COMPARISON OF DYNAMIC CONTOUR TONOMETRY (PASCAL®) WITH PNEUMOTONOMETRY AND GOLDMANN TONOMETRY

COMPARACIÓN DEL TONÓMETRO PASCAL® CON EL NEUMOTONÓMETRO Y EL TONÓMETRO GOLDMANN

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ABSTRACT

Purpose: To compare the intraocular pressure measurements as defined by the Pascal® tonometer, the Goldmann tonometer and the pneumotonometer.
Methods: This was an observational clinical study, which included two hundred and five randomly selected subjects recruited from the Ophthalmology Department. The intraocular pressure measurements were performed with each tonometry technique in a randomized order.
Results: The Pascal®'s intraocular pressure measurement was significantly higher than that measured by the other two tonometers ($p<0.05$). The quality data of Pascal® was: optimum in 27.3% (56 of 205 patients), acceptable in 42% (86 of 205 patients) and unacceptable in 23.4% (48 of 205 patients). In 7.3% (15 of 205 patients) it was impossible to obtain any measurement using Pascal®. A weak correlation coefficient between the Pascal® and the Goldmann, and between Pascal® and the pneumotonometer was found. The Bland-Altman method of measurement using these tonometers showed a high degree of discordance.
Conclusion: As reported by others authors, the Pascal®'s intraocular pressure measurement is higher

RESUMEN

Objetivo: Comparar la medición de presión intraocular con el tonómetro de Pascal® en córneas normales frente al tonómetro de Goldmann y al pneumotonómetro.
Método: Estudio clínico observacional en el que se han incluido 205 pacientes consecutivos y randomizados que han acudido a la consulta de oftalmología. Se realiza una medición con cada tonómetro en orden aleatorio.
Resultados: El Pascal®, dio una medición de la presión intraocular mayor que la del resto de tonómetros. Se obtienen diferencias significativas del Pascal® frente a los otros dos tonómetros ($p<0,05$). La fiabilidad del Pascal® fue: fiables en el 27,3% (56 de 205 pacientes), aceptable en el 42% (86 de 205 pacientes) y en el 23,4% (48 de 205 pacientes) inaceptable. En el 7,3% (15 de 205 pacientes) restante no se obtuvo ninguna medición con el tonómetro de Pascal®. Al comparar el tonómetro de Pascal® frente al de Goldmann y al neumotonómetro se observa que el coeficiente de correlación es débil y presenta alta discordancia con el método de Bland-Altman.

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than that of the Goldmann tonometer. The measurement differs from 0.7 to 4.4 mmHg. In corneas with pathology, it is very difficult or even unacceptable to measure the intraocular pressure using the Pascal® tonometer *(Arch Soc Esp Oftalmol 2007; 82: 337-342).*

Key words: Pascal, pneumotonometry, Goldmann tonometer, dynamic contour tonometry, intraocular pressure.

Conclusión: Diversos autores han comparado el tonómetro de Pascal® y el Goldmann coincidiendo todos en que el Pascal® ofrece una presión intraocular mayor que el Goldmann con unas diferencias que van de 0,7 a 4,4 mmHg. En córneas patológicas es muy difícil realizar la medición y cuando ésto ocurre ésta suele ser informada como inaceptable.

Palabras clave: Pascal, neumotonómetro, goldmann, tonómetro dinámico de contorno, presión intraocular.

INTRODUCTION

The Pascal® dynamic contour tonometer is a digital contact tonometer that measures intraocular pressure between 5 and 200 mmHg with a precision of 0.2 mmHg (1-3). Together with the value of intraocular pressure, it notes the level of reliability and quality of the measurement with Q1 being reliable, Q2 and Q3 acceptable and Q4 and Q5 unacceptable, which requires repeating the measurement. The Pascal® tonometer is independent of corneal thickness and biomechanical cornea properties such as elasticity, rigidity, level of corneal hydration or lamellar stroma configuration (1-3).

The Goldmann tonometer is considered the golden standard to measure intraocular pressure. However, it presents a series of limitations and sources of error since the value it provides is not digital, heart beats make the semicircles change position, the amount of coloring varies the thickness of the semicircles, thus modifying the measurement and finally, corneal properties such as thickness and curvature can lead to a wrong measurement (1-3).

The pneumatonometer (4) is an air pressure contact tonometer following the Mackay-Marg method. Compared to the Goldmann, it underestimates high pressures and overestimates low ones. This tonometer, as it is independent of cornea properties, is useful in edematous, irregular corneas or with leucomas.

The purpose of this study was to analyze the reliability of the Pascal® versus the Goldmann tonometer, the golden standard, and the pneumatonometer, which we know is not much influenced by the anatomical properties of the cornea.

SUBJECTS, MATERIAL AND METHOD

An observational clinical study was conducted which included 205 consecutive and randomized patients visiting the ophthalmology department. Of these 205 patients, 24 had glaucoma, 25 a cornea transplant and 156 patients had neither.

Measurements were always carried out by the same person, only one eye per patient was included, and both the order of the tonometers and the eye selected for examination were random. Three measurements were conducted for the pneumatonometer (Model 30 Classic Pneumatonometer, Medtronic Ophthalmics, Jacksonville, USA) and the Goldmann (Applanation Tonometer AT 900 BQ, Haag-Streit, Köniz, Switzerland) noting down the mean. With Pascal® (Pascal®, SMT Swiss Microtechnology AG, CH-2562 Port, Switzerland) three measurements were carried out, choosing whichever was equal or lower than Q3. For those patients with whom an acceptable measurement level was not achieved after three measurements, the pressure provided with the first Pascal® measurement was noted, together with its level of reliability.

Analysis of methods was conducted by a non-parametric test using the Spearman coefficient for correlation and the Wilcoxon test to compare paired samples. Consistency between tonometers was achieved through the Bland-Altman method. We assessed the median and the interquantile range (25-75%). The statistical suite used was SPSS 11.0 (SPSS for Windows, SPSS Inc, Chicago, USA).

RESULTS

The pneumatonometer offered measurements in 200 of the 205 patients, while the Goldmann tonometer did so in 198 patients and the Pascal® tonometer was only capable of conducting acceptable measurements in 190 of the 205 patients (Q1 to Q3). Pascal® provided a higher intraocular pressure measurement than that obtained with the other tonometers. When the measurements obtained with Pascal® were compared to those of the other two tonometers, there were significant differences (p<0.001), the results of Pascal® being different from those obtained with Goldmann or the pneumatonometer (table I).

When the level of reliability was analyzed with the Pascal® measurement, we found that in 27.3% (56 out of 205) of the patients, intraocular pressure figures were reported as reliable, in 42% (86 out of 205) acceptable and in 23.4% (48 out of 205) unacceptable, not reliable, and a new measurement was required; when a new measurement was conducted, a more reliable value was not obtained. In the remaining 7.3% (15 out of 205) it was not possible to obtain any measurements with the Pascal® tonometer.

When comparing the Pascal® tonometer to the Goldmann, we saw the Spearman correlation coefficient was weak, only 0.48 (p=0.01) (fig. 1a) and inconsistent with the Bland-Altman method (6.42%) (fig. 1b). When Pascal® was compared to the pneumatonometer, results were similar with a weak Spearman coefficient of 0.44 (p=0.01) (fig. 2a) and variance of 6.25% (fig. 2b). This might lead us to believe the results are due to the high percentage (23.4%, 48 out of 205 patients) of patients with low reliability with the Pascal® tonometer, however, when these patients were extracted and the measurements reported with Pascal® as acceptable were compared to the other two tonometers, results did not vary much. So that the Spearman coefficient of Pascal® versus that of Goldmann was 0.38 (p=0.01) (fig. 3a) and 0.47 (p=0.01) with the pneumatonometer (fig. 3b) and discordance between Pascal® versus Goldmann and the pneumatonometer was significant, 5.88% in both cases (fig. 4).

Table I. Summary table of data obtained with tonometers Pascal®, Goldmann and pneumatonometer

Tonometer	Cases	Median	IR (25-75)	p Wilcoxon*
Pascal®	190	18.4	6.1	
Goldmann	198	14	4.2	<0.001
Pneumatonometer	200	15	6.2	<0.001

* Comparisons conducted with Pascal® versus Goldmann and Pascal® versus pneumatonometer.

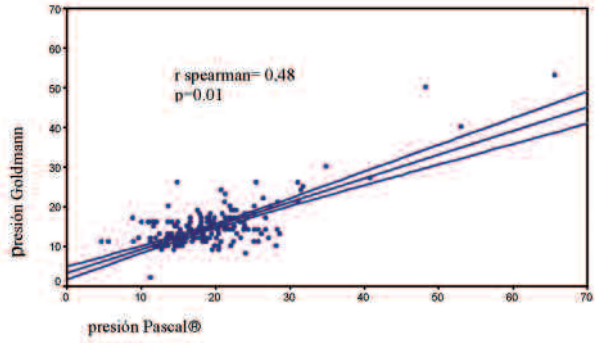

Fig. 1a: Linear regression and correlation coefficient for Pascal® and Goldmann.

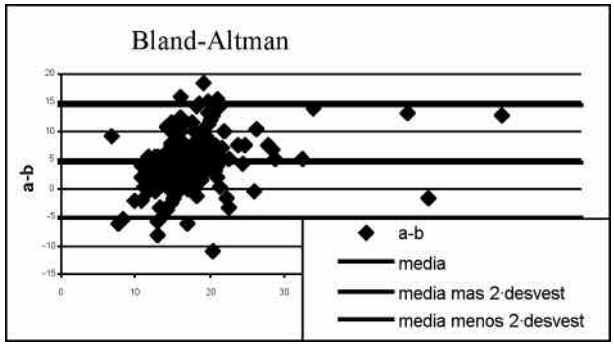

Fig. 1b: Bland-Altman for Pascal® and Goldmann with a discordance coefficient of 6.42%.

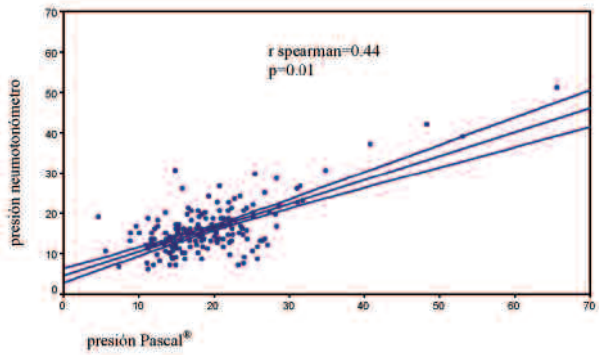

Fig. 2a: Linear regression and correlation coefficient for Pascal® and pneumatonometer.

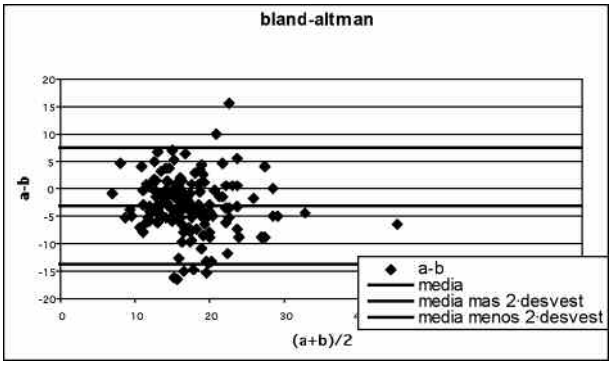

Fig. 2b: Bland-Altman for Pascal® and pneumatonometer with a discordance coefficient of 6.25%.

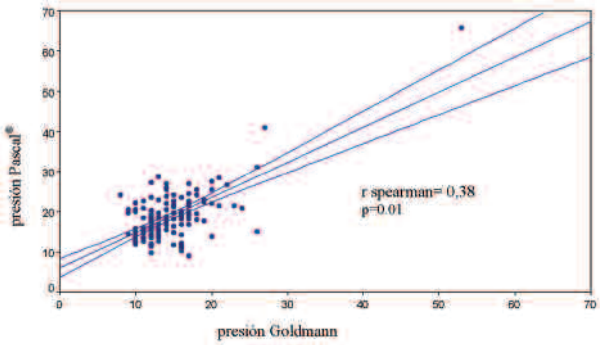

Fig. 3a: Linear regression and correlation coefficient for Pascal® and Goldmann only for values measured as acceptable for Pascal.

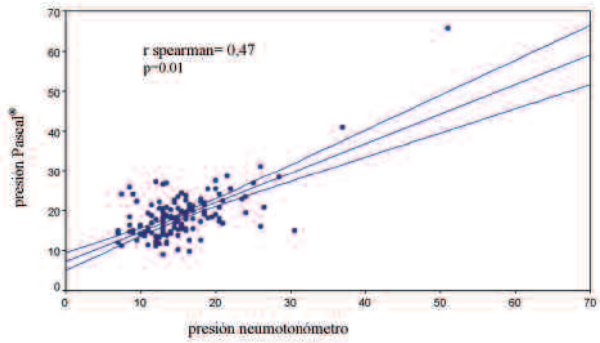

Fig. 3b: Linear regression and correlation coefficient for Pascal® and pneumatonometer only for values measured as acceptable for Pascal.

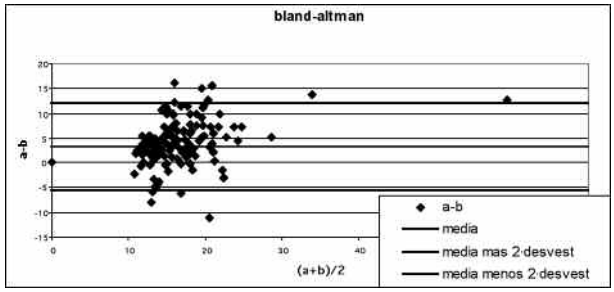

Fig. 4a: Bland-Altman for Pascal® and Goldmann with a discordance coefficient of 5.88%, only for values measured as acceptable for Pascal.

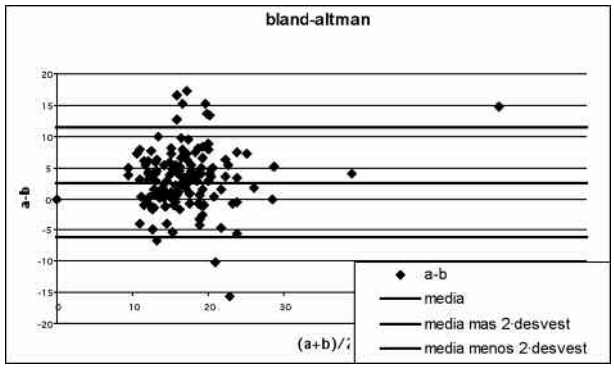

Fig. 4b: Bland-Altman for Pascal® and pneumatonometer with a variance coefficient of 5.88% only for values measured as acceptable for Pascal.

DISCUSSION

Several authors (1-3,5-7) have compared the Pascal® tonometer to the Goldmann one and all agree that the Pascal® provides greater intraocular pressure than Goldmann. Kotecha (2) has found the least differences, only an increase in favor of Pascal® of 0.7 mmHg, compared to our study, which has found that Pascal® overestimates intraocular pressure by 4.4 mmHg when compared to Goldmann. When we analyzed the existing correlation between Pascal® and Goldmann we found very disparate data in literature, ranging from the weakest correlation by Kotecha (2) with a coefficient of 0.22, and the present study (spearman r=0.48 p=0.01) up to reaching the almost perfect correlation by Kamppeter (1) of 0.95.

Doyle (3) analyzed the existing relation between the Goldmann and the Pascal® tonometers in various corneal thicknesses, noting that before a normal or thick cornea there were no significant differences in the intraocular pressure measurements, while when the cornea was thin there were differences (p=0.009) in the intraocular pressure measured with Goldmann and Pascal®.

In literature there is only one paper comparing Pascal®, Goldmann and the pneumatonometer and it was published by Kniestedt (4) in 2005. As all other authors have found, Pascal® provided an average intraocular pressure of 18.3 mmHg, higher than that obtained with the pneumatonometer (17.1 mmHg) and Goldmann (16 mmHg). Also, he analyzed the correlation of each one of the three tonometers with the corneal thickness, finding there was only correlation with the Goldmann tonometer ($r=0.24$ $p<0.01$), the pneumatonometer ($r=17.1$ $p=0.1$) and the Pascal® tonometer ($r<0.1$ $p=0.80$) being independent of corneal thickness.

It has struck us that Pascal® conducts, in many cases, not very reliable measurements or that it is not able to measure intraocular pressure. To conduct the measurement, this tonometer requires a round tear film contour not found in patients with lachrymal dryness, high astigmatism or keratoplasty. Although this tonometer can be very useful in healthy eyes, in patients with glaucoma under chronic treatment or elderly patients with ocular dryness, this low reliability can be clinically significant. Although Pascal® has become popular as a system to measure intraocular pressure following LASIK, its use should be assessed with all type of patients as a tonometer not affected by corneal thickness.

In this study, as in all other literature, the Pascal® tonometer overestimates intraocular pressure. Measurements were not reliable in 23.4% (48 out of 205) of patients, and it was impossible to conduct measurements in 7.3% (15 out of 205).

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