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Tono-Pen tonometry in normal and in post-keratoplasty eyes

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Abstract

Oculab Tono-Pen tonometry was compared with Goldmann applanation tonometry in 82 eyes of 82 patients with normal corneas and in 54 eyes of 54 patients who had undergone penetrating keratoplasty and whose corneas did not preclude the use of the Goldmann tonometer. We found that the intraocular pressure (IOP) in 48% of the eyes with normal corneas and in 57% after keratoplasty has different measurements with Goldmann and Tono-Pen pressures of 3 mm Hg or more. Despite the correlation between the Goldmann tonometer and the Tono-Pen in the group of eyes with normal corneas (r=0·83) as well as in the group of eyes after keratoplasty (r=0·79) the Tono-Pen tended to significantly overestimate the Goldmann tonometer reading (p<0·0001). The mean difference between the two instruments was highest across the lower IOP range (<9 mm Hg) in the group of eyes after keratoplasty. Because the mean absolute values of the paired differences between Goldmann and Tono-Pen measurements varied significantly across all IOP intervals it was not possible to establish a correction factor which could be used when comparing the two measurements. Based on this study the Tono-Pen consistently overestimated the actual IOP in an unpredictable manner. Where possible Goldmann measurements of the IOP are still to be preferred.

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The Goldmann applanation tonometer is the 'gold standard' for measuring intraocular pressure (IOP). An alternative tonometer is the Tono-Pen, which is an electronic applanation tonometer based on the same principle as the MacKay-Marg tonometer. It uses a strain gauge that converts IOP into an electrical signal transmitted to a microprocessor where it is analysed for acceptability. The mean value of four acceptable waves is determined, digitalised, and displayed on a liquid crystal panel. The nearest coefficient of variation is also shown on the panel.

This instrument has certain advantages over the Goldmann applanation tonometer. It is portable and compact, can be used regardless of the patient position, is easy to calibrate and operate, has a disposal tip cover which eliminates contamination risks, and the digital readout minimises user bias. Because of its small contact diameter (1·5 mm) the Tono-Pen was recommended for the measurement of the IOP in eyes with irregular corneas.[1]

Our goal was to try to find if the IOP differences between Tono-Pen and Goldmann in normal eyes would be similar in post-keratoplasty eyes which often have large and irregular astigmatism. In addition, we wanted to find a correction factor for the Tono-Pen which could be used to make it clinically comparable with the Goldmann tonometer.

Materials and method

A total of 82 eyes of 82 patients with normal corneas were randomly selected from our clinic population. Fifty four eyes of 54 patients, who had undergone penetrating keratoplasty and whose corneas did not preclude the use of the Goldmann tonometer, were selected from the cornea unit. The Goldmann tonometer and the Tono-Pen were calibrated according to the manufacturer's instructions each day before use.

In both groups of patients one drop of oxybuprocaine HCl 0·4% was instilled in each eye. We performed the examination in uniform sequence, using the Goldmann tonometer first. Measurements were performed on each eye until three consecutive readings were within 1·0 mm Hg. This was followed by Tono-Pen tonometry, where the measurements were repeated until three readings with a 5% range of coefficient of variance shown on the panel were achieved. A disposable latex membrane was applied on the transducer for each patient.

The tests were performed by two ophthalmologists familiar with both tonometers. One used the tonometer and the other the Tono-Pen. This was done in order to eliminate observer bias.

The data were collected and statistically analysed by regression test, paired *t* test and analysis of variance test.

Results

Figure 1 shows the regression line of the Tono-Pen IOPs compared with Goldmann IOPs (y= 0·87,×+5·63, correlation coefficient 0·83) in eyes with regular corneas.

Table 1 compares the measurements of both tonometers, in terms of mean paried differences and mean absolute value of paired differences in normal eyes. The analysis is divided into several Goldmann tonometry based IOP intervals. There were significant differences between the two instruments (−3·59 (SD 0·36) mm Hg, p<0·0001).

Figure 2 displays the distribution of paired IOP differences in the group of normal eyes. Most of the measurements are situated left of the zero, representing overestimation of the Tono-Pen; only 52% of the Tono-Pen measurements

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fell within 3 mm Hg of the Goldmann readings.

There was a significant difference ($p<0.0001$) in the mean value of the absolute paired difference between the two instruments of each IOP interval (Table 1, Fig 3).

Figure 4 shows the regression line of the Tono-Pen IOPs compared with the Goldman IOPs in eyes with irregular corneas caused by keratoplasty ($y=0.71,x+7.08$ with a correlation coefficient of 0·79).

Table 2 compares the measurements of both tonometers in terms of mean paired differences and mean absolute value of paired differences in the eyes with irregular corneas. The analysis is divided into several Goldman-based IOP intervals. There were significant differences between the two instruments (−2·96 (SD 5·05) mm Hg, $p<0.0001$).

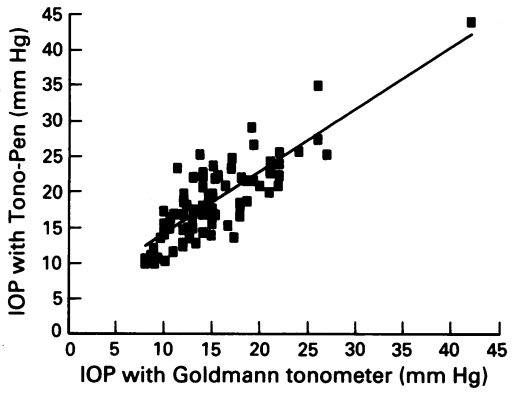

Figure 1 Scattergram and linear regression comparing Goldmann measurements with Tono-Pen measurements on the same normal eyes.

Table 1 Comparison of Goldmann tonometry and Tono-Pen measurements over different Goldmann-based IOP intervals (Goldmann minus Tono-Pen) in normal eyes

	IOP, mean (SD) (mm Hg)	
IOP intervals (mm Hg)	*Paired difference*	*Absolute paired difference*
0–4		
0–9 (*n*=8)*	−2·88 (1·78)	2·87 (1·8)
10–14 (*n*=37)	−4·76 (3·15)	4·77 (3·12)
15–19 (*n*=23)	−3·10 (3·70)	3·74 (3·01)
20–24 (*n*=10)	−1·37 (1·58)	1·77 (1·05)
25–29(*n*=3)	−2·89 (5·50)	4·00 (4·33)
30–34		
35–39		
40–44 (*n*=1)	−2·00	
Overall (*n*−82)	−3·59 (0·36) $p<0.0001$	

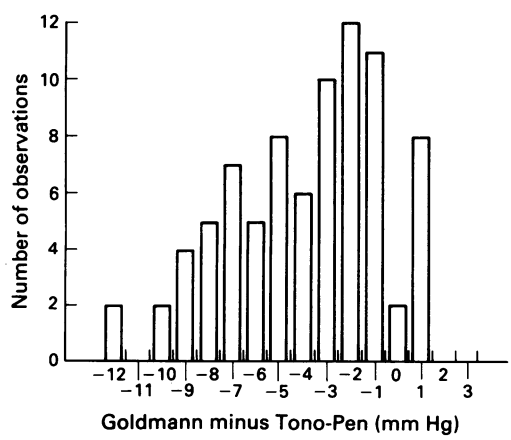

Figure 2 Frequency histogram of paired IOP differences between Goldmann and Tono-Pen measurements in normal eyes. Positive numbers on abscissa indicate that Tono-Pen IOPs are lower than Goldmann IOPs, and negative numbers are higher.

Figure 5 displays the distribution of paired IOP differences in eyes after keratoplasty. Most measurements are situated left of the zero representing overestimation of the Tono-Pen. Only 43·4% of the Tono-Pen measurements fell within 3 mm Hg of the Goldmann readings.

There was a significant difference ($p<0.0001$) in the mean value of absolute paired difference between the two instruments in each IOP interval (Table 2, Fig 6).

There were no significant differences in the discrepancies between Tono-Pen and Goldmann readings when comparing post-keratoplasty or normal patients ($p=0.281$).

Discussion

This is the first clinical study to compare the

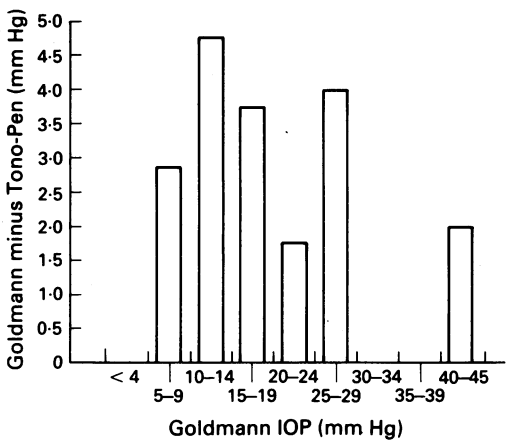

Figure 3 Histogram of the mean absolute value of paired differences between Goldmann and Tono-Pen measurements in different Goldman IOP intervals in normal eyes.

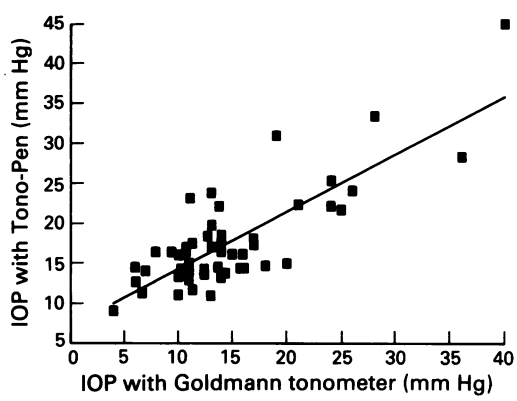

Figure 4 Scattergram and linear regression comparing Goldmann measurements with Tono-Pen measurements on same eyes after keratoplasy.

Table 2 Comparison of Goldmann tonometry and Tono-Pen measurements over different Goldmann-based IOP intervals (Goldmann minus Tono-Pen) in eyes after penetrating keratoplasty

	IOP, mean (SD) (mm Hg)	
IOP intervals (mm Hg)	*Paired difference*	*Absolute paired difference*
0–4 (*n*=2)*	−6·83 (2·54)	6·83 (2·6)
5–9 (*n*=6)	−7·00 (1·35)	1·35 (0·55)
10–14 (*n*=28)	−3·86 (3·26)	2·95 (0·56)
15–19 (*n*=8)	−1·00 (4·69)	3·93 (1·34)
20–24 (*n*=5)	−1·87 (3·17)	1·90 (0·85)
25–29 (*n*=3)	−1·11 (4·67)	1·68 (0·97)
30–34		
35–39 (*n*=1)	7·67	7·67
40–44 (*n*=1)	−5·00	5·00
Overall (*n*−54)	−2·96 (5·05) $p<0.0001$	

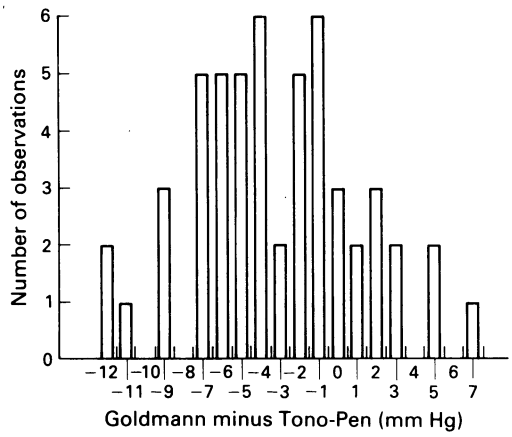

Figure 5 Frequency histogram of paired IOP differences between Goldmann and Tono-Pen measurements in eyes after keratoplasty. Positive numbers of abscissa indicate that Tono-Pen IOPs are lower than Goldmann IOPs, and negative numbers are higher.

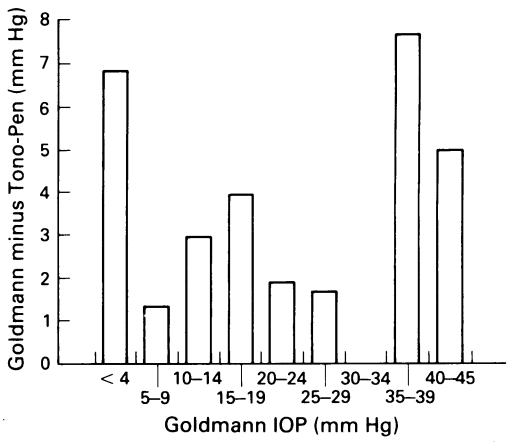

Figure 6 Histogram of the mean absolute value of paired differences between Goldmann and Tono-Pen measurements in different Goldmann IOP intervals in eyes after keratoplasty.

accuracy of the Tono-Pen in eyes with normal corneas with that of eyes which had undergone penetrating keratoplasty. The Tono-Pen was compared with the Goldmann tonometer.

Tono-Pen was found to be as accurate as the Mackay-Marg electronic tonometer in monitoring IOP in eyes with normal corneas and in eyes which had undergone penetrating keratoplasty.[1] However this does not prove the precision of the Tono-Pen, since both tonometers operate the same principle.

In our study there was good correlation between the Goldmann tonometer and Tono-Pen in the group of eyes with normal corneas ($r=0{\cdot}83$) as well as in the group of eyes after keratoplasty ($r=0{\cdot}79$). However, in both eyes, the Tono-Pen tended to significantly overestimate Goldmann tonometry ($p<0{\cdot}0001$).

Kao *et al*,[2] as well as Fenkel *et al*,[3] show that the Tono-Pen tends to overestimate at low IOP intervals (≤9 mm Hg) and underestimate at higher IOPs (≤30 mm Hg), while its measurement corresponds closely to Goldmann applanation tonometry at IOP intervals of 10–19 mm Hg.

Minckler *et al*[4] reported a relatively small overestimation of IOP with the Tono-Pen compared with the Goldmann tonometery and therefore the Tono-Pen could be considered clinically accurate. The large discrepancies in IOP between the two tonometer readings (>6 mm Hg) which they found in their study were attributable to corneal disorders known to interfere with the accuracy of tonometric readings. In our study, the overestimation was much higher than that reported by Minckler *et al*. The mean difference between the two instruments was higher across the lower IOP range (<9 mm Hg) in the group of eyes after keratoplasty compared with eyes with normal corneas. However the mean difference between the Goldmann and Tono-Pen values across the range of IOPs from 10 to 30 mm Hg was not significantly different when comparing both groups.

In order to evaluate how well a single Tono-Pen reading compares with Goldmann tonometry, the mean absolute value of the paired differences was analysed. This revealed that in both groups the Tono-Pen recorded significantly different measurements in all IOP intervals. Therefore, it was not possible to establish a correction factor which could be used to compare the two IOP readings.

Furthermore, IOP in 48% of the eyes with normal corneas and 57% of the eyes after keratoplasty measured differences in Goldmann and Tono-Pen pressures of 3 mm Hg or more and therefore would be considered clinically troublesome.

Based on this study the Tono-Pen is not an accurate means of measuring IOP but usually gives an overestimation with no consistent pattern. If possible IOP should always be measured by Goldmann tonometry.

1 Rootman DS, Insler MS, Thompson HW, *et al*. Accuracy and precision of the Tono-Pen in measuring intraocular pressure after keratoplasty and epikeratophakia and in scarred corneas. *Arch Ophthalmol* 1988; **106**: 1697–1700.
2 Kao SF, Lichter PR, Berstrom TJ, *et al*. Clinical comparison of the Oculab Tono-Pen to the Goldmann applanation tonometer. *Ophthalmlogy* 1987; **94**: 1541–4.
3 Frenkel REP, Hong YJ, Dong HS. Comparison of the Tono-Pen to the Goldmann applanation tonometer. *Arch Ophthalmol* 1988; **106**: 750–3.
4 Minckler DS, Baerveldt G, Heuer DK, *et al*. Clinical evaluation of the Oculab Tono-Pen. *Am J Ophthalmol* 1987; **104**: 168–73.