AUTOMATED DETECTION OF FUNDUS PHOTOGRAPHIC RED LESIONS IN DIABETIC RETINOPATHY

B. Sander¹, J. Godt², H. Lund-Andersen¹, M. Grunkin³, D. Owens⁴, N. Larsen¹, M. Larsen¹

1) Department of Ophthalmology, Herlev Hospital, Denmark  ²) Torsana Diabetes Diagnostics A/S, Horsholm, Denmark  ³) University of Wales College of Medicine, UK

Purpose
- To develop an automated fundus image analysis system for detection and quantification of red diabetic lesions (microaneurysms and hemorrhages)
- To validate the automated red lesion detection by categorizing patients according to independently read clinical grades of diabetic retinopathy (DR) and no-DR
- To evaluate the automatically detected red lesions as compared with six sets of lesion-outlines by six retinal experts

Material
Four hundred 35 mm color transparencies of 100 randomly and retrospectively selected patients were obtained from a follow-up visit of the Welch Community Diabetic Retinopathy Study (WCDRS). Using full mydriasis two transparencies were acquired of the macular and nasal region of each eye according to the Eurodiab protocol by a Canon CR4 45 NM fundus camera at a 45-degree angular field.

Methods
The transparencies were digitized using a Nikon Coolscan LS-2000 film-slide digitizer at 1350 dpi and 12 bits per pixel per color channel.

Each of six ophthalmologists independently and in a random order of presentation outlined all red lesions of the 400 digitized fundus images. The lesions were classified as being microaneurysms or hemorrhages, the latter comprising both dot-and-blot and flame-shaped intraretinal hemorrhages.

A consensus set of red lesion outlines was constructed using the outlines of the six individual experts. The development of the automated red lesion detection of the RetinaLyze™ System was based on the consensus set.

The RetinaLyze™ System uses advanced modeling of the fundus image and calculates a visibility measure of potential lesions with user-supplied parameter control of the sensitivity by specifying the threshold visibility above which lesions are detected (Figure 3). The area of the optic nerve head is automatically detected and excluded from the lesion analysis.

Bro-Taf fundus photograph grading: Two experienced readers of the Bro-Taf screening service of Wales independently and in a random order of presentation read the 400 digitized fundus images in accordance with the Bro-Taf protocol – a modification of the Eurodiab protocol. Presence or absence of diabetic retinopathy (DR or no-DR) of each eye was graded in consensus between the two readers and used in the final validation of the automated red lesion detection.

Red lesions of the 400 digitized fundus images were automatically detected by the red lesion detection of the RetinaLyze™ System. The automated red lesion detection was validated by categorizing patients according to the worst-case eye of the Bro-Taf clinical grades of DR and no-DR (Table 1). Any red lesion detected in any of the patient’s two eyes resulted in the patient being automatically categorized as having DR.

Results
The automated red lesion detection software compared to the Bro-Taf clinical grades of DR and no-DR demonstrated sensitivity of 96.7% and specificity of 71.4%.

Fifty patients (50%) were automatically and correctly classified as no-DR by the automated red lesion detection.

One patient (1%) diagnosed with minimal background DR was incorrectly classified in the no-DR group by the automated red lesion detection.

The area of the Receiver Operating Characteristics (ROC) curve of the automated red lesion detection was 0.90. Substantial variability was observed between the six retinal experts. The mean sensitivity of 91.1% and mean specificity of 82.9% of the six independent retinal experts was matched by the automated red lesion detection.

Conclusions
The RetinaLyze™ System featuring automated red lesion detection was able to correctly identify 96.7% of the diabetic patients with retinopathy and 71.4% of the patients without retinopathy.

These results were comparable to those observed by six independent retinal experts.

Automated detection of red lesions in fundus images show promising results in classifying diabetic patients with respect to the presence and absence of diabetic retinopathy demonstrating potential for substantial savings in future screening programs for diabetic retinopathy.

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