

# Comparison of the effectiveness of detecting diabetic eye disease: Diabetic retinal photography versus ophthalmic consultation

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## ABSTRACT

**Introduction:** This study determines the accuracy of reading a Polaroid retinal photograph in the diabetic retinal photography programme as compared to a clinical fundal examination in the diagnosis of diabetic retinopathy.

**Methods:** A prospective study recording the additional findings obtained from clinical examination of the eye using indirect ophthalmoscopy and slit lamp biomicroscopy in a restructured tertiary hospital serving an urban community was performed.

**Results:** Seventy-eight eyes in 39 diabetic patients were reviewed by an ophthalmologist for diabetic changes seen on fundus photography. The sensitivity of diabetic retinal photography in diagnosing diabetic eye conditions was 91.6 percent, with a specificity of 99.8 percent and a positive predictive value of 95.6 percent. The degree of agreement kappa was 0.94.

**Conclusion:** The use of diabetic retinal photographs to screen for diabetic eye disease achieved a high sensitivity by capturing diabetic retinal lesions. It was comparable to an examination performed by the ophthalmologist. With appropriate training, the person reading the diabetic retinal photographs can accurately diagnose diabetic eye conditions.

**Keywords:** diabetes mellitus, diabetic retinal photography, eye diseases, ophthalmologic diagnostic technique, vision tests

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## INTRODUCTION

Diabetic eye disease is the leading cause of adult blindness and visual impairment in many developed countries, with Singapore being no exception. While the prevalence of diabetes mellitus in Singapore is 9%<sup>(1)</sup>, the incidence of diabetic retinopathy in Singapore ranges from 38% in a hospital-based diabetic retinopathy screening programme (of which 17% was sight-threatening)<sup>(2)</sup>, 21.8% of 13,296 patients in a mass screening programme in primary care clinics<sup>(3)</sup>, to 18.8% estimated in a study seeking to design a protocol for screening diabetic retinopathy<sup>(4)</sup>. Left

undetected or untreated, many of these patients with diabetic retinopathy would become blind. Worldwide, great importance is attached to screening for sight-threatening diabetic eye changes<sup>(5-8)</sup>. Early detection and treatment can save more than 50% of eyes<sup>(10-13)</sup>. Laser photocoagulation, given in a timely manner in the course of the disease, can markedly reduce the number of diabetics losing their vision<sup>(14-16)</sup>.

In Singapore, diabetics are routinely screened for diabetic retinopathy with an annual diabetic retinal photograph (DRP) in the primary care setting such as polyclinics. Patients with sight-threatening changes are then referred to the ophthalmologist for further assessment. Previous studies have compared the use of different methods of screening for diabetic retinopathy. However, there is much controversy as to which is the most reliable method in detecting retinal changes<sup>(17-21)</sup>.

High sensitivity is required for any screening programme. Various studies have shown that retinal photography is a more sensitive method of detecting diabetic eye disease as compared to direct ophthalmoscopy. The inefficiency of direct ophthalmoscopy was demonstrated by studies conducted in the 1980s and 1990s<sup>(17,21,22)</sup>. This study compares the amount of clinical information obtained from a single 45 degree field retinal photograph centred on the macula as compared to a dilated clinical examination of the fundus.

## METHODS

Between April and June 2001, 39 consecutive patients who fulfilled the inclusion criteria and who were examined by a single ophthalmologist at Tan Tock Seng Hospital were studied. The inclusion criteria were a known history of diabetes mellitus, referral from a polyclinic doctor and a recently-taken retinal photograph. There was no restriction on the type of diabetes mellitus. The sample comprised routine referrals from polyclinic doctors. Only outpatient attendees in the eye clinic were studied.

Biographical data comprising age, gender, ethnic group, previous ophthalmic history and pertinent medical history were collected. All diabetic retinal photographs were taken by a standard non-mydriatic fundus camera using Polaroid film at the various polyclinics. The ophthalmologist carried out a complete

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ophthalmic examination that included visual acuity testing, tonometry, slit-lamp biomicroscopy and indirect ophthalmoscopy. Visual acuity was considered normal if the vision was 6/12 or better. Intraocular pressure was acceptable if it did not exceed 21mmHg. Cup-disc ratio was acceptable if it was equal or less than 0.4.

The diabetic retinal photographs were analysed by the ophthalmologist a week later without referring to the ophthalmic notes made, and the ocular disease of each patient as diagnosed by reading the diabetic retinal photographs was noted. The following conditions were included in the study: diabetic retinopathy, diabetic macular oedema, cataracts, increased cup-disc ratio and age-related macular degeneration. Diabetic retinopathy was further divided into grades of background, pre-proliferative and proliferative diabetic retinopathy as follows<sup>(23)</sup>.

- (1) Background diabetic retinopathy
  - microaneurysms only
  - mild degree of venous loops, retinal haemorrhages, hard exudates, cotton wool spots
- (2) Pre-proliferative diabetic retinopathy
 

One or more of the following:

  - retinal haemorrhages or microaneurysms in four quadrants
  - venous beading in two quadrants
  - intra-retinal microvascular abnormalities in one quadrant
- (3) Proliferative retinopathy
 

One or more of the following:

  - new vessels
  - new vessels at or near the optic disc
  - Moderate or severe new vessels (greater than 1/4 disc area)
  - vitreous haemorrhage
  - extensive neovascularisation
  - vitreous haemorrhage or fibrovascular proliferation with or without retinal detachment
- (4) Clinically-significant macular oedema
 

One or more of the following:

  - thickening of the retina at or within 500 microns of the centre of macula
  - hard exudates at or within 500 microns of the centre of the macula, if associated with thickening of adjacent retina
  - areas of retinal thickening 1 disc area or larger, any part of which is within 1 disc diameter of the centre of the macula

The diagnoses, made by reading the diabetic retinal photographs and by the ophthalmologist clinically on each eye of each patient for all referrals,

were then compared and analysed for diagnostic accuracy. For participants with ungradable diabetic retinal photographs, they were still evaluated by clinical examination. Masking was done and the diabetic retinal photographs were examined at a different time from the clinical examination. Diagnoses were considered to concur if the diagnosis obtained from reading the diabetic retinal photograph was confirmed clinically by the ophthalmologist. The ophthalmologist was the gold standard against which the retinal photograph diagnoses were compared and was assumed to be correct. The parameters studied were sensitivity, specificity, positive predictive value and the kappa statistic  $\kappa$ .

Sensitivity was defined as the number of eyes whose retinal photograph diagnosis was the same as that made by the ophthalmologist. Specificity was the rate of true negatives, where both the retinal photograph and ophthalmologist did not demonstrate any lesion in that eye. Positive predictive value was the rate of correct diagnoses confirmed clinically, out of all the retinal photographs diagnosed with that particular eye condition. Kappa  $\kappa$  was the degree of agreement between the retinal photograph reading and that of the ophthalmologist for that particular eye condition.  $\kappa$  ranges from zero to one. The higher the value of  $\kappa$ , the better the agreement. It took into account the degree of agreement by chance and measured the degree of agreement between observers above that expected by chance alone.

## RESULTS

There were 78 retinal photographs from the 39 diabetic patients, four of which were graded as unreadable by the polyclinic doctors. There were 17 males and 22 females, with a mean age of 62.4 years (range 43 to 76 years) and 61.2 years (range 37 to 84 years), respectively. Thirty (76.9%) subjects were Chinese, four (10.3%) were Malay and five (12.8%) were Indian. All subjects had a history of diabetes mellitus. Twenty-three patients had a history of hypertension, eight had hyperlipidaemia, four had ischaemic heart disease, two had tuberculosis, one had cerebrovascular accident, one had gout, and one suffered from fits.

Background diabetic retinopathy was seen on 31 retinal photographs. The ophthalmologist diagnosed two more eyes with background diabetic retinopathy which could not be detected on the retinal photograph. Both eyes had background changes in the fundus periphery and were not seen in the retinal photograph. This would not have any clinical consequence in background diabetic retinopathy, as patients would only need regular follow-up and no treatment.

Seven of 74 retinal photographs had pre-proliferative changes. The ophthalmologist did not detect additional eyes with pre-proliferative diabetic

**Table I. Diagnoses of ophthalmic conditions by polyclinic doctors.**

Variable	Sensitivity	Specificity	Positive predictive value	Kappa $\kappa$
All conditions	0.92	1.0	0.96	0.94
Retinopathy	0.95	0.98	0.93	0.92
– Background	0.94	1.0	1.0	0.95
– Pre-proliferative	1.0	1.0	1.0	1.0
– Proliferative	0.0	1.0	0.0	0.0
Diabetic macular oedema	1.0	1.0	1.0	1.0
Cataract	0.94	0.98	0.97	0.92
Increased cup-disc ratio	1.0	1.0	1.0	1.0
Age-related macular degeneration	0.89	1.0	1.0	0.93

retinopathy. No proliferative changes were seen on the retinal photographs, and this was confirmed by the ophthalmologist. Diabetic macular oedema was seen in eight retinal photographs and also in eight eyes on clinical examination.

All 78 diabetic retinal photographs were used. Those that were ungradable were labelled as having cataracts. Cataract was suspected in 32 retinal photographs. Clinical examination showed that 31 eyes had cataracts. No abnormalities or media opacities were found in the remaining eye. Possible reasons for the ungradable photographs included small pupil, decentered photograph or poor fixation by the patient. Another six eyes were discovered to have early cataracts that were not detected on the retinal photograph. Again, there was no clinical consequence as vision was still good.

Ten eyes showed an increased cup-disc ratio. None were diagnosed by clinical examination. However, two eyes had increased intraocular pressure as measured by an applanation tonometer without an increased cup-disc ratio. Eight retinal photographs had drusen. Another retinal photograph was found to have drusen on clinical examination. However, none had the wet type of age-related macular degeneration.

A total of 522 possible occurrences of the specified eye diseases were assessed in 78 diabetic retinal photographs. The overall sensitivity, specificity and positive predictive value of the diabetic retinal photographs in diagnosing the diabetic eye conditions under study were 91.6%, 99.8% and 95.6%, respectively. The degree of agreement  $\kappa$  was 0.94. Peripapillary degeneration, macular degeneration and asteroid hyalosis could be detected on diabetic retinal photographs and by clinical examination. Early cataracts, diabetic retinopathy outside the field of the diabetic retinal photographs, epiretinal membranes (unless they were dense), aphakia and the presence of intraocular lenses resulting from cataract surgery were detected by the ophthalmologist using the ophthalmoscope and slit lamp but not from reading the diabetic retinal photographs.

The intraocular pressure was recorded by tonometry for all 78 eyes. Four eyes from two individuals had

raised intraocular pressures. The first had both eyes with intraocular pressures measuring 24mmHg, while the other had one eye measuring 50mmHg and the other measuring 30mmHg. It was noted that the former had increased cup-disc ratios in both eyes, while the latter had none in both eyes. The absence of the increased cup-disc ratio may be due to acute glaucoma or related to pharmacologically-dilated pupils. No information was given on the ophthalmologist's gonioscopy finding to determine the drainage angle or of the outcome and management.

Best-corrected visual acuity (bcva) was measured for all 78 eyes. Ten eyes had abnormal visual acuities. There were four eyes with 6/15 bcva, one eye each with 6/18, counting fingers and light perception bcva, respectively. These were all due to cataracts. Another eye had hand movement from chronic glaucoma. The four diabetic retinal photographs that were classified as ungradable had advanced cataracts, thus explaining the media opacity. They did not have any of the other eye conditions being studied.

## DISCUSSION

Screening for diabetic eye disease is one of the major screening programmes in Singapore. It is chiefly driven by the fact that the major complications, such as proliferative diabetic retinopathy and diabetic macular oedema, are responsive to treatment by photocoagulation. By implementing such treatment, we can reduce the incidence of blindness due to diabetic eye disease. To detect potentially sight-threatening diabetic eye conditions, the diabetic retinal photographs must be gradable and this, in turn, is dependent on media clarity and quality of the diabetic retinal photograph. In this study, the incidence of ungradable diabetic retinal photographs was 5%, reflecting the low rate of poorly-taken retinal photographs or media opacities.

Although the sensitivities of diagnosing the five eye conditions were high, the fact remains that the ophthalmologist can diagnose other lesions in the eye, including diabetic retinopathy lesions in the retinal periphery and development of early cataract. These additional diagnoses are not clinically significant, and

did not affect the patient management of the patient in any way. Visual acuity can be measured in the polyclinic. Tonometry can also be done in the polyclinic. Hence, it can be concluded that the diabetic retinal photograph is sensitive enough to be used for screening purposes.

Comparison of both methods reveals their advantages and disadvantages in detecting eye disease. The clinical examination had the advantage of detecting lesions in the peripheral areas of the fundus as compared to the diabetic retinal photograph, which was limited to the posterior pole. The diabetic retinal photograph was advantageous for its permanency of record. This study acknowledges the assumption that the ophthalmologist was always correct in his diagnoses and severity of grading. However, since only one ophthalmologist was involved in the assessment of the diabetic retinal photograph and examination of the eyes, there was no assessment of interobserver variability. Hence, there were few disagreements on the grading and final diagnoses of the diabetic retinal photographs.

The authors are also aware of the fact that the knowledge of the clinical history of the duration of diabetes mellitus in each patient could have resulted in observer bias in looking for diabetic retinopathy in the peripheral regions. The detection of diabetic eye disease was also limited by the fact that the patients were referred from primary care for further specialised ophthalmologic examination. Hence, they did not form a random population. Observer bias in detecting diabetic eye disease could be due to increased vigilance in looking for changes in the fundus.

From our study, it appears that the reading of one good-quality photograph suffices as a primary screening option for diabetic eye disease and as a method to detect sight-threatening diabetic retinopathy. To have an effective screening programme in primary care, the primary care physician must be able to detect the appropriate conditions for further referral to the ophthalmologist.

Any results suggesting that the diabetic retinal photograph is of a poor quality or has media opacity should be referred for ophthalmic consultation. Evans et al<sup>(22)</sup> demonstrated that these patients have an increased risk of diabetic retinopathy that will not be detected unless funduscopy is performed. They noted sight-threatening diabetic retinopathy in 6.8% of those with poor-quality retinal photographs, as compared to 4.2% of those with readable retinal photographs<sup>(22)</sup>. However, this result was not borne out by our study.

In conclusion, the diabetic retinal photograph achieves a high sensitivity in capturing diabetic retinal lesions. It is comparable to a clinical examination by the ophthalmologist. It is recommended that the diabetic retinal photograph continues to be the mainstay of mass screening for diabetic retinopathy and diabetic macular oedema.

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