Chapter 6

Electronic Communication and Digital Images: Referral Pathways and Clinical Uses in Ophthalmology

Hannah Timlin and Roshini Sanders

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/58309

1. Introduction

Our eyes are the only place in the body where abnormalities such as blocked blood vessels and pale atrophied nerves can be directly visualised and subsequently diagnosed without further invasive tests. This is due to the transparent properties of the cornea, aqueous humour, lens and vitreous. This unique property of the eye lends itself well to being photographed. We now have the technology to image all the structures of the eye, all the way from the cornea, through the lens to the retina, choroid and optic nerve. This even includes anterior chamber cells and flair. We now live in a world where the average camera has superseded the resolution of the human eye, allowing the ability to visualise small retinal lesions such as exudates only when digital imaging and zooming is performed. Additionally, technology which uses optical coherence tomography and scanning lasers produce images, which show information and data on the layers of the retina and nerve fibre thickness which cannot be visualised by the ophthalmologists' examination. This chapter aims to describe how digital images and internet connections, including the roll out of 3G and 4G mobile networks, are utilised to aid ophthalmologists and benefit patients around the world.

Internet connections have grown exponentially over the last 20 years, connecting rural areas to cities, and developing countries to developed countries. The rapid adoption of smartphones has also helped to increase the number of doctors and patients who have easy access to the internet. This rapid adoption of smartphone internet access is particularly apparent in developing countries, who previously had little internet access due to a sparse fixed line telecommunication infrastructure. The cost of smartphone handsets and mobile data prices are dropping and thus becoming more affordable for many. Broadband, 3G and 4G connections allow these digital images to be sent anywhere around the world within seconds. Thus, eye conditions can be diagnosed in patients who are remote to the doctor, in both place and time.

Ophthalmology departments worldwide are under intensifying pressure to reduce referral waiting times and work at a faster pace to deliver new sight saving treatments. Studies increasingly demonstrate that treatment of potentially blinding conditions, such as wet age related macular degeneration (ARMD) and retinal vein occlusion are most efficacious in preventing sight loss when treatment is commenced promptly [1]. This strain on ophthalmology departments has been compounded by the exponential growth of wet ARMD in an aging population where life expectancy is increasing. This means that traditional systems for referring patients and reviewing them in clinics many weeks later need to be updated to adapt to these time pressures. Digital electronic communication, if embraced, can have a significant impact on ophthalmic service. Digital image referrals can be reviewed within seconds and can avoid an unnecessary wait for the clinic review before investigation or treatment can begin.

2. Benefits of electronic digital diagnosis

Electronic digital diagnoses in ophthalmology mean that the patient and the doctor do not have to meet face to face, nor at the same time. These two basic principles have widespread benefits for the patient, non-ophthalmic clinicians and ophthalmologists;

- The patient doesn't have to travel long distances to see the doctor, benefiting patients' time and reducing cost.
- The patient can be seen in a location and at a time which suits them best.
- The patient's images can be seen by the most appropriate subspecialty doctor, rather than the doctor in the hospital on the day that the patient visits, who may not be an expert in that subspecialty.
- It facilitates rapid discussion of difficult cases between multiple doctors around the world, rather than the patient travelling to different hospitals for multiple opinions.
- It facilitates the screening of referrals, leading to some patients not requiring hospital review.
- The patient can be triaged, ensuring that conditions requiring urgent review and treatment are given priority clinics.
- Doctors can monitor patients' progress through self-photographing and emailing to their consultant.

There are many examples of how Ophthalmology departments worldwide are starting to use digital images to aid with telemedicine, for diagnosis, triage and follow up communication with other ophthalmologists or non-ophthalmic clinicians. Additionally digital images are enhancing communication between patients and their ophthalmologist. Some of these are described below.

http://dx.doi.org/10.5772/58309

3. Anterior segment

3.1. Periocular skin abnormalities

There are many differential diagnoses to eyelid lumps, which may pose diagnostic difficulty for General Practitioners. These lesions are easily amenable to photography with either a standard camera at the GP practice or a slit lamp mounted camera at the optometry practice. The most important thing is to differentiate between benign and malignant lesions. Most benign lesions such as cysts, naevae, chalazia, molluscum contagiosum and xanthelasma need not be seen by an ophthalmologist, whereas malignant lesions require soon review and treatment in an appropriate oculoplastic oncology clinic. The most common eyelid tumour is a basal cell carcinoma, which can be diagnosed in many cases by an ophthalmologist from a photograph though signs such as a skin lump with rolled pearly edges, ulceration, crusting or loss of lashes. However, care must be taken with morphoeic basal cell carcinomas or sebaceous cell carcinomas as these have subtle signs and are often misdiagnosed as scarring or blepharitis from photographs or clinical examination. Patients with an obvious malignant lesion on a referral photograph can be directly booked into a one-stop minor procedure clinic. This misses out the assessment clinic step, thus reducing the time from referral to treatment.

It is important to estimate the size of a malignant lesion so that appropriate reconstruction can be planned in the correct location, such as theatre if the lesion is large rather than a clinical procedure room if the lesion is small. This can be difficult to do on digital images and we have found it extremely useful for referrers to place a ruler within the photograph.

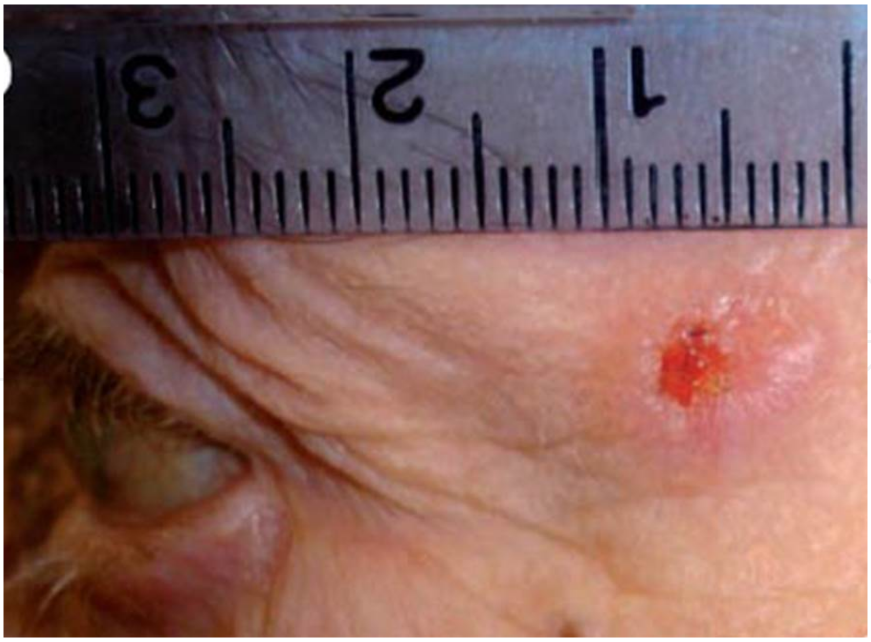

Figure 1. Photograph of a 10mm Periocular Basal Cell Carcinoma referred by an optometrist. This shows the classic signs of rolled pearly edges with central ulceration. This patient was booked directly into a minor procedure list for excision and rhomboid flap reconstruction.

Figure 2. Photograph of an eyelid naevus, demonstrating normal growth of lashes though the benign lesion

3.1.1. Patient communication examples

Although there is limited published evidence of the use of electronic digital diagnosis in the periocular area of the skin by ophthalmologists, we can utilize the experience from dermatologists. In Brisbane, patient generated photographs of melanocytic skin lesions from camera phones showed 69% diagnostic concordance with face to face diagnosis, suggesting potential for remote diagnosis [2]. In Dundee, referrals of suspected malignant skin lesions from GPs which included digital images had reduced time to diagnosis by 81% and time to treatment by 30%, with diagnostic accuracy comparable to face to face diagnosis [3].

Digital images can also be useful for monitoring progress following skin surgery. In Heidelberg, plastic surgeons monitor post-operative skin flaps using smart phone images sent from the patient at home. Compared to traditional in-person clinic review, the response time to re-exploration was significantly shorter [4]. In Taiwan, this method enabled rapid and thus successful re-exploration [5].

It is relatively simple for patients to use their own phone to photograph themselves and email the image within a few seconds, without having to get off their sofa. This can be planned every day postoperatively, or as and when the patient has concerns. It is easy to foresee how this enables rapid detection of problems when compared with a planned one week follow up hospital appointment. It is not unimaginable that patients following ptosis surgery or periocular reconstruction could be monitored by their consultant through smartphone images, with a hospital visit only required if an abnormality is seen on the photographs such as erythema and discharge. Other potential examples of their use are; a patient emailing in a photograph showing over correction of a ptosis could be advised to perform lash traction over an email without needing to attend the hospital, or a patient emailing in a camera phone image of a graft showing contraction and ectropion can be advised to perform firm massage without having to attend the hospital.

http://dx.doi.org/10.5772/58309

3.2. Corneal, conjunctival and anterior chamber abnormalities

Many corneal and conjunctival images are amenable to digital imaging for example pterygium, pinguecula, conjunctival pigmentation, corneal scarring, corneal vascularisation, ulcers and hypopion. Larger lesions can be photographed with a standard camera, whereas smaller lesions, particularly of the cornea are best imaged using a slit lamp camera. Various illumination techniques commonly used by the ophthalmologist can be used for the slit lamp camera also. Direct diffuse illumination is most commonly used. However, more information can be gained by using the fine slit direct illumination or retroillumination using the red reflex from the fundus. Indirect and scleral scatter can be harder to photograph.

Figure 3. Photograph of a benign pigmented conjunctival naevus in a child

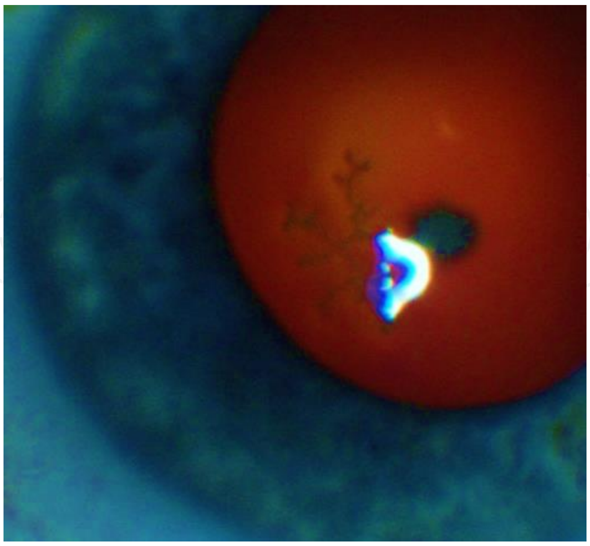

Figure 4. Slit lamp photograph of a dendritic ulcer seen with retroillumination, using the red reflex of the fundus to illuminate the corneal epithelial lesion.

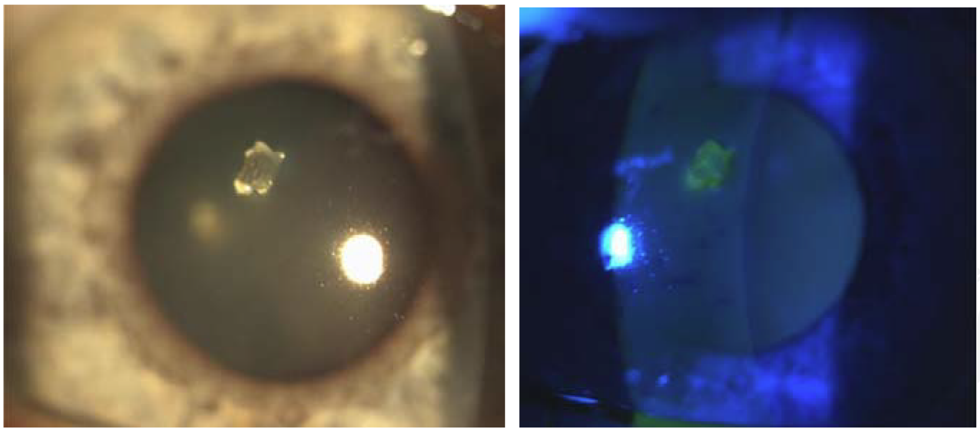

Figure 5. Slit lamp photographs using white light with no filter and cobalt blue filter showing a white foreign body on the cornea which stains with fluorescence.

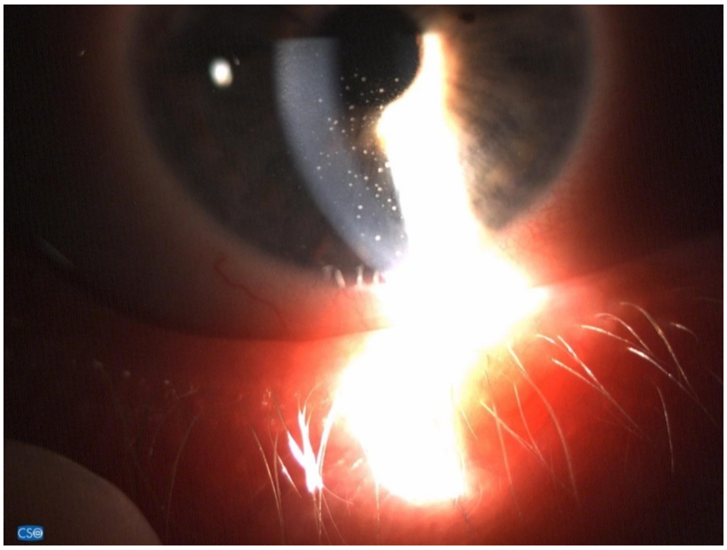

Figure 6. Slit lamp photograph using a broad beam of light showing keratic precipitates on the endothelium

3.2.1. Non-ophthalmic clinician communication example

In Perth, Western Australia, a portable hand held slit lamp camera has been created to be small, portable and simple to operate by health care workers across the large geographical area of Western Australia. They have demonstrated that this instrument had good correlation to slit lamp anterior segment image diagnoses [6].

3.2.2. Patient communication example

Perhaps ophthalmologists could learn from dermatologists in Austria, whose patients on biologics for psoriasis send in weekly camera phone images for monitoring [7]. This could potentially be used for conditions such as mucous membrane pemphigoid, where frequent

http://dx.doi.org/10.5772/58309

images over years can perhaps be made into a time-lapse video, which could potentially show clearer evidence of disease progression than clinical drawings. This technology is currently used in natural history programmes to demonstrate slowly changing environments such as sand dunes, within a few seconds of film, and could be easily adapted into the ophthalmic domain.

4. Posterior segment

4.1. Glaucoma

Glaucoma is a massive worldwide problem. The problem with open angle glaucoma is the lack of symptoms perceived by the patient. This means that patients will only self-present with end-stage glaucoma once central vision is being lost, when treatment is less effective. In poorer communities, most of the population is not examined regularly by an optometrist or ophthalmologist. In these places, the issue is the lack of diagnosis, which could be assisted with the use of health care assistants with camera phones, sending the images over the internet to a distant ophthalmologist for diagnosis.

In more affluent communities, optometrists are trained to rigorously screen for any sign or suspicion of glaucoma and refer to a hospital assessment e.g. raised intraocular pressure, field loss and abnormal optic disc appearance including thinned rim, change in cup disc ratio and disc haemorrhage. The main issues here are that of a high rate of false positives (the worried well) and the large volume of patients requiring long term hospital follow up. Many of these glaucoma suspects require hospital review over a few years only to then be discharged without requiring any treatment. Additionally, many ocular hypertensives are detected and require long term follow up without ever developing any field loss. These two examples constitute a large volume of patients seen in hospital eye services, and who would benefit from a digital electronic virtual clinic. All the data required by the consultant for the patients' management can be viewed digitally with computerised field of vision data sheets, intraocular pressure documentation and optic disc images with or without further ancillary glaucoma tests including red free photographs of the nerve fibre layer, optic disc Ocular Coherence Tomography, Heidelberg Retina Tomography and Scanning Laser Polarimetry. Thus large numbers of patients can be monitored by the consultant ophthalmologist virtually.

There is an obvious difference between slit lamp disc examination of the optic disc, which is binocular and thus 3D, and a standard fundus image which is 2D. The optic disc rim shape and cup disc ratio in 2D images are often interpreted using the colour change from the peach coloured optic rim to the whiter coloured optic cup and the distortion of blood vessels, rather than depth perception. This can lead to inaccurate interpretation of the optic disc. However, this can be accommodated for to some extent using serial photographs to identify subtle anatomical change over time and with stereo images where two photographs of the optic disc are taken from slightly different angles and viewed on a screen either side by side and viewed with specially designed goggles or displayed alternately with a fast flicker, where no goggles are required.

4.1.1. Allied ophthalmic professionals communication examples

Data from Virtual Glaucoma Clinics in Portsmouth have been published. These virtual clinics involve the glaucoma consultant electronically reviewing digital disc images, Humphrey visual field tests and Goldman intraocular pressure results to assess new glaucoma referrals without meeting the patients. 94% of disc photographs were gradable and only 32% of patients required to be accepted into the hospital eye clinic, thus saving 1400 clinic appointments per year [8]. Swansea performed a virtual glaucoma clinic trial using scanning laser ophthalmoscopy. Although 22% of images were unable to be graded, the remaining had 94% sensitivity and 87% specificity when compared to clinical assessment, with no case of glaucoma being misdiagnosed [9]. These two examples demonstrate how digital images can enable a consultant to review more glaucoma referrals in a shorter period of time than if examining the patient themselves thus saving money.

In these two published virtual glaucoma clinics, the patients still attended the hospital but were seen directly by photographers, nurses and hospital optometrists. There is potential for the tests to be performed at the patients' local optometry practice to save on travel time and costs. However, this would be limited by the costs of purchasing investigative equipment such as computerised field of vision analysers and fundus cameras.

Figure 7. Right optic disc photograph taken by an optometrist at a local practise. This shows inferior temporal disc haemorrhage and rim thinning. This rim thinning is seen on this 2D image by the location of both the colour change and blood vessel distortion. This patient was given a glaucoma assessment clinic and diagnosed with glaucoma.

4.2. Disc anomalies

Normal optic discs have a huge range of appearances. Thus there is a large grey area where an unusual looking disc can either be at one end of the normal range or be showing pathology. Pattern recognition plays a large part in determining a diagnosis in these patients. Optometrists and General Practitioners see large volumes of normal optic discs and thus find it difficult to distinguish between disease and normal range. The main condition which causes concern in this area is bilateral swollen discs with diagnosis of possible raised intracranial pressure. This can trigger referral for a CT scan and lumbar puncture, both of which have side effects. Actual diagnoses are often myopic discs, where the large peripapillary atrophy is misinterpreted as

http://dx.doi.org/10.5772/58309

disc oedema and swelling when performing a uniocular examination through a direct ophthalmoscope by a non-ophthalmologist, or optic disc drusen which can give a lumpy raised appearance and scalloped margins with anomalous vascular branching. Digital imaging and an ophthalmologist's opinion can negate the need for these unnecessary tests in many within a few seconds of seeing the image.

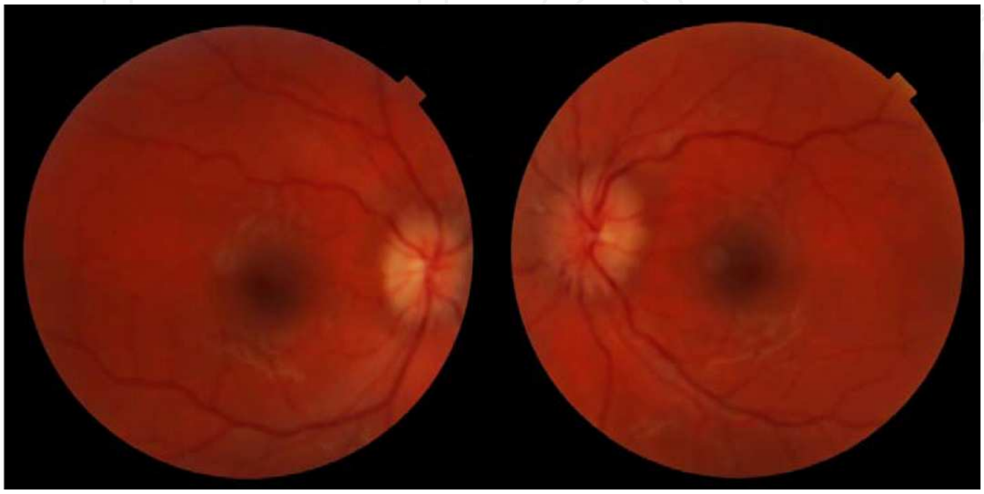

Figure 8. Fundus photographs of a child, taken at their local optometry practice showing bilateral disc swelling. This is characterised on digital 2D image as blurred disc margin due to oedema, curving of blood vessels over the swollen nerve with an angle as the vessel flattens onto the retina, reduced or no colour change from optic disc rim to cup due to swelling. The digital electronic referral of these images was seen within minutes by a consultant ophthalmologist who was able to arrange a CT scan and paediatric admission to the patient's local hospital all of which was performed within 2 hours, without the need for long travel and time delay to the regional Emergency Eye Clinic. The patient was diagnosed with a brain tumour and raised intracranial pressure.

Figure 9. Fundus photographs of a patient with myopic discs. This patient was misdiagnosed as swollen discs due to the 'large' pale discs with no visible cup. An ophthalmologist can see in the photo that this is significant peripapillary atrophy and reassure the referrer. The digital image electronic referral means that a diagnosis is made quickly and the patient does not need to travel to the eye department or undergo CT scans or lumbar punctures.

4.3. Retinopathy of prematurity

Retinopathy of prematurity guidelines recommend fundus screening to be performed 1 to 2 weekly in babies of <32 weeks gestation or <=1.5kg at birth [10]. Physical examination with an indirect ophthalmoscope and indentation is a difficult skill to master and is thus done by very experienced ophthalmologists. Additionally, the process of examination can be distressing for the baby and often affects their vital signs. The guidelines recommend grading retinopathy according to the area of retina where normal vascular development has occurred as well as the extent of abnormal vessels that have grown, along with their sequelae. These grades dictate whether treatment of the peripheral retina with laser is recommended, which is done by an expert usually in a tertiary referral centre [10].

4.3.1. Non-ophthalmic clinician communication examples

However, these premature babies have multiple other comorbidities making transfer over long distances to tertiary hospitals precarious for their health and life. Studies have shown that only 6% of these babies actually develop sight threatening disease [10] and require treatment by a specialist ophthalmologist. Thus, this condition is ideally suited to digital image screening where babies in peripheral hospitals have their fundus photographs taken by trained nurses. These are then emailed to the specialist ophthalmologist in the distant tertiary centre for grading. This method of viewing the fundus is also potentially less distressing for the baby. For some time, the wide field 120 degrees camera Retcam has been used for this purpose, producing clear images and reliable grading [11-16]. The use of this digital screening system means that most babies can stay in their hospital surroundings without the instability of a transfer. The only babies requiring transfer are those 6% requiring laser treatment, without which vision loss and blindness can develop. More recently, the noncontact ultra-widefield Optos dual wavelength scanning laser ophthalmoscope Optomap is being used for this purpose in Oxford [17].

Recent advances in neonatology have led to an increase in the number of premature babies at risk of sight loss. However, the frequency of sight threatening retinopathy is low, meaning that experts in the field are small in number and often covering a large geographic area. In poorer, remote populations, these fundus cameras could allow robust and effective retinopathy of prematurity screening, where there had previously been none.

4.4. Diabetic retinopathy

4.4.1. Non-clinical personnel communication examples (medical photographers)

A national screening programme for diabetic retinopathy has been set up in the UK [18] with the use of mobile non-mydriatic fundus cameras operated by technicians. This programme enables all diabetic patients to have a fundus examination close to their home. These fundus images are graded electronically, with patients only needing to travel to the hospital ophthalmology clinic if there are signs of sight threatening retinopathy or maculopathy. In some regions, Optical Coherence Tomography images are also taken to screen for macula oedema, thus further reducing the number of patients requiring hospital appointments. The attendance rate is likely to be higher if the patients have to give up less time and money for travelling, thus screening occurs in multiple locations with mobile cameras. Teleretinal screening data for diabetic retinopathy has also been published from the USA [19,20], Bahrain [21], Canada [22,23] and France [24].

Figure 10. Diabetic Retinopathy screening photograph taken with a non-mydriatic fundus camera showing proliferative diabetic retinopathy with new vessels visible and previous pigmented pan retinal photocoagulation scars.

4.5. Wet age related macular degeneration

Age Related Macular Degeneration is a common condition causing visual loss. Unfortunately, only the less common wet subtype is treatable. Unnecessary referral and review of patients with the dry subtype are common and results in a large number of unnecessary hospital appointments. The wet type results from abnormal growth of vessels from the choroidal circulation into the retina and is identified clinically by intraretinal fluid and / or haemorrhage. Intraretinal fluid is best seen as retinal thickening when examining binocularly on the slit lamp, which cannot be perceived on a fundus photograph. However, photographic signs of fluid identifiable are a grey appearance, loss of focus of fine detail of the retina and distortion of blood vessels. Additionally Optical Coherence Tomography machines are becoming more widely available. These are now used routinely in the macular degeneration clinics as they can show even very small pockets of fluid within the retina which are not perceivable on slit lamp examination of the fundus. Use of these fundus and OCT images with referrals, has the scope to avoid the unnecessary hospital visit of a patient with dry age related macular degeneration.

4.5.1. Allied ophthalmic professionals communication examples

Evaluating colour retinal images of patients referred with suspected wet age related macular degeneration has been reported to have high sensitivity and specificity and facilitate more timely treatment [25]. In York, there is a Mobile Community Eye Care Clinic with OCT machines. This is relocated overnight on a 4 weekly location cycle around the region, with fundus and OCT images viewed at the central hospital [26]. In Salford, an optometry practise with an OCT machine refers in patient details with the OCT image via nhsmail, meaning that patients can attend directly for a treatment clinic [26]. Thus the patient's number of visits to the hospital is reduced.

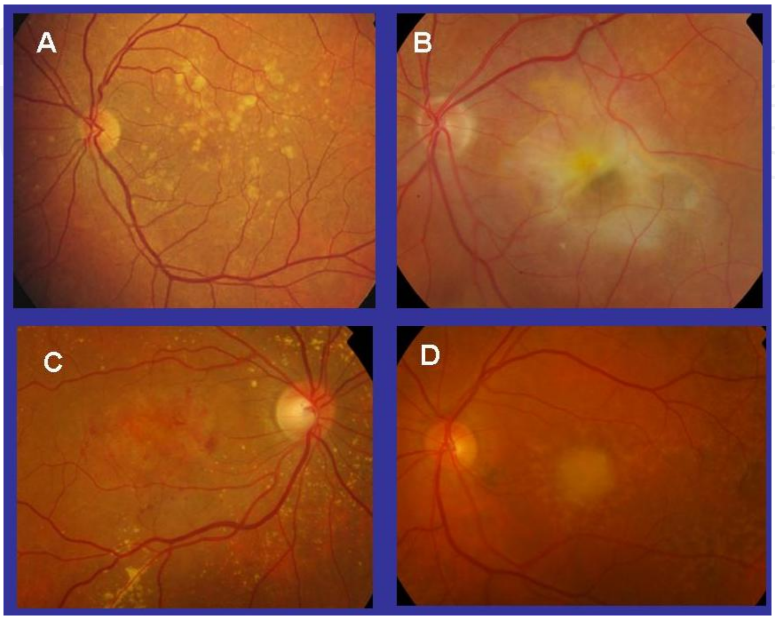

Figure 11. Four fundus photographs of patients referred by optometrists with macular degeneration, illustrating the benefit of fundus photographs when triaging hospital referrals. Figure 11A shows dry age related macular degeneration, which does not require hospital review. Figure 11B shows scaring from advanced wet age related macular degeneration with vision worse than 6/96, who can be directed to the low vision services. Figure 11C shows wet age related macular degeneration, which can be triaged to an urgent wet ARMD treatment clinic. Figure 11D shows a pigment epithelial detachment, which needs triage into an assessment clinic within 2 weeks. This last image illustrates the limitations of using images. In this case, the patient requires an Optical Coherence Tomography image, which their local optometrist did not have and thus required to be done at a hospital visit, in order to detect any intraretinal fluid that would require treatment.

Treatment of wet age related macular degeneration requires multiple intravitreal injections of anti vascular endothelial growth factor often over many years. Best visual outcomes occur when treatment is given within the first two weeks of disease onset. However, the number of wet age related macular degeneration patients are already greater than capacity, and with an aging population this is set to worsen. One solution to this crisis is a virtual clinic, which can be used to follow up patients who have been treated. Electronic Patient Databases have been shown to facilitate virtual wet age related macular degeneration diagnosis and monitoring by consultants, who can view a patient's vision, fundus image and OCT without face to face contact. This increases the number of patients monitored by a consultant within the same session [26].

4.6. Retinal vein occlusion

Central and branch retinal vein occlusions are common causes of reduced vision. The vast majority of cases do not require treatment. However, patients need to be monitored for the

http://dx.doi.org/10.5772/58309

growth of new vessels, which requires laser treatment. More recently, treatment with intravitreal steroid or anti vascular endothelial growth factor have shown benefit in patients with macular oedema. Additionally, manufacturers report better visual outcomes if treatment is commenced promptly. Therefore patients with a vein occlusion would benefit from a digital electronic referral from the optometrist in a similar way to those with wet age related macular degeneration, where the referral is made via a fundus image email along with an Optical Coherence Tomography image when available to demonstrate the macular oedema. This would enable rapid triage for a soon appointment directly into a treatment clinic when macular oedema is seen.

4.7. Retinal lesions

Abnormal pigmentary changes are commonly detected by optometrists at routine review in asymptomatic patients. Common lesions detected are choroidal naevae, chorioretinal scars, congenital hypertrophy of retinal pigmented epithelium, laser scars and myelinated nerve fibres. None of these lesions are visually significant and thus are best managed in the community with digital imaging. The digital image acts firstly as a referral to an ophthalmologist who will often be happy to diagnose the condition on the image alone. Secondly, the image acts as a record for long term monitoring. If a choroidal naevus shows even a small growth from one image to the next, then referral for investigation for melanoma is required. Subtle changes in lesion appearance are much easier to detect when comparing image to image, rather than fundus examination to a drawing. Thus digital imaging enables rapid diagnosis and accurate monitoring for malignant signs.

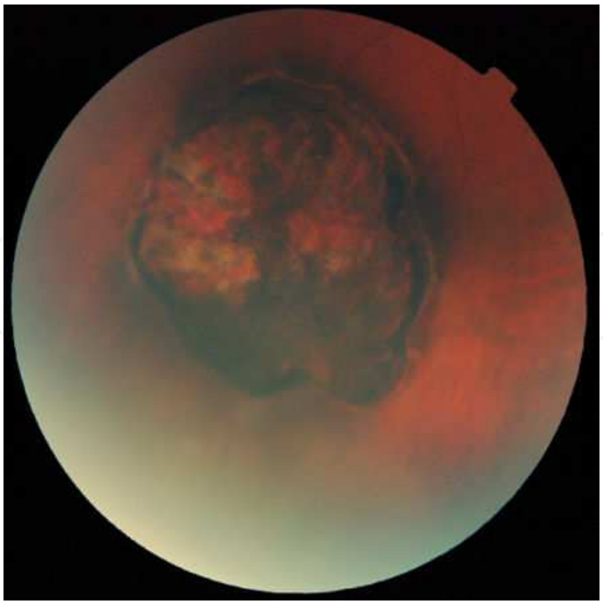

Figure 12. Fundus image showing pigmented chorioretinal scar. This is most likely a longstanding scar as the lesion has sharp pigmentary boundaries and no acute signs of haemorrhage or exudation. Therefore, the patient does not require hospital review.

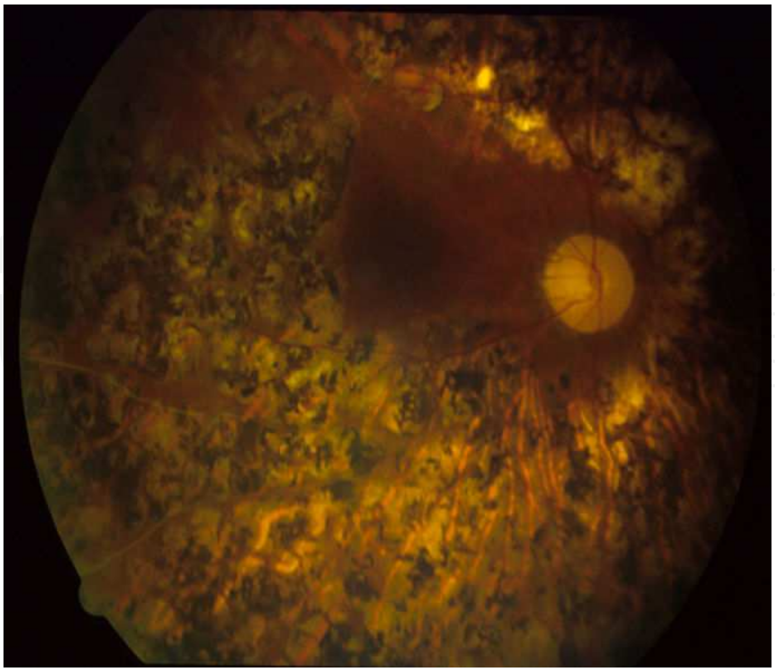

Figure 13. Fundus image showing heavy pan retinal photocoagulation, not requiring hospital review

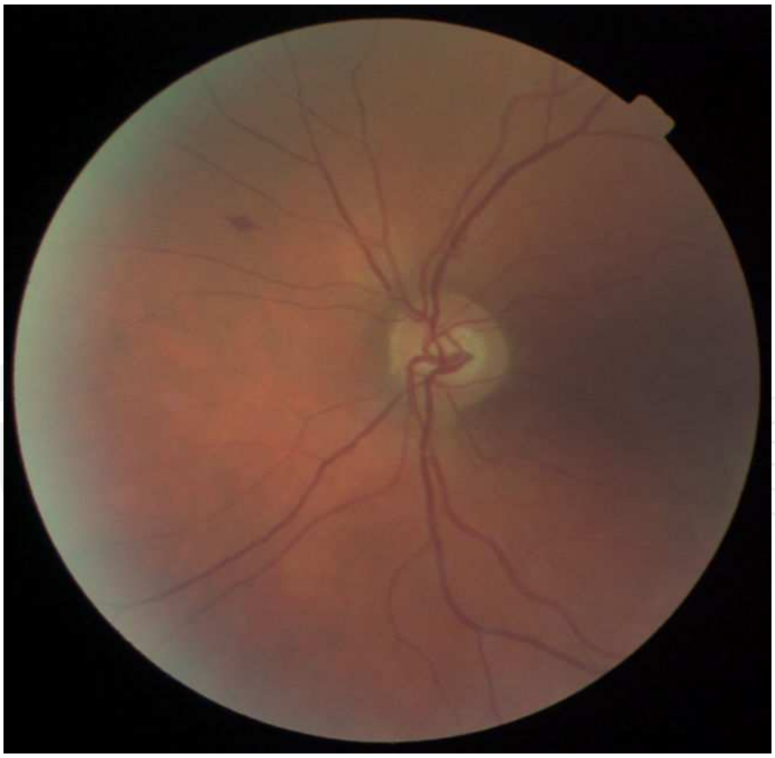

Figure 14. Fundus image showing an isolated small blot haemorrhage

http://dx.doi.org/10.5772/58309

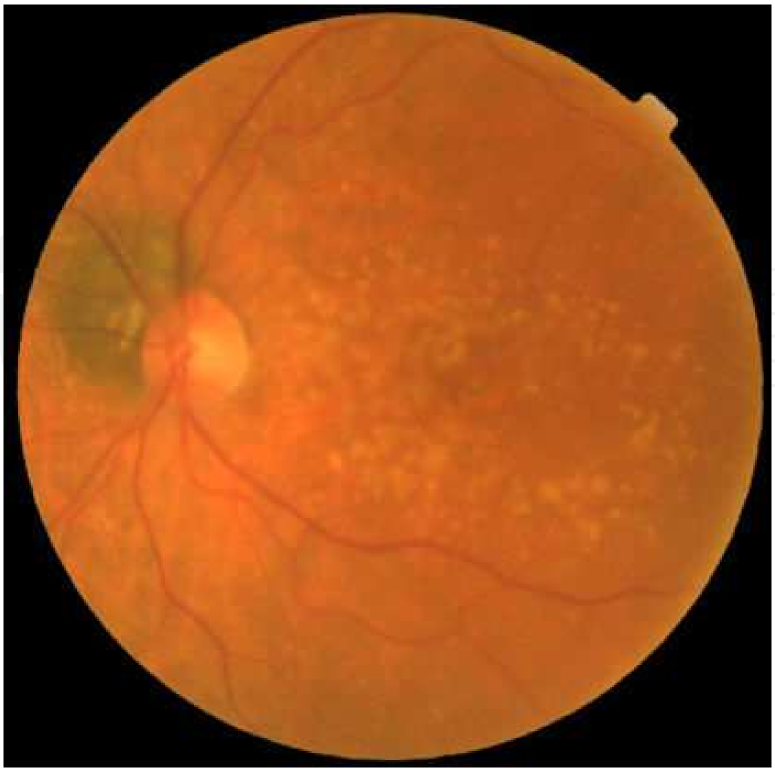

Figure 15. Fundus image showing a choroidal naevus at the disc and drusen. Careful monitoring is required and changes in the lesion are best detected by comparing fundus image to fundus image side by side.

4.8. Optos

One of the limitations of standard fundus imaging is the small field of view of 45 degrees, making it difficult to capture the mid peripheral and peripheral retina. Optos have developed the optomap ultra-widefield scanning laser ophthalmoscope which produces a pseudo-colour image [27].This is a significant addition to the current ophthalmic imaging tools. It has a 200 degree field of view enabling peripheral lesion imaging whilst simultaneously imaging the disc and macula, which enables the location of the lesion in relation to them. This is especially useful for picking up retinal detachments by non-ophthalmologists or documenting peripheral choroidal naevae or melanomas for long term follow up. The two main benefits to this system are that dilation is not required, and that it requires very little training to perform enabling a non-ophthalmologist to view large areas of the retina and share electronically via email.

4.8.1. Non clinical personnel example (medical photographers)

Studies in an emergency eye clinic have shown the Optos limitations at picking up only 33% of peripheral retinal tears and holes [28], although interestingly, this was the same accuracy as their casualty doctor's examination. However, it accurately photographed retinal detachments, which are commonly missed on conventional fundus imaging.

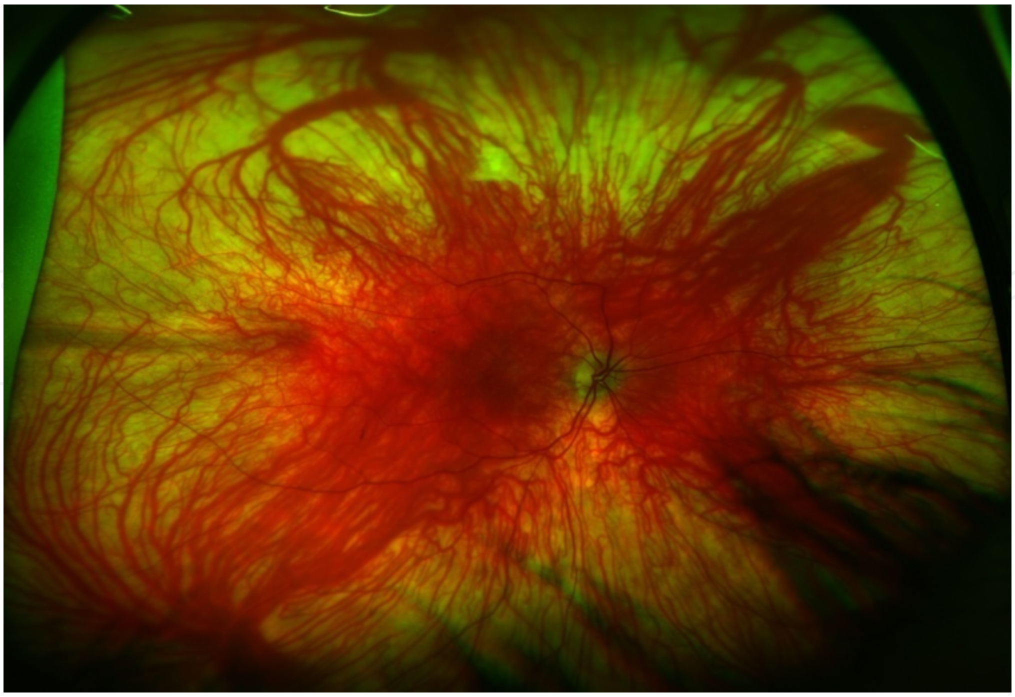

Figure 16. Optomap fundus image of a patient with ocular albinism showing more peripheral changes than can be visualised with standard fundus cameras.

5. Video conferencing

Live video conferencing facilitates live consultation between either doctor and patient or doctor and the doctor/optometrist/nurse currently examining a patient. It requires a faster internet connection than that needed for sending images via email, which is becoming increasingly available in more rural areas. Skype and FaceTime are commonly used software which are user friendly and regularly used non-professionally by the internet generation to communicate to friends and family. Thus it is an acceptable and non-frightening means of communication for both patients and doctors.

5.1. Non-ophthalmic clinicians example

Telemedicine video conferencing has been utilised in Western Australia, in a remote hospital where an ophthalmologist from Perth only visits twice a year. The average video conference length was 30 minutes and reduced emergency air evacuations to Perth from seven per year to none. This lead to a huge cost saving, better utilisation of air transfer staff and potentially increased patient satisfaction at remaining in their own home [29].

This is clearly a valuable resource in locations where there is no local ophthalmologist. Perhaps there will be increased access in Accident and Emergency Departments worldwide, which would most likely be utilised at night when ophthalmologists are on duty from home.

http://dx.doi.org/10.5772/58309

Video Technology is useful for conditions such as nystagmus and pupil abnormalities, which are difficult to capture with photographs.

6. Referrals to the hospital eye service

Trying to encompass all ophthalmic telemedical digital imaging techniques is the Central Ophthalmic electronic Referral Unit (COeRU) in Fife, Scotland. Here, patients have benefited from a Government financed set up of broadband connection from all community optometrists to the hospital. All referrals to the hospital Ophthalmology Department are done electronically by the local optometrist with electronic images from any machinery attached. It has demonstrated a global benefit to the hospital department of; a reduction in waiting times from 14 to 4 weeks, a reduction in the number of patients seen in the emergency clinic, and a reduction in 'Did Not Attend' patients [30]. This has had enormous benefit from patients who are now seen rapidly, especially patients with wet ARMD who are rapidly seen and treated.

The pilot study was set up in 2005 on 350 consecutive patients who were electronically referred with attached digital images by their community optometrists to the hospital using NHS mail [31]. The results were encouraging and showed that sight threatening disease could be identified early and that 37% of referral images allowed an electronic diagnosis which did not require a hospital appointment. Following the success of the pilot, the scheme was rolled out to the entire region in 2007 and a central ophthalmic electronic referral unit (COeRU) was created. In 2011, the five year data was studied, which analysed over 40,000 patient episodes [30]. The new electronic pathway meant that waiting times were reduced, which was mainly because the old tortuous paper referral pathway was bypassed by emailing the referral directly to the ophthalmology department and simultaneously copying in the GP. Significant changes to service delivery were achieved with all sight threatening disease seen within days rather than weeks, 15% of new patient referrals retained in the community and between 20 – 25% reduction in both the casualty attendance and DNA (did not attend) rate.

The Fife service data following implementation of COeRU was compelling and fed into three business case submissions to the Scottish government between 2009 – 2010 for electronic connection between community optometrists and hospital ophthalmic departments across the whole of Scotland.

In 2010 the Scottish government health department (SGHD) committed 6.6 million pounds for electronic connections between the community and the hospitals and in 2011 the Eyecare Integration Project was formed. The group has representation from Eyecare Scotland (all Scottish lead clinicians), Optometry Scotland, general practice (GP) and the Royal National Institute for the Blind. There is also representation from subdivisions of the SGHD that support the project to include the Practitioner Services Division (PSD), eHealth, SCI Gateway, ISD (information and statistics division) and National Information Systems Groups (NISG). The goals of this project are to provide a nationally supported electronic link between every community optometry practice and hospital ophthalmic department, which will enable electronic referrals with attached digital images. Concurrently the PSD are working on electronic software that will connect with the optometry practices' IT management systems to enable electronic payment verification [32].

The effect of this Scotland wide implementation of digital image referral is much awaited by other regions of the UK and worldwide.

7. Limitations of diagnoses with digital imaging

One of the main limitations of digital images is that they are 2D rather than the 3D image seen when using the slit lamp or indirect ophthalmoscope binocularly. This can make it difficult to identify oedema or raised suspicious choroidal naevae. However, the Optical Coherence Tomography images can help to overcome this concern, by providing a cross sectional view of the retina. Another difficulty in using digital images is the difficulty in imaging the peripheral retina, which is the common location of retinal tears. The Optomap ultrawide field images have improved peripheral retinal visualisation on images and have been shown to pick up lesions posterior to the equator with high specificity. However, they do not pick up all lesions anterior to the equator [33].

8. Conclusion

With the widespread access to camera phones in both developed and developing countries, imaging of eyes by patients and health carers becomes more accessible. Additionally, accessories have been designed to fit onto phone cameras to act as non mydriatic fundus cameras [34]. The new Portable Eye Examination Kit (PEEK) [35] is a smartphone App that enables health carers to perform detailed eye examinations including vision, fields, lens and fundus imaging in extremely rural homes with only a £300 iPhone and clip on camera hardware with little training. The diagnoses and management plans are then made remotely in the UK from the electronic data and images. Patients can then be located for treatment via the GPS coordinates of their home, which is automatically attached to smartphone photographs at the time of image capture.

The future of ophthalmology will undoubtedly involve more virtual clinics and perhaps more digital imaging from patients themselves. Perhaps there will be a time where all diabetics have a fundus camera phone accessory to photograph their own fundi and email their images to the hospital graders themselves.

In summary, electronic communication with digital images and teleconferencing has huge potential for eye care service delivery. It has the ability to overcome geographical barriers and pick up sight threatening disease at the earliest opportunity. With the exponential growth in global electronic communication there is no doubt that this will be incorporated into several health service delivery models. We have outlined the existing models within ophthalmology and have also outlined the future growth areas.

http://dx.doi.org/10.5772/58309

Author details

Hannah Timlin and Roshini Sanders

*Address all correspondence to: hannahtimlin@nhs.net.uk

Cataract Unit, Queen Margaret Hospital, Dunfermline, NHS Fife, UK

References

[1] Matthe E, Sandner D. Early treatment of exudative age-related macular degeneration with ranibizumab: the key to success. Ophthalmologe. 2011;108(3):237-43.

[2] Boyce Z, Gilmore S, Xu C, Soyer HP. The remote assessment of melanocytic skin lesions: a viable alternative to face-face consultation. Dermatology 2011;223(3):244-50.

[3] Tadros A, Murdoch R, Stevenson JH. Digital image referral for suspected skin malignancy – A pilot study of 300 patients. Journal of Plastic, Reconstructive & Aesthetic Surgery 2009;62:1048-1053.

[4] Engel H, Huang JJ, Tsao CK, Lin CY, Chou PY, Brey EM, Henry SL, Cheng MH. Remote real-time monitoring of free flaps via smartphone photography and 3G wireless Internet: a prospective study evidencing diagnostic accuracy. Microsurgery 2011;31(8):589-95.

[5] Varkey P, Tan NC, Girotto R, Tang WR, Liu YT, Chen HC. A picture speaks a thousand words: the use of digital photography and the internet as a cost-effective tool in monitoring free flaps. Annals of Plastic Surgery 2008;60(1):45-8.

[6] Kumar S, Yogesan K, Constable IJ. Telemedical diagnosis of anterior segment eye disease: validation of digital slit-lamp still images. Eye 2009;23(3):652-60.

[7] Koller S, Hofmann-Wellenhof R, Hayn D, Weger W, Kastner P, Schreier G, Salmhofer W. Acta Dermato-Venereologica 2011;91(6):680-5.

[8] Trikha S, Macgregor C, Jeffery, Kirwan J. The Portsmouth-based glaucoma refinement scheme: a role for virtual clinics in the future. Eye 2012;26(10):1288-94.

[9] Rathod D, Win T, Pickering S, Austin M. Incorporation of a virtual assessment into a care pathway for initial glaucoma management: feasibility study. Clinical & Experimental Ophthalmology 2008;36(6):543-6.

[10] Guidelines for the screening and treatment of retinopathy of prematurity. May 2008. Royal college of ophthalmologists and Royal college of Paediatrics and Child Health.

[11] Lorenz B, Spasovska K, Elflein H, Schneider N. Wide-field digital imaging based telemedicine for screening for acute retinopathy of prematurity. Six-year results of a

multicentre field study. Graefes Archive for Clinical & Experimental Ophthalmology 2009;247(9):1251-62.

[12] Weaver DT, Murdock TJ. Telemedicine detection of type 1 ROP in a distant neonatal intensive care unit. Journal of Aapos: American Association for Pediatric Ophthalmology & Strabismus 2012;16(3):229-33.

[13] Salcone EM, Johnston S, Vanderveen D. Review of the use of digital imaging in retinopathy of prematurity screening. Seminars in Ophthalmology 2010;25(5-6):214-7.

[14] Dai S, Chow K, Vincent A. Efficacy of wide-field digital retinal imaging for retinopathy of prematurity screening. Clinical & Experimental Ophthalmology 2011;39(1): 23-9.

[15] Ells AL, Holmes JM, Astle WF, Williams G, Leske DA, Fielden M, Uphill B, Jennett P, Hebert M. Telemedicine approach to screening for severe retinopathy of prematurity: a pilot study. Ophthalmology 2003;110(11):2113-7.

[16] Schwartz SD, Harrison SA, Ferrone PJ, Trese MT. Telemedical evaluation and management of retinopathy of prematurity using a fiberoptic digital fundus camera. Ophthalmology 2000;107(1):25-8.

[17] Patel CK, Fung THM, Muqit MMK, Mordant DJ, Brett J, Smith L, Adams E. Non-contact ultra-widefield imaging of retinopathy of prematurity using the Optos dual wavelength scanning laser ophthalmoscope. Eye 2013;27:589-596.

[18] www.diabeticeye.screening.nhs.uk/national

[19] Ogunyemi O, Terrien E, Eccles A, Patty L, George S, Fish A, Teklehaimanot S, Ilapakurthi R, Aimiuwu O, Baker R. Teleretinal screening for diabetic retinopathy in six Los Angeles urban safety-net clinics: Initial findings. AMIA Annual Symposium Proceedings / AMIA Symposium 2011:1027-35.

[20] Li Z, Wu C, Olayiwola JN, Hilaire DS, Huang JJ. Conneticut Medicine 2012;76(2): 85-90.

[21] Al alawi E, Ahmed AA. Screening for diabetic retinopathy: the first telemedicine approach in a primary care setting in Bahrain. Middle East African Journal of Ophthalmology 2012;19(3):295-8.

[22] Boucher MC, Nguyen QT, Angioi K. Mass Community Screening for diabetic retinopathy using a nonmydriatic camera with telemedicine. Canadian Journal of Ophthalmology 2005;40(6):734-42.

[23] Choremis J, Chow DR. Use of telemedicine in screening for diabetic retinopathy. Canadian Journal of Ophthalmology 2003;38(7):575-9.

[24] Massin P, Aubert JP, Erginay A, Bourovitch JC, Benmehidi A, Audran G, Bernit B, Jamet M, Collet C, Laloi-Michelin M, Guillausseau PJ, Gaudric A, Marre M. Screen-

ing for diabetic retinopathy: the first telemedical approach in a primary care setting in France. Diabetes & Metabolism 2004;30(5):451-7.

[25] Maberley DAL, Isbister C, MacKenzie P, Aralar A. An evaluation of photographic screening for neovascular age-related macular degeneration. Eye 2005;19:611-616.

[26] Amoaku W, Blakeney S, Freeman M, Gale R, Johnston R, Kelly SP, McLauglan, Sahu D, Varma D, Action on AMD Group. Action on AMD. Optimising patient management: act now to ensure current and continual delivery of best possible patient care. Eye 201; 26(S1)S2-S21.

[27] www.optos.com

[28] Khandhadia S, Madhusudhana KC, Kostakou A, Forrester JV, Newsom RSB. Use of optomap for retinal screening within an eye casualty setting. British Journal of Ophthalmology 2009;93(1):52-55.

[29] Kumar S, Yogesan K, Hudson B, Tay-Kearney ML, Constable IJ. Emergency eye care in rural Australia: role of internet. Eye 2006;20(12):1342-4.

[30] Borooah S, Grant B, Blaikie A, Styles C, Sutherland S, Forrest G, Curry P, Legg J, Walker A, Sanders R. Using electronic referral with digital imaging between primary and secondary ophthalmic services: a long term prospective analysis of regional service redesign. Eye 2013;27:392-397.

[31] Cameron JR, Ahmed S, Curry P, Forrest G, Sanders R. Impact of direct electronic referral with ocular imaging to a hospital eye service. Eye 2009;23:1134-1140

[32] Timlin H, Styles C, McPherson S, Sanders R. Eyecare Integration Project (Scotland); Electronic connections between primary and secondary sectors. Eye News 2013;20(1); 6-10.

[33] Mackenzie PJ, Russell M, Ma PE, Isbister CM, Maberley DA. Sensitivity and specificity of the optos optomap for detecting peripheral retinal lesions. Retina 2007;27(8): 1119-24.

[34] Lamirel C, Bruce BB, Wright DW, Newman, NJ, Biousse V. Nonmydriatic digital ocular fundus photography on the iPhone 3G: the FOTO-ED study. Archives of Ophthalmology 2012;130(7):939-40.

[35] www.peekvision.org

IntechOpen