Corneal parameters among normal Egyptians with Pentacam Scheimpflug camera

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Received 16 May 2017
Accepted 22 June 2017

The Egyptian Journal of Cataract and Refractive Surgery 2017, 23:17–22

Purpose
The aim of the study was to evaluate the corneal parameters [anterior and posterior elevation, keratometry values in the steep (K_1) and flat (K_2) meridians, central corneal thickness, and thinnest location] among normal Egyptians of different age with Pentacam Scheimpflug camera and to detect repeatability of Pentacam.
Patients and methods
A total of 2000 randomly chosen participants representing normal Egyptian population presenting to the outpatient clinic of the Ophthalmic Center were included in the study. They were aged from 20 to 60 years and included both sexes. They were divided into four groups. All patients were examined by Pentacam Tomey TMS-5 (topographic modeling system). The technique was repeated three times for each eye on the same day and three times the next day by two different observers.
Results
There were statistically significant differences in anterior elevation, posterior elevation, central corneal thickness, thinnest location, and K_2 between the four groups (P=0.02, <0.001, 0.001, 0.002, and 0.004, respectively). However, there was no statistically significant difference in K_1 between the four groups (P=0.092). Coefficient of variation for K_1 and K_2 was 0.17 and 0.19, respectively.
Conclusion
There were increases in the values of posterior elevation, K_1, and K_2 with the aging process. Excellent intraobserver and interobserver repeatability for K_1, K_2, and pachymetry maps and poor intraobserver and interobserver repeatability for astigmatism axis were observed.

Keywords:
cornea, pentacam, scheimpflug

Egypt J Cataract Refract 23:17–22

1687-6997

Introduction

Anatomical and functional changes happen in eye tissues as much as all in other tissues in the body because of aging [1].

Many ocular structures develop until the age of 14 years, but the lens keeps on changing through a lifetime [2].

The Pentacam is a popular device for detecting the anterior segment of the eye. Previous studies have shown excellent reproducibility of this device for automated measurements of the anterior segment structures [3,4].

Despite several reports on corneal thickness, anterior and posterior corneal curvature, and elevation measurements, little is known about the distribution of these measurements in the normal population and its relation to their age groups [5,6].

The aim of the work was to evaluate the anterior segment parameters [anterior and posterior elevation, K_1, K_2, central corneal thickness (CCT), and thinnest location] according to age with Pentacam Scheimpflug camera and to detect reproducibility and repeatability of Pentacam.

Patients and methods

A total of 2000 randomly chosen normal Egyptian individuals presenting to the outpatient clinic of Mansoura Ophthalmic Center from January 2016 to June 2017 aged 20–60 years from both sexes were included in the study. They were divided into four groups according to their age: group 1 from 20 to 29 years, group 2 from 30 to 39 years, group 3 from 40 to 49 years, and group 4 from 50 to 59 years.

The study was approved by the hospital's ethics committee and followed the tenants of declaration of

 DOI: 10.4103/JCRS.JCRS_8_17

Helsinki; duly signed informed consent forms were taken from all patients.

The exclusion criteria included the following: prior history of significant ocular disease, ocular surgery, irregular or abnormal cornea media, opacity, poor-quality image, glaucoma, ocular tumors or trauma, error of refraction more than ±0.5, pregnant female, history of uveitis, and retinal disease.

All participants underwent complete ocular examination including a Snellen best-corrected visual acuity test and slit lamp biomicroscopy to ensure absence of corneal opacity or irregularity, normal anterior chamber; normal iris with no atrophic patches, posterior synechiae, or rubeosis iridis; the state of the crystalline lens with no lens opacities, and absence of previous ocular surgery.

Intraocular pressure was measured by the Goldmann applanation tonometry and dilated fundus examination.

All eyes were examined by Pentacam.

Pentacam

The Pentacam used in this study was Tomey TMS-5 (Tomey GmbH, Technology and Vision, Nürnberg, Germany) (topographic modeling system).

TMS-5 consists of a placid ring topographer and a rotating 3D Scheimpflug camera. This rotating process supplies pictures in three dimensions and also allows the center of the cornea to be measured precisely. In addition, the Pentacam contains a second camera that detects any residual eye movements, which are corrected for by the Pentacam's software [7]. The Pentacam is the only camera whose software includes an algorithm for automatic distortion correction [8].

It takes a maximum of 2 s to generate a complete image of the anterior eye segment [9].

Technique

The patient was asked to keep his or her eye open and fixed; the image was focused and centered. After which the software automatically began taking the measurements.

The technique was repeated three times for each eye on the same day and three times the next day by two different observers. Coefficient of variation (COV) was assessed to check repeatability and reproducibility. COV was calculated as the ratio of subject's SD to overall mean. A smaller COV means that repeatability was higher.

The following data were obtained: keratomery values in the steep (K_1) and flat (K_2) meridians, corneal astigmatism (cylinder), corneal thickness at the center (central pachymetry) and at thinnest location of the cornea (minimal pachymetry), and local elevation (anterior and posterior elevation) values.

Data analysis

Data were analyzed using SPSS version 23.0 (SPSS Inc., Chicago, Illinois, USA). Qualitative data were described using number and percent. Quantitative data were described using Kolmogrov–Smirnov test. Significance of the obtained results was judged at the 5% level.

Results

A total of 2000 participants (4000 eyes), comprising 1148 (57.4%) female and 852 (42.6%) male participants, were included in the study. Demographic characteristics are shown in Table 1.

In group 1, the mean anterior elevation, posterior elevation, CCT, thinnest location, K_1, and K_2 were 5.99±2.5, 11.69±4.4, 539.19±36.6, 534.04±37.01, 42.84±1.4, and 44.15±1.62, respectively.

In group 2, the mean anterior elevation, posterior elevation, CCT, thinnest location, K_1, and K_2 were 5.86±2.8, 12.59±5.1, 528.43±35.9, 523.35±35.7, 42.93±1.7, and 44.51±1.85, respectively.

In group 3, the mean anterior elevation, posterior elevation, CCT, thinnest location, K_1, and K_2 were 6.1±3.41, 13.27±4.97, 536.04±26.8, 530.34±27.99, 42.9±1.6, and 44.57±1.94, respectively.

In group 4, the mean anterior elevation, posterior elevation, CCT, thinnest location, K_1, and K_2 were 5.34±2.7, 13.2±4.8, 531.9±33.11, 527.16±32.55, 45.14±24.2, and 44.63±1.68, respectively.

There was a statistically significant difference in anterior elevation, posterior elevation, CCT, thinnest location,

Table 1 Demographic characteristics of the studied groups

Groups	Age (mean±SD)	Sex [*n* (%)]	
		Male	Female
Group 1 (*n*=666)	24.02±3.08	282 (42.3)	384 (57.6)
Group 2 (*n*=548)	33.55±2.9	240 (43.8)	308 (56.2)
Group 3 (*n*=294)	42.74±2.68	118 (40.1)	176 (59.9)
Group 4 (*n*=488)	56.28±3.2	208 (42.6)	280 (57.4)

and K_2 between the four groups, with P values being 0.02, less than 0.001, 0.001, 0.002, 0.004, respectively; however, there was no statistically significant difference in K_2 between the four groups, with P value being 0.092 (Table 2).

Anterior elevation value was highest in group 3 and lowest in group 4, whereas posterior elevation value was highest in group 3 and lowest in group 1. On the contrary, CCT and thickness of the thinnest corneal location values were highest in group 1 and lowest in group 2. K1 and K2 values were highest in group 4 and lowest in group 1.

Age is a significant predictor for K_2 in 1.2% of patients (K_2=43.88+0.015×age) (Table 3 and Fig. 1).

Age is a significant predictor for posterior elevation in 1.7% of patients (posterior elevation=10.71+0.049×age) (Table 4 and Fig. 2).

Age is a nonsignificant predictor of anterior elevation, CCT, thinnest location, and K_1, as P values were 0.013, 0.023, 0.031, and 0.034, respectively.

The most common form was regular astigmatism (with rule). It was present in 1800 participants (3600 eyes, 90%) (Figs 3–5).

COV of K_1, K_2, central thickness, and astigmatism axis were 0.17, 0.19, 0.15, and 0.5, respectively.

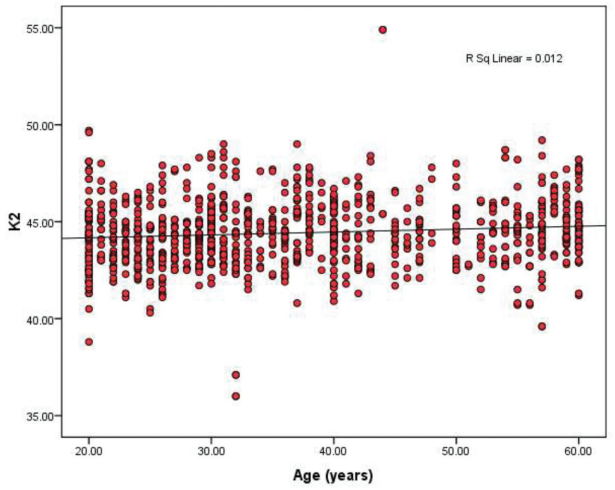
Results of correlation analysis for corneal parameters showed a strong positive correlation between anterior elevation and posterior elevation (r=0.58, P<0.001) and between CCT and thinnest location (r=0.98, P<0.001).

Discussion

Corneal aging produces both structural and functional changes. These changes affect the ability of the organ to refract light, to repair itself, and to protect itself and the internal structures. A variety of corneal aging changes have been reported [10].

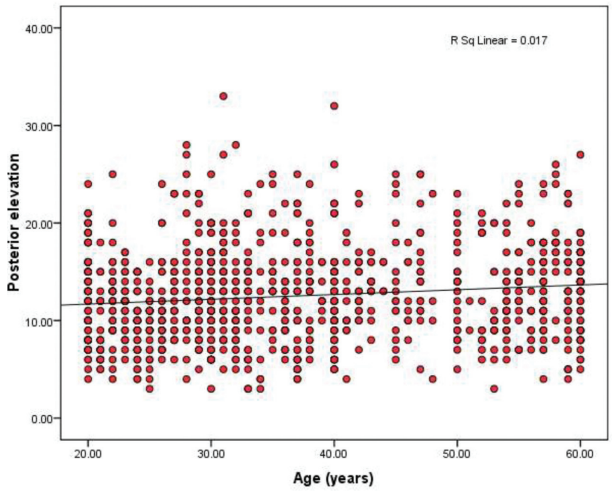
Changes in the shape and optical properties in the form of steepening of keratometry and shift from, with the rule to against the rule astigmatism, increase of Descemet membrane thickness, and intramolecular and interfibrillar spacing increase via increased

Figure 1



Age as a significant predictor for K_2 in 1.2% of patients (K_2=43.88 +0.015×age).

Figure 2



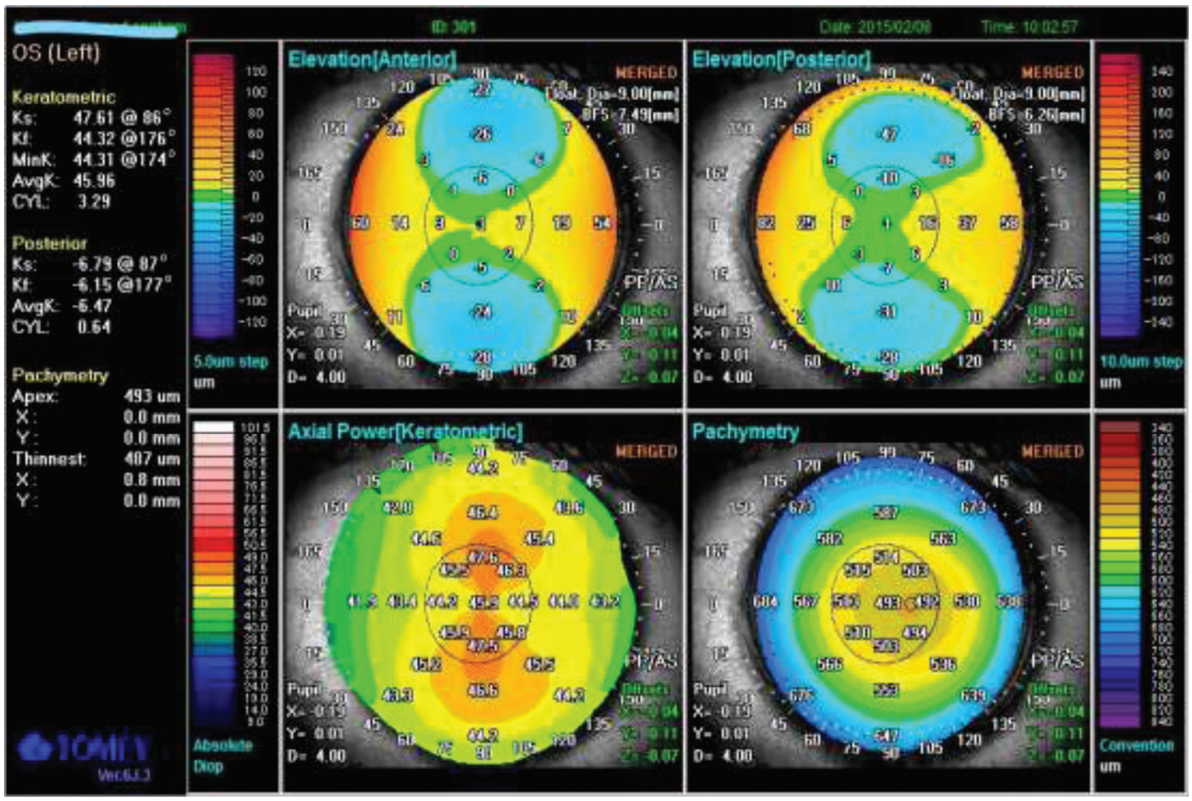
Age as a significant predictor for posterior elevation in 1.7% of patients (posterior elevation=10.71+0.049×age).

Table 2 Corneal parameters between the studied groups

	Group 1 (mean±SD)	Group 2 (mean±SD)	Group 3 (mean±SD)	Group 4 (mean±SD)	Test of significance (P)
Anterior elevation	5.99±2.5^{A}	5.86±2.8^{B}	6.1±3.41^{C}	5.34±2.7^{A,B,C}	0.02*
Posterior elevation	11.69±4.4 ^{A,B,C}	12.59±5.1^{A}	13.27±4.97^{B}	13.2±4.8^{C}	<0.001**
CCT	539.19±36.6^{A,B}	528.43±35.9^{A,C}	536.04±26.8^{C}	531.9±33.11^{B}	0.001**
Thinnest location	534.04±37.01^{A,B}	523.35±35.7^{A,C}	530.34±27.99^{C}	527.16±32.55^{B}	0.002**
K_1	42.84±1.4^{A}	42.93±1.7^{B}	42.9±1.6	45.14±24.2^{A,B}	0.092
K_2	44.15±1.62^{A,B,C}	44.51±1.85^{A}	44.57±1.94^{B}	44.63±1.68^{C}	0.004**

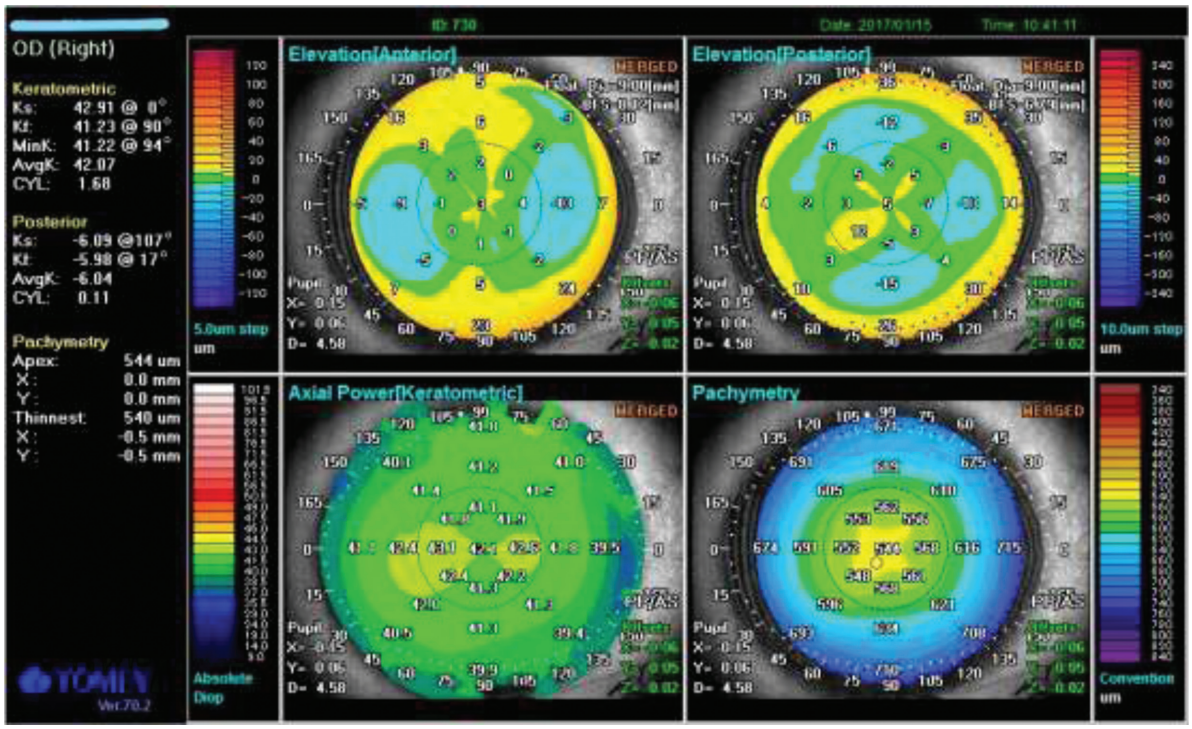
Similar letters denote significant difference between the studied groups by post-hoc LSD test; CCT, central corneal thickness; $^{**}P$<0.01, high statistically significant.

Figure 3



A case of regular astigmatism with the rule (symmetrical bow tie).

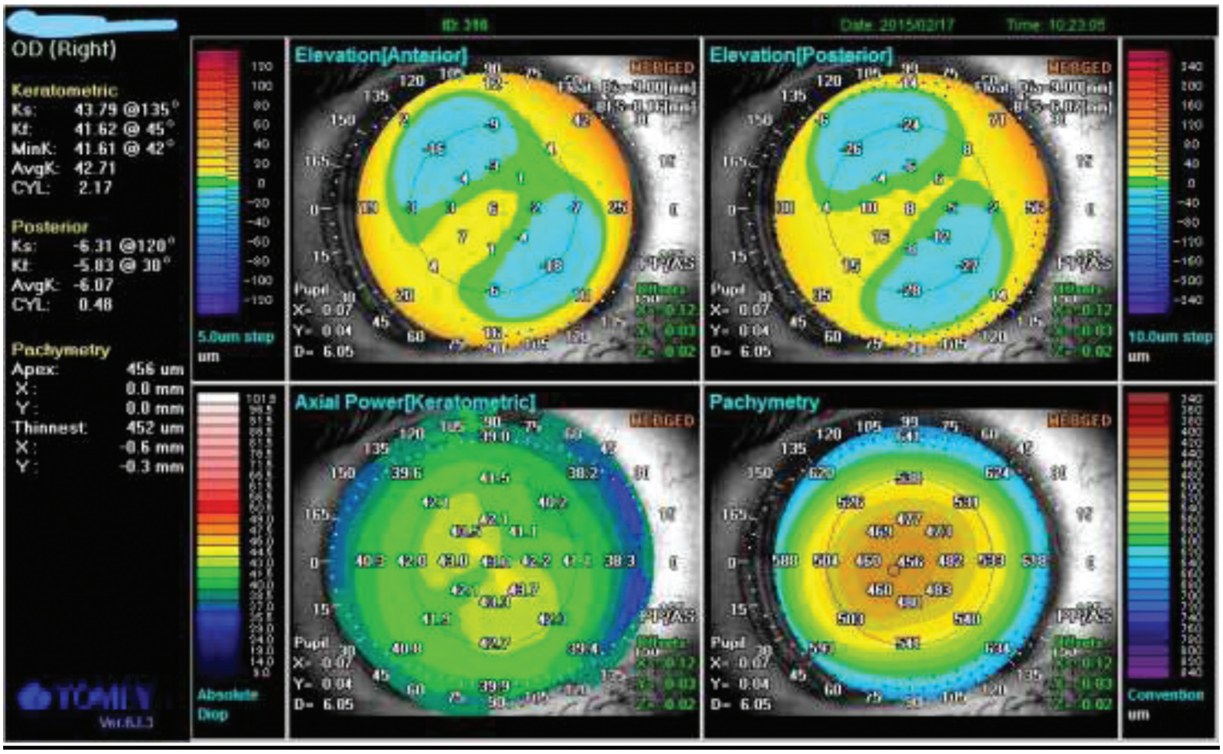
Figure 4



Against the rule astigmatism (asymmetrical bow tie).

protein glycation. Physical properties of the cornea are affected by decreased resistance to infection, decreased phagocytically active cell after infection, and increased epithelium permeability to fluorescein [11].

Figure 5



A case of oblique astigmatism.

Table 3 Linear regression model to predict K_2 associated with age

Predictor	β	P	r^2
Age	0.015	0.001**	0.012
K_2=43.88+0.015×age			

This table shows that age is a significant predictor for K_2 in 1.2% of patients (K_2=43.88+0.015×age).

Table 4 Linear regression model to predict posterior elevation associated with age

Predictor	β	P	r^2
Age	0.049	<0.001**	0.017
Posterior elevation=10.71+0.049×age			

Corneal parameters may change with aging as anterior elevation, posterior elevation, K_1, K_2, anterior elevation, posterior elevation, CCT, thinnest location and plays an important role in diagnosing some eye pathologies such as glaucoma, corneal dystrophy, and keratoconus.

There are various tools to analyze those parameters such as ultrasound biomicroscopy, the Pentacam Scheimpflug camera, anterior segment optic coherence tomography, and Orbscan [12].

CCT plays an important role in diagnosis of glaucoma, as 10% increase of CCT causes increase in intraocular pressure of 3.4 mmHg with Goldman applanation tonometer [13].

These parameters, such as CCT, thinnest location, K_1, K_2, anterior elevation, and posterior elevation, are very important in refractive operations especially in myopic patient as thickness of the cornea may lead to development keratectasia with stromal ablation [14].

In addition, in ring application and collagen cross linkage, if CCT is less than 400 µm, it will lead to extrusion of the implant and endothelial decompensation [14,15].

In this study, the changes in the anterior segment parameters with the age were investigated. The data were obtained via Pentacam Tomey TMS-5 rotating Scheimpflug camera system.

When examining the CCT with the age, there are significant differences between group 1 and group 2 and group 1 and 4, as mean±SD in groups 1, 2, and 4 were 539.19±36.6, 528.43±35.9, and 531.9±33.11, respectively.

These results are similar to Rüfer *et al.* [16], who studied for 5 years changes in CCT and found the thickness decreases with age.

However, in another study, there was no difference between the age groups of 8–16 years old and the age groups of 30–68 years [17].

In this study, regarding keratometry, K_1 and K_2 were increased with the age, and there were significant differences of K_2 between groups 1 and 2 and groups 3 and 4, as mean±SD in groups 1, 2, 3, and 4 were 11.69±4.4, 12.59±5.11, 13.27±4.97, and 13.2±4.8, respectively. There was no significant difference between K_1 in the different age groups.

In addition, Emre *et al*. [17], and Jonsson *et al*. [18], found a decrease in *K* reading because of age.

When examining anterior elevation with the age, there were significant differences between groups, as mean± SD in groups 1, 2, 3, and 4 were 5.99±2.5, 5.86±2.8, 6.1±3.41, and 5.34±2.7, respectively.

When examining posterior elevation with the age, there were highly significant differences between the groups as mean±SD in groups 1, 2, 3, and 4 were 11.69±4.4, 12.59±5.1, 13.27±4.97, and 13.2±4.8, respectively.

Good precise and excellent intraobserver and interobserver repeatability were observed for K_1, K_2, and pachymetry maps. Poor precision and poor intraobserver and interobserver repeatability were reported for axis of cylinder.

Moreover, Chen *et al*. [4] reported good reproducibility of Pentacam for keratometry in the steep and flat meridians.

Although the Pentacam is a very useful clinical and research tool, the measurement of corneal axes should be interpreted with caution.

In this study, we reviewed corneal parameters in different age groups. There were increases in posterior elevation, K_1, and K_2 with the aging process; alterations in corneal parameters should be considered in refractive surgery. The Pentacam is a noncontact screening device with high repeatability. It is quite comfortable for the patient, does not require local anesthesia, and has no risk of corneal erosion. With one single measurement, numerical data can be acquired.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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