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Fluid reservoir thickness and corneal oedema during closed eye scleral lens wear: experimental and theoretical outcomes

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We thank the authors [1] for their interest in our recent paper [2] which examined the effect of fluid reservoir thickness upon scleral lens-induced corneal oedema under closed eye conditions following 90 minutes of unilateral highly oxygen permeable scleral lens wear.

The authors suggest [1] that “*the main finding of this work is that closed-eye corneal swelling after 90 min of wear appears to be less than that for closed-eye overnight wear.*” However, this was an expected result and not the primary focus of this repeated measures experiment. As outlined in the discussion of the paper [2], since the participants in our study wore a scleral lens in one eye only for 90 minutes with the eyelid closed and patched, and the fellow non-lens wearing eye open, the magnitude of oedema would be expected to be less than that observed after overnight scleral lens wear with bilateral eyelid closure [3,4].

The main finding from our experiment [2] was that the rate of change in corneal oedema with increasing fluid reservoir thickness, irrespective of the overall magnitude of corneal oedema induced, differed substantially from the rate of change in predicted corneal oedema with increasing fluid reservoir thickness reported in a theoretical model of overnight closed eye scleral lens wear [5]. These data were presented in Figure 2 of our paper [2] and for clarity, we have replotted these data [2] and data from the theoretical model across a range of scleral lens Dk/t values [5], relative to the thinnest fluid reservoir condition (without data extrapolation). This highlights the difference observed in the rate of change (slope) in corneal oedema, as a function of fluid reservoir thickness, between the measured data [2] and theoretical model [5] (Figure 1).

The authors suggest [1] that the observed difference in the rate of change in corneal oedema with increasing fluid reservoir thickness between our short-term repeated measures unilateral closed eye experiment [2] and the overnight closed eye model [5] is ‘*because the edema-model predictions apply to the larger observed overnight swellings for which PoLTF thickness plays a more sensitive role.’* They further explain that ‘*Small changes of oxygen tension at the ocular surface result in more change in the corneal thickness when the cornea is under extreme hypoxic stress than when the cornea is under minimal hypoxic stress.*’ If this were the case (i.e. more hypoxic stress results in a greater rate of change in corneal oedema with increasing fluid reservoir thickness), then the following results would be anticipated.

1. A greater rate of change in corneal oedema with increasing fluid reservoir thickness should be observed under closed eye conditions (more hypoxic stress) than open eye conditions (as predicted in theoretical modelling [5]). However, this was not observed in the repeated measures experiments using the same participants and protocol, under open and closed eye

conditions, when controlling for other variables such as wearing time, lens Dk/t, and fluid reservoir thickness (Figure 2) [2,6]. In fact, the opposite is observed, with a steeper slope for the open eye lens wear condition (i.e. more hypoxic stress does not result in a greater rate of change in corneal oedema with increasing fluid reservoir thickness).

2. Theoretical modelling should show an increase in the rate of change in corneal oedema with increasing fluid reservoir thickness (an increase in the slope of the data) as hypoxic stress increases. That is, an increase in the slope of the data should be apparent as lens Dk/t decreases (greater hypoxic stress). However, the theoretical modelling [5] shows the opposite effect, with an increase in the slope of the data with increasing Dk/t (Figure 3). This is also apparent in Figure 1.

We agree with the authors [1] that theoretical models can be useful tools, however, the unresolved differences between theoretical calculations and measured corneal oedema under controlled conditions require further investigation.

References

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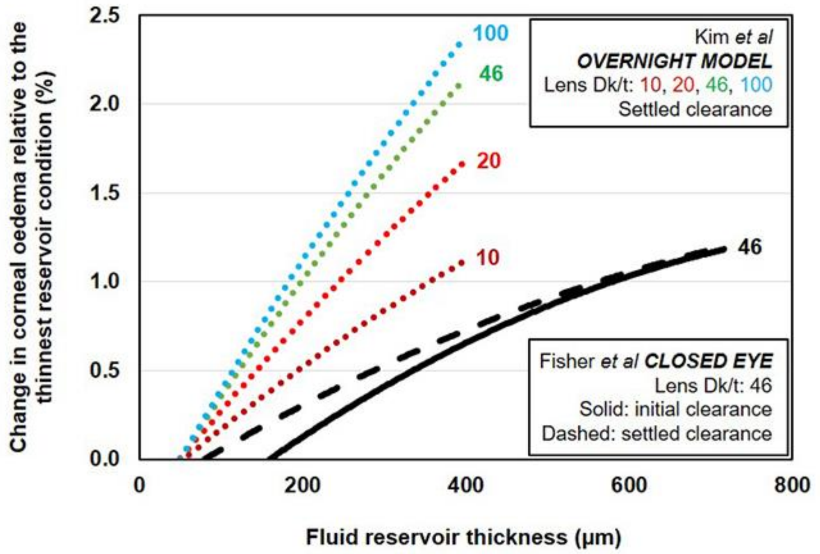

Figure 1. The change in predicted corneal oedema relative to the thinnest fluid reservoir condition for a theoretical model of closed eye overnight scleral lens wear without data extrapolation (lens Dk/t 10 to 100, coloured lines) [5] and the change in corneal oedema measured using optical coherence tomography in young healthy participants (lens Dk/t 46, black lines) following 90 minutes of unilateral closed eye scleral lens wear [2].

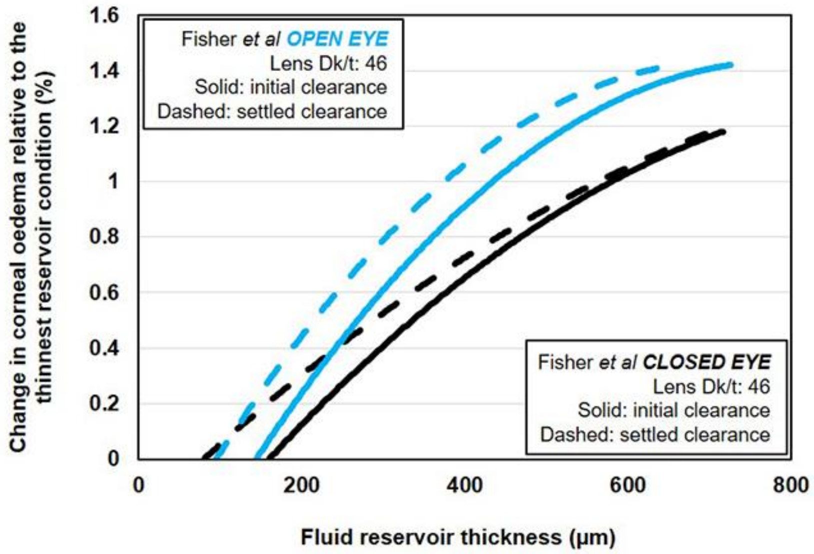

Figure 2. The change in corneal oedema relative to the thinnest fluid reservoir condition measured using optical coherence tomography in young healthy participants (lens Dk/t 46) following 90 minutes of unilateral open (blue lines) [6] and closed eye (black lines) [2] scleral lens wear. The rate of change in corneal oedema with increasing fluid reservoir thickness was greater for open eye lens wear compared to closed eye lens wear.

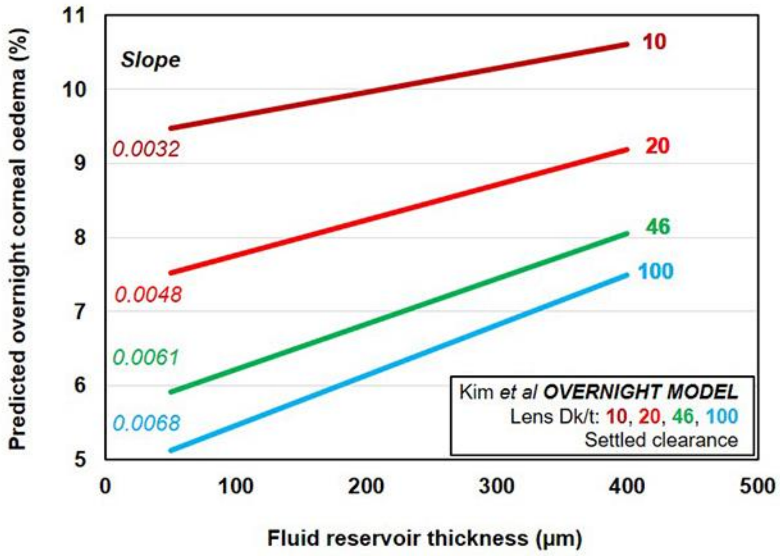

Figure 3. Predicted corneal oedema data from a theoretical model of closed eye overnight scleral lens wear (without extrapolation) [5] as a function of fluid reservoir thickness. The slope of the data (italicised numbers) increases with increasing lens Dk/t, which is not consistent with the contention that greater hypoxic stress leads to an increase in the rate of corneal oedema with increasing fluid reservoir thickness.