PACHYMETRY BEFORE OR AFTER APPLANATION TONOMETRY: DOES IT MATTER?

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SUMMARY

We examined prospectively 60 healthy volunteers to evaluate if the accuracy of central corneal thickness (CCT) measurement is influenced by Goldmann applanation tonometry (GAT) and vice versa.
The sequence of the examinations in the right eye was CCT - GAT - CCT, in the left eye GAT - CCT - GAT and the measurements were done consecutively. Two tonometry and five pachymetry measurements were averaged each time. Pearson correlation coefficients and Bland-Altman plots were used to assess the correlation between the measurements. In the right eye the mean CCT measurement before and after GAT was 565.22 ±32.99 μ and 566.04 ±33.50 μ (p=0.34, r=0.98) respectively. In the left eye the mean GAT before and after pachymetry was 19.38 ±4.71 mmHg and 19.16 ±4.32 mmHg (p=0.43, r=0.86) respectively. The study suggests that the sequence of the two examinations doesn't matter.

RÉSUMÉ

Une étude prospective a été réalisée sur 60 volontaires en bonne santé pour vérifier si les mesures de l'épaisseur cornéenne centrale sont influencées par les mesures de tonométrie à aplanation et vice versa. La séquence des examens dans l'œil droit était pachymétrie-tonométrie-pachymétrie et dans l'œil gauche tonométrie-pachymétrie-tonométrie. Les examens ont été réalisés successivement. Chaque tonométrie était la moyenne de 2 mesures et chaque pachymétrie la moyenne de 5 échographies. Le coefficient de corrélation de Pearson et les graphiques de Bland-Altman ont été utilisés pour démontrer la corrélation entre les mesures. Dans l'œil droit, la moyenne de la pachymétrie avant et après la tonométrie était de 565.22 ±32.99 μ et 566.04 ±33.50 μ (p=0.34, r=0.98) respectivement. Dans l'œil gauche, la moyenne de la tonométrie avant et après la pachymétrie était de 19.38 ±4.71 mmHg et 19.16 ±4.32 mmHg (p=0.43, r=0.86) respectivement. Notre étude suggère que l'ordre des mesures, aplanation avant ou après la pachymétrie, ne semble avoir aucune incidence sur les résultats.

KEY WORDS

Central corneal thickness, intraocular pressure, tonometry, pachymetry, glaucoma screening.

MOTS-CLÉS:

Epaisseur cornéenne centrale, pression intra-oculaire, tonométrie, pachymétrie, dépistage de glaucome.

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INTRODUCTION

Increased intraocular pressure (IOP) is still considered as the most important risk factor for the development and progression of glaucoma. The accuracy of Goldmann applanation tonometry (GAT) is influenced by the properties of the cornea including central corneal thickness (17, 18). Goldmann assumed a standard corneal thickness in the calibration of the applanation tonometer and emphasized that theoretically a thick cornea could lead to overestimation of the IOP and a thin cornea to underestimation (6). Patients with normal tension glaucoma tend to have a thinner cornea (5, 15); hence their GAT might be underestimated (4). The opposite is true for patients with ocular hypertension (1, 2, 8, 19). It has also been postulated that a thinner cornea might be a risk factor for glaucoma progression independently from IOP underevaluation (7, 9). Recently it was even suggested that CCT could be an indicator of the IOP lowering effect of medications (3). Therefore pachymetry has become a standard assessment in glaucoma patients. The aim of this study was to evaluate if the accuracy of central corneal thickness measurement (CCT) was influenced by preceding Goldmann applanation tonometry and vice versa. To the best of our knowledge there has been no previous study looking at the importance of the sequence of the two examinations.

MATERIAL AND METHODS

The DGH-500 Pachette™ was used for central corneal thickness (CCT) measurements during the study. The same pachymeter was also used in the Ocular Hypertension Treatment Study (OHTS study) (2) and in the European Glaucoma Prevention Study (EGPS) (13, 14, 16). Pachette™ is an ultrasonic pachymeter that uses echo spike techniques to measure the central corneal thickness. This technique offers several advantages such as reproducibility, high accuracy, ability to take measurements anywhere on the cornea, independence from patient fixation and ease of use. The measurements are given in microns (μm) and are based on the currently accepted value for the velocity of sound through the cornea of 1640m/second. Pachette ™ initiates the procedure by an automatic probe quality test. A probe of satisfactory quality should yield a Probe Quality Factor (PQF) of 100%. The result of PQF is displayed on the machine.

We examined prospectively 60 healthy volunteers who came for a routine IOP control to our glaucoma clinic. Patients with abnormal cornea, previous refractive surgery, contact lenses and topical medication were excluded. The sequence of the examinations in the right eye was CCT-GAT-CCT, and in the left eye GAT-CCT-GAT. The measurements were done consecutively and in a masked fashion. The patients were asked to blink after each CCT and GAT measurement to prevent decrease of CCT by corneal drying. The same Goldmann applanation tonometer (GAT) was used throughout the study. Two tonometry and five pachymetry measurements were averaged each time.

The CCT of one eye at random was examined in a separate group of 20 healthy subjects twice within one hour to determine the variability of the instrument. Probability plots were used to evaluate the normality of the data. Differences between group means were tested with the paired t-test. The Pearson correlation coefficient was used to calculate the correlations and Bland-Altman plots were used to compare the differences against the mean. The level of statistical significance used was $p<0.05$. The power of the study was 80% to detect a difference of 2μm of CCT or 0.75 mmHg of ATO.

RESULTS

The patients' characteristics are described in table 1.

Table 1: *Patients' characteristics*

Number of patients	60
Normal	48
OHT	12
Gender:	
Male	24
Female	36
Age (range)	61.95 (27-95) years
IOP OD=OS (μ ± SD)	19.4 mmHg ± 4.5
Average refractive error ODS (range)	+0.3D (-6.2D to +6.3D)

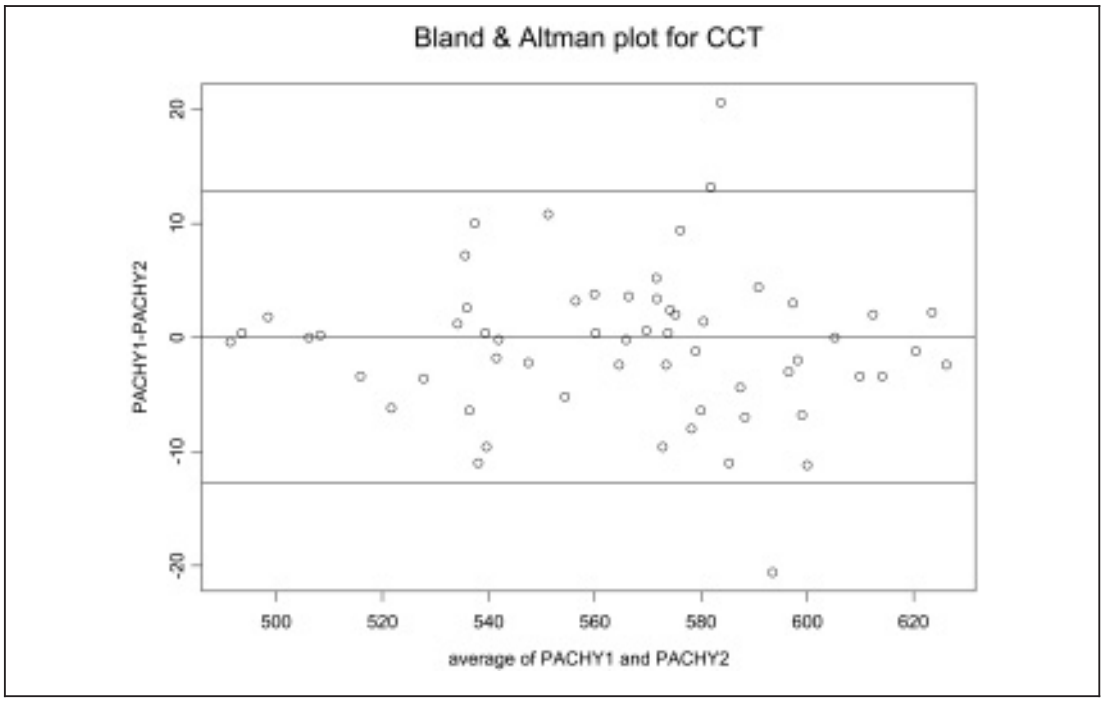


Fig. 1. Bland-Altman plot of the differences between pachymetry (CCT) measurements before and after applanation tonometry (Y-axis) against the mean of the CCT measurements (X-axis)

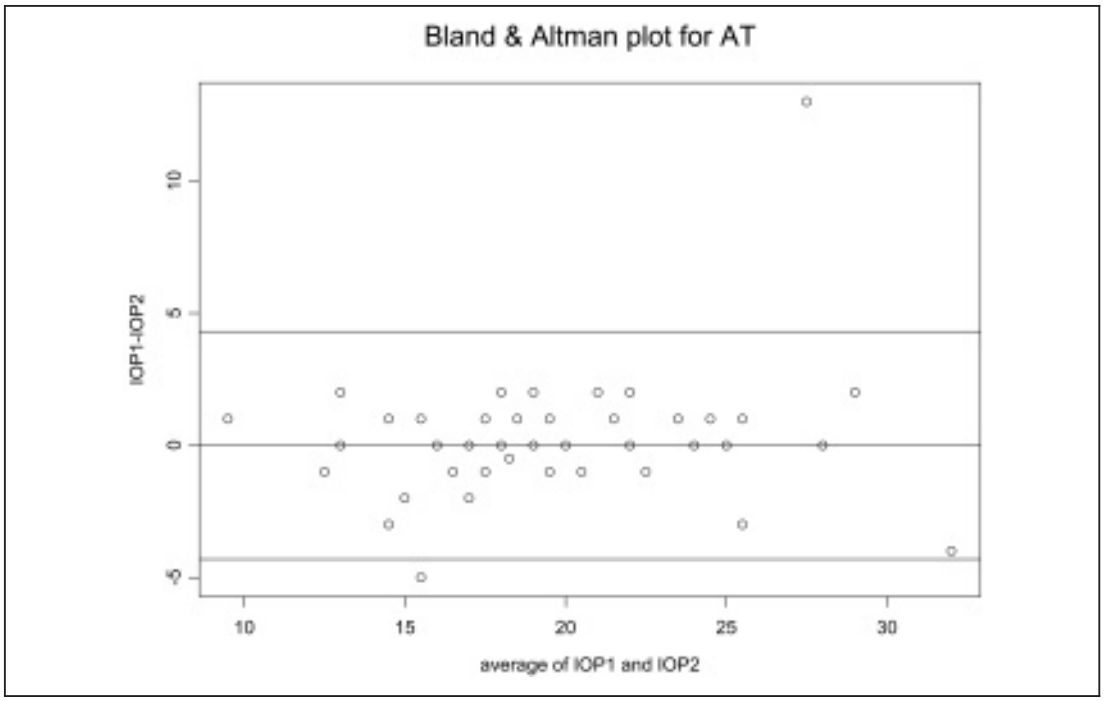


Fig. 2. Bland-Altman plot of the differences between applanation tonometry (GAT) measurements before and after pachymetry (Y-axis) against the mean of the GAT measurements (X-axis)

Of the 60 volunteers 12 patients had previously unknown ocular hypertension with normal optic disc and visual field. 36 female and 24 males were included in this study. The mean age was 61.95 ±13.12 years (27 - 90 years). The average refractive error for both eyes was +0.3 D (-6.2 to +6.3 D). In the right eye the mean CCT measurement before and after tonometry was 565.22 ±32.99 μ and 566.04 ±33.50 μ (p=0.34, r=0.98) respectively. In the left eye the mean GAT before and after pachymetry was 19.38 ±4.71 mmHg and 19.16 ±4.32 mmHg (p=0.43, r=0.86) respectively. Bland-Altman plots of the differences between pachymetry (CCT) measurements before and after applanation tonometry against the mean of the CCT measurements (Figure 1) and of the differences between applanation tonometry (GAT) measurements before and after pachymetry against the mean of the GAT measurements (Figure 2) showed clinically relevant limits of agreement and no systematic bias. In a separate group of 20 volunteers the mean CCT of the same eye measured twice within one hour were 557.38 ±46.60 μ and 552.28 ±34.72 μ (p=0.22, r=0.9).

DISCUSSION

CCT measurement is becoming part of the routine examination in the follow-up of glaucoma patients. Not only because of its role in the over- or underestimation of the IOP, but also because CCT can be an independent risk factor for the development of glaucoma. Indeed the Ocular Hypertension Treatment Study was the first study to document prospectively that the central corneal thickness appeared to be a strong risk factor for the development of primary open-angle glaucoma, even after adjusting for the effects of baseline age, IOP, cup/disc ratio, and PSD (2). It is likely that the predictive power of corneal thickness is due to its effect on the measured IOP but it may well be that corneal thickness is related to other factors affecting the susceptibility to glaucomatous damage like thinner supporting tissue around the optic nerve.
GAT remains the golden standard in glaucoma practice and CCT evaluation is essential to interpret the GAT measurements. Additionally, CCT measurement can be useful to assess one risk factor for the development and progression of glaucoma and a possible indicator of the IOP lowering response to medication (3).
The sequence of performing tonometry and pachymetry has been a source of disagreement among the clinicians. Should the pachymetry be performed before or after applanation tonometry?
Some believe that CCT measurement after GAT might be influenced by micro erosions of the epithelium surface or its desquamation (12, 20). Conversely GAT might be influenced by contact CCT measurements because repeated globe contact might induce a reduction of the IOP. Our prospective study showed that the sequence of the examination is not important.
To the best of our knowledge there has been no previous study looking at the importance of the sequence of the two examinations.
It may well be that in the future a more accurate instrument will replace GAT; ideally it should be capable of measuring the IOP independently from the biophysical properties of the cornea, particularly CCT.
Currently, two new devices exist to measure the IOP independently from CCT: the Pascal Dynamic Contour Tonometer (DCT) and the Reichert Ocular Response Analyzer (ORA). DCT additionally measures the ocular pulse amplitude (OPA).
These measurements of both instruments seem to be in good agreement with GAT readings (10, 11). It is at this point unclear whether those new devices will replace GAT as the golden standard.

CONCLUSION

There was no difference in the central corneal thickness measurement taken before or just after applanation tonometry, nor was there any difference between applanation tonometry measurements taken before or just after pachymetry. The accuracy of central corneal thickness (CCT) measurement is not influenced by preceding Goldmann applanation tonometry (GAT) and vice versa.

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