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Intraocular pressure measurement with ocular response analyzer over soft contact lens

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ABSTRACT

Purpose: To compare intraocular pressure (IOP) measured with ocular response analyzer (ORA) with and without soft contact lenses (CL) on eye.
Methods: Goldmann correlated intraocular pressure (IOPg) and corneal compensated intraocular pressure (IOPcc) were measured in 56 eyes of 28 subjects without any ocular pathology, using ORA. One eye was fitted with Narafilcon A (1-Day Acuvue True Eye, Johnson & Johnson) and the other eye with Nelfilcon A (Daily AquaComfort Plus, Ciba Vision), each with −3.00D and IOPg and IOPcc were again measured over CL. The variation in the IOP with and without CL was determined.
Results: Out of 28 subjects, 54% (15) were female. Mean age of the subjects was 29.4 ± 9.8 years. Both the IOPg and IOPcc when measured with CL, were found statistically significantly lower than without CL ($p < 0.05$). In subjects wearing Narafilcon A lens, IOPg and IOPcc were found 0.88 ± 2.04 mmHg and 1.55 ± 2.16 mmHg lower than without CL, respectively. Similarly, with Nelfilcon A lens, IOPg and IOPcc were found to be 1.03 ± 1.93 mmHg and 1.62 ± 3.12 mmHg lower, respectively. IOPcc was highly affected and underestimated by more than 3 mmHg in upto 36% of the subjects.
Conclusion: Measurement of IOP over minus (−3.00D) CL with ORA is dependent upon CL properties when measured in normal IOP population. It showed lower IOP over Narafilcon A and Nelfilcon A soft CL in comparison to the pressures measured without lenses. IOPg was found less affected by CL. For the accurate measurement of IOP with ORA, CL should be removed.

1. Introduction

There are estimated 140 million people wearing contact lens (CL) in the world for refractive purposes [1]. Many other people are also wearing CL for therapeutic purpose, since some CLs were found to be effective in pain relief, corneal healing or mechanical support in some corneal diseases: persistent epithelial defects, recurrent corneal erosions, filamentous keratitis, corneal thinning, bullous keratopathy [2,3].

For the complete ocular examination and the follow up examinations of glaucoma susceptible patients, accurate intraocular pressure (IOP) measurement is important. Measurement of IOP by Goldmann Applanation Tonometry (GAT) is the gold standard and is being used since many years with good accuracy [4]. However, IOP measured by GAT is dependent upon the corneal biomechanical properties [5,6]. Moreover, in many countries, optometrists are not allowed to use anesthetic drop and fluorescein dye which are necessary in GAT. So, non-contact tonometry is popular for many practitioners. The ocular response analyzer (ORA; Reichert Ophthalmic Instruments, Buffalo, NY) measures IOP, regardless of corneal biomechanical properties [6]. The principle of the ORA is based on those of non-contact tonometry, in which the IOP is determined by the air pressure required to applanate the central cornea. The detailed information about the ORA can be found in other studies [7]. Briefly, this instrument utilizes a rapid air impulse to deform the cornea during which the shape of the cornea is monitored by an electro-optical system. The instrument fires a metered collimated air pulse at the cornea so that the convex shaped cornea changes to plane (inward applanation) and to slight concave shape. After the air puff pressure reduces, the cornea comes again to plane shape (outward applanation) and to the convex shape as normal. All these processes complete within 20–25 ms. The inward applanation pressure is always less than the outward applanation pressure due to some energy absorption by cornea [7]. The average of these two pressures is Goldmann correlated intraocular pressure (IOPg) which is correlated with pressure measured by

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Table 1
Preview of studies comparing the intraocular pressure measured with and without contact lens with different tonometry.

Author (year)	*N* (eyes)	Measurement technique	Material (parameter)	Remarks
Gogniat et al. [10]	42	DCT	Nelfilcon A, Narafilcon A (Power = +5.00D, −0.50D and −5.00D)	No significant difference except +5.00D Nelfilcon A
Schollmayer et al. [12]	120	Non-contact pneumotonometry	Lotrafilcon A (Power = −1.00D, −4.00D, +1.00D, +4.00D)	Underestimation in minus lenses Overestimation in plus lenses The difference was correlated with the power of the lenses
Zeri et al. [13]	136	GAT	Hilafilcon A (parameter not available)	No significant difference
Patel et al. [14]	50	NCT	Lotrafilcon A and Nelfilcon A	Minus lenses: underestimation plus lenses: overestimation Difference correlated with power
Liu et al. [15]	32	NCT	Hilafilcon A (Power = −3.00D to −12.00D)	Underestimation, correlated with power
Allen et al. [18]	20	GAT	Silicone hydrogel lenses (parameter not available)	No significant difference
Schornack et al. [19]	78	Tonopen XL	Galyfilcon A, Senofilcon A, Lotrafilcon B (Power = −0.25D to −3.00D and −3.25D to −6.00D)	No significant difference except with high power Lotrafilcon B lenses
Boyraz et al. [20]	30	Tonopen XL	Lotrafilcon A, Balafilcon A and Vifilcon A (Power = −3.00D)	Overestimation
Anton et al. [21]	39	ICare rebound tonometry and Airpuff tonometry	Therapeutic soft lenses (materials not available)	ICare: overestimation Airpuff: no difference

GAT – Goldmann applanation tonometry, NCT – non-contact tonometry, DCT – dynamic contour tonometry.

Goldmann applanation tonometry [8]. The corneal compensated intraocular pressure (IOPcc) is calculated with linear relationship of these two pressures and is considered to be less affected by corneal thickness and corneal biomechanical properties [6].

Patients, who wear CL, usually remove them before IOP measurements. Removal of CL may cause temporal changes in IOP and may cause impairment in epithelization process in some cases [9]. Many people may not desire to remove the CL for IOP measurements, especially if it is required frequently. In many countries, optometrists are not allowed to use anesthetic eye drop. So, if measurement of IOP over CL is accurate, it can be considered as an option in these situations.

Many studies have been done to evaluate the IOP with and without CL using different methods of tonometry as summarized in Table 1 [10–21]. Some of them found significant differences in the two measurements [12,14,15,17,20], while others did not find any differences [10,13,16,18,19]. However, in our knowledge, no studies have been conducted comparing IOP with and without CL using ORA. One of the aims of this study was to investigate the influence of soft CL in the IOP measurement by ORA. Another aim of this study was to determine – out of IOPg and IOPcc – which one is less affected by the presence of CL. If there is no clinically significant difference, there is no need to remove soft CL before IOP measurements.

2. Methods

A cross-sectional prospective study was conducted in normal subjects recruited from University of Minho, Portugal. A general primary ocular examination was done and, subjects having any ocular pathology, ocular surgery and those apparently normal but resulting in IOPg or IOPcc values more than 21 mmHg in at least one eye, were excluded.

This study was approved by the School of Science Ethical Committee, University of Minho. All the subjects gave informed consent after nature of the study had been explained and the tenets of the Declaration of Helsinki were followed.

Initially, IOPg and IOPcc were measured in both the eyes with ORA. Tonometry was done initially without CL on eye to prevent the possible alteration in intraocular pressure due to change in corneal curvature immediately after CL removal [22]. After that, subjects were fitted with a silicone hydrogel lens (Narafilcon A) in one eye (Group A) and a hydrogel lens (Nelfilcon A) in the other eye (Group B) each with −3.00D. These lenses were chosen because of their different material properties and designs (CL details are specified in Table 2). After 10 min of CL wear, as in previous study [14], IOPg and IOPcc were measured over the CL by the same investigator using the same instrument. For all the measurements, three readings were taken and average was used in the subsequent analysis. All these assessments were done at 14:00–17:00 h.

Data were analyzed with IBM SPSS 21 statistical software (IBM Corp., Armonk, NY). Kolmogorov–Smirnov test was used to evaluate the normality of the data distribution. Parametric tests were applied for the normally distributed variables and non-parametric tests for the others. Pearson correlation test was applied to determine the correlation in IOPg and IOPcc measurements with and without CL. Paired sample test was applied to determine the variation of IOP with and without CL. Bland Altman plots were used to assess the variation in IOP without and with CL as function of IOP value. For all the analysis, $p \leq 0.05$ was considered as statistically significant.

3. Results

A total of 28 subjects with mean (±standard deviation) age of 29.4 ± 9.8 years have participated in this study. Fifty four percent (15) were female. None of the subjects were wearing CL or spectacle before.

Both IOPg and IOPcc presented lower values for the measurements done over the lens in both types of CL than that of the measurements without CL (Table 3). These differences were higher for the Nelfilcon A CL in comparison to Narafilcon A but not statistically significant ($p > 0.05$). The values of IOPcc were more affected

Table 2
Details of the contact lenses used in the study.

Parameters	Group A	Group B
Company name	Johnson & Johnson	Ciba Vision
Brand name	1-Day Acuvue True Eye	Daily AquaComfort Plus
Material	Narafilcon A	Nelfilcon A
Power (Dioptre)	−3.00	−3.00
Water content	46%	69%
Base curve/diameter (mm)	8.5/14.2	8.7/14
Oxygen permeability (Barrer)	100	26
Center thickness (mm)	0.085	0.10
Modulus (MPa)	0.66	0.89