TEAR MENISCUS DISTRIBUTION ALONG THE LOWER LID MARGIN

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INTRODUCTION

As approximately 75–90% of the total tear volume is contained within the lower tear meniscus, measurement of tear meniscus height (TMH) is considered a reliable and non-invasive method for assessing tear film volume. To ensure standardized and reproducible measurements, TMH should be determined within 1 mm of the pupil center, as tear distribution along the lower lid margin may vary. The timing of the measurement after blinking should also be standardized. Measurements obtained between 1.0 and 2.5 seconds after the second of two non-forced blinks have been shown to provide the most robust and reproducible results. However, TMH may vary along the lower lid margin, raising the question of whether a single measurement adequately represents the spatial distribution of the tear meniscus. Recent imaging techniques allow TMH to be quantified at multiple positions along the lower lid margin, enabling the assessment of minimum, maximum, and mean TMH.

PURPOSE

The aim of this study was therefore to assess the agreement between centrally measured TMH and the minimum, maximum, and mean values determined for a 12-mm zone along the lower lid margin.

METHODS

Thirty-two participants (mean age, 25.4 ± 3.8 years; 22 female and 10 male) were recruited from the clinical facilities of the Cologne School of Optometry. For each participant, the lower tear meniscus was imaged 1.0–2.5 seconds after the second of two non-forced blinks using the TERA Dry Eye Imager (Topcon Healthcare, Tokyo, Japan) (Fig. 1). Central tear meniscus height (TMH) was manually measured at the central position using the caliper tool on the captured image (Fig. 3). In addition, TMH was manually measured at five predefined locations along the lower lid margin to assess the spatial distribution of the tear meniscus (Fig. 3). Based on these five measurements, the instrument software automatically delineated the boundaries of the tear meniscus and subsequently calculated the minimum, maximum, and mean TMH.

The associations between centrally measured TMH and the minimum, maximum, and mean TMH obtained from the five-point measurements were assessed using Spearman's rank correlation coefficient. Agreement between the central measurement and the respective minimum, maximum, and mean TMH values was evaluated using Bland–Altman analysis and paired t-tests.



Fig. 1: TERA Dry Eye Imager used for tear meniscus imaging (Topcon Healthcare, Tokyo, Japan).

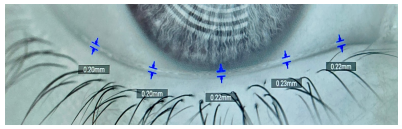


Fig. 2. Screenshot showing tear meniscus height measurements at five positions along the lower lid margin.

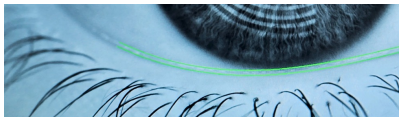


Fig. 3: Screenshot showing the spatial distribution of tear meniscus height along the lower lid margin.

RESULTS

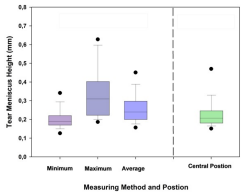


Fig. 4. Distribution of centrally measured TMH and the minimum, maximum, and mean TMH obtained from the five-point measurements. Boxes indicate the interquartile range, horizontal lines the median, whiskers the range, and points indicate outliers.

Mean centrally measured TMH was 0.246 ± 0.084 mm. Mean minimum, maximum and average TMH obtained from the five-point measurements were 0.202 ± 0.058 mm, 0.336 ± 0.137 mm and 0.260 ± 0.080 mm, respectively (Fig. 4). Central TMH showed a strong correlation with the minimum TMH (Spearman's ρ = 0.890, p <0.001), a moderate-to-strong correlation with the maximum TMH (ρ = 0.665, p < 0.001), and a strong correlation with the five-point mean TMH (ρ = 0.768, p <0.001) (Fig. 5). Paired comparisons revealed that central TMH was significantly higher than the minimum TMH (mean difference +0.043 mm, p < 0.001) and significantly lower than the maximum TMH (−0.090 mm, p < 0.001). In contrast, there was no significant difference between central and five-point mean TMH (−0.014 mm, p = 0.093).

Bland–Altman analysis showed a mean bias of +0.043 mm between central and minimum TMH, with 95% limits of agreement (LoA) from −0.043 to +0.129 mm. For central versus maximum TMH, the mean bias was −0.090 mm (95% LoA: −0.288 to +0.108 mm). For central versus five-point mean TMH, the bias was −0.014 mm, with 95% LoA of −0.099 to +0.072 mm (Fig. 6).

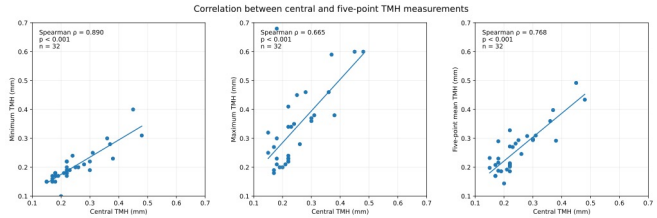


Fig. 5. Correlations between central TMH and minimum (left), maximum (middle), and mean TMH (right) measured across five positions along the lower lid margin.

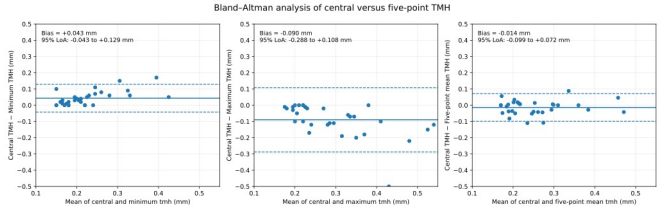


Fig. 6. Bland–Altman plots showing the agreement between centrally measured TMH and the minimum (left), maximum (middle), and five-point mean TMH (right). The solid line represents the mean bias, and the dashed lines indicate the 95% limits of agreement (LoA).

CONCLUSION

- Central TMH showed no significant difference from five-point mean TMH.
- Central TMH therefore provides a reasonable estimate of average TMH.
- Central TMH does not capture spatial extremes of the tear meniscus; multi-point measurements provide additional information when spatial distribution is relevant.

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