AUTOMATED NON-INVASIVE METHOD FOR DRY EYE PREDICTION

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INTRODUCTION

Dry eye disease (DED) is one of the most common pathological conditions in ophtalmology. It is a multifactorial disease where the stability of the tear film is reduced and is accompanied by increased osmolarity of the tears and inflammation of the ocular surface. Traditional clinical test used in DED diagnose are invasive and/or subjective, likewise there is a lack of agreement between them and patients symptoms. High speed videokeratoscopy (HSV) can assess the stability of the tear film by analyzing the structure of the reflected Placido disk pattern. Recently we have proposed a novel technique to automatically and objectively analyze the pattern regularity of HSV recordings by means of estimating its fractal dimension.[1] From this analysis three dynamic descriptors are extracted for each recording in order to characterize the tear film:

- **Breaks Feature Indicator (BFI):** related to "holes" in the reflected Placido disk pattern.
- **Distortions Feature Indicator (DFI):** related to an uneven reflected Placido disk pattern.
- **Tear Film Surface Quality (TFSQ) index:** describes the quality of the tear film, is obtained from the weighted addition of BFI and DFI (30% and 70%, respectively).

PURPOSE

To assess the ability of the recently proposed automated method, which analyzes the texture of HSV images with a fractal dimension approach, to differentiate between normal and dry eye subjects.

METHODS

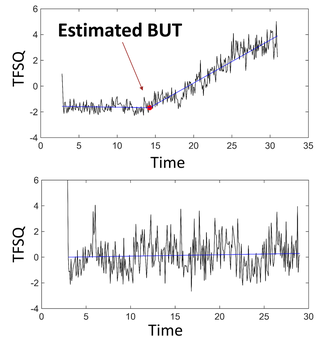
Subjects: 19 normal subjects and 11 dry eye diagnosed subjects.

HSV

Three measurements per subject (righ eye) in suppressed blinking conditions.
Maximum time of measurement: 30 s

- Remove 1st second of recording (TF build-up phase)
- Compute FD for each frame of the raw data.
- Compute tear film surface quality index (TFSQ), breaks feature indicator (BFI) and distortions feature indicator (DFI).

Fit time series with a linear or bilinear function



Estimate features from each dynamic descriptor:

- Mean value of the descriptor in the inter-blink interval
- General trend of the time series data
- Estimated break up time (BUT)

Calculate the receiver operating characteristics (ROC) curves and extract numerical parameters that provide the discrimination perfomance of the method

1. Area under the ROC curve (AUC)

2. Cut-off value that optimizes the discrimination between dry eye and normal subjects

3. Sensitivity (true positive rate) and specificity (1-false positive rate)

4. Youlden's Index

$$\gamma = sensitivity + specificity - 1$$

5. Discriminant Power

$$DP = \frac{\sqrt{3}}{\pi}\left(\log\left(\frac{sensitivity}{1-sensitivity}\right) + log\left(\frac{specificity}{1-specificity}\right)\right)$$

Where $DP < 1$ Poor discrimination
$DP < 2$ Limited discrimination
$DP < 3$ Fair discrimination

RESULTS

Figure 1. ROC curves of each dynamic descriptor of the tear film for the features with best perfomance in discriminating dry eye from normal subjects. Ordinates represent the true positive rate (TPR) and abscisae the false alarm rate (FA).

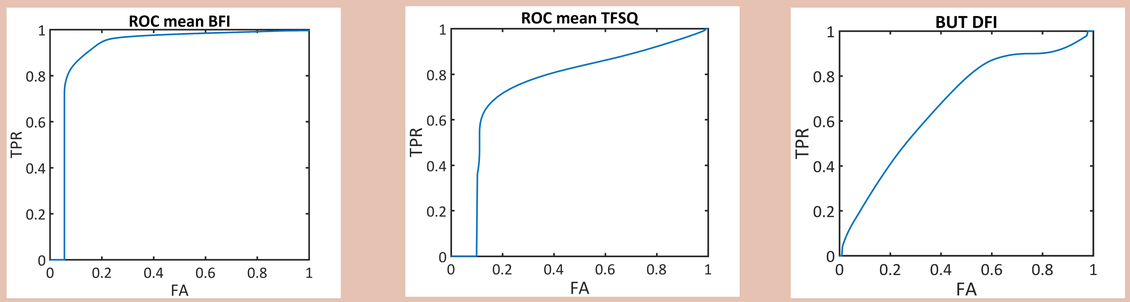


Table 1. ROC effectiveness for the best performing parameter of each of the dynamics descriptors.

	AUC	Cut-off value	Sensitivity	Specificity	γ	DP
Mean BFI	0.91	50.17	90%	86%	0.76	2.23
Mean TFSQ	0.76	59.77	68%	84%	0.52	1.33
BUT DFI	0.68	13.19	81%	50%	0.30	0.75

- A break up point shorter than the inter blink interval was identified in 43% of the measurements, meaning that the bilinear model was more appropiate to describe the dynamics of the tear film. When this was not the case, and a linear function was more appropiated, the estimated BUT was the whole inter blink interval time or was considered zero if the slope had a positive trend.
- 44% of the measurements of normal subjects were fitted with the bilinear model and in 11% of the measurements the BUT was zero, whereas in the case of dry eye subjects 38% of the measurements were fitted with the bilinear model and in the 19.4% BUT was zero.
- As a result from this fitting, mean BUT was 15 seconds for normal subjects and 9.3 seconds for dry eye diagnosed subjects.
- Figure 1 shows the power to discriminate dry eye subjects from normal subjects for each of the dynamic descriptors of the tear film for the feature with better performance.
- Table 1 summarizes the extracted numerical parameters from ROC curves (AUC, sensitivity, specificity, Youlden's Index and discriminant power) for the optimized cut-off point for each of the ROC curves in Figure 1.
- The mean BFI value along all the interblink interval provided the best performance in dry eye diagnosis (AUC=0.91).
- Although the BUT is an important measurement of tear film stability and the proposed method has shown to identify it correctly, the mean quality of the tear film along the inter blink interval seems to be a more powerful discriminator between normal and dry eye subjects.

CONCLUSIONS

The proposed fractal dimension approach for the analysis of HSV recordings, has shown to achieve better discrimination results than previously proposed method[2], bringing the performance of the HSV technology closer to that of the more sophisticated, but clinically unavailable, techniques such as the Lateral Sharing Interferometry[3]. HSV may be an advantageous tool to aid clinicians in the diagnosis and monitoring of DED.

REFERENCES

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