Noncontact detection of dry eye using a custom designed IR thermal image system

Tai Yuan Su[a], Kerh Hwa Chen[b], Po Hsuan Liu[c], Ming Hong Wu[c], David O. Chang[c], and Huihua Kenny Chiang1[a]*,
[a] Institute of Biomedical Engineering, National Yang-Ming University, Taipei, Taiwan;
[b] Department of Ophthalmology, Taipei Veterans General Hospital, Taipei, Taiwan;
[c] United Integrated Services Co. Ltd., Taipei, Taiwan

ABSTRACT

Dry eye syndrome is a common irritating eye disease. Current clinical diagnostic methods are invasive and uncomfortable to patients. A custom designed noncontact infrared (IR) thermal image system was developed to measure the spatial and temporal variation of the ocular surface temperature over a 6-second eye-opening period. We defined two parameters: the temperature difference value and the compactness value to represent the degree of the temperature change and irregularity of the temperature distribution on the tear film. By using these two parameters, in this study, a linear discrimination result for the dry eye and the normal eye groups; the sensitivity is 0.9, the specificity is 0.86 and the receiver operating characteristic (ROC) area is 0.91. The result suggests that the custom designed IR thermal image system may be used as an effective tool for noncontact detection of dry eye.

Keywords: dry eye, IR image system, tear film stability, temperature difference value, compactness value

1. INTRODUCTION

Tear film provides lubrication and constant moisture to maintain vision and comfort of the eye. The outer layer of tear film is a lipid layer which prevents excessive tear evaporation and maintains lubrication to the eye. A person may experience dry eye symptom when there is an imbalance in the tear film system or the tear film cannot remain continuous between blinks [1].

The diagnosis of dry eye syndrome in clinics is based on measuring the amount of tear production and tear film stability. Schirmer's test with anesthesia (STA) is the most widely used method in tear production measurement. It is performed by placing filter paper inside the lower lid of the eye to measure the volume of tear production over 5 minutes period. In tear film stability measurement, fluorescent break-up time (FBUT) method applies fluorescent sodium drops on the ocular surface and measures the time it takes the tear film to break. Therefore, both STA and FBUT tests are invasive methods. They require the use of filter paper or fluorescent sodium drops on the ocular surface and cause discomfort to patients.

Over the past 15 years, researchers have used IR thermal image to observe the ocular surface temperature (OST) and tear film stability noninvasively [2]. The OST is essentially affected by the tear film stability [3]. The tear film instability is one of the major reasons causing dry eye symptom [4]. The dry eye group has been reported to have a greater degree of temperature decrease in the OST than the control group [5]; the greater rate of cooling in the dry eye group was attributed to a greater rate of tear evaporation [6]. However, in a later study, an opposite finding was reported that dry eye patients had smaller temperature decrease in the OST [2, 7]. On the other hand, the patterns of the IR thermal image of the dry eye group appeared more irregular and unstable than those of the normal eye group [6, 8-9]. However, the degree of the irregularity of the IR thermal image of the tear film has not been quantitatively studied. A recent study shows that the temperature profile across a normal eye is a smooth curve [10], which suggests that the abnormal tear film may be different from this smooth form.

In this study, a custom designed IR thermal image system was developed to measure both of the temporal variation of the OST and spatial variation of thermal image of the tear film noninvasively to distinguish between the dry and normal eye groups.

Ophthalmic Technologies XXI, edited by Fabrice Manns, Per G. Söderberg, Arthur Ho, Proc. of SPIE Vol. 7885, 788504