Original Article *นิพนธ์ต้นฉบับ*

A Model for Diabetic Retinopathy Screening in Communities in Thailand

Suravit Techathuvanan*
Paisan Ruamviboonsuk**
**Ministry of Public Health, Nonthaburi*
***Department of Ophthalmology, Rajavithi Hospital, Bangkok*

Abstract The objective of this comparative study was to evaluate a pilot implementation of a diabetic retinopathy (DR) screening model that used digital retinal photography for detecting cases for referral to ophthalmologists. Patients with diabetes in Tak province were examined using single-field digital retinal photography interpreted initially by trained paramedical personnel who captured the images and supervised by the comprehensive ophthalmologist in Tak provincial hospital. Retinal cameras used in this model were rotated to capture retinal images locally in communities in each district of the geographical areas of the provincial hospital. The coverage of cases and prevalence of DR detected using this model in the year 2008 was compared to those detected by the comprehensive ophthalmologist performing indirect ophthalmoscopy in the same communities in the previous two years. During five months of the fiscal year 2008, 2,290 patients with diabetes (47.8%) were digitally screened for DR; this coverage was significantly different ($p < 0.01$) from the same period of the previous two years. The prevalence of non-proliferative DR, 32.1 percent, detected using this digital model was also significantly higher than 15.1 percent detected by ophthalmoscopy in the previous two years. However, the prevalence of proliferative DR, 2.6 percent, using by this digital model was not significantly different ($p = 4.8$) from the prevalence detected by the ophthalmoscopy. The digital model for DR screening can cover more patients in a shorter period of time and may be able to detect more positive cases than the conventional ophthalmoscopy. To have most patients with diabetes screened for DR for prevention of blindness, this model should be implemented nationwide as an alternative to clinical examination by ophthalmologists.

Key words: **diabetic retinopathy, digital retinal photography, community screening**

Introduction

Diabetic retinopathy (DR) is one of the major complications of diabetes and one of the leading causes of blindness throughout the world[1-4]. There is strong evidence in the literature suggests that tight control of blood sugar[5-7] can decelerate DR progression, and timely laser treatment[8] or retinal surgery can reduce the risk of visual loss in patients with DR. A number

of patients with DR may also have advanced disease severity without any ocular symptoms. Therefore, early detection is highly recommended for reducing the risk of visual loss from DR. A conventional modality for DR detection, recommended by the American Diabetes Association, is comprehensive ocular examination including dilated fundus examination using indirect ophthalmoscopes by ophthalmologists[9].

However, there are a limited number of ophthalmologists of roughly 700-800 in Thailand to deal with a growing population of patients with diabetes. It was predicted that the global prevalence of diabetes would increase from 4.5 percent to 6.2 percent by the year 2030[10]. The International Collaborative Study of Cardiovascular Disease in Asia has also pointed out that there was an estimated 9.6 percent prevalence of diabetes among Thai adults[11]. Therefore, approximately 6 million Thai adults are expected to have diabetes. It was found further in the Thailand Diabetes Registry Project[12] that, among the 9,419 registrants, 30.7 percent had retinopathy. In that connection, it was estimated that the 6 million Thai patients with diabetes in Thailand might account for more than 1.5 million patients suffering from DR. These data indicate that there are not enough ophthalmologists to detect DR for prevention of blindness in Thailand. Furthermore, limited access to ophthalmic care for patients with diabetes in rural areas could also accelerate this problem.

The use of retinal photography[13-15], especially from a digital fundus camera, could be an alternative modality to ophthalmic examination[16] by ophthalmologists for early DR detection. The digital retinal imaging system has been confirmed in many studies as being practical and cost-effective[17]. Furthermore, the system can be implemented as a local screening unit in local communities to reduce the problem of ophthalmic care access for remote patients[18-21].

This study was conducted to evaluate a DR screening model using the digital retinal photography system in a study area. Tak was selected since the provincial ophthalmologist regularly screened patients with diabetes in the province in the past two years. The rate of DR screening and the prevalence of DR detected before and after implementing the model was compared. Advantages and disadvantages of these two models will also be discussed.

Methodology

Setting and Subjects

This study was approved by the Bureau of Medical and Technical Development, Department of Medical Services, Ministry of Public Health. All patients with diabetes were recruited from existing database of each district of the province and written informed consents were given. They were excluded if they had any contraindication for using mydriatic eye drops, had retinal diseases which precluded the diagnosis of DR, and had ocular media not clear enough to make a diagnosis by interpretation of digital retinal images. This study was conducted in Tak province since there was complete data of patients with diabetes screened by a comprehensive ophthalmologist using conventional indirect ophthalmoscopy in Tak provincial hospital in the past two years. These data could be compared with data obtained using the new model in this study.

Method and measurements

All included patients were examined by capturing their retinal images using digital nonmydriatic retinal cameras. Although the images can be obtained through nonmydriatic pupils, it is more practical to capture the images through mydriatic pupils since up to 30 percent of images captured through nonmydriatic pupils may not be readable. After their pupils were dilated by one drop of 1% tropicamide under surveillance of potential angle closure of the eye, each pa-

tient was examined first in the right eye and then the left eye. The final DR severity level was determined by the findings in the worse eye. The examination for each eye was 45° single-field[22] digital image capture of the posterior pole, including the optic disc and macula, using a Cannon® non-mydriatic fundus camera (Tokyo, Japan). The technicians who performed image capturing interpreted the 5-million pixel retinal images of each patient immediately; the interpretations were then confirmed by a provincial comprehensive ophthalmologist. The outcomes measured were the coverage percentage of patients with diabetes and prevalence of DR using the digital retinal image model compared to the coverage and prevalence determined by the provincial ophthalmologist in the previous years.

International clinical disease severity scales of DR

The DR severity level was based on the International Clinical Diabetic Retinopathy and Diabetic Macular Edema Disease Severity Scales[23]. In short, DR was classified into five severity levels: no retinopathy, mild retinopathy, moderate retinopathy, severe non-proliferative diabetic retinopathy (NPDR), and proliferative diabetic retinopathy (PDR). Mild NPDR included cases with microaneurysms only. Severe NPDR included cases with more than 20 microaneurysms in each of four quadrants, venous beadings in two or more quadrants, or intraretinal microvascular abnormalities in at least one quadrant. Other cases with more than just microaneurysms alone, but less than severe NPDR, fell into the moderate NPDR category. PDR included cases with neovascularization, and vitreous or preretinal hemorrhage.

Chi-square test was employed to compare the proportion of patients with diabetes in Tak province who had retina screened for diabetic retinopathy in the year 2008 and the proportion of patients screened in the previous two years. The prevalence of non-proliferative DR and proliferative DR in the screened populations in the year 2008 and the previous two years were also compared. The level of significance was defined at 0.01.

Results

There were 4,787 patients with diabetes registered in the database of Tak provincial hospital in the fiscal year of 2008. This was not significantly different from the number registered in the year 2007 and 2006 (Table 1). During five months of 2008, 2,290 patients with diabetes (47.8%) were screened for DR; this coverage was significantly higher ($p < 0.01$) from the same period of the previous two years. The coverage data in 2008 was collected from the screening only between February and June when the digital model was implemented.

The proportion of NPDR detected in 2008 using the digital model was significantly higher than the proportion detected in 2007 and 2006 ($p < 0.01$) although the proportion of PDR was not significantly different (Table 1). Table 2 demonstrates the DR severity levels of patients screened in 2008 in details. In the first four months of fiscal year 2008 when the clinical examination was used for screening, the proportion of No DR detected was not significantly different from the previous two years. However, the prevalence of mild and moderate NPDR detected using the digital model during February to June 2008 was significantly different from the clinical examination during the first four months of fiscal year 2008. Clinical examination detected 19.7 percent in mild category but only 1.9 percent in moderate whereas the digital model detected 22.3 percent in moderate and only 8.9 percent in mild NPDR. The prevalences of severe NPDR or PDR detected by both models were not significantly different. There were 67 patients whom the digital model could not determine the presence of DR; how-

Table 1 Screening coverage of patients with diabetes in Tak province in the fiscal years 2006, 2007, and 2008.

	Number of patients (%)		
	2006	**2007**	**2008****
Patients with diabetes	4,088	4,618	4,787
Patients with diabetes who were screened for DR (%)	1,786 (43.7)	1,677 (36.3)	2,290 (47.8)*
DR severity levels:			
No DR	1,460 (81.7)	1,351 (80.6)	1,429 (62.4)*
NPDR	269 (15.1)	253 (15.1)	734 (32.1)*
PDR	57 (3.2)	73 (4.3)	60 (2.6)

*DR = diabetic retinopathy; NPDR = nonproliferative diabetic retinopathy; PDR = proliferative diabetic retinopathy; * the proportion is significantly different from the previous two years, p < 0.01, chi-square test. There were 67 (2.9%) patients in the year 2008 whose retinal images were not gradable, therefore, they were not reported in the Table.*
***recorded from February to June.*

Table 2 The prevalence of diabetic retinopathy severity levels detected using the digital model and clinical examination in the year 2008.

	Number of patients (%)	
	Digital model (n = 2,290)	**Clinical examination (n = 641)**
No DR	1,429 (62.4)	474 (73.9)
Mild NPDR	203 (8.9)	126 (19.7)
Moderate NPDR	511 (22.3)	12 (1.9)
Severe NPDR	20 (0.9)	7 (1.1)
PDR	60 (2.6)	22 (3.4)
Ungradable	67 (2.9)	0

DR = diabetic retinopathy, NPDR = nonproliferative diabetic retinopathy, PDR = proliferative diabetic retinopathy, digital model was implemented during February - June 2008 whereas clinical examination was conducted from October 2007 - January 2008. The prevalence of each DR level detected by the two modalities was significantly different (p < 0.01), by chi-square test.

ever, there was no patients whom the clinical examination could not detect the presence of DR.

Discussion

It is well demonstrated in this study that the implementation of the digital retinal camera in communities for detecting DR for referral to ophthalmologists can cover more cases than the conventional clinical examination. The digital model was implemented for only five months in the year 2008, but the coverage was already 47.8 percent of all targeted patients. This coverage accounted for only roughly 450 patients per month. More cases could be screened with a well-planned system. This should include the setting up of provincial DR managers who should have specific tasks of DR management in the province. The tasks should include analysis of database of patients with diabetes in the province, planning for retinal camera rotation, co-ordinating technicians and nurses for training, verifying diagnostic data, and maintenance the referral system.

The previous studies concerning DR in Thailand,

conducted between 1990 and 1999 in Nakhon Ratchasima[24], Trang[25], and Lampang[26], had reported the prevalence of NPDR, determined by indirect ophthalmoscopy performed by comprehensive ophthalmologists, was between 12 percent and 25 percent, and the prevalence of PDR was between 1.9 percent and 5.2 percent.

Compared to these studies, the prevalences of NPDR determined by the same modality in this study in the previous two years, 15.1 percent, were approximately the same. The higher prevalence of NPDR determined by digital retinal photography, 32.1 percent, reflects a tendency of this screening modality for detecting more positive cases. Moreover, the prevalence of NPDR in Trang province[25], also determined using the digital modality in a recent study, was 23.8 percent. This prevalence was also higher than that determined by clinical examination.

On the contrary, the prevalence of PDR, determined by both clinical examination and digital retinal photography, was not significantly different. This may be explained by the inherent factor of lesions of PDR, such as neovascularization of the optic disc and elsewhere, which can be well recognized by both modalities.

The standard method for diagnosis of DR is neither comprehensive clinical examination nor digital image interpretation. It is the interpretation of standard 7-field stereoscopic retinal film photography described in the Early treatment Diabetic Retinopathy Study (ETDRS)[8]. This method is impractical and was not used in majority of studies in communities, or even in clinical practice, since it is inconvenient for patients to have their retinal images captured 14 times in one eye for diagnosis. Furthermore, this standard method requires expertise in both image capture and interpretation.

Advantages of the comprehensive eye examination over the photography is its ability to examine peripheral lesions and other ocular diseases which may be missed in the single-field photography[27]. Another advantage of the clinical examination includes an ability to examine through opaque ocular media better than the digital model. This was reflected in this study that there were 2.9 percent of ungradable cases from digital model, but there was no clinically ungradable case. The examination is also cheaper. The major disadvantage of the examination is the consumption of ophthalmologist task forces which are still limited in our country.

Retinal photography, on the other hand, may have advantages in mass screening. For individual patients, the model may detect subtle changes which can easily be missed during a live examination, especially when time was a constraint. In addition, the photography has an advantage in implementing as an alternative to clinical examination to identify cases for referra[28] via telemedicine practice. The model can be utilized by trained paramedical personnel with ophthalmologist supervision. The disadvantage of this model is the high initial investment cost, although it was found to be cost-effective in some studies[17-18].

In summary, the digital model for DR screening can screen more patients in a shorter period of time and may be able to detect more positive cases than the conventional ophthalmoscopy. To have most patients with diabetes screened for DR prevention of blindness. This model should be implemented nationwide as an alternative to clinical examination by ophthalmologists.

References

1. Centers for Disease Control and Prevention (CDC). Prevalence of visual impairment and selected eye diseases among persons aged >/=50 years with and without diabetes-United States, 2002. MMWR Morb Mortal Wkly Re. 2004; 53:1069-71.
2. Buch H, Vinding T, La Cour M, Appleyard M, Jensen GB, Nielsen NV. Prevalence and causes of visual im-

pairment and blindness among 9980 Scandinavian adults: the Copenhagen City Eye Study. Ophthalmology 2004; 111:53-61.
3. Idil A, Caliskan D, Ocaktan E. The prevalence of blindness and low vision in older onset diabetes mellitus and associated factors: a community-based study. Eur J Ophthalmo. 2004; 14:298-305.
4. Pardhan S, Gilchrist J, Mahomed I. Impact of age and duration on sight-threatening retinopathy in South Asians and Caucasians attending a diabetic clinic. Eye 2004; 18:233-40.
5. UK Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulfonylurea or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). Lancet 1998; 352:837-53.
6. UK Prospective Diabetes Study (UKPDS) Group. Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38. BMJ 1998; 317:703-13.
7. Diabetes Control and Complications Trial Research Group. Progression of retinopathy with intensive versus conventional treatment in the Diabetes Control and Complications Trial. Ophthalmology 1995; 102:647-61.
8. Early Treatment Diabetic Retinopathy Study Research Group. Early photocoagulation for diabetic retinopathy: ETDRS Report Number 9. Ophthalmology 1991; 98:766-85.
9. American Diabetes Association. Diabetic retinopathy. Diabetes Care 2002; 25(l):590-3.
10. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes Care 2004; 27:1047-53.
11. Aekplakorn W, Stolk RP, Neal B, Suriyawongpaisal P, Chongsuvivatwong V, Cheepudomwit S, et al. INTERASIA Collaborative Group. The prevalence and management of diabetes in Thai adults: the international collaborative study of cardiovascular disease in Asia. Diabetes Care 2003; 26:2758-63.
12. Chetthakul T, Deerochanawong C, Suwanwalaikorn S, Kosachunhanun N, Ngarmukos C, Rawdaree P, et al. Thailand diabetes registry project: prevalence of diabetic retinopathy and associated factors in type 2 diabetes mellitus. J Med Assoc Thai 2006; 89(1):27-36.
13. Lin DY, Blumenkranz MS, Brothers R, Digital Diabetic Screening Group (DDSG). The role of digital fundus photography in diabetic retinopathy screening. Diabetes Technol Ther 1999; 1:477-87.
14. Lim JI, LaBree L, Nichols T, Cardenas I. A comparison of digital nonmydriatic fundus imaging with standard 35-millimeter slides for diabetic retinopathy. Ophthalmology 2000; 107:866-70.
15. George LD, Halliwell M, Hill R, Aldington SJ, Lusty J, Dunatan F, et al. A comparison of digital retinal images and 35 mm colour transparencies in detecting and grading diabetic retinopathy. Diabet Med 1998; 15:250-3.
16. Fong DS, Aiello L, Gardner TW, King GL, Blankenship G, Cavallerano JD, et al. Retinopathy in diabetes. Diabetes Care 2004; 27(l):84-7.
17. Javitt JC, Canner JK, Sommer A. Cost effectiveness of current approaches to the control of retinopathy in type 1 diabetics. Ophthalmology 1989; 96:255-64.
18. Taylor DJ, Fisher J, Jacob J, Tooke JE. The use of digital cameras in a mobile retinal screening environment. Diabet Med 1999; 16:680-6.
19. Li HK. Telemedicine and ophthalmology. Surv Ophthalmol 1999; 44:61-72.
20. Gomez-Ulla F, Rodriguez-Cid MJ, Fernandez MI, Casanueva FF, Gonzalez F, Tome M, et al. Digital retinal images and teleophthalmology for detecting and grading diabetic retinopathy. Diabetes Care 2002; 25:1384-9.
21. Ruamviboonsuk P, Wongcumchang N, Surawongsin P, Panyawatananukul E, Tiensuwan M. Screening for diabetic retinopathy in rural area using single-field, digital fundus images. J Med Assoc Thai 2005; 88:176-180.
22. Williams GA, Scott IU, Haller JA, Maguire AM, Marcus D, McDonald HR. Single-field fundus photography for diabetic retinopathy screening: a report by the American Academy of Ophthalmology. Ophthalmology 2004; 111:1055-62.
23. Wilkinson CP, Ferris FL 3rd, Klein RE, Lee PP, Agardh CD, Davis M, et al. Proposed international clinical diabetic retinopathy and diabetic macular edema disease severity scales. Ophthalmology 2003; 110:1677-82.
24. Nitiapinyasakul N, Nitiapinyasakul A, Chedtakul T. Diabetic retinopathy screening in community hospitals. Thai J Ophthalmol 2004; 8(2):95-102
25. Supapluksakul S, Ruamviboonsuk P, Chaowakul W. The prevalence of diabetic retinopathy in Trang province determined by retinal photography and comprehensive eye examination. J Med Assoc Thai 2008; 91:716-22.
26. Samaiporn S, Lertmeemongkolchai P, Chongwiriyanurak T, Aunjaree P, Chayaboon D, Photikamjorn A, et al. Prevalence and risk of diabetic

retinopathy in relation to duration of diabetes mellitus in community hospital in Lampang. Thai J Ophthalmol 2001; 15(1):1-8

27. Ruamviboonsuk P, Teerasuwanajak K, Tiensuwan M, Yuttitham K. Interobserver agreement in the interpretation of single-field digital fundus images for diabetic retinopathy screening. Ophthalmology 2006; 113:826-32.
28. Choremis J, Chow DR. Use of telemedicine in screening for diabetic retinopathy. Can J Ophthalmol 2003; 38:537-8.

บทคัดย่อ **รูปแบบการคัดกรองโรคจอตาจากเบาหวานในชุมชนของประเทศไทย**

สุรวิทย์ เตชธุวานันท์*, ไพศาล ร่วมวิบูลย์สุข**

*สำนักวิชาการสาธารณสุข กระทรวงสาธารณสุข นนทบุรี, **แผนกจักษุวิทยา โรงพยาบาลราชวิถี กรุงเทพมหานคร

วารสารวิชาการสาธารณสุข **2551; 17:SV1254-60.**

วัตถุประสงค์ของงานวิจัยเปรียบเทียบนี้ เพื่อประเมินการนำร่องใช้ภาพถ่ายจอตาแบบดิจิตอล เพื่อค้นหาผู้ป่วยโรคจอตาจากเบาหวานในชุมชนเพื่อส่งต่อจักษุแพทย์ ผู้ป่วยเบาหวานในจังหวัดตาก ได้รับการตรวจจอตาด้วยการถ่ายภาพจอตาแบบดิจิตอล ซึ่งอ่านผลขั้นแรกโดย บุคลากรทางการแพทย์ผู้รับการอบรมและได้รับการกำกับดูแลโดยจักษุแพทย์ในโรงพยาบาลตาก ได้หมุนเวียนกล้องถ่ายภาพจอตาไปตรวจจอตาของผู้ป่วยเบาหวานในชุมชนต่าง ๆ ในเขตรับผิดชอบของโรงพยาบาล อัตราการตรวจตา รวมทั้งความชุกของเบาหวานเข้าจอตา ซึ่งตรวจได้จากวิธีนี้ใน พ.ศ. 2551 ได้เปรียบเทียบการตรวจด้วยวิธีดั้งเดิมคือ การตรวจตาโดยจักษุแพทย์ด้วยเครื่องมือ indirect ophthalmoscope ในเขตชุมชนเดียวกัน เมื่อ 2 ปีก่อน พบว่าในเวลา 5 เดือนของปีงบประมาณ 2551 ผู้ป่วยเบาหวานจำนวน 2,290 คน (47.8%) ได้รับการตรวจตาด้วยระบบดิจิตอล ซึ่งมี มากกว่าจำนวนการตรวจได้ในช่วงเวลาเดียวกันของปีงบประมาณ 2550 และ 2549 อย่างมีนัยสำคัญทางสถิติ ($p < 0.01$) ความชุกของเบาหวานเข้าจอตาชนิด non-proliferative เท่ากับ 32.1 เปอร์เซ็นต์ ก็มากกว่าความชุกที่ตรวจได้จากวิธีเดิม ซึ่งเท่ากับ 15.1 เปอร์เซนต์ อย่างมีนัยสำคัญทางสถิติ ($p < 0.01$) อย่างไรก็ตาม ความชุกของเบาหวานเข้าจอตาชนิด proliferative เท่ากับ 2.6 เปอร์เซ็นต์ ไม่มีความแตกต่างจากความชุกที่ตรวจได้จากวิธีเดิม อย่างมีนัยสำคัญทางสถิติ ($p = 4.8$) การตรวจจอตาด้วยการใช้ภาพดิจิตอลนี้ สามารถตรวจผู้ป่วยได้จำนวนมากกว่าวิธีเดิมในเวลาที่สั้นกว่า และยังค้นหาผู้ป่วยที่มีเบาหวานเข้าจอตาได้มากกว่า วิธีการตรวจนี้ควรจะได้รับนำไปใช้ทั่วประเทศ เพื่อลดปัญหาตาบอดของประเทศต่อไป

คำสำคัญ: **โรคจอตาจากเบาหวาน, ถ่ายภาพจอตาแบบดิจิตอล, การคัดกรองในชุมชน**