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Original Article

Use of telemedicine in remote screening for retinopathy in type 2 diabetes

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ABSTRACT

Background: Telemedicine is developed to bridge the gaps in health care delivery systems. We evaluated the role of telemedicine in screening for diabetic retinopathy (DR).**Methods:** The study population (T2DM > 1 year, aged 20–75 years) were screened for retinopathy using 3nethra royal non-mydriatic 3 megapixel fundus camera from Forus Health Private Ltd. The image is analyzed using telemedicine and the final report is generated within 30 min. The baseline demographic parameters were noted and the data were analyzed using appropriate statistical methods.**Results:** The study participants (196M:269F) had a mean age of 55.7 ± 10 years and duration of diabetes of 10.4 ± 6.78 years. The retinopathy screening resulted in a final diagnosis of normal fundus in 86%, non-proliferative diabetic retinopathy (NPDR) in 11%, proliferative diabetic retinopathy in 2%, and clinically significant macular edema in 1% of patients. The NPDR is seen in mild ($n = 20$), moderate ($n = 22$), and severe ($n = 9$) forms.**Conclusion:** Our study highlights the importance and ease of telemedicine in screening of DR. The use of technology improved the access to a retinal specialist enabling the patients to receive comprehensive care under a single roof.

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1. Background

India has the second highest number of diabetic patients across the world with estimated number close to 70 million individuals. Further, the prevalence of diabetes in India is rapidly increasing and the diabetic patient population is

projected to reach 100 million by 2030.¹ Diabetic retinopathy (DR) is one of the classical microvascular complications of diabetes and may lead to blindness in advanced stages. DR progresses from the asymptomatic stage of mild to moderate non-proliferative diabetic retinopathy (NPDR) to severe NPDR and proliferative diabetic retinopathy (PDR).² The disease is detectable at the asymptomatic stage by retinal examination

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after dilating the pupil by a trained specialist. The annual screening for retinopathy helps in identifying the patients early and helps in the prevention of the blindness.³ Comprehensive management of diabetes, thus, requires a multi-disciplinary approach. However, the screening aspects are neglected by many patients due to the physical burden involved in the additional visit to an ophthalmology center. Previous reports suggest that only <50% of the referred patients visit the eye centers in the developed countries.⁴ Thus, there is an unmet need of bridging this gap in the management of diabetes, helping in early detection of diabetes retinopathy.⁵

Telemedicine as an independent specialty is growing rapidly by leaps and bounds to help the mankind in alleviating the suffering. The major role of telemedicine is in connecting the remote areas to the advanced care centers and this exchange of information results in better outcomes to the patient.⁶ Telemedicine has been used extensively in wide areas of diabetes, including diagnosis, management, and prevention of complications.^{7,8} The diabetes care in India is provided mainly by the physicians and endocrinologists in a 'small clinic' based setup. The situation is similar in both urban and rural areas with <10% of patients following up regularly at a corporate hospital. Most of the ophthalmologists trained in vitreoretinal subject are located in urban areas and in the largest specialty eye hospitals. The inconvenience of visiting another hospital for a comprehensive retinal examination leads to increased dropout rates. Previous reports suggest an encouraging role of telemedicine in the screening of DR and the same has not been studied in detail from our country.^{9,10} Hence, we explored the feasibility of using telemedicine for screening of diabetes retinopathy at the physician clinic and report our preliminary observations in this paper.

2. Methods

2.1. Study participants

The study was conducted in a diabetes clinic located at the Hyderabad, the capital city of the newly formed Telangana state of India. The estimated prevalence of diabetes in Hyderabad is about 16%, which is much above the national average.¹¹ The site of the study is a diabetic and an endocrine outpatient clinic with a daily outpatient load of about 40–50 patients. The patients with a diagnosis of type 2 diabetes (aged between 20 and 75 years, duration more than one year, and willing to undergo the nonmydriatic fundus screening test at the clinic) were included in the study. The demographic characteristics, including the age, duration of diabetes, sex, height, weight, and body mass index, were recorded from the patient's records. All the participants gave verbal informed consent for their participation in the study. Our study does not require ethical committee approval, as the procedure involves routine screening for complications of diabetes.

2.2. Retinopathy screening

All patients initially undergo a normal visual field examination using the Snellen's charts. The patients are then explained

about the procedure of fundal imaging. Digital retinal photographs are taken to cover the entire retinal area (posterior pole covering disk and macula, nasal, superior, and inferior areas) using a nonmydriatic camera (3nethra royal non-mydratic 3 megapixel CMOS fundus camera) from Forus Health Private Ltd, India. The apparatus consists of an imaging unit and an operator console. The acquired retinal images are transferred by Internet to the central office with the availability of retinal specialist. The images are reviewed by the vitreoretinal specialist and graded using the standard diabetes retinopathy classification.¹²

The final report is generated immediately incorporating the comments of the ophthalmologist and handed over to the patient. A sample report is shown in Fig. 1 and the total turnaround time for the procedure is less than 30 min. Patients with a diagnosis of severe NPDR, PDR, or clinically significant macular edema (CSME) are referred to an advanced eye care center for further management. We did not follow up these patients further after the ophthalmic intervention. Other patients are advised yearly follow-up for retinopathy in addition to the management of diabetes and hypertension. All the patients were interviewed after the procedure to document any problems faced by the patients during the screening procedure.

2.3. Statistical analysis

Data are presented as mean \pm S.D. and descriptive statistics were used for the data analysis. The sample size and power of the study analysis was performed to estimate the total number of patients required to be screened for retinopathy. It was estimated that a minimum 375 patients would be required to ensure with a 95% confidence level, that at least 15 patients with PDR would be diagnosed based on the population estimate of 5% of PDR. Hence, we studied 465 patients with a confidence interval of 4 giving 90% power to our study. A *p* value of less than 0.05 was considered significant for all the tests. The statistical analysis was done using the Graph Pad Prism Software, Version 6 (Graph Pad Software, San Deigo, CA, USA).

3. Results

The study participants (196M:269F) had a mean age of 55.7 ± 10 years, BMI of 24.5 ± 6.7 kg/m² and diabetes duration of 10.4 ± 6.7 years. In 385/465 (87%) patients, it showed normal fundus. NPDR was seen in 51/465 (11%) (mild 20, moderate 22, and severe 9) patients. Six patients had CSME and 3 patients had PDR. In 20 patients, changes of cataract were seen (cataract both eyes 12 patients, single eye 8 patients) precluding the fundal imaging. The requirement of re-examination due to a hazy or unclear picture was observed in only 10 patients (2%). Fig. 1 shows fundus image of a patient with severe NPDR with CSME along with the reporting format.

The majority of the patients who underwent screening procedures had long duration of diabetes (>5 years, *n* = 356) than short duration (duration <5 years, *n* = 109). Fig. 2 shows the prevalence of retinopathy as per the duration of diabetes. The number of patients with retinopathy increases with

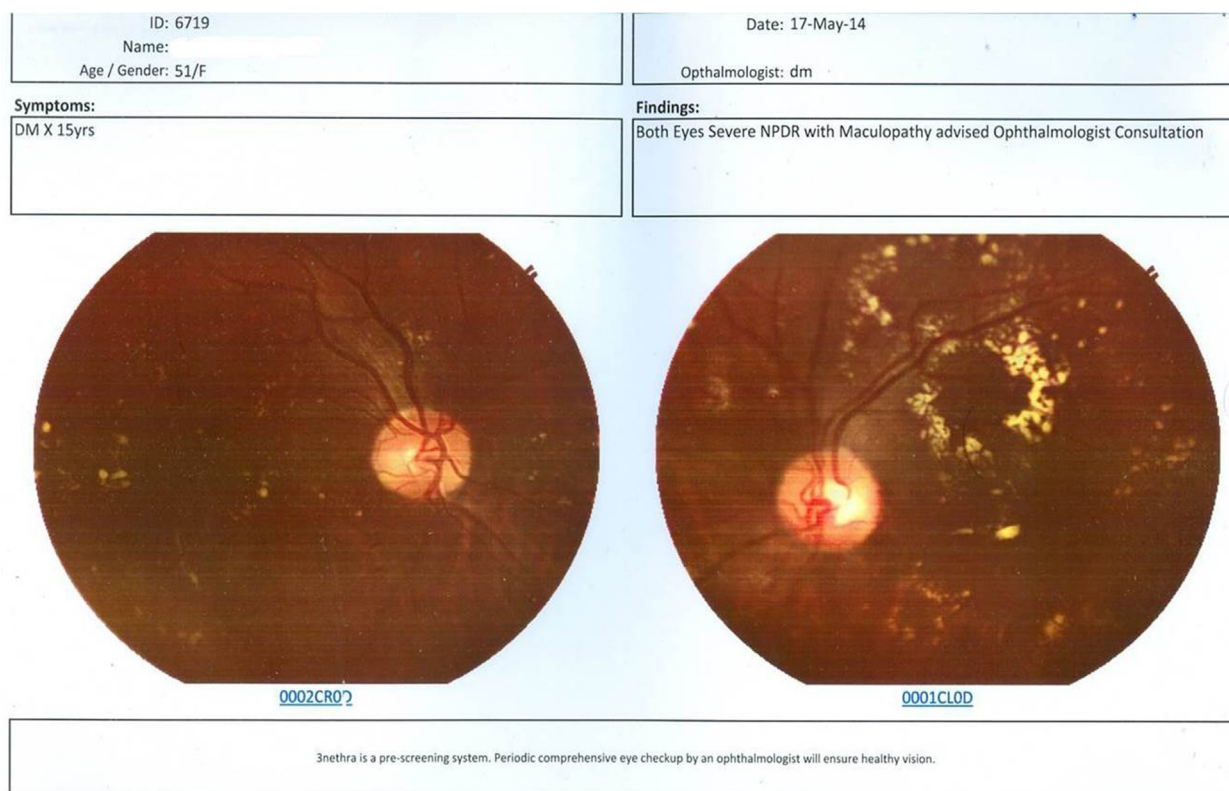


Fig. 1 – Sample image of fundus camera of a patient with NPDR.

increasing duration of diabetes. In patients with diabetes duration more than 5 years ($n = 356$) retinopathy was observed in 55 patients (15%) in contrast to 5 patients with retinopathy among 109 patients (5%) with DM duration ≤ 5 years ($p = 0.01$).

4. Discussion

Our study establishes the effectiveness of telemedicine for screening patients for DR in a small clinic set up in an urban area. Our study also confirms the feasibility, safety, and ease of

conducting this patient-friendly screening procedure for retinopathy. Previous reports from India also suggest similar findings from South India and also the highlight the need for establishing the satellite clinics in rural areas.^{9,13,14} Telemedicine is defined as a distant delivery of health-related services through transfer of audio, video, and graphical information via telecommunication networks, including consultative and diagnostic services along with the enablement of planning, coordination, collaboration, and education.¹⁵ The use of telemedicine can potentially enable the extension of medical knowledge to remote areas, thus enhancing accessibility, affordability, and quality of health care services.

There are two broad types of telemedicine design, namely, human-human “interaction in real-time” (synchronous consultations) and “store and transfer” mode.¹⁶ Real-time interactions may involve various levels of healthcare workers: Doctor-doctor, doctor-paramedic, or doctor-patient. In the “store and transfer” type, data are collected, stored, and transferred from peripheral centers to the central node for a specialist's opinion, for example image of an X-ray (tele-radiology) or ECG (tele-cardiology) or an image of the fundus of the eye (tele-ophthalmology).¹⁷ Telescreening for DR is cost-effective, accurate, and reliable method that helps in screening for DR. The American Telemedicine Association has issued guidelines recently to help in providing quality screening services to people with diabetes.¹⁸

DR is a typically slow progressing complication of diabetes, which is amenable to image-based diagnosis in the early asymptomatic stage. Socio-economic and infrastructural constraints are the main challenges for patients to undergo

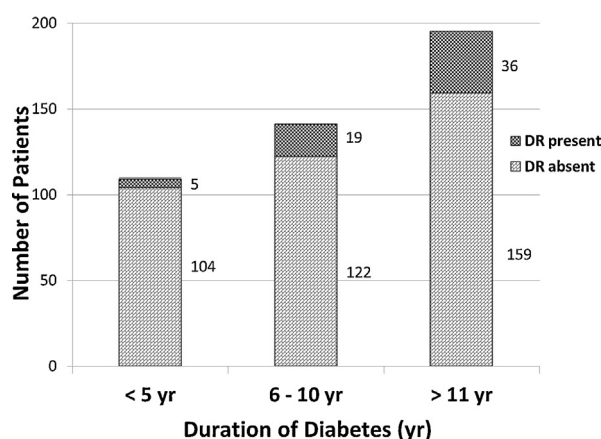


Fig. 2 – Prevalence of retinopathy as per the duration of diabetes.

annual screening for DR.¹⁹ Previous studies from India have demonstrated the effectiveness of telemedicine in the DR screening program.^{9,10,14} They also suggest improved patient satisfaction with telemedicine rather than direct screening by an ophthalmologist.²⁰ We did not compare the study findings with ophthalmology consultations in every patient, preventing similar analysis from our database. Few authors have established the mobile eye care centers and the fundal camera is transported to the remote areas for screening purpose.²¹ Satellite-based connectivity models are also used to circumvent the problem of lack of electricity in these models.

Our study is based on a small number of patients attending an out-patient diabetes and endocrinology clinic in Hyderabad. The same technology has the potential for mass screening program due to the ease of multidisciplinary care through telemedicine. The strength of our study is to establish the use of this novel screening measure in a diabetes clinic for the benefit of retinopathy screening. Our study participants reside mostly in urban areas, which is a major limiting factor of the study. The acceptance of any new technology is different between the urban and rural areas due to the prevailing customs and beliefs of the population.²² Another limitation of our study is the lack of retinopathy screening by established methods in the patients to assess the sensitivity and specificity of the fundal imaging. Further elaborate studies involving a larger number of patients are required to confirm our findings.

5. Conclusion

To conclude, we propose that telemedicine can be used for providing 'multi-disciplinary' care for a diabetic patient visiting primary care physician. The technology using the fundus camera is cost effective, reliable, and accurate in the examination. This patient-friendly application has the potential to reach a wider audience with adequate support from the organizations involved in diabetes care.

Conflicts of interest

The authors have none to declare.

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