Implementation of medical retina virtual clinics in a tertiary eye care referral centre

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ABSTRACT

Background The increasing incidence of medical retinal diseases has created capacity issues across UK. In this study, we describe the implementation and outcomes of virtual medical retina clinics (VMRCs) at Moorfields Eye Hospital, South Division, London. It represents a promising solution to ensure that patients are seen and treated in a timely fashion

Methods First attendances in the VMRC (September 2016–May 2017) were included. It was open to non-urgent external referrals and to existing patients in a face-to-face clinic (F2FC). All patients received visual acuity testing, dilated fundus photography and optical coherence tomography scans. Grading was performed by consultants, fellows and allied healthcare professionals. Outcomes of these virtual consultations and reasons for F2FC referrals were assessed.

Results A total number of 1729 patients were included (1543 were internal and 186 external referrals). The majority were diagnosed with diabetic retinopathy (75.1% of internal and 46.8% of external referrals). Of the internal referrals, 14.6% were discharged, 54.5% continued in VMRC and 30.9% were brought to a F2FC. Of the external referrals, 45.5% were discharged, 37.1% continued in VMRC and 17.4% were brought to a F2FC. The main reason for F2FC referrals was image quality (34.7%), followed by detection of potentially treatable disease (20.2%).

Conclusion VMRC can be implemented successfully using existing resources within a hospital eye service. It may also serve as a first-line rapid-access clinic for low-risk referrals. This would enable medical retinal services to cope with increasing demand and efficiently allocate resources to those who require treatment.

INTRODUCTION

The origins of the virtual consultation emerged in the early 1900s, when radio communication was invented and 'radio doctors' could attend to patients by the means of two-way radios, akin to walkie-talkies of today. However, it was not until the 1940s when the first store-and-forward model of telemedicine transpired when radiology images were transmitted via telephone lines.[1] In the past 10 years, the disruptive impact that optical coherence tomography (OCT) has had on the management of retinal disease has led to a surge in ocular imaging within this subspecialty.[2] This shift in the way we manage retinal disease has lent itself very well to the field of telemedicine.

A major challenge in eye care is capacity: hospitals continue to receive an increasing number of referrals from community care providers due largely to an ageing population and the wider availability of ophthalmic imaging devices in optometry practices.[3] The first published reports on the use of telemedicine to improve efficiency of eye clinics in UK have been in glaucoma.[4 5] These appointments usually consist of non-mydriatic photos of the optic disc, visual fields and visual acuity (VA) measurements carried out by a technician, stored and later reviewed by an ophthalmologist. These early reports observed that the majority of patients (62%–89%) did not require treatment[4] and further demonstrated that virtual clinics were reliable, cost-effective, freeing up clinical appointments for those in need of hospital care.[6]

The increase in demand for hospital eye service appointments is felt by the glaucoma service and in all other subspecialties of ophthalmology. In 2016, the Royal College of Ophthalmologists estimated that about 20 patients per month face severe vision loss while waiting for their appointment.[7] The situation in UK is aggravated by one of the lowest numbers of ophthalmologists per capita (52/1 million inhabitants) of all industrialised countries.[8] This supply-demand imbalance is also evident globally.[9] To overcome this burden, efforts are underway to improve efficiency and better utilisation of non-medical staff for the provision of eye care. One example in UK is the introduction of nurse-led injection clinics, which have been shown to be as safe and acceptable to patients as doctor-led injection clinics.[10]

Within medical retina services, projections for the volume of patients with diabetes requiring a hospital appointment suggest we have only hit the tip of the iceberg.[11] In 2012, there were 28 million people with vision-threatening diabetic retinopathy (DR) worldwide, estimated to rise to 43 million by 2035.[12] Moreover, recent major advances in the treatment of DR such as intravitreal injection therapy have added to the increasing demands on healthcare systems.[13 14]

In UK, a successful and cost-effective national diabetic retinopathy screening services (DRSS) has been existing for more than a decade and is widely credited with the successful reduction of vision loss from diabetic eye disease in the working age group nationally.[15–17] Early detection of DR by screening saves patients from having to attend hospital eye services for their annual eye examination. However,

Table 1 Patient demographics of first time attendees to virtual clinic

	Number	DNAs	Female	Age (years)
Internal referrals	1543	316 (20.5%)	701 (45.4%)	66.1 (female); 62.2 (male)
New patients	186	18 (9.7%)	85 (45.7%)	55.7 (female); 57.1 (male)

DNA, patients who did not attend their appointment.

the flip side of early detection is the low thresholds for referral set within the screening services. 'Referrable retinopathy' does not equate 'treatable retinopathy'. Hospitals are therefore faced with an increasing number of referrals that do not yet and may never require treatment.

In this study, we report on the implementation and integration of virtual medical retina clinics (VMRCs) from four sites of Moorfields Eye Hospital, South Division, London and report on the outcomes of those consultations.

Table 2 Comparison between internal referrals and external referrals of new patients

	Internal referrals	New patients
Patient data		
Number of patients	1227	168
Average review processing time	8.34 days	13.6 days
VA of better eye (average)	64.1 ETDRS letters	81.5 ETDRS letters
Disease and grade		
Diabetic retinopathy (not graded)	20 (1.6%)	2 (1.2%)
R0M0	72 (5.9%)	2 (1.2%)
R0M1A	1 (0.1%)	
R1M0	239 (19.5%)	38 (22.8%)
R1M1	351 (28.6%)	34 (20.4%)
R1M1A	2 (0.2%)	
R1M1S	39 (3.2%)	
R2M0	32 (2.6%)	2 (1.2%)
R2M1	76 (6.2%)	
R2M1A	8 (0.7%)	
R3M0	56 (0.7%)	
R3M1	64 (5.2%)	
R3M1A	7 (0.6%)	
Dry AMD	74 (6.0%)	17 (10.2%)
Retinal vein occlusion	56 (4.6%)	2 (1.2%)
Central serous retinopathy	21 (1.7%)	2 (1.2%)
Other	101 (8.2%)	68 (40.7%)
Not gradable due to bad image quality	8 (0.7%)	1 (0.6%)
Outcomes		
Percentage of patients discharged	179 (14.6%)	76 (45.5%)
Percentage of patients continued in virtual clinic	669 (54.5%)	62 (37.1%)
Time until next follow-up in virtual clinic	211.6 days (+/− 80.3)	243.8 days (+/−78.8)
Patients brought to face-to-face clinic	379 (30.9%)	29 (17.4%)
Time until next follow-up in face-to-face clinic	178.2 days (+/− 103.9)	139.3 days (+/−88.6)

Only those patients are included, who attended their first appointment. AMD, age-related macular degeneration; ETDRS, early treatment diabetic retinopathy study; VA, visual acuity.

MATERIALS AND METHODS

All first attendances (September 2016–May 2017) at the VMRC at Moorfields Eye Hospital, South Division (St. George's hospital, The Nelson Health Centre, Purley War Memorial Hospital and Croydon University Hospital) were included. Patients were either referred internally from a medical retina clinic or new referrals from DRSS. Retrospective clinical data from MR clinics 3 months prior to the next clinic date at the above locations were reviewed over a period of 12 months, and more than 7000 patients were scrutinised for suitability for virtual clinics in this 9 months period. This study was part of a registered audit with the Audit Department of Moorfields Eye Hospital NHS trust. Patients who were graded as low risk were referred to the virtual clinic. Risk stratification, inclusion and exclusion criteria for virtual clinics are listed in online supplementary table 1.

The virtual clinic appointment consisted of a clinical examination where past medical history, VA and non-contact intraocular pressure were taken by trained nurses and entered in an electronic medical record (EMR), which was, depending on the site, either Medisoft (Medisoft, Leeds, UK) or OpenEyes (OpenEyes Foundation, London, UK). Patients then received dilated fundus photography. Depending on the availability of retinal imaging at locations, either 2-field 45° fundus photography or wide field fundus photography (Optos) was obtained.[18] Additionally, every patient received an OCT volume scan (Topcon 3D OCT scan).[19]

An intranet-based worklist with data from EMRs and patient administration system (Silverlink PAS) was created using Microsoft SQL Server Reports Software (Microsoft). Patients were identified from this tool by reviewers. In total, there were six reviewers; three were ophthalmological consultants, one medical retinal fellow, one optometrist and one a senior screener grader with a DRSS background. For patients with diabetes, grading of findings was performed according to the national UK guidelines.[20] According to these, retinopathies are graded into four levels: none (R0), background (R1), preproliferative (R2) and proliferative (R3). Maculopathy and photocoagulation are graded as absent (M0, P0) or present (M1, P1). The review took place within 1 week of examination. After finishing the virtual review, a letter with the outcome was sent to the patient, the GP and if applicable the DRSS. Outcome could be either follow-up in the virtual clinic, follow-up in a face-to-face clinic (F2FC) or discharge. Period of observation was from June 2016 until June 2017.

Data were extracted into an Excel spreadsheet from the hospital's data warehouse containing PAS and EMR data, running on a Microsoft SQL server in the hospital's data centre. All patient encounters were reviewed manually in the EMRs to include the disease state and the outcome. Outcomes were stratified by follow-up in virtual clinic, discharge from virtual clinic and referral to face-to-face medical retina clinic. Face-to-face referrals were further categorised by:

► Urgent referral needed, that is, urgent need for an intervention like pan-retinal laser treatment in proliferative DR.
► Routine referral: for example, due to cataract or non-urgent interventions needed.
► Patient request as noted by nurses or technicians.
► Not suitable for virtual clinic, for example, patient is wheelchair user.
► Booking error: that patient was not intended to turn into a virtual consultation.
► Glaucoma suspect: on assessment, there was suspicion of glaucoma, when not noted before in the records.

Table 3 Outcomes in numbers of the virtual clinical consultation stratified by clinical rank of reviewing person and diabetic retinopathy grade respectively for other retinal diseases

Disease and grade		Clinical rank			Disease and grade		Clinical rank		
		Consultant	Fellow	Grader			Consultant	Fellow	Grader
R0	F2F	20	1	11	CSR	F2F	2		1
	Virtual	12	0	5		Virtual	8		4
	DC	15	0	8		DC	7		0
R1	F2F	60	13	67	RVO	F2F	14	0	4
	Virtual	95	106	248		Virtual	24	1	3
	DC	20	9	42		DC	11	0	1
R2	F2F	18	9	23	AMD	F2F	15	2	5
	Virtual	15	9	34		Virtual	14	6	6
	DC	0	0	1		DC	38	0	5
R3	F2F	16	4	47					
	Virtual	21	8	21					
	DC	1	0	2					

The most frequent outcome is highlighted for every clinical rank and disease.

AMD, age-related macular degeneration; CSR, central serous retinopathy; DC, discharge; F2F, face-to-face clinic; RVO, retinal vein occlusion.

► Image quality: in the presence of optical axis opacity or inadequate photographs, patients were referred to face-to-face consultation.

Statistical analyses were performed using SPSS 24 (IBM) for Microsoft Windows.

RESULTS

A total of 1729 patients were referred to the virtual clinic. The average time for internal referrals between last consultation in a medical F2FC and their appointment in the virtual clinic was 107.4 days (SD +/–84.3 days). The average waiting time for new referrals was 45.3 days (SD +/–27.6 days). Table 1 shows the patient demographics, the referral source of all referred patients and the rate of patients who did not attend (DNA) their first appointment.

Diagnoses of patients seen in virtual medical retina clinic

75.1% (internal referrals) and 46.8% (external referrals) of patients were reviewed for diabetic eye disease, with 28.6% (internal referrals)/20.4% (external referrals) mild non-proliferative DR (R1M1 equivalent), 22.8% (internal referrals)/24% (external referrals) previously treated stable retinopathy (R3S equivalent), 40% (internal referrals)/20.4% (external referrals)

previously treated stable maculopathy (M1S equivalent). Age-related macular degeneration (AMD), retinal vein occlusion (RVO) and central serous retinopathy (CSR) were the most common diagnoses in descending order after diabetes. Table 2 gives an overview of the medical data of all patients who attended their first appointment at the VMRC.

Outcome of virtual medical retina consultations

Table 2 also indicates what the outcomes (continue in virtual clinic, bring patient to F2FC or discharge) of those patients were. Of all internal referrals, 14.6% of patients were discharged, 54.5% of patients could continue their therapy in a virtual clinic and 30.9% of patients were booked for a face-to-face appointment. For new referrals, 45.5% of patients could be discharged straight away, 37.1% of patients continued virtually and 17.4% of patients were brought to a F2FC . The decisions made in correlation to the clinical rank of the reviewing person can be seen in table 3 broken down by disease.

Stratification of outcomes by diagnosis

Figure 1 shows in detail what the outcomes were, based on the underlying disease and state. Early stages of diabetic eye affection (R1M0 and R0M0) had the highest discharge rate of all DR stages. Patients graded as R1M1 had the highest rate of continuation in virtual clinic. Reasons for F2FC referral from the virtual clinic.

Table 4 gives the reasons stratified by disease why patients were brought to F2FC. The most common reason for a referral to a F2FC was poor image quality. This could be, for example, poor imaging acquisition technique or opacified optical media like advanced cataract.

DISCUSSION

In this study, the feasibility of implementing an integrated VMRC from four sites within a hospital eye service was demonstrated. In the 1729 patients reviewed, the majority had a diagnosis of diabetic eye disease. We furthermore reviewed patients with other retinal conditions in the VMRC namely: AMD, RVO and CSR. With an inclusion criteria set at the level where the legal requirements for driving are met, only a minority 0.7% of patients had ungradable images and therefore required an additional F2FC review. The turnaround time for obtaining
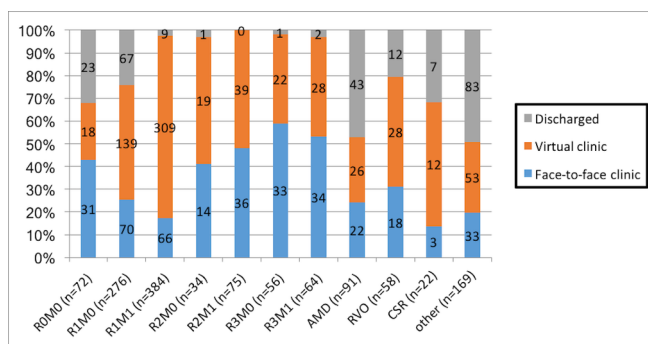

Figure 1 Outcomes of virtual clinic stratified by disease and diabetic retinopathy grading. Vertical axis gives percentages, numbers on bars give absolute numbers of patient. AMD, age-related macular degeneration; CSR, central serous retinopathy; RVO, retinal vein occlusion.

Table 4 Reasons for face-to-face referrals stratified by disease and diabetic retinopathy grading

DR grade	Referrals to face to face	Urgent (detection of treatable disease)	Image quality	Not suitable for virtual	Regular (eg, cataract)	Booking error	Patient request	Glaucoma suspect
R0M0	31	1 (3.0%)	19 (57.6%)	3 (9.1%)	8 (24.2%)			
R1M0	70	2 (2.8%)	45 (63.4%)	8 (11.3%)	12 (16.9%)	1 (1.4%)	1 (1.4%)	1 (1.4%)
R1M1	66	19 (28.4%)	12 (17.9%)	11 (16.4%)	22 (32.8$)	1 (1.5%)	1 (1.5%)	
R2M0	14	1 (7.1%)	4 (28.6%)	4 (28.6%)	5 (35.7%)			
R2M1	36	14 (37.8%)	6 (16.2%)	9 (24.3%)	6 (16.2%)	1 (2.7%)		
R3M0	33	1 (3.0%)	11 (33.3%)	13 (39.4%)	6 (18.2%)	1 (3.0%)	1 (3.0%)	
R3M1	34	3 (8.8%)	14 (41.2%)	9 (26.5%)	7 (20.6%)		1 (2.9%)	
AMD	22	11 (50%)		5 (22.7%)	5 (22.7%)	1 (4.5%)		
RVO	17	13 (72.2%)	1 (5.6%)	2 (11.2%)	1 (5.6%)			
CSR	3	1 (33.5)		2 (66.7%)				
Total	326	66 (20.2%)	112 (34.7%)	66 (20.2%)	72 (22.1%)	5 (1.5%)	4 (1.2%)	1 (0.3%)

AMD, age-related macular degeneration; CSR, central serous retinopathy; DR, diabetic retinopathy; RVO, retinal vein occlusion.

an outcome in a virtual clinic was less than 2 weeks in most cases with a mean of 8 days for follow-up appointments. The majority of patients from internal referrals could be followed up in the virtual clinic whereas most of the new referrals could be discharged, creating capacity in the face-to-face medical retina clinics.

A major discussion point during the inception of these VMRCs was whether to implement 'single-disease' clinics both at the point of image acquisition and outcome grading. A major advantage of 'single-disease' clinics is the ability to train non-medical health professionals like in a DRSS. This means a significant difference in cost, as the price of one consultant's working hour is 41.11 pounds/hour compared with 17.26 pounds/hour of a grader. Overall, it could be shown in a systematic review study that running a grader-based screening service is cost-efficient and safe.[21] In this study, at most DR grades, the different clinical ranks decided similarly to either follow up a patient virtually, bring them to a F2FC or discharge them.

The advantage of 'mixed-pathology' clinics is that it can free-up capacity in medical retina clinics, where there is a rising demand.[7] However, often patients do not need treatment like patients suffering from dry AMD and do not need to be followed up in a F2FC. This can be observed in our study, where a high percentage of patients with other diseases are being discharged. There is a tendency in consultants towards more decisive actions in all diseases, including diabetes. When running virtual clinics, an audit and feedback system could be implemented to assess quality and maintain a high and consistent standard of care.

To allow for further improvement of virtual clinics, referral criteria into virtual clinics allowing for good image quality should be well defined. We found that some referrals back to a F2FC might be avoidable by assessing clarity of optical media, as image quality already in the F2FC was low. In new referrals, this preselection is harder to make, as there is limited information about the patients from the DRSS. In a previous study, it could be shown that age is the strongest predictor of ungradable image rates.[22] Non-mydriatic imaging is according to a systematic review inferior to dilated fundus examinations.[23] In general, these referrals back into F2FCs cause duplication of work, reduction of efficiency and increasing costs. We set the VA limit for new referrals into the virtual clinic at minimum legal driving requirements, as we expected to have patients with moderate to good optical media clarity and mild to moderate disease stages. This threshold could be modified and for example lowered where virtual clinics are the only way of delivering fast clinic appointments to the community (eg, underserved areas, overburden of hospital eye services).

The nature of this study being retrospective is a limitation. However, it represents a large-scale pilot project which contributes to help dealing with rising patient numbers and constraints in face-to-face appointments. Further studies need to be undertaken which analyse prospectively the outcome of this virtual medical retina service and demonstrate non-inferiority to today's gold standard, a clinical face-to-face eye examination. Also, the patients' perspectives were not reported, which was not in the scope of this paper. This may help to gain more insight, why patients DNA their appointment. From our experience, DNA rates in F2FC for referrals of R1M1 patients with diabetes from DRSS are also between 15% and 25%. More advanced DR states such as moderate or severe nonproliferative DR or recently treated proliferative DR may not be suitable for virtual review as no angle assessment can be done. Some patients with a more severe DR grade were seen in the virtual clinic, despite their DR grade being worse than defined in the referral criteria. This could be due to worsening of DR between appointments or due to undergrading or overgrading of DR on examination; either in the F2FC or in the VMRC.

Although the introduction of VMRCs led to a drastic reduction of referral to appointment times, there is significant scope for further improving service access and reducing turnaround times. One reason for slow processing times might be improper software, which does not show all relevant clinical information along with images in one application. Currently, several software programs (EMR, worklist, OCT software and fundus imaging software) need to be run in parallel. As they are not linked to each other, patient searches need to be carried out manually. A purpose-built software needs to be developed, ideally running in a secure cloud-based environment, enabling cross-site data entries and reviews. Also shared-care setting between eye hospitals and optometrists became possible. Centralised image grading could improve turnaround times further, as for this initial setup all reviews were done alongside the reviewers' daily work. A Reading Centre-based centralised review system using bespoke software would drastically increase capacity for virtual clinics and enable economies of scale. The emerging field of machine learning also holds promise for reducing processing times by analysing OCT scans and fundus images automatically, within a quality-assured failsafe structure with safety checks. Most of current approaches use deep-learning to achieve this task.[24 25]

In this proof-of-concept report, we demonstrate the potential of virtual clinics to enable rapid-access services for patients with medical retina low-risk referrals using up-to-date technology. Further adoption of modern technologies such as comprehensive virtual review platforms and machine learning tools along with the centralisation of the review process will further increase capacity while maintaining high standards of safety and quality of care. This could help to save limited resources for those who need it most.

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