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ARTICLE

The effect of the timing of the cessation of contact lens use on the results of biometry

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Abstract

Background Current guidelines vary regarding when to remove contact lenses prior to performing biometry, and there is no clear evidence behind these guidelines. This study aimed to determine the effect of soft contact lens wear on biometric measurements by examining the change in predicted lens power for emmetropia at several time points following removal of soft contact lenses.

Methods A prospective, controlled study of healthy soft contact lens wearers. Biometry was performed immediately after removing contact lenses and then after 2, 4 and 7 days of no contact lens use. Healthy non-contact lens wearers were used as controls. All measurements were taken with the Zeiss IOLMaster.

Results In all, 14 subjects and 13 controls were recruited. There was no significant difference in age or gender between groups. Eight of the fourteen subjects wore daily disposable CLs, two wore 2-weekly and four wore monthly soft CLs. Measurements from controls and contact lens-wearing subjects showed similar degrees of variation over time. The within-subject SD in predicted intraocular lens (IOL) power for emmetropia for contact lens wearers was 0.20 D (95% CI 0.16–0.25 D) compared to 0.18 D (95% CI 0.12–0.26 D) for controls.

Conclusions There is a significant variation in UK practice regarding advice on the timing of cessation of contact lens wear prior to having biometry performed. Our study suggests that it is likely that soft contact lens wearers are currently being advised to remove their contact lenses for an unnecessarily long period of time prior to having biometry performed.

Introduction

One of the key steps in optimising the refractive outcome of cataract surgery is obtaining accurate measurements of the corneal curvature during biometry. Patients frequently choose to correct refractive error using contact lenses, which can temporarily change the shape of the cornea [1–3] and therefore adversely affect the accuracy of the biometry. However, as far as we can ascertain there are no published studies specifically examining the effect of the timing of cessation of contact lens wear prior to biometry on the predicted refractive result. The Royal College of Ophthalmologists' Cataract Surgery Guideline [4] states 'ideally, soft lenses should be left out for 1 week and hard lenses for 4 weeks prior to measurement', but the evidence on which this recommendation is based is unclear.

The present study aimed to determine the effect of soft contact lens wear on biometric measurements by examining the change in predicted lens power for emmetropia at several time points following removal of soft contact lenses. Changes in contact lens wearers were compared to a control group of non-contact lens wearers to account for visit-to-visit variability in biometry. In addition, we surveyed consultant ophthalmologists to determine current practice regarding cessation of contact lens wear and biometry prior to cataract surgery.

Methods

A prospective controlled study was conducted at Princess Alexandra Eye Pavilion, Edinburgh, including 14 contact lens wearers (27 eyes) and 13 similarly aged controls (26

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Table 1 Demographic details and contact lens-wearing habits of participants included in the study

	Subjects ($n = 14$)	Controls ($n = 13$)	P value
Age	37 (Range 23–69)	29 (Range 22–40)	0.166*
Gender	10 Female	10 Female	0.745**
Years of CL wear	13 (2–30)	–	–
Days of CL use/week	4.5 (1–7)	–	–
Hours of CL use/day	11.8 (9–14)	–	–
Contact lens power right (D)	−2.00 (+4.00–6.00)	–	–
Contact lens power left (D)	−2.00 (+4.00–6.50)	–	–

(*calculated using Student's t-test. **calculated using X^2-test)

eyes). Ethical approval was granted prospectively by the East Midlands (Leicester Central) Research Ethics Committee and all study methods adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained prospectively from all participants.

Subjects were recruited from advertisements placed on notice boards in the ophthalmology clinic at Princess Alexandra Eye Pavilion. Inclusion criteria included subjects who were daily soft contact lens wearers over the age of 18. Those with a history of dry eye, corneal or ocular surface disease, glaucoma or ocular hypertension, retinal disease, diabetes or previous eye surgery, including refractive surgery, were excluded. Participants were instructed to wear their contact lenses as normal prior to biometry. Biometry was performed using the Zeiss IOLMaster (Carl Zeiss Meditec, Dublin, CA, USA) using the SKR(T) algorithm immediately after contact lens removal. The participant was then prohibited from using contact lenses until their involvement in the study was complete. Participants returned for repeat biometry on days 2, 4 and 7. Each test was conducted by the same individual (C.G.) at the same time of day (+/− 2 h). Measurements obtained included K-readings and axial length (from which cylinder and axis are calculated, as well as a range of intraocular lens (IOL) powers to give a specified refractive outcome are calculated). Details of contact lens use including type of contact lens, number of hours of lens use per day, number of days of lens use per week and number of years of lens use were recorded for each participant and current refraction was obtained from their primary care optometrists' records. The control group consisted of healthy non-contact lens wearers who had biometry performed to both eyes on two separate days.

To ascertain current practice regarding advice given to patients for discontinuing contact lens wear prior to biometry, an electronic survey was sent to 89 consultant ophthalmologists in Scotland. Ophthalmologists identified locally using departmental email addresses were sent an email invitation to complete a Survey Monkey questionnaire in July 2016. A reminder invitation was sent to non-responders after 2 weeks. Questions asked included which machine the surgeon uses routinely to perform biometry and for how long they insist contact lenses to be removed prior to biometry for each of; soft daily disposable, soft 2-weekly, monthly or rigid gas-permeable contact lenses.

A review of current advice available online for patients was performed. This was done by a Google search using the terms 'contact lens removal prior to biometry', 'how long do I need to remove contact lenses before cataract assessment' and 'cataract patient information leaflet'. Results returned that included advice regarding removal of contact lenses prior to biometry, from within the UK, were recorded.

Statistical analysis

Descriptive statistics yielded median, interquartile ranges and Wilcoxon rank sum test for non-parametrically distributed variables. As there is often correlation between two eyes of an individual, analyses were conducted using the right eye of each subject. Agreement between predicted IOL power for emmetropia in control subjects on repeat measurements was examined using Bland–Altman plots, with 95% limits of agreement calculated. A similar analysis was conducted for average K-values. A mixed model was used to calculate within-subject SD in predicted IOL powers for emmetropia between control subjects and contact lens wearers, and a random coefficients model, a type of linear mixed model involving random intervals and random slopes, was used to examine the effect of time on predicted IOL power for emmetropia. Predicted IOL power for emmetropia was considered the dependent variable with the variable CONTACT LENS included as a fixed-effect covariate with the value of 0 for the control group and a value of 1 for contact lens wearers. The variable TIME in days from baseline was included as a continuous predictor. The significance of the coefficients of the variable TIME indicated whether there was a significant change in predicted IOL power for emmetropia over time. The interaction between CONTACT LENS and TIME (CONTACT LENS × TIME) was used to evaluate whether there was a significant difference in change in biometry between those wearing and not wearing contact lenses. Statistical analyses

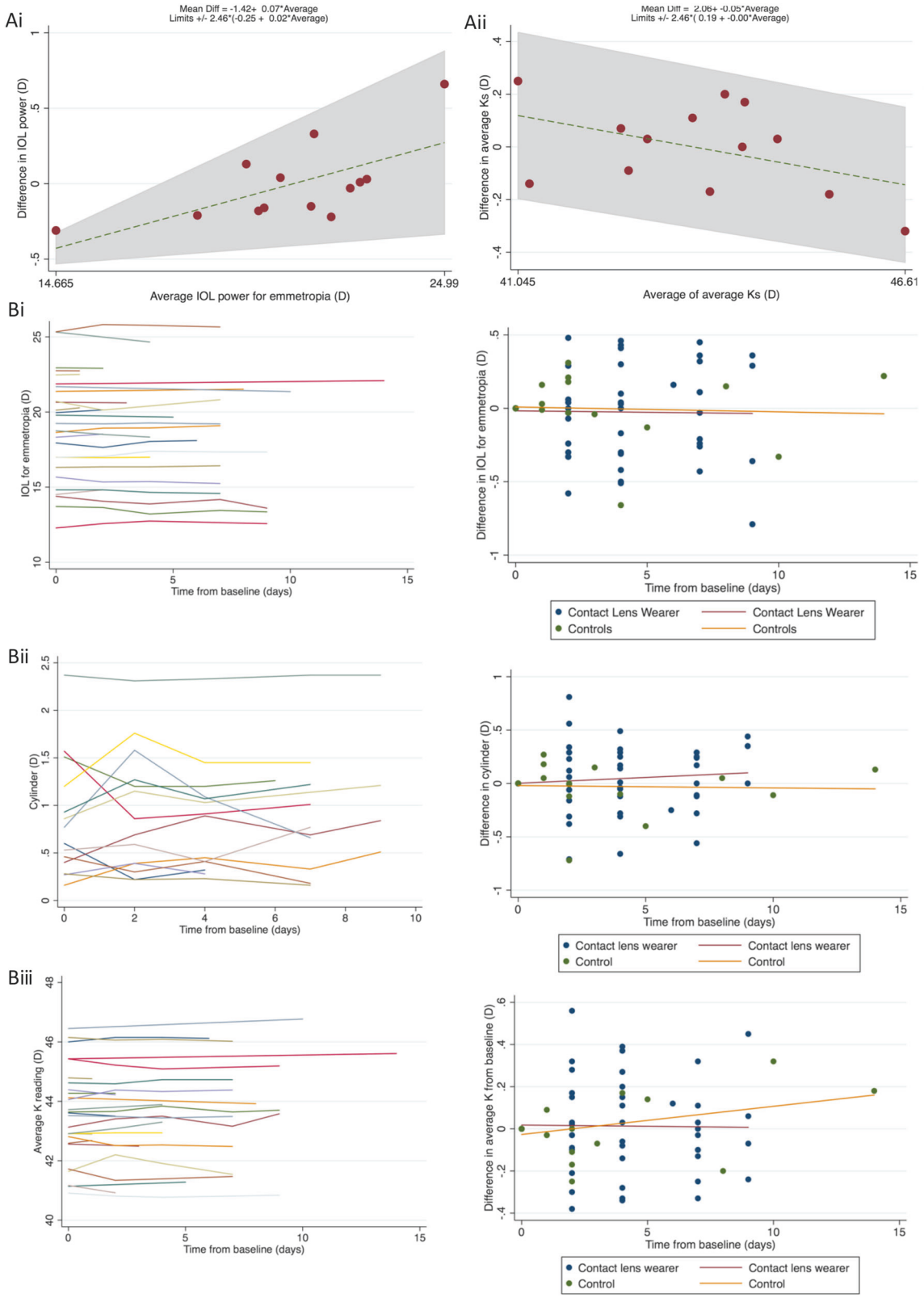

Fig. 1 **a** Bland–Altman plots comparing predicted IOL for emmetropia for repeat measures for controls (i) and average K-readings for repeat measures for controls (ii). **b** Change in predicted IOL power for emmetropia (i), corneal cylinder (ii) and average K-readings (iii) over time for contact lens wearers and controls

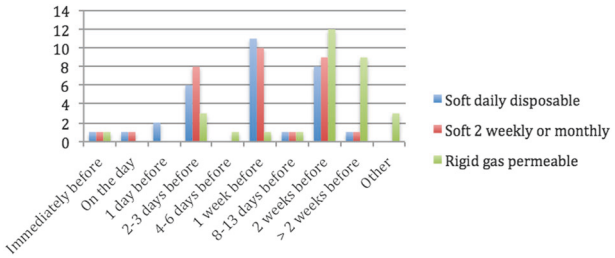

Fig. 2 Variation in advice about when to stop wearing contact lenses before biometry prior to cataract surgery: results from audit of current Scottish practice

were conducted using Stata, version 13 (StataCorp LP, Texas, USA) with the alpha level (type 1 error) set at 0.05.

Results

Demographic and clinical details of included subjects are shown in Table 1.

There was no significant difference in age or gender between groups. Eight of fourteen subjects wore daily disposable CLs, two wore 2-weekly and four wore monthly soft CLs. Contact lenses were worn on average for a median of 12 h per day (IQ range 10–14). Among controls, repeat biometry readings were taken a median of 2 days (IQ range 1.5–7) after the first reading. Twelve out of thirteen (92.3%) repeat biometry measures were within 0.5 D of the first predicted IOL for emmetropia, with an average absolute difference of 0.16+/−0.11 D (Fig. 1ai). All repeat average K-readings were within 0.4 D for controls with an average absolute difference of 0.12+/−0.09 D (Fig. 1aii).

Measurements from controls and contact lens-wearing subjects showed similar degrees of variation over time. The within-subject SD in predicted IOL power for emmetropia for contact lenses wearers was 0.20 D (95% CI 0.16–0.25 D) compared to 0.18 D (95% CI 0.12–0.26 D) for controls. Change in predicted IOL for emmetropia, cyclinder power and average K-readings over time is shown in Fig. 2.

The random coefficients model showed that there was no overall change in predicted IOL power over time as indicated by the *P* value of 0.910 for the variable TIME in Table 2. There was also no difference in change in estimated IOL for emmetropia over time between those wearing and not wearing contact lenses as indicated by the *P* value of 0.651 for the variable CONTACT LENS × TIME. Similar analyses for the left eyes of included subjects also found no significant change in predicted IOL for emmetropis over time ($P = 0.661$) and no difference between contact lens wearers and controls ($P = 0.722$). Similar analyses were conducted for average K-readings but there was no significant change in K-readings over time ($P = 0.976$) or effect of CL wear on change ($P = 0.726$; Table 2). Within-subject SD in average Ks was 0.14 D (95% CI 0.12–0.18 D) for subjects wearing contact lenses compared to 0.11 D (95% CI 0.07–0.16 D) for controls.

Table 2 Results of the random coefficients model examining the association between change in predicted IOL power for emmetropia and time from baseline biometry for contact lens wearers and the control group

Parameter	Coefficient	95% CI	*P* value
Predicted IOL Power			
Time (days from baseline)	0.001	−0.02 to 0.22	0.910
Contact lens (0 or 1)	3.67	1.52 to 5.82	0.001
Contact lens × time	−0.01	−0.05 to 0.03	0.651
Average K-readings			
TIme (days from baseline)	−0.0002	−0.01 to 0.01	0.976
Contact lens (0 or 1)	0.066	−1.08 to 1.21	0.910
Contact lens × time	0.004	−0.02 to 0.03	0.726

Similar results shown for change in average K-readings

There were 31 responses from the 89 consultant ophthalmologists in Scotland surveyed (35%). Twenty-seven out of thirty-one (87%) use IOLMaster. There was variation in practice, which is shown in Fig. 2.

Results from the audit of information that is available online to patients also show significant variation in advice. This is shown in Table 3.

Discussion

Our audit of current UK wide practice shows significant variation in advice given to patients regarding the timing of cessation of contact lens use (ranging from 1 to 14 days for soft contact lenses) prior to having biometry performed. This may well reflect the lack of objective evidence currently available. The audit of current practice within Scotland gave a similar wide variation in clinical practice from a response rate of 35%, which is similar to previously published electronic-questionnaire-based studies in ophthalmic research [5–7].

There are an estimated 125 million contact lens wearers worldwide [8], a significant proportion of whom will undergo cataract surgery.

Many contact lens wearers consider wearing spectacles, even for a few days, to be a major inconvenience. This was a commonly cited reason for non-participation in our study. Some individuals depend wholly on contact lenses and do not have a suitable pair of glasses to wear in the interval between contact lens removal and biometry. While this period of time (currently 48 h to 4 weeks based on Table 1) may seem insignificant, the inconvenience to the patient should be minimised and be evidence-based.

Table 3 Variation in advice about when to stop wearing contact lenses before biometry for cataract surgery, available online

Source	Lens type—recommended duration of abstinence			
RCOphth Cataract Guideline 2010[4]	Soft—1 week	Hard—4 weeks		
Moorfields Eye Hospital [16]	Soft—1 week	Hard—4 weeks	GP—4 weeks	
Moorfields Eye Hosp, Bedfordshire [17]	Soft—2 weeks		GP—4 weeks	
University Hospital Southampton [18]	Soft—48 h		GP—48 h	PMMA/scleral—'longer'
Royal Berkshire [19]	Soft—2 weeks	Hard—4 weeks		
East Kent Hospital [20]	Soft—24 h	Hard—1 week		
East Sussex Healthcare NHS Trust [21]	Any lens type—2 weeks			
London Eye Hospital [22]	Soft: daily disposable – 24 h, 2-weekly/monthly – 48 h, Extended wear—1 week		RGP—2 weeks	

GP gas-permeable, *RGP* rigid gas-permeable, *PMMA* poly(methyl methacrylate)

While we could find no published studies specifically looking at the effect of the timing of the cessation of contact lens use prior to biometry on the predicted refractive result, there have been a number of studies looking at the effects of contact lens use on the cornea.

Tyagi et al. [9] measured corneal thickness and topography (using the Pentacam) in healthy soft contact lens wearers before and after 8 h of contact lens wear and on 2 days without lens wear. They found that, despite regional changes in corneal shape, the magnitude of these changes was less than that of the natural diurnal variation.

Ng et al. [10] performed a masked, prospective study to assess corneal refractive stability after soft contact lens wear, in photorefractive candidates. Manifest refraction, keratometry, corneal topography and optical pachymetry were performed 7 days after contact lens removal and then at 14 day intervals up to 84 days. The time to stability varied depending on the parameter measured, varying from 10.7 days (+/−10.4 days) with manifest refraction to 35.1 days (+/−20.8 days) with pachymetry.

Hashemi et al. [11] looked more specifically at short-term corneal stability in a group of soft contact lens wearers prior to refractive surgery. Their non-controlled, prospective study suggested that a proportion (7 out of 21) of eyes required at least 3 days to reach stability after contact lens removal, using the EyeSys Corneal Analysis System to provide topography and keratometry. The EyeSys Corneal Analysis System was developed for corneal topography over 20 years ago [12] and has since been superseded by more modern machines. A more recent study by the same group determined and compared the repeatability of keratometry measurements using different techniques [13]. Of the five methods tested they found IOLMaster, which we used in this study, to provide the most repeatable and reproducible keratometry values, while the least repeatable and reproducable results were given by EyeSys. In the audit of current practice within Scotland, 87% of consultants who responded use IOLMaster to perform biometry prior to cataract surgery.

The IOLMaster produces a large amount of data for each biometry test, including K1, K2, average K, spherical equivalent, cylinder and axis and axial length before providing predicted refractive outcomes.

There was no statistically significant difference in either the predicted IOL power or the average K-readings (Table 2) at any of the time points; 2, 4 or 7 days after cessation of contact lens use when compared with the immediate post-contact lens removal measurements. Figure 2 shows the change in the estimated 'Emmetropic IOL' for contact lens wearers and controls. Although these data are calculated based on a number of the other variables, this gives the most practical outcome measure. To minimise confounding factors we analysed data for the right eye of each participant only. When we repeated our analysis for the left eye only, our results were the same. These results allow us to conclude that in the group studied, contact lens use had no significant effect on the shape of the cornea. Biometry measurements in our participants provided stable IOL choices regardless of when contact lenses were removed in relation to the measurement.

All of the participants in our prospective study used soft contact lenses. Soft lenses are the most commonly used [8], and it is likely that when compared to hard or rigid alternatives, they will have less of an influence on the shape of the cornea. Our results suggest that any change in corneal shape following soft contact lens does not affect the results of biometry, using the IOLMaster.

This study has a number of limitations, the most obvious one being the small number of participants. This reflected a combination of factors; the study protocol required four attendances over a period of a week and the significant number of potential participants that when approached did not want to abstain from contact lens use for a week. Small study numbers meant that we were unable to analyse

variations in subgroups, for example, to determine whether variables such as contact lens power, myopic vs. hypermetropic contact lens correction, number of years of contact lens use and frequency of contact lens use had any influence on outcomes. The other weakness in our study was the mismatch between average age of our participants; 37 (range 23–69) and the average age of patients undergoing cataract surgery. As we age, the cornea changes in a number of structural and functional way [14, 15]. Biomechanical properties such as corneal hysteresis (indicating viscosity) and corneal resistance factor (indicating elasticity) have both been shown to decrease with age. This may influence the normalisation of corneal shape after lens removal; however, given the small study numbers and the lack of significant change in corneal shape in any of our participants after 7 days, there was no merit in analysing the data based on age or corneal biomechanical properties. Our study therefore does not address the question of how ageing affects the resolution of corneal shape after contact lens removal.

Conclusion

In conclusion, we have highlighted significant variation in UK practice with regards to advice on the timing of cessation of contact lens wear prior to having biometry performed. Our prospective, controlled study showed that any change in corneal shape following soft contact lens use does not significantly affect biometry, therefore, has no impact on IOL choice or refractive outcome. This suggests that soft contact lens wearers are currently being advised to remove their contact lenses for an unnecessarily long period of time prior to having biometry performed.

Summary

What was known before

- Contact lens use alters the shape of the cornea, which affects the results of biometry, an investigation that is essential before cataract surgery.
- There is no clear evidence about when to remove contact lenses before performing biometry to provide accurate measurements.

What this study adds

- Advise regarding when to remove contact lenses prior to biometry varies, depending on surgeon, hospital and region within the UK.
- In our group of soft contact lens wearers, change in corneal shape after contact lens use did not significantly affect biometry, therefore, has no impact on IOL choice or refractive outcome.
- Soft contact lens wearers are being advised to remove their lenses for an unnecessarily long time prior to assessment for cataract surgery.

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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