

Comparison of subjective and objective assessments of tear film stability in patients scheduled for cataract surgery

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The aim of this study was to compare subjective and objective assessments of tear film break-up time (TBUT). Data from 61 eyes of patients referred for cataract surgery were analyzed. The results of subjectively assessed fluorescein tear film break-up time (FBUT) and objectively assessed non-invasive break-up time (NIKBUT) were compared to subjective analysis of image sequences recorded by Oculus Keratograph 5M (K5M). Significant differences between the assessment methods, with the subjective NIKBUT evaluation yielding systematically longer TBUT values. Bland–Altman analysis confirmed the lack of interchangeability between invasive and noninvasive methods. The Poor agreement between objective and subjective NIKBUT requires further analysis.

Keywords: tear film break-up time; NIKBUT; FBUT; subjective assessment; Keratograph 5M

INTRODUCTION

Tear film stability is a key factor in maintaining normal ocular surface function and visual quality. One of the primary parameters used to assess tear film stability is tear film break-up time (TBUT), which is widely applied in the diagnosis of ocular surface disease (OSD). Conventionally, TBUT is assessed clinically using fluorescein (fluorescein tear break-up time, FBUT) however, this method is largely observer-dependent and influenced by examination conditions [1]. In response to these limitations, non-invasive measurement techniques have been developed, allowing for objective assessment of tear film stability [2].

Comparative studies have demonstrated significant discrepancies between TBUT values obtained using fluorescein-based and non-invasive methods, suggesting that individual techniques capture different aspects of tear film instability [2,3]. A greater disagreement was observed in healthy eyes than in eyes with OSD [1]. The incidence of OSD increases with age, and tear film assessment should be routinely performed before surgical procedures. The aim of this study was to compare methods for assessing tear film stability in older adults referred for cataract surgery and to determine differences in results between the various assessment methods.

METHODS

The study included 61 participants. Tear film stability was assessed using Oculus Keratograph 5M (K5M), which projects Placido rings onto the corneal surface and detects tear film break-up based on distortions in their reflected pattern. Three image sequences at 16 Hz were recorded on the eye scheduled for cataract surgery. The device software automatically detects the moment of the first local distortion of the Placido rings, reported as non-invasive keratograph break-up time (NIKBUT_obj). Subsequently, FBUT was evaluated clinically using a slit-lamp examination.

Additionally, the image sequences obtained from the K5M were analyzed subjectively using a custom-developed Matlab interface. The analysis involved visually identifying the first frame that

showed a local distortion or discontinuity of the reflected Placido ring pattern, which was interpreted as subjective tear film break-up (NIK BUT_sub). The mean value of three measurements was calculated for each method and used for further analysis.

RESULTS

The distributions of FBUT, NIK BUT_obj and NIK BUT_sub significantly deviated from normality (Shapiro–Wilk test, $p < 0.01$). Therefore, non-parametric statistical methods were applied for further analysis.

TBUT values differed depending on the applied measurement method. The shortest break-up times were observed for FBUT (median: 8.0 s; IQR: 6.3 s), followed by NIK BUT_obj (median: 11.34 s; IQR: 9.8 s), while the highest values were obtained for NIK BUT_sub (median: 14.3 s; IQR: 18.5 s). The distribution of results for individual methods is presented in the boxplot in fig. 1.

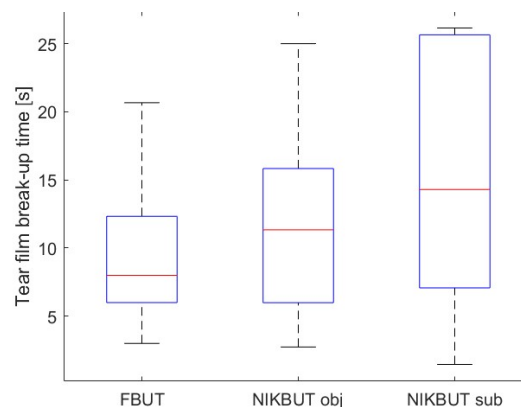


Figure. 1. Boxplots of tear film break-up time assessed invasively using FBUT, NIK BUT_obj and NIK BUT_sub

The Friedman test revealed statistically significant differences between the TBUT measurement methods ($\chi^2 = 26.85$; $p < 0.001$). Post-hoc analysis showed significant differences between NIK BUT_sub and FBUT ($p < 0.001$) as well as between NIK BUT_sub and NIK BUT_obj ($p = 0.008$). The difference between FBUT and NIK BUT_obj did not reach statistical significance ($p = 0.076$), despite the observed tendency toward longer break-up times in non-invasive measurements.

Agreement between the methods was further evaluated using Bland–Altman analysis based on mean values calculated from three repeated measurements for each eye. The comparison between NIK BUT_obj and NIK BUT_sub (Fig. 2a) revealed a mean difference (bias) of -3.37 s, with the limits of agreement ranging from -13.49 s to 6.75 s, indicating a systematic trend towards a longer tear film break-up times in the subjective evaluation. Bland–Altman analysis of FBUT and NIK BUT_obj (Fig.2b) demonstrated a mean difference of -2.08 s and limits of agreement (-13.23 s to 9.07 s), despite the lack of statistically significant differences between median values.

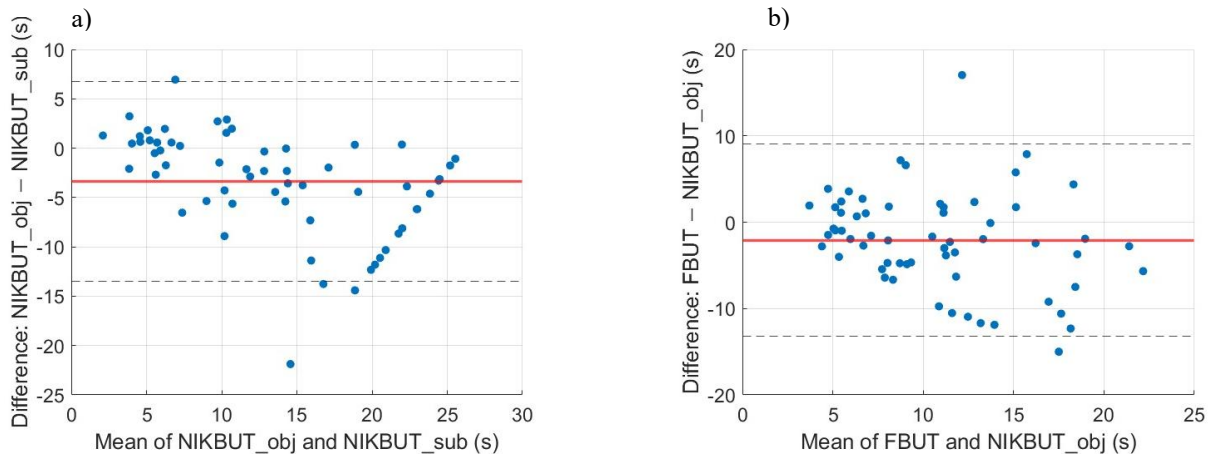


Figure. 2. Bland–Altman analysis of agreement between (a) NIKBUT_{sub} and NIKBUT_{obj} and (b) FBUT and NIKBUT_{obj}. Note that the scale in the Y-axis is different in these graphs.

CONCLUSIONS

The results confirm that TBUT values varies across methods of assessment. Subjective image-based analysis yielded systematically longer TBUT values compared to both fluorescein-based clinical assessment and automated non-invasive measurements. Although the best agreement was observed between NIKBUT_{sub} and NIKBUT_{obj}, Bland–Altman analysis revealed a consistent bias and wide limits of agreement, indicating that these methods are not interchangeable.

The observed differences are consistent with previous reports emphasizing the significant influence of methodological factors on tear film stability assessment. In particular, earlier studies have demonstrated that blink characteristics and the interpretation of tear film break-up substantially affect TBUT values and limit the direct comparability of invasive and non-invasive methods [1]. Similar conclusions regarding the lack of full agreement between FBUT and NIKBUT have been reported in other comparative studies conducted in adult populations, without a specific focus on age-related differences [2,3].

The findings of the present study indicate that subjective and objective non-invasive assessments of tear film break-up are characterized by different sensitivities to distortions in the reflected Placido ring pattern. In most individual image sequences, subjective assessment identifies tear film break-up later than the device software. However, there have been cases with opposite results. This reflects differences in the interpretation of local changes in ring regularity. There have been also cases in which NIKBUT_{obj} < 10 s, and the observer did not notice any distortion of the Placido rings until the end of the 24-second sequence. In such cases, it is possible that the software algorithm misinterprets local changes in the image. Although the averaged NIKBUT_{obj} values were closer to clinically commonly recognized FBUT measurements, automatically reported NIKBUT_{obj} values should sometimes be treated with caution and the operator should review the images of the reflected Placido rings.

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