DYNAMIC CONTOUR TONOMETRY (DCT) VERSUS NON-CONTACT TONOMETRY(NCT): A COMPARISON STUDY

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RÉSUMÉ

Dans une étude prospective nous avons mesuré la tension intra-oculaire a l'aide d'un tonomètre à non-contact(NCT) et à l'aide d'un tonomètre dynamique de contour de Pascal (DCT), et l'épaisseur centrale de la cornée a l'aide d'un pachymètre à contact dans 294 yeux emmétropes ou amétropes.

Il y a une relation linéaire entre la tonométrie non-contact et la pachymétrie.

Cette relation linéaire n'existe pas entre la tonométrie dynamique de contour et la pachymétrie.

Les mêmes examens ont été faits avant et 6 semaines après une intervention de Lasik chez 58 yeux myopes.

L'intervention de Lasik a une influence manifeste sur la NCT, mais pas d'influence sur la DCT.

SUMMARY

In a prospective study we measured the intraocular pressure (IOP) by means of a Non-Contact Tonometer (NCT) and by means of a Pascal Dynamic Contour Tonometer (DCT), and the Central Corneal Thickness (CCT) by means of a contact pachymeter in 294 emmetropic or ametropic eyes. There is a linear relation between NCT and CCT. This linear relation doesn't exist between DCT and CCT.

The same measurements were done before and 6 weeks after a Lasik intervention in 58 myopic eyes.

Lasik intervention influences NCT but doesn't influence DCT.

KEY WORDS

Intraocular pressure (IOP), applanation tonometry, non-contact tonometry (NCT), dynamic contour tonometry (DCT), pachymetry.

MOTS-CLÉS

Pression intra-oculaire, tonométrie à applanation, tonométrie à non-contact (NCT), tonométrie dynamique de contour (DCT), pachymétrie.

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INTRODUCTION

Increased IOP is considered the main risk factor for glaucoma. Tonometry is a non-invasive technique to measure this IOP.

Since the applanation method was introduced by Goldmann in 1957, two types of tonometers have been most currently used: the Goldmann contact tonometer (GAT) and the non-contact pneumotonometer (NCT). Until now GAT is considered as the Gold Standard in tonometry. NCT can be used as an alternative because it has the advantage of being non-contact.

Both systems work according to the Imbert-Fick law: a force needed to flatten a sferical surface of a container is an indicator of the internal pressure .

Corneal thickness and perhaps other biomechanical properties are responsible for the rigidity of the cornea resulting in many errors in IOP measurement (1,2).

The PASCAL tonometer is a new electronic device and measures the IOP according to an other principle. It is mounted on a slit lamp like a Goldmann tonometer and has great resemblance to it (7).

In this device the appositional force is used to take away by deformation the tangential forces that keep the corneal vault stretched. Once these tangential forces are neutralized, an electronic pressosensor directly takes the IOP (8).

There are 3 conditions for accuracy:

1/The radius of the cornea has to be smaller than the radius of the the tip (keratometry steeper than 32,5 D)

2/The diameter of the contact area has to be greater than the diameter of the pressure sensor area (5-6 mm equals 55-66 D) . Keratometry has to be flatter than 55-66 D.

3/Corneal thickness and rigidity must tolerate a deformation of the curvature (pachy 300-700 μ)

A contact time of 5-7 seconds also gives a diastolic and systolic IOP with the difference called Ocular Pulse Amplitude (OPA). The mean purpose of this study is to investigate the influence of the biomechanical properties (6) of the cornea on IOP measurement with the new device.

SUBJECTS AND METHODS

In a first series we measured the intraocular pressure with NCT (Nidek NT 2000) and DCT (Pascal tonometer), and we measured the central corneal thickness with an electronical pachymeter (pocket pachymeter Quantelmedical) in a group of 294 apparent healthy eyes, ametropic or emmetropic with no evidence of glaucomatous damage. Both eyes of the patients were used in the study.

In a second series we performed the same measurements in a group of 58 myopic eyes before and six weeks after a Lasik intervention. These patients were a separate group of patients not included in the first group. Both eyes of the patients were included in the calculation.

The IOP measured with NCT was the mean of 3 consecutive measurements.
The IOP measured with DCT was the mean of the diastolic and systolic value with a Quality factor $\leqslant 3$.
The measurements were done consecutively; first NCT then DCT, by the same investigator.

RESULTS

In a first series we did consecutive measurements of IOP by NCT and DCT followed by a measurement of CCT in 294 eyes:

	NCT mm Hg	DCT mm Hg	CCT μ
mean	16,5	19,2	555
std	±4,4	±4,1	±36,4
min	7	11	450
max	29	35	670

The mean CCT in eyes without glaucomatous damage is 555 μ ± 36,4.
The correlation coefficient of the relationship between NCT and CCT is 0,49 *. It shows that the use of the regression line as an approximation of the relationship between NCT and CCT is useful. A thin cornea gives a lower IOP reading than a thick cornea (fig 1).

The correlation coefficient of the relationship between DCT and CCT is 0,05 ** , what means

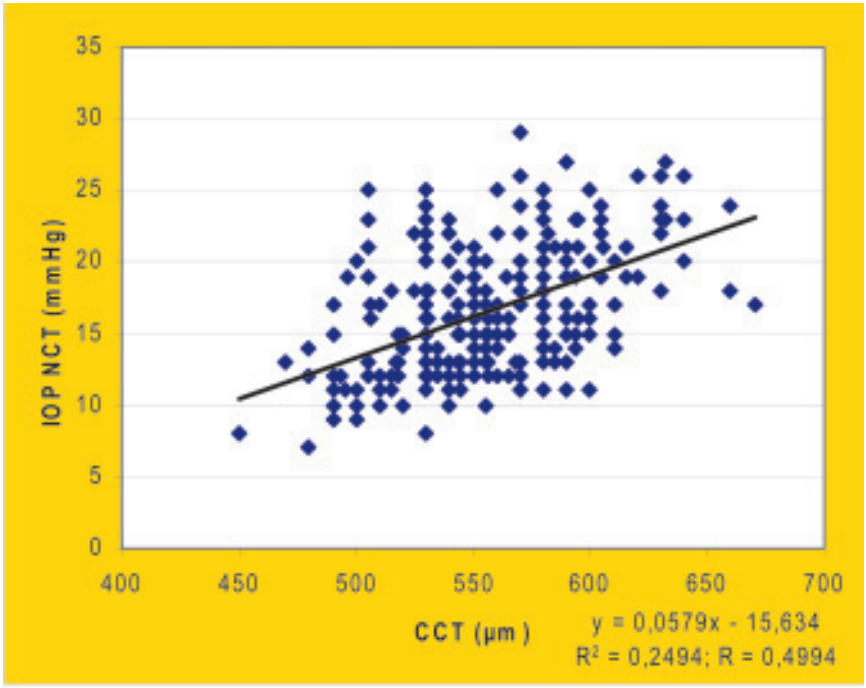

Fig.1 Non-Contact Tonometry versus Central Corneal Thickness: strong relation.

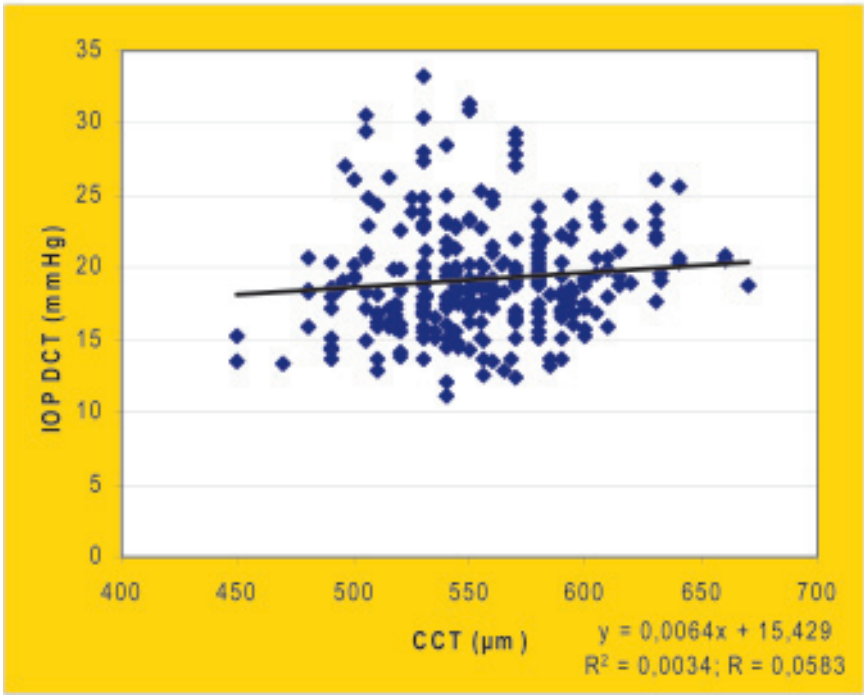

Fig.2 Dynamic Contour Tonometry versus Central Corneal Thickness: no relation.

	NCT mm Hg			DCT mm Hg			CCT μ		
	pre	post	diff	pre	post	diff	pre	post	diff
Mean	15	10	-5	17	17	-0.9	554	475	79
Std	±2	±2	±2	±1.9	±2.3	±2.3	±25	±48	±42
Min	10	6	-1	13	12	+5.4	490	405	10
Max	19	15	-10	22	22	-6.8	610	570	180

that there is no relationship between IOP measured with DCT and CCT (fig 2). The regression line is practically flat. The thickness of the cornea has no influence on the IOP reading with the Pascal tonometer.

*$F(1,292) = 90{,}901$ ($p < .001$). The relation between CCT and NCT is statistical significant.
**$F(1,292) = 3{,}269$ ($p > .05$). The relation between CCT and DCT is not statistical significant.

In a second series we did consecutively a NCT and DCT and a measurement of CCT in 58 myopic eyes before and six weeks after a Lasik intervention. All measurements were done post meridiem.

An F test was used to determine the statistical significance of the relationship between the differences of CCT and NCT.
$F(1,56) = 17{,}08$, ($p < .001$). It means that thinning of the cornea is strongly related to the drop in NCT.
The same F test was used to determine the statistical significance of the relationship between the differences of CCT and DCT.
$F(1,56) = 0{,}105$, ($p > .05$). It means that thinning of the cornea is not related to a change in DCT.
A paired t-test between the difference in NCT before and after Lasik and the difference in DCT before and after Lasik is statistical significant: $t(57) = -12{,}1$, $p < .001$.

In all post myopic Lasik eyes the IOP measured with NCT was lower; there was a correlation between the difference in NCT and the difference in CCT. The regression equation is calculated as $Y = -0{,}028 \times -2{,}8397$ ($R = 0{,}49$) (fig 3).

In post myopic Lasik eyes IOP measured with DCT was lower, equal or higher. The regression equation is calculated as $Y = -0{,}0025 \times -0{,}7453$ ($R = 0{,}045$). There is no correlation between the difference in DCT and the difference in CCT. The mean IOP measured with DCT didn't change (fig. 4).

DISCUSSION

Applanation tonometry is influenced by central corneal thickness and perhaps by biomechanical properties of the cornea (4) .The applanation principle is used in the Goldmann tonometer (GAT) as well as in the non-contact tonometer. Until now the Goldmann tonometer is considered as the gold standard. Nevertheless many papers show that the accuracy of this gold standard has to be corrected by the pachymetric evaluation of the cornea.
Dynamic Contour Tonometry (DCT) is a new principle of IOP measurement totally independent of the biomechanical properties of the cornea. As shown in our statistical calculation there is no correlation between DCT and CCT. Applanation tonometry performed with a non-contact tonometer (NCT) is influenced by CCT.
The DCT technique needs a direct contact with the cornea and is applicable in all cases where GAT is possible. Inter-observer variability is minimal because of the quality score and a dynamic registration in an adapted software. There is also a good distinction between the diastolic and systolic IOP. Perhaps this Ocular Pulse Amplitude will provide us more information about the predictability of glaucoma progression.
This study was done with a non-contact tonometer because of practical reasons: a private practice with a great turn-over of patients and lack of time.
Many papers show a good correlation between GAT and NCT (11-14). Some authors claim a stronger influence of CCT on NCT than on GAT (11). To the best of our knowledge no paper was published comparing DCT with NCT.

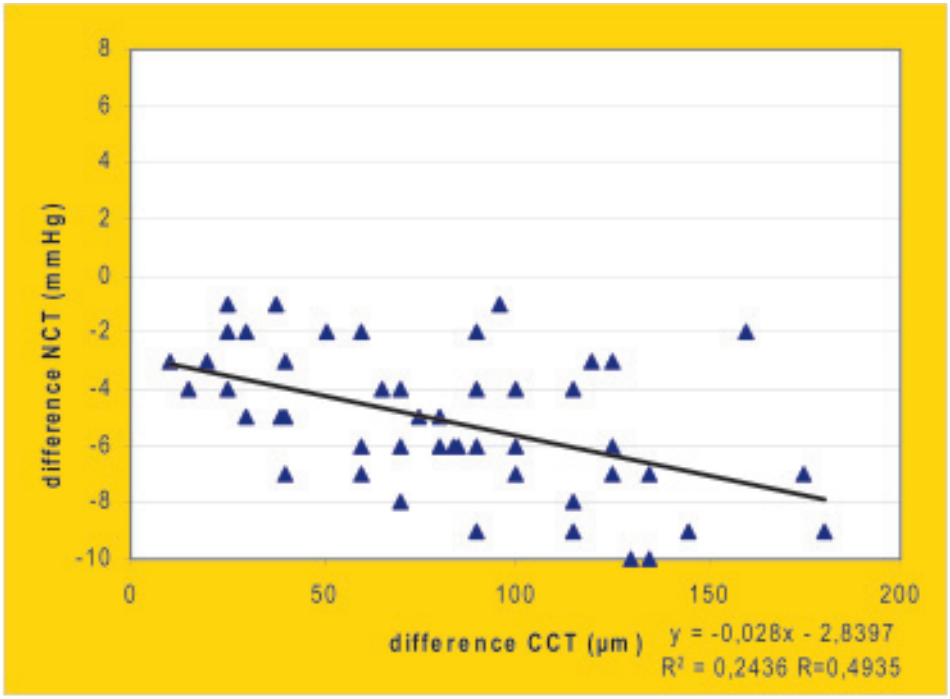

Fig 3: post Lasik intervention: lowering of IOP measurement with NCT in each eye.

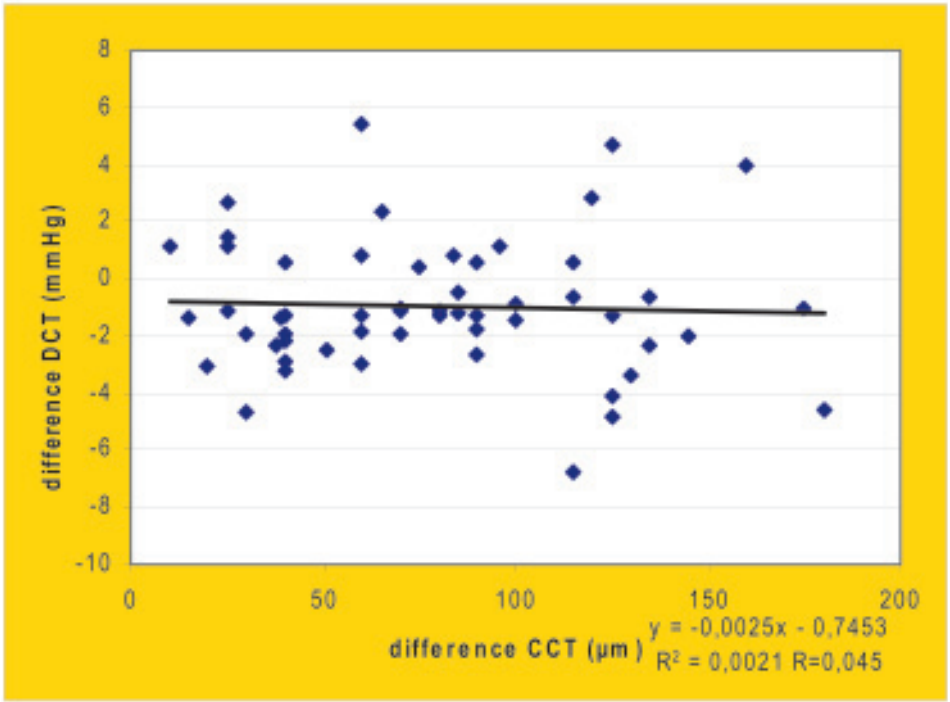

Fig 4: post Lasik intervention: no mean change in IOP measurement with DCT (Pascal).

Some authors state that in Lasik patients the change of IOP measurement by applanation tonometry before and after the Lasik intervention is not always linear with the amount of thinning of the cornea (2,3). It is important to keep in mind that differences in GAT and NCT before and after Lasik can be explained not only by corneal thinning but also by differences in the structure of the cornea.
Attention has to be paid to the fact that the IOP lowering capabilities of topical medication could be overestimated by thinning of the cornea or perhaps by change in the biomechanical properties (9).
The dynamic contour tonometry claims to measure the IOP independently of the corneal structure and the central cornea thickness (5,8,10).

In the first group of randomized eyes consulting for low refractive errors the correlation coefficient between NCT and CCT is 0,49. It shows that the use of a regression line as an approximation of the relationship between NCT and CCT can be useful.
On the other hand there was no correlation between DCT and CCT (R=0,05).

The change in CCT and biomechanical properties of the cornea in the Lasik group doesn't influence DCT (R=0,045).
In myopic Lasik eyes each IOP measurement by NCT was lower 6 weeks after the intervention.
The IOP measurement by DCT showed lower, equal or higher IOP values. The mean change in IOP was 0. This confirms the results of Duba et al (5) and Siganos et al (10).

CONCLUSIONS

1. The mean CCT in our series of normal eyes is 555 ± 36 μ.
2. In normal eyes there is a linear relation between CCT and NCT.
3. In normal eyes there is no linear relation between CCT and DCT.
4. Myopic Lasik intervention influences NCT.
5. Myopic Lasik intervention doesn't influences DCT.

Further studies have to confirm that dynamic contour tonometry better reflects the real IOP than applanation tonometry does. Of course we need more information concerning the correlation between DCT and intra-cameral manometric measurements. In that case there is a possibility that it becomes the standard in IOP measurement.

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