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Teleophthalmology

Manoj Kulshrestha¹, Simon P Kelly² and Usman Mahmood¹

¹*Aberystwyth Eye Centre/Hywel Dda Local Health Board*

²*Royal Bolton Hospital
United Kingdom*

1.Introduction

In the recent years there has been significant growth in Information Technology. The internet has also transformed clinical care. IT interventions and consultations are being introduced rapidly and on a large scale across health care. These telemedicine consultations can be divided into two categories: 'synchronous telemedicine' utilizes telecommunications for real time interactions between participants (e.g. video conferencing), and 'store-and-forward' telemedicine which involves the capture of patient data for subsequent interpretation by a remote expert.

In image-oriented specialties such as ophthalmology, radiology, cardiology, and dermatology, diagnostic decisions are often based on review of photographic/imaging studies and which are often captured by technicians. Therefore, remote diagnosis using store-and-forward telemedicine may be a promising strategy for improving the delivery and accessibility of care in image-oriented fields.

Randomised controlled trial evaluation of such service innovations on service provision would be ideal, but are rarely possible. A recent such report by Chiang MF et al., 2010 favourably compared telemedicine examination in retinopathy of prematurity infants against direct examination. A service evaluation by Stoves J et al., 2010 showed e-consultation with hospital nephrologists promotes effective management of patients with mild-to-moderate chronic kidney disease in primary care in the National Health Service (NHS). In areas where accessibility to clinical care is problematic such as in parts of Canada, Australia, India and Wales, there are major challenges to healthcare. Advances in videoconferencing technologies have had a positive impact in telemedicine care in such rural regions. We have worked in ophthalmology in rural Wales, where district general hospitals and community hospitals have excellent telemedicine links. This chapter provides case studies from telemedicine in ophthalmology based on our experience and that of others elsewhere.

Rurality has its own unique problems for healthcare, patients, medical and nursing staff. All usually have longer distances to travel compared to urban areas. There are increased fuel and transport costs and often poor transport infrastructure. However such rural areas in Wales (Figure 1) may have a high concentration of elderly people with sight problems.

The learning goal of this chapter is better understanding of novel technology for ophthalmic disease management deployed in the digital health environment. This is a topic of considerable significance in retinal care given the explosion of relevant clinical imaging

technology and the huge burden of certain retinal disease (age-related macular degeneration, retinal vein occlusion and diabetic retinopathy) and which are set to expand even more.



Fig. 1. Sparsely populated rural environment in Wales.

Smarter ways of working, using new technology, are required to cope with this clinical need and organisational burden. The need includes better use of IT infrastructure; innovation in primary to secondary care referral management and enhanced productivity in secondary care. Some **clinical IT/imaging driven solutions** to such challenges will be explored.

Teleophthalmology may be considered a division of telemedicine and is technological method by which medical expertise from an ophthalmologist is provided electronically to another clinical location, sometimes in rural or remote areas. Teleophthalmology includes enabling the ophthalmologist to interact with patients at a remote location through video conferencing, share data, and diagnose the patient with the help of local non ophthalmologist doctor or nurse or other practitioner who uses ophthalmic diagnostic equipment to digitally transfer images.

Telemedicine in general is an area which brings collaboration between secondary and primary care, enabling secure transmission of information and in particular for ophthalmology, transfer of digital clinical images. Ophthalmology relies greatly on clinical visual information. Dermatology is another specialty with similar matters. The pilot project of teledermatology in Bristol described in the Practical Commissioning Magazine (2009) found that referrals fell by about 62% in a single practice, providing patients with a faster, closer service. Safety and cost effectiveness of any telemedicine specialty needs further assessment. The provision of a safe, reliable and fast telemedicine ophthalmic service to the public may have merit in rural areas.

Currently there are only 2.3 ophthalmologists per 100,000 population in the UK. This is fewer, pro rata, than in any other European Union nation (European Union of Medical Specialties www.uems.net). Together with a high level of undetected, yet treatable visual

morbidity and an increasing elderly population, improvements in primary eye care are needed. Telemedicine in ophthalmology, or teleophthalmology, offers some merit in responding to these pressures in the digital era in both developed and emerging economies with sparse ophthalmic manpower and in any economy where distance to the ophthalmologist is a problem. The latter is especially relevant in rural and remote areas.

2. Digital retinal fundus photography imaging

Modern fundus cameras (such as the Topcon non-mydratic camera shown in Figure 2) have high resolution and an ability to alter contrast and colour thereby allowing for such manipulation of images that at times might not be possible even with direct view. Such cameras are presently employed for diabetic retinopathy (DR) screening in the community. All diabetic patients in the UK are now able to have regular screening for sight threatening diabetic retinopathy and such screening significantly reduces visual morbidity. High resolution fundus photographs are taken and linked via servers to trained primary retinal screeners who grade the image by retinopathy severity status and arrange referral if needed. Such diabetic patients often may not need to travel to the hospital. Secondary or tertiary screeners can also undertake remote digital imaging screening.

(www.diabetes.org.uk/About_us/Our_Views/Position_statements/retinal_screening)



Fig. 2. Digital fundus camera. (Topcon)

The Central Ophthalmology Receiving Unit in NHS Fife, Scotland reported the benefits of improving use of existing resources to bridge the gap between primary and secondary ophthalmic care (Cameron JR et al., 2009). Hansen C et al., 2008 have described a similar government funded scheme in Alberta and in the Northwest Territories of Canada (www.teleophthalmology.com) which allows remote rural optometrists to transmit fundus photographs to retinal specialists in the regional centre.

In countries where such an infrastructure does not currently exist, Universal Service Funds (USFs) could be utilised for this purpose. These are internationally available funds that accompany government tax breaks (Nakajima L ,2010). USF promotes the development of telecommunication services in un-served and under-served areas throughout the length and breadth of a country. They help to bring the digital image transfer to a rural population and increase the level of connectivity significantly in the rural areas through effective and fair utilization of the fund. They help towards significant advances towards enhancement of e-services, both in rural as well as urban areas of the country.

2.1 Diabetic retinopathy screening service for Wales

In Wales all diabetic patients undergo annual screening for retinopathy in local community hospitals or GP surgeries depending on the rural location. Digital fundus imaging is carried out with dilation of the patients’ pupils. The photographs are saved onto laptops with strict security access codes. Images are stored in data centres in North Wales, (Carnaervon), Mid and South West Wales (Carmarthen) and Trefforest near Cardiff at Fairway Court which is the main centre to which all images are sent for data backup. These centres are linked through a DAWN₂METRO VPN (Figure 3). A virtual private network (VPN) is a secure

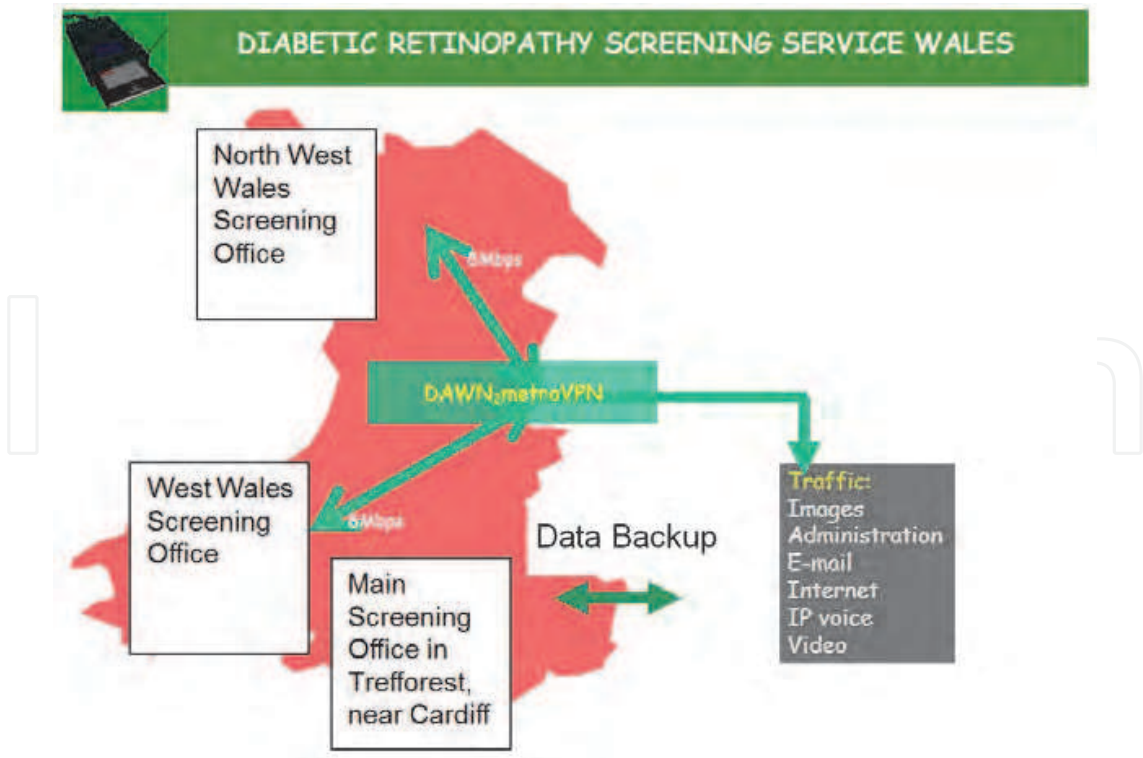


Fig. 3. Overview of IT Links between 3 Sites in Wales for Diabetic Retinopathy Screening Service for Wales using DAWN₂metroVPN

authentication to a network enabling a gateway for all computers at all sites to be connected. Tele-ophthalmology is enabled as all computers are on the same network. Graders at Trefforest carry out primary and secondary retinal screening across this VPN.

2.2 Teleophthalmology for paediatric retinal disorders

Retinopathy of prematurity (ROP) is a leading cause of irreversible visual impairment in childhood. Timely treatment usually prevents blindness. Provision of objective documented clinical images is critical in ROP care. Digital retinal image capture is used for screening of premature or low birth weight babies for retinopathy of prematurity. Images are captured with a digital retinal camera, most often the Retcam instrument (Fig 4). Furthermore such images can be captured by non-ophthalmic staff in the neonatal intensive care unit. Validation studies of telemedicine for ROP diagnosis have demonstrated that its accuracy, intergrader reliability, and intra-grader reliability are high and are comparable to or better than that of other widely accepted diagnostic tests (Victor G et al., 2009).



Fig. 4. Retcam instrument (Clarity Medical Systems) for retinopathy of prematurity screening

Skilled ROP screeners may grade neonatal retinal images in a central location that can be remote from the neonatal unit. Where a shortage of ophthalmologists capable of undertaking or providing ROP screening exists, this mode of teleophthalmology is a solution to maintaining a credible and efficient screening service. Other urgent paediatric ophthalmic pathology, such as retinoblastoma, can also be imaged via the Retcam. Fundus images of retinæ of suspected non-accidental injury (shaken babies) for diagnostic and medico legal purposes can also be taken via a Retcam and the images subsequently transferred for expert opinion.

Advantages of the Retcam include its portability and manoeuvrability to the bedside in constrained areas such as on the Neonatal Intensive Unit. It can be transported between hospitals and clinics, and allows transfer of retinal images to any networked system. It allows timely remote evaluation of patient images and provides advanced image analysis and comparison capability of previous images with review software.

3. Urgent eye care and teleophthalmology

Anterior segment cameras (Figure 5) can be used in Accident and Emergency settings by nurses and ophthalmologists. Images from such instruments are similarly uploaded via a central server. The ophthalmologist in a central location is then able to make decisions on the urgency of an ophthalmic opinion, suggest treatment online that can be accessed by the remote practitioner after a specified time (very similar to PACS reporting of radiology images) or arrange a referral. This allows rural populations to benefit from an emergency ophthalmic service.



Fig. 5. Anterior segment digital camera in peripheral clinic in Wales.

Ophthalmologic accidents and emergencies,) are an important public health matter and component of hospital workload. (Bhopal RS (1993). The most prevalent such problems are corneal foreign bodies, corneal abrasions and conjunctivitis (Girard B et al., 2002). In rural areas, such patients are usually seen by general practitioners, who often lack expertise or the equipment for the management of eye emergencies.

3.1 The Welsh experience of teleophthalmology for urgent eye care

We piloted a teleophthalmology service in rural Wales, as described by Kulshrestha MK et al., 2010. Tywyn Hospital is located in a rural setting in Gwynedd, Snowdonia, North Wales (Figure 6). Ophthalmic medical staff are based at Bronglais District General Hospital, Aberystwyth, which lies in the neighbouring county of Ceredigion. Management of ophthalmic services is controlled from Carmarthen, in South Wales. There is poor provision of public transport between Tywyn and Aberystwyth which is one hour away by car. The road journey from Carmarthen to Tywyn is three and a half hours. The region therefore extends over a wide area of North and West Wales.



Fig. 6. Map of Wales and Counties, showing location of Tywyn, in South Gwynedd (Snowdonia)

More than 80% of the population live in rural areas and there are 1.88 ophthalmologists per 100,000 population, with narrow roads and poor transport links. This is lower than the UK average figure of 2.3 ophthalmologists per 100,000 population.

This teleophthalmology service involved nurses, IT professionals and managers from the Betsi Cadwaladr Local Health Board (Gwynedd, Snowdonia) and ophthalmologists from the neighbouring Hywel Dda Health Board (Carmarthenshire, Ceredigion and Pembrokeshire), illustrating partnership by working across these two different Health Boards.

All ophthalmic emergencies from South Gwynedd are assessed by nurses in Tywyn Accident and Emergency Department. Any patients who require a consultant ophthalmologist's opinion need referral to Bronglais Accident and Emergency for specialist referral. One hundred and twenty four eye emergencies were seen in Tywyn Accident and Emergency Department in 2008. Consultant Ophthalmologist clinics are held once every two weeks. Some emergencies are seen in the eye clinic, but if these urgent cases occur/present at other times and require a ophthalmic opinion, transfer to Aberystwyth by ambulance is required. A teleophthalmology service has now been developed between the peripheral unit in Tywyn and the central unit at Bronglais Hospital, so eye emergency patients seen by the nurses on duty in Tywyn can be better treated. Ophthalmic signs are visualised by transmission of images from a Topcon SL D7 Slit Lamp camera (Fig 5) in the peripheral clinic through a Polycom or NEC Videoconferencing Unit (Figure 8) to the central Bronglais Hospital, Aberystwyth. Live or real time video tele-consultations with patients and staff can be held to initiate immediate management, treatment and advice.

Fenton et al found in an audit of emergencies presenting to a city centre eye department in Dublin that 60 – 70% of these referrals did not constitute accidents or urgent conditions needing urgent specialist attention. (Fenton et al., 2001) Given this scenario, an internet-based system for eye care (teleophthalmology) would help to avoid unnecessary transfer of patients with non-urgent problems by emergency ambulance or helicopter, saving transport costs and time, as well as road traffic pollution in rural areas.

3.2 Tele-ophthalmology in Australia

In the state of Western Australia, with a land area ten times larger than UK, most ophthalmologists are based in Perth, the major city of this region. Models of teleophthalmology services exist between Carnarvon in North West Australia, where clinics are run by nurses and Perth consultant ophthalmologists (Figure 7). Patients detected to have an urgent sight threatening problem in Carnarvon are sent by helicopter for emergency treatment in Perth (Kumar S et al., 2006).

Access to emergency treatment in rural areas can often mean the difference between life and death. Internet-based technologies have the potential to provide earlier diagnosis and intervention, save lives and avoid unnecessary transfers from rural hospital emergency departments to urban hospitals (Kumar S et al., 2006) Benefits for rural healthcare staff in skills acquisition and education are also evident.

There is a real need for ophthalmic emergency services in rural regional hospitals. An internet service may be the most efficient way to triage these emergencies. A decline (15%) in the number of eye related cases in Carnarvon, Australia may be related to a number of people presenting themselves directly for the teleconsultation service.

While acknowledging that the time comparisons need to be more appropriate by comparing 'like-for-like', at Carnarvon, the average time of an internet consultation was 30 min against a 2-h and 45-min turnaround time for an emergency department evaluation (Ellis et al.,

2001). A variety of emergency complaints were managed effectively using relatively low-cost internet-based telemedicine technology, thereby eliminating the need for transportation of the distant patient to the city-centre emergency department.

Specialist diagnostics is readily available and a better assessment of patient's evacuation urgency is made using the internet service. Other benefits included earlier diagnosis and intervention, a shorter stay in hospital (if hospitalisation is deemed necessary) and avoided traveling for the patient.

While conventional, face-to-face consultation with a specialist doctor is beneficial; availability, access and costs are often barriers in remote regions. Internet services offer a substitution for conventionally provided emergency services in rural and remote regions. Furthermore, urban specialists are usually satisfied with such arrangement as it may enhance potential income, skill and practice, without disrupting conventional consultations at central hospital facilities.



Fig. 7. Map of Western Australia showing Carnarvon to the NorthWest where Nurses have Teleophthalmology equipment and Perth on the South West Coast where Consultant Ophthalmologists can obtain photographic or live video images

The cost of an established tele-ophthalmology service has been compared with the cost of three other existing eye-care service delivery options by Kanagasingam and Yogesan K, 2006. During a 12-month study period, 118 persons took part in the tele-ophthalmology consultations between a rural clinic located approximately 900 km from the Lions Eye Institute in Perth. The variable costs of tele-ophthalmology were \$166.89 (AUD) per patient, and the alternatives cost \$445.96, \$271.48 and \$665.44 per patient. Tele-ophthalmology incurred a set-up cost of \$13,340. The threshold at which tele-ophthalmology became

cheaper than any of the alternative options occurred at a total workload of 128 patients. Tele-ophthalmology therefore offered a viable alternative to conventional eye-care service in rural and remote areas.

3.3 Experience in India with teleophthalmology

Eighty percent of India's population lives in rural areas (Gullapi N, 2000). However, seventy percent of the healthcare resources are in urban areas. There is one ophthalmologist per 100,000 population, 70% of whom practice in urban area.

Teleophthalmology reduced the need to travel and holds potential for improved quality, access and affordability of healthcare. There can be at least 50 community centres attached to one tertiary hospital centre (http://www.laico.org/v2020resource/files/teleophthalmology_in_india.PDF). In these 'Vision Centres' there are mid level ophthalmic personnel (MLOP), who are similar to trained Ophthalmic Nurse Practitioners (<http://www.laico.org/v2020resource/files/mlpICO.pdf>). They are trained to take anterior segment and retinal images and perform intraocular pressure checks. They communicate online with a consultant ophthalmologist at the main hospital providing anterior segment and retinal images as appropriate and discuss clinical details of the patient. Of 91698 patients examined by this means from 5 community centres at the Aravind Eye Hospital, Tamil Nadu, South India, only 12.5% needed referral to the main centre for surgery, specialist consultation or investigations (Khurana M et al., 2011).

Eyestalk (www.aravind.org/telemedicine/eyestalkhome.htm) is dynamic software in use at the Aravind Eye Hospital that makes it safe and simple to send complete consultation records along with images from slit lamps to specialists at main eye centres for second opinions. It allows complete confidentiality of patient information. This system simply requires a telephone line and computer with a modem to function.

The Sankaranethralaya teleophthalmology network as described by Thulasi Bai et al., 2007 utilizes mobile units with teleophthalmology equipment with satellite connectivity. There are 6 such vans providing local ophthalmic care in community outreach villages. In over 800 community camps over 15,000 patients have benefited from a teleophthalmological consultation. There was no degrading effect on compressed or uncompressed images on transfer via satellite, and consultations were extremely cost effectiveness compared to hospital based appointments.

4. Video links in ophthalmology

Live or synchronous video links are currently used in Wales, Australia, Canada and remote parts of the USA to allow patients in remote or inaccessible areas to be examined in emergency settings by an ophthalmologist (Figure 8). Before the advent of teleophthalmology either treatment was delayed or patients needed to be evacuated to a central hospital. Video links allow live anterior ocular segment examination and also a direct communication with the patient. Fundus cameras and optical coherence tomography (OCT) imaging can also be employed for retinal examination.

The zoom control function allows accurate assessment of ocular motility, allowing assessment of trauma/falls and accident cases where there has been orbital injury. In case of suspected orbital fracture the nurse practitioner or doctor can be instructed to check the infra-orbital nerve sensation and a management plan/treatment can be given over the video-link by the ophthalmologist without the need for the patient to travel to the main

centre. Orbital radiological imaging is also undertaken taken locally and are available for viewing by the radiologist through the PACS system.

The Sony or Canon pan/tilt/zoom video cameras used with many of the desktop videoconferencing systems can also be used for acquiring diagnostic still images, as well as video clips during the ocular motility assessment. These cameras generally have at least 470 horizontal lines of resolution, which is equivalent to a digital still image resolution of 640 x 480 pixels.

Most of these cameras have either a composite or S-video signal output to allow the video signal from the camera to be transferred to any standard PC video capture card. Thus, both still image captures of the ocular alignment in primary gaze can be obtained. The PC video capture card is purchased separately and should be TWAIN compliant. Flashbus, Pinnacle, AVI, Matrox video capture cards are some of the popular video capture cards used in many of the telemedicine systems. The video capture card chosen should support JPEG, TIFF, MPEG, and AVI file formats. Cards that support MJPEG or MPEG-2 compression formats would be ideal, because they provide higher image quality. Some healthcare organisations such as NHS Trusts, however do not support storage of clinical data on video cards and only support clinical data storage on the networked central server.



Fig. 8. Videoconferencing instrument at Tywyn Hospital

Pre-recorded video files can be used by optometrists and nurse practitioners. Video files record anterior segment, retinal or fluorescein imaging and these are uploaded via a central server and examined and reported by an ophthalmologist. The ophthalmologist may be able to access the video AVI file from the central server at any location within the region providing the community hospital has teleophthalmology equipment which is linked to the main server.

4.1 Clinical advantages include

- Increase productivity of healthcare professionals
- Strengthen referral patterns
- Effectively educate hospital staff, clinicians and the community
- Extend patient care and expertise to remote areas
- Improve patient care

4.2 Non-clinical and administrative advantages include

- More effective planning and administrative meetings with point-and-click sharing of content
- Remote connection for executive and business meetings avoids unnecessary travel and expenses. In rural healthcare settings staff attending business meetings from different areas, often involves a large amount of travelling to a central location for managers and clinicians based at community hospitals. Use of videoconferencing has helped teams to make maximum use of the time available in the day, with minimum disruption to the general working day. This has dramatically reduced travelling times for staff in Wales
- Support Human Resources, which may be located far away from the main hospital, eye clinic. At community hospitals workforce issues may arise on a daily basis and Human Resource departments may be anything from 2-4 hours away by car in Wales. Use of videoconferencing to members of the human resources department has helped to resolve emergency staffing issues

4.3 Educational advantages include

- **Attend Continuing Medical Education events** by videoconference. Community nurses have attended teaching sessions at the main hospital via live videoconferencing and live power point presentations, thereby enhancing their knowledge and skills.
- **Conduct video grand rounds** sharing PC content, live patient encounters, or recorded procedures
- **Video connect to nursing schools** for up to date training and medical information
- **Conduct administrative training and medical education** using live or streaming video

5. Optical coherence tomography (OCT) and retinal imaging

Optical coherence tomography (OCT) imaging (Huang D et al.,1991) is a relatively new, non-invasive, tool in clinical imaging. In ophthalmic clinical practice OCT allows real time imaging of the layers of the retina. OCT allows much better diagnosis of retinal conditions than conventional ophthalmoscopy and or retinal photography. Importantly, many retinal conditions can be diagnosed rapidly using OCT scanning, where undertaken, and in our opinion referral triage be improved upon. In 'virtual macular clinics' review of OCT images,

combined with fundus photographs for review of patients with macular degeneration is now being used. Fluorescein angiogram images can also be correlated in these virtual clinics, with OCT and other retinal images.

5.1 Teleophthalmology and age-related macular degeneration (AMD)

Age-related macular degeneration (AMD) is the leading cause of blindness in developed economies. Neovascular or wet-AMD accounts for more than half of all cases of registered sight and severe sight impairment (Bruce C et al., 2010) and approximately 26,000 new cases of wet-AMD develop every year in the UK (Owen et al., 2003). There have been major recent advances in the treatment of wet-AMD with the use of biological agents and in particular with vascular endothelial growth factor (VEGF) inhibitor medications - frequently termed 'anti-VEGF agents'- following publication of key trial results, (Gragoudas et al., 2004, Rosenfeld et al., 2006 Brown DM et al., 2006). These studies showed that wet-AMD patients treated with monthly intravitreal injections of anti VEGF agents had a greatly reduced risk of visual loss compared to no treatment or other existing treatments. Wet-AMD patient care requires regular injections of such anti-VEGF medication whenever visual acuity drops or the retina is found to thicken on monthly OCT scanning. This is thus an area of both high volume, frequent, time sensitive care. Delay in access to treatment for wet AMD patients was found to be a major problem in a recent review of NHS patient safety data across England and Wales (Kelly and Barua, 2011). Pressures on AMD services are mounting as the numbers of such patients enlarge. For example in West Wales, Aberystwyth, in February 2010, 51 patients were undergoing such treatment. This increased to over 200 such patients by February 2011. Nurses in the clinic have been trained to undertake OCT imaging, facilitating timely review of patients' results by the consultant ophthalmologist to determine whether a further VEGF inhibitor injection is indicated.

The use of nurses and assistant nurse practitioners (Figure 9) to capture OCT images has allowed our AMD service to develop. Feed back from patients is positive. Nurses have been involved with formulating an electronic record incorporating the OCT scans for individual patients and in setting up a local community hospital service using telemedicine facilities. There has been improvement in the quality of life for the elderly patients in our community as a result of maintaining eyesight. Poor vision is associated with depression, suicide, falls and fractures.

5.2 Virtual clinics in macular disorders

Virtual macular clinics have been organised in centres to cope with increasing demand of retinal disease and to free up capacity issues within the hospital service. Such innovation may allow patients to be managed with the click of a mouse. The multidisciplinary team undertakes clinical history review and carries out digital fundus photography and optical coherence tomography imaging. These clinical images together with an electronic -or paper based- clinical record are reviewed by a consultant ophthalmologist either in the eye clinic or possibly at another location. Such clinics are becoming established at facilities for wet AMD patient care such as Sheffield, Cheltenham and Gloucester and West Wales.

Ophthalmology medical staff may not need to examine every patient, provided they are still involved in the decision making process at vital points in the patient pathway. Face-to-face patient contact can be undertaken by suitably skilled nursing and optometry staff. Consideration can also be given to electronic transfer of ophthalmic images from the community for review at the hospital. This can be problematic, due to IT issues, but is

possible. This type of digital image transfer is currently under investigation at community hospitals in West Wales using videoconferencing equipment.

In the North West of England we are piloting use of the PACS system, (mostly used for radiology at this time), for OCT and fundus images, with transfer of such images to ophthalmologists in other locations, clinics and hospitals for consultation or review. The iPhone and iPad have an application into which OCT images may be downloaded for viewing at remote locations (Figure 10)



Fig. 9. Nurse undertaking optical coherence tomography examination

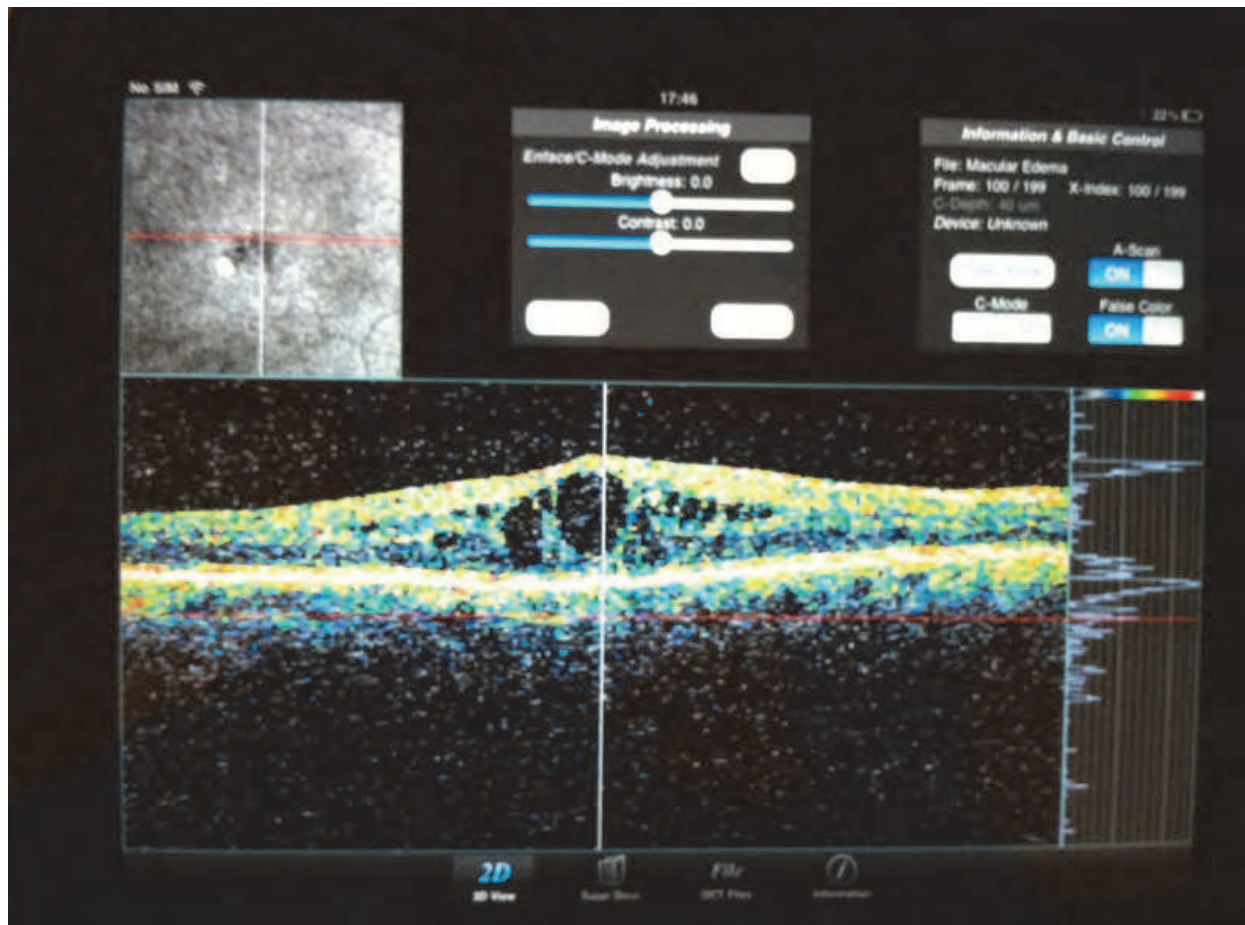


Fig. 10. OCT Scan showing abnormal macular fluid accumulation and which has been wirelessly downloaded to an Apple iPad through an app downloaded from iTunes

Large size clinical image transfer in the NHS requires N3 connectivity. Image exchange portal (IEP) services are being commissioned by NHS at present. Such facilities may be an additional tool for ophthalmology image transfer. Comprehensive ophthalmic image data management systems such as EyeRoute Synergy (Topcon Medical Systems) and Forum (Carl Zeiss Instruments) are available to assist such teleophthalmology endeavours. Interoperability with electronic medical records leads to enhanced productivity in busy ophthalmic clinics and across clinical boundaries.

It is likely that such systems will be more integrated into more ophthalmology clinics and thus facilitating development of virtual clinics and the introduction of wireless technology instruments into clinical care.

Some optometrists are now using NHSmail and which enables secure electronic transmission of patient information. NHSmail accounts are available to optometrists in Scotland and England. As such connectivity to NHSmail to community optometrists is available, publicity within the optometry profession to encourage uptake is now required. Use of NHSmail has successfully allowed collaboration between consultant ophthalmologists and community optometrists in Bolton in a pilot clinical study, allowing the rapid access of patients into treatment for AMD and other retinal disorders when required. However, if large file sizes are being transmitted N3 connections are required. N3 connectivity provides a centrally funded, resilient network connection for every NHS site in

England. Placement of virtual clinics in the correct place in the patient pathway is critical for success

Multiple OCT units have been successfully integrated in Australia through the beta release of V5.2 software for the Zeiss Cirrus OCT instrument. This enables the sharing of OCT raw data between multiple Cirrus units via FORUM 2.6 software. (Person communication C Hawke, Zeiss Australia). Depending on internet connection speed this could also be performed between multiple sites. This could either be running live or possibly by synchronisation via scheduled transfer of data, perhaps overnight. There are also future developments underway by Zeiss not only for OCT data synchronisation but all ophthalmic data synchronisation. Such a setup may perhaps better facilitate integration of ophthalmic image data files between diverse departments, such as rural community clinics and the central departments. Such innovation may facilitate the better development of virtual clinics.

Similarly EyeRoute Synergy Ophthalmic Data Management System from Topcon integrates images and reports from many instrument manufacturers into a single, secure, digital environment. With the ability to view, compare, annotate and transmit patient images, EyeRoute Synergy provides for fluent workflow efficiency. The web based system allows for rapid access to patient information, anytime, from virtually anywhere, including workstations and remote computers. As this system can store, manage and share data and images from many medical devices and can facilitate better sharing of information between colleagues in real time through a secure Synergy Community Portal. It has been used in remote diabetic retinopathy screening in the USA.

6. Glaucoma and optic disc imaging

Glaucoma is a common condition and a potentially blinding eye disorder for which effective treatment (usually with eye drop medications) exists and guidance from NICE is present. <http://guidance.nice.org.uk/CG85>

Delay in NHS glaucoma patient follow up appointment provision emerged from a review by the National Patient Safety Agency (NPSA). A NPSA alert followed in 2009 seeking to improve patient safety in this area of high volume care.

<http://www.nrls.npsa.nhs.uk/resources/type/alerts/?entryid45=61908>

Optic disc OCT imaging is useful in glaucoma and can record progression of nerve fibre layer thinning. The findings obtained with OCT can be used in conjunction with visual field tracings, also recorded digitally and thus available remotely. The glaucoma service in West Wales is presently being modified to increase the role of the community diagnostic and treatment centres with glaucoma teams who record the visual fields, the intraocular pressures and optic disc OCT image and digital photograph. The glaucoma specialist can make decisions on the need for referral or indeed the need for the patients to be seen in the hospital or not, based on assessment of images of visual fields, optic discs, optic disc OCT and an updated patient electronic record.

Once glaucoma or ocular hypertension is diagnosed and treatment initiated, some patients can be managed via virtual glaucoma clinics. There are models which have been developed for Virtual Glaucoma clinics in South Wales, (Llandeilo and Swansea), with Diagnostic Centres control stations, where decisions are made through telemedicine by a consultant

ophthalmologist with a specialist interest in glaucoma at the main University Hospital. Though futuristic, there are plans underway to role these clinics out throughout urban and rural Wales using the community hospitals as diagnostic and treatment centres. Training is in place in the Carmarthenshire Glaucoma Referral Refinement Scheme to ensure nurses and community optometrists have the skills to take part in these glaucoma teams, as described by Devrajan et al., 2011.

Tele-glaucoma clinics have been piloted in Finland. Tuulonen compared patients seen in community telemedicine clinics in Finland and those seen in the hospital. (Tuulonen A et al., 1999). Both patient groups were equally satisfied with the ophthalmic service. Nearly all patients in the telemedicine group (96%) wanted to have their next visit in their own healthcare centre instead of the university eye clinic. The most important reasons were reduction in travelling (97%), costs (92%), and time (92%). The costs of the telemedicine and conventional care visits were equal, but decreased travelling with telemedicine option saved \$55 per visit. With greater emphasis on team leadership, introduction of these clinics to rural areas will help cope with the increased demands of seeing an ever increasing number of follow up patients on time.

7. Conclusions

Telemedicine is well suited to ophthalmology patient care. The term teleophthalmology provides a framework for such innovation. Teleophthalmology also offers benefits to the organisation of patient care and enhances the skills of local first level eye care practitioners, such as community optometrists and ophthalmic nurses. Teleophthalmology has merit both in urban and rural settings. Better integration of teleophthalmology with local services is improving emergency eye care, diabetic eye screening and virtual macular and glaucoma clinics. Teleophthalmology helps reduce costs while maximising productivity, and reduces patient travel or transfer. It is not intended that teleophthalmology consultations would replace face to face ophthalmic consultations and clinical examination. Rather electronic referral of ophthalmic images, rather than of patients, is a useful and rapid tool to assist, prioritise and refine referral of many ophthalmic patients, especially retinal patients in the digital age. This is the case in our experience in Wales. (Kulshrestha et al 2010)

There are many advantages of this exciting technology in revolutionising the way care is provided given an expanding numbers of ophthalmic patients. Furthermore there are increasing applications for emergency and out of hours care; management and administrative meetings; CPD and educational training. These advantages are particularly relevant in rural areas, with patients who may otherwise have to travel long distances to access ophthalmic care. Importantly the introduction of virtual clinics allows greater team working between primary and secondary care and may thus help to solve some of the problems of slippage and delay in hard pressed retinal and glaucoma patient care.

Although there is strong evidence that teleophthalmology is particularly useful in the treatment of retinal disease, 93% of published projects in a recent review concern 'store and forward' applications rather than transfer of real time images schemes. Over 90% of projects in that review had a positive view on teleophthalmology services, indicating its role as a reliable method of eye care delivery.

http://www.intechopen.com/source/pdfs/14329/InTechAdvances_in_teleophthalmology_summarising_published_papers_on_teleophthalmology_projects.pdf

The use of modern wireless technologies in mobile and hand held devices -such as smart phones (eg Apple iPhone) and tablets (eg Apple iPad), - together with the potential wider use of PACS to allow image transfer is likely expand the options and usage of teleophthalmology solutions in the future.

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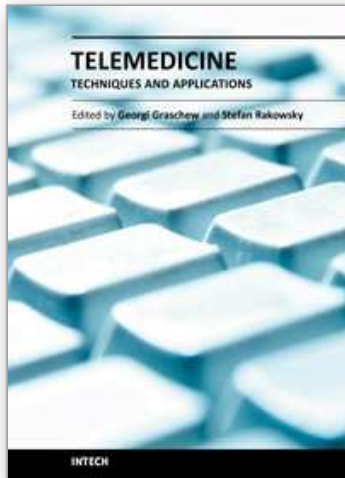
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