

Effectiveness of non-mydriatic retinal photography and direct ophthalmoscopy in detecting diabetic retinopathy

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This is a prospective study to compare the effectiveness of non-mydriatic photography with that of direct ophthalmoscopy in screening for diabetic retinopathy in 153 patients attending a hospital clinic in Hong Kong. Retinal photography under physiological mydriasis and direct ophthalmoscopy of patients with dilated pupils were compared with the ophthalmologists' examination results as a reference standard. The prevalence of diabetic retinopathy in this sample population was 15%. The sensitivity of detecting diabetic retinopathy by retinal photography was higher than that of direct ophthalmoscopy (64% versus 41%, respectively; 95% confidence interval of difference, 1.2%-44.3%). Of five patients who had serious retinopathy, retinal photography failed to detect the disease in two; direct ophthalmoscopy failed to detect the disease in all five patients. Specificities of retinal photography and direct ophthalmoscopy were 90% (95% confidence interval, 84%-96%) and 93% (95% confidence interval, 88%-97%), respectively. We conclude that retinal photography is significantly more effective than direct ophthalmoscopy in detecting diabetic retinopathy. In addition, the non-mydriatic camera is easy to use and is the preferred method of screening.

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Key words: Diabetic retinopathy; Mass screening; Photography; Sensitivity and specificity

Introduction

Diabetic retinopathy is one of the leading causes of blindness in adults in the United Kingdom¹ and the United States,² and this is likely to be true in Hong Kong. However, treatment of severe proliferative retinopathy and macula oedema is possible,^{3,4} and screening for diabetic retinopathy not only prevents blindness but is also cost-effective.^{5,6} Many clinical guidelines recommend annual screening.^{7,8}

Unfortunately, most diabetic patients in Hong Kong never receive an eye examination (McGhee SM et al, unpublished observations, 1997). This may be due to patients' lack of knowledge and ophthalmologists' lack of readily available resources. Furthermore, eye examination of every diabetic patient by ophthalmologists is expensive and is not feasible due to the very large number of diabetic patients in Hong Kong.

The non-mydriatic retinal camera has been advocated as a screening tool.^{9,10} It covers a wide angle of the retina, is easy to use, and requires little training. Direct ophthalmoscopy is an alternative screening method. Establishing the sensitivity and specificity of every screening method is necessary to assess its effectiveness. This study evaluates the sensitivity and specificity of non-mydriatic retinal photography and direct ophthalmoscopy in screening patients for diabetic retinopathy in Hong Kong.

Subjects and methods

Consecutive patients attending the Diabetes Centre at the Tung Wah Eastern Hospital from 21 August 1996 to 28 January 1997 were examined. Those who were blind, had cataract, or who were already consulting an ophthalmologist were excluded. Retinal photographs were taken with a non-mydriatic 45-degree retinal camera (Canon CR-45UAF; Canon Inc. Medical Equipment Business Group, Kanagawa, Japan) by nurses at the Diabetes Centre. The retinal photographs were taken during physiological mydriasis by exposing the eyes to darkness and covering the disc, macula, and temporal vasculature of each retina. The photographs were interpreted by an experienced ophthalmologist.

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Diabetic retinopathy was graded as follows: no diabetic retinopathy; non-proliferative diabetic retinopathy; proliferative diabetic retinopathy; macular oedema; and vitreous haemorrhage. Proliferative diabetic retinopathy, macular oedema, and vitreous haemorrhage were considered to be serious cases of retinopathy. Macular oedema was diagnosed whenever hard exudate or suspicious retinal thickening was present within a two-disc diameter of the fovea.

Physicians at the Diabetes Clinic performed direct ophthalmoscopy during mydriasis, without knowledge of the findings from the retinal photographs. The physicians also had no knowledge of the patients' diabetic or ophthalmic history. Diabetic retinopathy was graded in the same manner as it was during photography.

All patients were routinely referred to two experienced ophthalmologists within 1 month of the retinal photography/direct ophthalmoscopy. Each patient was examined during mydriasis by one of the ophthalmologists and the results were used as a reference standard. The fundi were examined by indirect ophthalmoscopy with a 20-dioptre lens directed at the post-equatorial region, and maculae were examined by a 78-dioptre lens and a Haag Streit slit lamp. The two examiners had no knowledge of the patient's diabetic or ophthalmic history, or the results of the retinal photographs. The sensitivity, specificity, and positive predictive value of each screening method were calculated according to standard equations.¹¹

Results

Retinal photographs were taken of 153 patients. Of these, 150 (98%) were examined by the examiners within 1 month, 78 were male, and 72 were female. The mean age was 55.9 years (range, 23.0-79.0 years) and the mean duration of diabetes was 3.7 years (range, 0.0-21.0 years). Thirty-eight (25%) patients were treated by dietary control, 106 (71%) were receiving oral diabetic drugs, and six (4%) were receiving insulin.

The results from four of 150 patients were ungradable by the examiners; data from the remaining 146 patients were analysed. Ten (7%) of 150 patients had ungradable photographs: three due to cataract and one due to vitreous body degeneration. Of these 10 patients, diabetic retinopathy was detected in three: two had non-proliferative retinopathy and one had maculopathy. Two of the 150 patients had ungradable direct ophthalmoscopy results; both had normal retinae.

Diabetic retinopathy was detected by the examiners in 22 patients—a prevalence of 15%. The Table shows the sensitivity and specificity of retinal photography and direct ophthalmoscopy in screening for diabetic retinopathy. Sensitivities of detecting diabetic retinopathy by retinal photography and direct ophthalmoscopy were 64% and 41%, respectively. The difference in the sensitivities was statistically significant (95% confidence interval, 1.2%-44.3%) despite the small number of patients with retinopathy. Of the 13 patients for whom diabetic retinopathy was missed by direct ophthalmoscopy, retinopathy was identified by retinal photography in six. But of the eight patients for whom diabetic retinopathy was missed by retinal photography, direct ophthalmoscopy detected retinopathy in only one. Five patients had serious diabetic retinopathy, as identified by slit lamp examination; all had maculopathy. Retinal photography failed to detect retinopathy in two of the five patients: one was graded as having non-proliferative retinopathy and the other had an ungradable photograph. Direct ophthalmoscopy missed retinopathy in all five patients: one was graded as being normal and the other four were graded as having non-proliferative diabetic retinopathy.

When serious diabetic retinopathy that was detected by the examiners was compared with diabetic retinopathy as detected by screening methods, the sensitivities of retinal photography and direct ophthalmoscopy were 100% and 80%, respectively. The specificity of detecting diabetic retinopathy by retinal photography was 90% (95% confidence interval, 84%-96%) and that of direct ophthalmoscopy was 93%

Table. Results of retinal photography and direct ophthalmoscopy in diabetic retinopathy screening

	No. of patients				Sensitivity (%) [95% confidence interval]	Specificity (%) [95% confidence interval]
	True positive	True negative	False positive	False negative		
Retinal photography *	14	112	12	8	64 (43-85)	90 (84-96)
Direct ophthalmoscopy*	9	115	9	13	41 (20-62)	93 (88-97)

* Ungradable patients were regarded as being 'positive'

(95% confidence interval, 88%-97%). The positive predictive value of retinal photography was 54% (95% confidence interval, 34%-74%) and that of direct ophthalmoscopy was 50% (95% confidence interval, 26%-74%).

Discussion

At the Diabetes Centre at the Tung Wah Eastern Hospital, retinal photography is performed for every diabetic patient. Patients with any retinopathy or who have ungradable retinal photographs are referred to ophthalmologists. Patients with serious diabetic retinopathy, as detected by retinal photography, are given an early appointment. Patients with normal retinal photographs will have retinal photography performed 1 to 2 years later.

Although seven-field stereoscopic photography and fluorescein angiography have been regarded as the gold standard,¹² they are expensive and time-consuming, and are not readily available. In the real-world situation, we base our management of diabetic retinopathy on the results of the ophthalmologists' examination.

In this study, the prevalence of diabetic retinopathy of 15% is low because we have excluded patients who are already under the care of ophthalmologists. The proportion of ungradable retinal photographs (7%) is also relatively low when compared with other studies,^{10,13} probably because we have excluded patients who are known to have cataract. In addition, we may have graded the poorer-quality photographs.

The sensitivity of retinal photography is higher than that of direct ophthalmoscopy performed by physicians (64% versus 41%); this result agrees with that of studies showing that direct ophthalmoscopy performed by general practitioners and ophthalmologists is ineffective.¹⁴⁻¹⁶ Even when performed by an experienced ophthalmologist, direct ophthalmoscopy is limited by weaknesses inherent to the ophthalmoscope.¹⁶ Retinal photography is also superior to direct ophthalmoscopy in detecting maculopathy. The poor performance of doctors in detecting maculopathy in this study has also been reported by Taylor et al.¹⁷

An important issue is whether serious retinopathy beyond the 45-degree photograph will be missed. Ryder et al¹⁸ have shown that in all cases where more serious diabetic retinopathy was present outside the 45-degree field, background diabetic retinopathy was detected in the photographs. Based on our management

protocol of referring all patients with any diabetic retinopathy or ungradable photographs to ophthalmologists, we are able to detect all serious diabetic retinopathies. The effectiveness of this protocol has also been confirmed by another study.¹³ A recent technological advancement has been the development of the digital camera which requires less brilliant flashes, thereby decreasing the patients' discomfort; consequently, more fields can easily be taken. In addition, Harding et al¹⁶ have shown that the sensitivity of retinal photography can be increased to 89% by using three fields and dilated pupils.

There were 112 (77%) patients who had no retinopathy, as shown by both retinal photography and the results of the ophthalmologists' examination. They did not require routine consultations with ophthalmologists, contrary to some published recommendations.^{7,8} This would save ophthalmologists' time, enabling health care resources to be used more efficiently. Combined direct ophthalmoscopy and retinal photography has been advocated as the best screening method.¹⁹⁻²¹ However, this method entails additional consultation time; at the Tung Wah Eastern Hospital, there are not enough resources to perform combined screening for every patient annually.

The cost of retinal photography is modest. The two Polaroid films cost HK\$14, and the nurse only needs approximately 10 minutes to take the photographs. Retinal photography is also well tolerated by patients. Although the technique causes transient eye discomfort due to the bright flash, no patient has refused to attend the subsequent photography screening.

In conclusion, retinal photography and its interpretation by an ophthalmologist is significantly more sensitive than direct ophthalmoscopy as performed by general physicians. Retinal photography is easy to perform and should be the preferred method of screening in this setting.

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