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RESEARCH ARTICLE

THE ACCURACY OF INTRAOCULAR PRESSURE MEASUREMENT BY ACCUPEN

[1,*]Dr. Furkaan M. Hamied, [2]Dr. Ali Naji Al sharifi and [3]Dr. Ali M. AlDeen

[1]Assistant Professor of Ophthalmology, Department of Surgery, College of Medicine, Al-Qadisiya University, Iraq
[2]C.A.B. Ophth Ibin –Al Haitham Teaching Hospital
[3]M.B.Ch.B. College of Medicine, Al-Qadisiya University, Iraq

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ABSTRACT

Background: Intraocular pressure measurement (tonometry) has prime importance because it is the most significant risk factor for the development and progression of glaucoma, and due to the presence of numerous types of tonometers, it is important to compare between different tonometers readings [in this study Goldmann and Tono-pen (AccuPen)]

Objectives: This study aims to evaluate the sensitivity, specificity and accuracy of theAccuPen tonometer in our clinical practice by comparing the measurement of intraocular pressure using this method with that using the Goldmann applanation tonometer (gold standard).

Subjects and methods: A comparative study was done during the period from December 2014 to April 2015, during which the intraocular pressure for the (110) eyes of (55) Iraqi citizens (all of them attendants of the outpatient department of Ibn-Al Haitham-teaching hospital) was measured using both the Goldmann applanation tonometer and the AccuPen handheld electronic applanation tonometer.

Results: The average difference between the readings of AccuPen and Goldmann tonometer's (AccuPen minus Goldmann's readings) was 3.0 mmHg. Regarding the validity of the AccuPen test, this study found the sensitivity to be 100% and the accuracy to be 88% in comparison with the gold standard Goldmann tonometer.

Conclusions: AccuPen is a good screening method for the detection of increased IOP with high sensitivity and accuracy in comparison with gold standard method (Goldmann tonometer).

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INTRODUCTION

The term "intraocular pressure" (IOP) describes the tension exerted by the aqueous humor in the intraocular tissues as a result of the balance between its production and drainage (Garlos Gostavo *et al*., 2008). There is currently no safe method of measuring the IOP intraocularly, as a true measurement of IOP needs a direct fluid connection to the anterior chamber by cannulation. While this is done frequently in laboratories, it entails too many hazards for routine clinical measurement of IOP. Consequently, in clinical practice it is more correct to say that IOP is "estimated" rather than "measured". However, because of its widely accepted use in the literature and in practice, we will use the term "measurement" in this review.

Corresponding author: Dr. Furkaan M. Hamied,
Assistant Professor of Ophthalmology, Department of Surgery, College of Medicine, Al-Qadisiya University, Iraq.

The IOP measurement has prime importance because it is the most significant risk factor for the development and progression of glaucoma, (Leske *et al*., 2003) (Garlos Gostavo *et al*., 2008) the most important cause of irreversible blindness worldwide (Quigley and Broman, 2006). Precise IOP measurement is subject to some variables, such as circadian variation (Liu, 2001) and changes in corneal structure (like CCT) which may influence IOP measurements by different methods and could affect the management of these patients once they are referred to a glaucoma practice (Medeiros and Weinreb, 2006). (Garlos Gostavo *et al*., 2008) Goldmann applanation tonometry, developed in the 1950s, is based on the Imbert-Fick law, which states that "the pressure in a sphere filled with fluid and surrounded by an infinitely thin, dry and flexible membrane is measured by the counter-pressure, which just flattens the membrane to a plane (Goldmann and Schmidt, 1957; William Tasman *et al*., 2008). Theoretically, average corneal rigidity and the capillary attraction of the tear meniscus cancel each other out when the flattened area has the 3.06 diameter contact surface of the Goldmann prism (Jack *et al*.,

2011; Myron Yanoff *et al*., 2014). The cornea is anesthetized and fluorescein is applied to the inferior conjunctival fornix to improve visualization of the two semicircles. The tonometer's head is applied to the surface of the cornea and a variable force is applied using a sensitive spring system regulated by a dial. The dial is turned in either direction until the inner edges of the two semicircles, which are visualized using a cobalt blue light, meet; at that point, the examiner knows that a central corneal area of 7.35 mm^2 has been applanated. The examiner then reads the value on the dial (expressed in mmHg) to determine the IOP (Myron Yanoff *et al*., 2014). The AccuPen tonometeris a lightweight contact electronic applanation tonometer, which is portable and easy to calibrate and operate, as well as being self–contained and battery powered. Its digital reading of IOP reduces user bias, and due to its small contact area (2.36 mm^2 compared to 7.35 mm^2 in Goldmann applanation tonometry), it is recommended for IOP measurements in irregular, distorted or edematous corneas through a bandage contact lens. It is also useful when there is poor patient cooperation, allowing measurements in both supine and sitting positions (George *et al*., 2014; Leske *et al*., 2003; Quigley, 2006; Liu, 2001; Medeiros and Weinreb, 2006; Goldmann and Schmidt, 1957; William Tasman *et al*., 2008; Jack, 2011).

Sources of error

In the Goldmann tonometer

- Inappropriate fluorescein pattern.
- Pressure on the globe from the examiner's fingers, the patient squeezing the eyelids or from restricted extraocular muscles (e.g. thyroid myopathy) may result in an artificially high reading.
- Central corneal thickness (CCT). Calculations of IOP by Goldmann applanation tonometry assume that central corneal thickness is 520 ❍□m, with minimal normal variation. If the cornea is thinner, underestimation of IOP may result, and if thicker an overestimation.
- Corneal edema may result in artificial lowering of IOP.
- Astigmatism, if significant, may give distorted mires.
- Repeated readings over a short period will often be associated with a slight fall in IOP due to the massaging effect on the eye.
- Other factors that may be associated with overestimation of IOP include a tight collar and breath holding, both of which obstruct venous return (Jack *et al*., 2011).

In the AccuPen tonometer

- Mechanical or electronic damage.
- Improper technique e.g. tip cover too tight or tip cover too loose, ortip of AccuPen not perpendicular to the cornea
- Out of calibration ormeasurable range, or out of tolerance (Accutome - Ophthalmic Instruments Company, 2012).

The Pentacam takes up to 2 seconds and/while/then the rotating Scheimpflug camera photographs cross sections of the anterior segment, which are illuminated by slit lights at different meridians. Since all these slits overlap in the center of the cornea, the accuracy of central measurements is increased (Hassan *et al*., 2010).

Aim of study

This study aimed to assess the diagnostic performance of the Tono-pen and its accuracy in IOP in comparison with the gold standard method (Goldmann tonometer).

Subjects and Methods

A comparative study was done during a period from December 2014 to April 2015, during which the IOP for (110) eyes of (55) Iraqi citizen was measured. The age group included in this study lies between 19-46 years, all attendants to the out-patient department of Ibn-Al Haitham teaching hospital. Exclusion criteria include; ageless than 20 and more than 60, individuals with serious eye diseases (e.g. external eye disease, cataract, glaucoma), previous ocular trauma or surgery, and known cases with systemic medical disorders like diabetes mellitus, asthma, and hypertension. IOP measurements were undertaken using the Goldman applanation tonometer and the AccuPen handheld electronic applanation tonometer. Two measurements were taken, one by using the Goldmann tonometer and the other by using the AccuPen tonometer.

The IOP measurement was conducted after anesthetizing the eyes with topical anesthetic drops and, when Goldmann was used, staining the eyes with fluoresce in before the IOP measurement. All measurements were done between 9:00 AM and 1:00 PM. We considered the central corneal thickness (CCT) in this review by doing pachy me try with the pentacam machine. The central corneal thickness readings were included within the Accu Pen and then the adjusted IOP calculated, and the readings by Goldmann tonometer take into consideration the correction factors for measured central corneal thickness according to the following Table 1 (Ashish *et al*., 2008):

Statistical Analysis

Statistical package for social sciences version 20 (SPSS v20) was used for data input and to obtain descriptive data.

RESULTS

This study had enrolled 55 patients in total, 30 males and 25 females. Both eyes (right and left eyes) of each patient were examined for IOP with both AccuPen and Goldmanntono meters, giving a total of 110 examined eyes (Table 2). All 110 eyes were examined with both tools for measuring IOP (AccuPen and Goldmann). The age of participants varied from 19 to 46 years with a mean of 28.9±7.2 years.

Readings with Goldmann ranged from 10 to 24 mmHg with a mean of 15.4±2.5 mmHg while readings with Accu Pen varied from 11 to 25 mmHg with a mean reading of 18.4±2.8 mmHg (Table 2). The average difference between the readings of AccuPen and Goldmann (AccuPen minus Goldmann's readings) was 3.0 mmHg (the median was 3.0 mmHg) with a standard deviation of 2.3 mmHg (Fig 1).

Table 1. Correction table used for adjusting IOP based on central corneal thickness

Central Corneal Thickness (Microns)	Adjustment in IOP (mm Hg)
445	+7
455	+6
465	+6
475	+5
485	+4
495	+4
505	+3
515	+2
525	+1
535	+1
545	0
555	-1
565	-1
575	-2
585	-3
595	-4
605	-4
615	-5
625	-6
635	-6
645	-7

The interpretation of these examination results was as follows (Table 3-A, Fig 1):

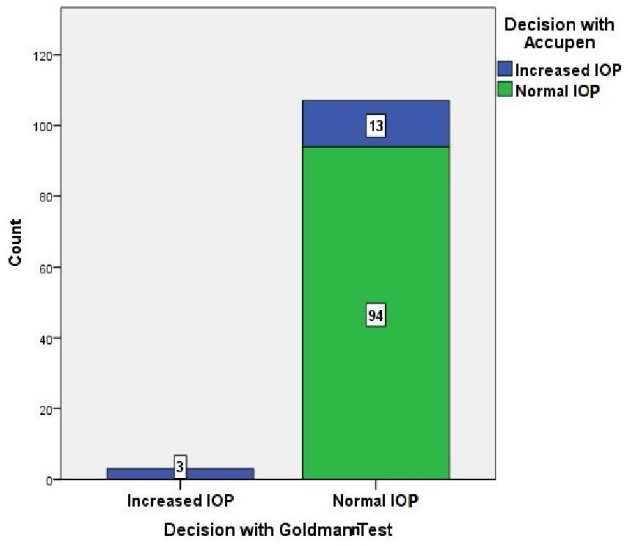

Fig. 1. Distribution of participants according to results of Goldmann and Accu Pen

- Three patients (one eye for each) had increased IOP above 21 mmHg according to Goldmann, and all of those three eyes were labeled as having increased IOP by AccuPen.
- 2.107 eyes had normal IOP according to Goldmann. But AccuPen labeled 13 of these eyes as having increased IOP and the remaining 94 eyes as having normal IOP.

The prevalence of increased IOP among this study sample was 3% (Table 3-B).

Regarding the validity of the AccuPen test to correctly detect (sensitivity) or exclude (specificity) increased IOP, this study found the following (Table 3-B):

- AccuPen detected all three patients with increased IOP above 21 mmHg (100% sensitive).
- Accupen was able to exclude increased IOP (to detect normal IOP) in 94 (88%) out of 107 eyes having normal IOP.
- This means that around 12% of normal eyes were erroneously labeled as having increased IOP. This test has a total of 88% of readings with correct IOP status (accuracy).

Regarding the predictive values of AccuPen in having increased IOP in presence of positive results (predictive value of positive test result) or having normal IOP in presence of negative results(predictive value of negative test result), in reference to table 3, this study found the followings:

Only 19% of positive results were correctly detected as having increased IOP (PVP =19%).

صورة

All those with negative results were correctly detected as having normal IOP (PVN=100%).

DISCUSSION

After the introduction of the new microprocessor controlled tonometers as alternative instruments for the measurement of IOP in many countries, it can be expected that these will gradually replace the classic older instruments such as the Schiotz tonometer. The greatest advantage of the new instruments is the simplicity of their use. Before they can be accepted as equivalent devices to standard tonometers, it is necessary to perform extensive clinical testing and evaluation. Discrepancies in IOP measurements could lead to incorrect clinical decisions - for example, in the detection and treatment of glaucoma. This clinical study evaluated the sensitivity, specificity and accuracy of the new tonometer AccuPen. The results of this study showed a good agreement between the AccuPen tonometer and the gold standard Goldmann applanation tonometer.

The results of this study agree with a study done by Kao *et al*. in which the overall sensitivity of the Tono-Pen in detecting IOPs of 21 mmHg or higher (as measured by the Goldmann instrument) was 72.4%, with corresponding specificity of 97.1%. The Tono-Pen appears adequate for screening programs where an IOP of 21 mmHg or above is considered abnormal. However, at higher IOPs (greater than or equal to 30 mmHg) the Tono-pens tended to underestimate more than Goldmann IOPs and at low IOPs (less than or equal to 9 mmHg) the Tono-Pens tended to overestimate the IOPs. Other studies have shown that the tono-Pen has a tendency to overestimate pressures at low IOP levels and underestimate pressures at high IOP levels (Kao *et al*., 1997; Farrar *et al*., 1995). In the results of this study the tool AccuPen overestimated IOP in comparison with the Goldmann tonometer, supposing the our

Table 2. Descriptive statistics for study sample

Variables	N	Minimum	Maximum	Mean	SD
Age (year)	55	19	46	28.9	7.2
Readings with Goldmann (mmHg)	110	10	24	15.4	2.5
Readings with AccuPen (mmHg)	110	11	25	18.4	2.8

Table 3. Performance of AccuPen as a tool to detect increased IOP compared to Goldmann test: A) frequency distribution of patients according to obtained results of both tools. B) Performance indicators for AccuPen

A)

		Decision with Goldmann		Total
		Increased IOP	Normal IOP	
		No.	No.	No.
Decision with AccuPen	Increased IOP	3	13	16
	Normal IOP	0	94	94
Total		3	107	110

B)

Indicator	Value	[95% CI(confedence interval)]
Prevalence of increased IOP	3%	[1%; 8%]
Validity indicators:		
.*Sensitivity*	100%	[31%; 97%]
.*Specificity*	88%	[80%; 93%]
.*Accuracy*	88%	[80%; 93%]
Predictive values:		
.*Predictive value of +ve result*	19%	[5%; 46%]
.*Predictive value of -ve result*	100%	[95%; 100%]

readings ranged from 10 to 25mmHg by both tools. Also our results are in agreement with a study conducted by Armstrong TA (Armstrong, 1999), in which the average deviation for the Tono-Pen was a significant 2.70mmHg; this instrument was highly sensitive and specific for detecting IOPs greater than 21mmHg.

Conclusion

AccuPen is a good screening method for detection of increased IOP with high sensitivity and accuracy in comparison with gold standard method (Goldmann tonometer).

Recommendations

- As the AccuPen is easy to use, portable and highly sensitive and accurate we suggest to use it as screening methods for detection of increased IOP in primary health care centers and with those patients which are uncooperative with Goldmann tonometer.
- Doing further studies about this tool especially in glaucomatous patients, and in patients with corneal scaring.

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