mobility difficulties who are unable to sit forward on a slit lamp. Like the GAT procedure, it requires the topical instillation of fluorescein and anaesthetic.

Principle of Perkins

The cone surface is applied to the cornea, applanating a diameter of between 3-4mm, so the surface tension of the tears pulling the cone towards the eye is approximately equal to the resistance provided by the combination of the tears and corneal rigidity (0.5mmHg). Also, by using an exact diameter of 3.06mm, (area 7.354mm²), 1g force against the eye corresponds to 10mmHg IOP, making conversion quick and easy.

The flat face of the cone is 7mm in diameter and contains a bi-prism which shifts the top half of the field to the left and the bottom half to the right (or vice versa) so that the centres are separate by exactly 3.06mm when the correct area is applanated. The force applied is assessed visually by varying the distance between the two semi-circular fluorescein rings which form around the edge of the applanated area. By increasing the force of the cone on the eye, a greater diameter of cornea is flattened, thereby reducing the ring separation to an eventual overlap. When sufficient force has been applied to applanate the correct diameter, the fluorescein semicircles will each have a diameter of 3.06mm and hence their inner edges will be seen to touch.¹⁹

Measurements can be made with the patient supine, reclined or sitting upright, as the pivoted forehead rest allows accurate alignment with the central cornea. The instrument is capable of measuring a range of IOP between 0-50mmHg and the technique is known to induce minimal displacement of aqueous on measurement. The newer Perkins Mark II model has an additional blue light to improve visibility of the rings and the option of an extension telescope allowing the practitioner to view the semicircles from a greater distance.

Regular calibration of the instrument is advised using a 2g and 5g weight in turn, as provided in the carrier case.

Reason for study

A small study was undertaken to compare the accuracy of IOP readings obtained using the iCare rebound tonometer against the Perkins and to

assess the influence of other factors in readings obtained with both instruments.

Subjects and methods

The study group comprised of 20 optometry students (50 per cent male and 50 per cent female), aged between 20-25 years old with a mean \pm SD, 21.3 ± 1.38 . With each subject, both right and left eyes were measured and all measurements were considered for statistical analysis. Subjects were chosen at random from a normal sample with no known ocular diseases. Experienced optometrists evaluated the IOP readings obtained with both instruments. The data collected for each instrument included the date and time of test, instrumentation, name of anaesthetic and staining agent used, actual IOP reading as well as subject details of age and gender.

Measurements with the iCare instrument were taken first, to ensure the topical anaesthetic had no effect on

the six IOP measurements obtained for each eye. A new probe was used for each patient to prevent any cross-contamination of microbes. The subject was asked to fixate on a target in the distance, while the probe was held approximately 4-8mm from the subject's eye. The measurement button was then depressed six times to obtain all the necessary readings.

The instrument informed optometrists if an erroneous reading was taken by sounding a short sharp beep. Once six good readings were taken, the IOP reading along with the standard deviation of the results was displayed on the LCD screen of the main instrument body.

In the Perkins procedure, oxybuprocaine was employed as an anaesthetic agent along with fluorescein in the form of a saline wetted impregnated strip.

Only one reading was taken for each eye as the longer duration of corneal contact accounts for fluctuations in

TABLE 1
Mean readings obtained between males and females

Instrument/gender	Minimum IOP	Maximum IOP	Mean	SD
iCare				
Female	10	23	17	3.09
Male	10	22	15	4.06
Perkins				
Female	10	22	17	3.11
Male	10	21	15	3.47

TABLE 2
Mean age

Gender	Minimum age	Maximum age	Mean age
Female	20	23	20.8
Male	20	25	21.8

TABLE 3
Minimum, maximum and mean IOP, and SD readings obtained with the two tonometers

	Minimum	Maximum	Mean	SD
iCare	10	23	16	3.72
Perkins	10	22	16	3.45

TABLE 4
Mean difference, significance level and 95% CI limits between the two tonometers

				Limits of agreement	
	Mean	S.D	P	Mean - 1.96 X SD	Mean + 1.96 X SD
iCare - Perkins	0.1	1.35	<0.001	-2.5	2.6
iCare	10	22	16	3.45	

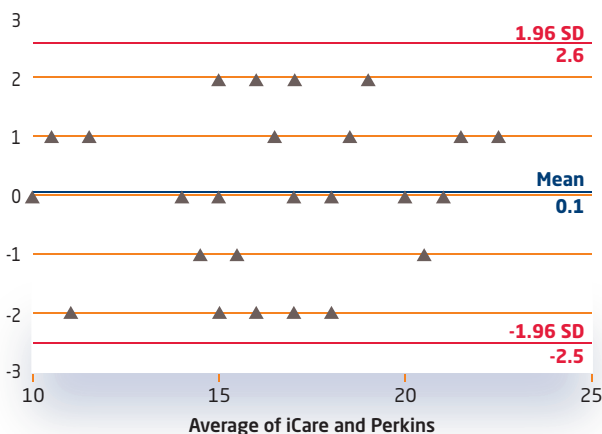


Figure 1 Bland-Altman plot of difference vs mean of IOP with iCare and Perkins

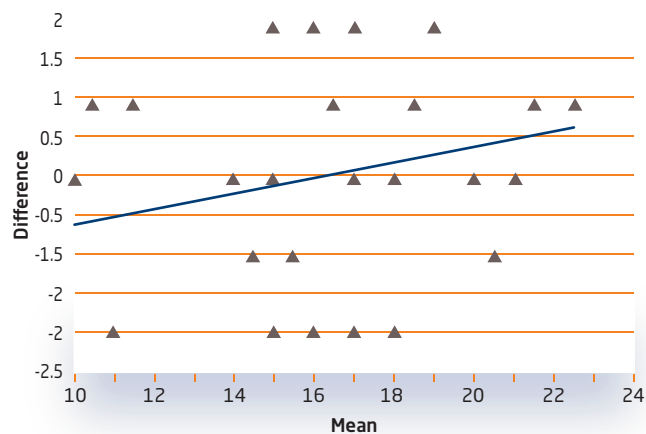


Figure 2 Regression line showing the correlation coefficient between the iCare and Perkins tonometer

IOP with the cardiac pulse. Subjects were informed of the use and need for anaesthetic and advised of the post care procedures. The cone, consisting of a bi-prism was inserted into the holder in a horizontal orientation. On use of fluorescein, care was taken to prevent excessive instillation, which could otherwise adversely affect the interpretation of the results. Once appplanation was attained, the force applied was adjusted from its initial setting of 1g so that the inner edges of the semi-circular rings created by the bi-prism were just touching and a reading obtained.

Results

Since the readings obtained from the right and left eyes were found to be similar, both results were used for statistical analysis. Readings between the two eyes were not differentiated. Moreover, no statistical differences were observed in relation to gender or age.

Table 1 displays the minimum, maximum, mean and standard deviation of IOP measurements obtained with the two tonometers comparing gender variations.

Table 2 displays the minimum, maximum and mean age of subjects measured.

Table 3 displays the minimum, maximum, mean and standard deviation of IOP measurements obtained with the two tonometers irrespective of gender.

Table 4 presents the mean difference, level of statistical significance, and the limits of agreement between the two tonometers at the 95 per cent confidence interval.

Graphical analyses of the agreement between the two instruments were also

plotted. Figure 1 plots the difference between the two instruments as a function of the mean, in order to present the agreement between the measurements. Figure 2 plots the regression line to determine the correlation co-efficient between the two instruments

Discussion

The mean IOP value as shown in Table 3 with both the iCare and Perkins tonometer, agreed with IOP values commonly found in the normal population of between 15 and 16mmHg.²⁰ J M Gonzalez-Mejome *et al*¹⁶ carried out a study to investigate IOP differences with increasing age and found that the rebound tonometer showed lower IOP readings with increasing age.

In this study no statistical differences were observed in relation to age; however, this may be attributed to the limited age range sampled for the study.

Figure 1 shows the mean difference between the iCare and Perkins tonometer to be 0.1mmHg with the 95 per cent limits of agreement ± 2.5 mmHg. Studies using the gold standard GAT show limits of agreement ranging from ± 2 mmHg, therefore in this study the iCare showed good correlation.

A study has shown iCare to overestimate IOP values by 1.34mmHg. In this study, Figure 2 shows a small trend, such that at high IOPs, the iCare measures greater readings comparative to Perkins. The regression line, however, has a small co-efficient of variation (0.07) which is not significant.

This suggests that in this small sample there is good agreement between devices, although high IOP

measurements with iCare need to be viewed with caution.

The iCare is advantageous over Perkins tonometry due to its ease of use on the non-anaesthetised eye and relatively simple procedure. Measurements are objective and free of operator bias present in Perkins in the visual interpretation of force applied.

In addition, Badouin and Gastaud¹² showed that the instillation of topical anaesthetic in the latter can lower the measured IOP readings. In this study the iCare tonometer was always used first to prevent any adverse effects on the results. The use of anaesthetic does not come without further complications, such as allergic reactions, reduced corneal permeability, retarded healing of the epithelial surface and the stinging effect on instillation. Hence, eliminating the use of anaesthetic reduces the risk of adverse reactions.

When conducting Perkins tonometry, care must be taken to ensure that when instilling fluorescein, broad rings are not created by the bi-prism, which can lead to an over-estimation of IOP readings up to 4.6mmHg. Furthermore, studies have shown *Pseudomonas* has an affinity for fluorescein, and use on a damaged cornea can increase the risk of microbial infection. Since fluorescein is not required when using the iCare rebound tonometer, the practitioner eliminates the need for the diagnostic agent, and the risk of over- or under-estimating IOP measurements due to examiner variability.

The Perkins hand-held tonometer was chosen for this comparison as it is considered to be the portable version of the gold standard Goldmann

tonometer.²² Both the instruments required disposable tips to be used, thereby eliminating the risk of cross-contamination of microbial infections.²³

The optometrists using the iCare were asked to comment on the ease of use of the instrument. The instrument was easy to hold and manoeuvre and readings were attained quickly and non-invasively with little stress on the patient. The loading of the disposable probe was simple. Compared to the Perkins disposable cone, there was no risk of touching the iCare probe as it was held within a disposable package which was simply placed against the collar and the probe dropped into the base.

On instillation, the device was raised and a button depressed to activate the magnetic mechanism. An adjustable forehead ensured that the probe was placed as close as possible to the cornea (4-8mm).

However, users did on occasion find it difficult to position accurately on patients with deep-set eyes. Similarly, patients tolerated the iCare well and felt safe with the technique in a study carried out by M E Lliev *et al.*²⁴

The iCare software considers the relationship between all the measurements taken by estimating the standard deviation to ensure a coherent final result. Following the final IOP reading, a letter P appears in the display. If the IOP reading is followed by a static P, the reading is of the highest reliability. If the P is blinking then the SD of the measurement is considered to be greater than normal.

Alternatively, if the P is followed by a horizontal line, below or above the letter the IOP reading is slightly greater, clearly greater or too great comparative to normal measurements. This informs the practitioner of results sets with a wider spread from the mean than expected in the normal sample population.

The practitioners found this tool useful for identifying erroneous readings which could therefore be eliminated from the final results pool. This did, however, mean that more than six readings were required in many cases to obtain the 'best' results. This could invariably affect the final IOP measurement relating to fluid displacement, although the manufacturer suggests that this is minimal due to the small size of the contact probe. Further studies could be carried out to investigate this phenomenon.

Conclusion

In this small sample study there is good agreement between the two devices, although high IOP measurements with iCare need to be viewed with caution.

A larger study is required to investigate this further. Although there has been a rapid development and improvement of non-contact tonometers, they are not always suitable for bedridden patients, for younger children, or even patients who find the air puff uncomfortable.

Some studies have also shown a tendency for NCT to over-estimate low pressures and under-estimate high pressures compared with the gold standard. Clinical comparative studies with GAT have shown that iCare generates higher readings. In general, measurements are considered accurate within the normal range, but alternative investigative techniques are recommended in ocular hypertensive patients.

As yet few studies have been undertaken on the effects of anaesthesia and diagnostic dyes on the measurement of IOP; this is another potential area of research in the continuing search for the best screening tool for ocular hypertension.

The iCare is a low cost, easy to use tonometer. It will appeal to those optometrists looking for a lightweight and portable alternative, eliminating the need for anaesthesia and staining agents. ●

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● Tina Romanay is director of City University Fight for Sight Optometry Clinic