



## OPEN ACCESS

## Teleglaucoma: ready to go?

N G Strouthidis,<sup>1,2</sup> G Chandrasekharan,<sup>3</sup> J P Diamond,<sup>4</sup> I E Murdoch<sup>3</sup>

<sup>1</sup>NIHR Biomedical Research Centre at Moorfields Eye Hospital NHS Foundation Trust and UCL Institute of Ophthalmology, London, UK  
<sup>2</sup>Singapore Eye Research Institute, Singapore, Singapore  
<sup>3</sup>Institute of Ophthalmology, London, UK  
<sup>4</sup>Bristol Eye Hospital, Bristol, UK

**Correspondence to**  
 Ian E Murdoch, Institute of Ophthalmology, 11–43 Bath Street, London EC1V 9EL, UK; [i.murdoch@ucl.ac.uk](mailto:i.murdoch@ucl.ac.uk)

Received 5 August 2013  
 Revised 22 January 2014  
 Accepted 16 March 2014  
 Published Online First 10 April 2014

**ABSTRACT**

Telemedicine technologies and services allow today's ophthalmic clinicians to remotely diagnose, manage and monitor several ophthalmic conditions from a distance. But is this the case for glaucomas? There has been a proliferation of telemedicine friendly devices in recent years that improves the capabilities of the clinician in managing glaucomas. The existing instruments still need to align themselves with accepted industry standards. There are successful programmes running in several areas of the world. The safety and efficacy of these programmes needs further exploration. The inability of a single device or test to diagnose glaucomas satisfactorily has also hampered progress in remotely diagnosing these conditions. There is, however, significant potential for telemedicine-friendly devices to remotely monitor the progress of glaucoma and, thereby, reduce some of the workload on an overstretched health service.

**INTRODUCTION**

Telemedicine, or telehealth, refers to the practice of medicine at a spatial and/or temporal distance by exchanging medical information via electronic communications.<sup>1</sup> The key aspect in the development of telemedicine is the constantly evolving interaction between medicine and information and communication technology (ICT). Given that ICT can support data collection and exchange, this can enable improved communication and integration of clinical services. Radiology has been at the vanguard of telemedicine; electronic transfer of digital images between radiological departments is now standard practice because the images do not diminish in quality with transfer.

Telemedicine principles have already been successfully applied within ophthalmology in the National Health Service Diabetic Retinopathy Screening Programme and retinopathy of prematurity screening. A 'store and forward' approach is used whereby images/data acquired at one site are transferred to a remote grader who views these images at a different time. Alternative approaches include remote monitoring and interactive telemedicine where self-testing allows clinicians to monitor a patient, and real-time interaction may occur between the clinician and the patient.

Glaucoma management increasingly involves use of devices that are perceived to be 'telemedicine-friendly'. Automated perimetry, tonometry, corneal pachymetry, imaging of the optic disc, nerve fibre layer and anterior segment, may all generate digital outputs that can be transferred electronically and viewed remotely.

This review outlines the validity of remote review with current technology and work reported to date using remote technology in glaucoma detection and management. Papers included in this

review were identified through pubmed searches using the keywords 'teleophthalmology', 'teleglaucoma', 'glaucoma imaging', 'glaucoma screening', 'glaucoma case detection', 'glaucoma progression' and 'IOP measurement'; references in English were included.

**TECHNOLOGY: STANDARDISATION AND INTEGRATION**

For any telemedicine/telehealth system to be implemented it is vital that open information exchange standards are used. Table 1 illustrates the principal standards and associated organisations that exist in this field.

While some glaucoma devices can already be configured to automatically upload data in a standardised format, others cannot (eg, older Goldmann applanation tonometers and corneal pachymeters). Standardised digital interfaces for most monitoring devices are awaited, and until such point, manual data entry into the electronic patient record will be required.

**POLITICAL CLIMATE AND RATIONALE FOR TELEGLAUCOMA**

In general, regulatory, legal and financial issues are all barriers to adoption of telehealth. The political momentum in the UK supporting 'telehealth' is strong, with the prime minister, David Cameron, pledging that up to 3 million people with chronic conditions will be managed using telehealth technology, funded through the government's Life Sciences Strategy.<sup>15</sup> The principal cited reason was the success of the Whole Systems Demonstrator (WSD) trial. This was a cluster randomised trial conducted in 3230 people with diabetes, chronic obstructive pulmonary disease and heart failure.<sup>16</sup> Subjects randomised to the telehealth arm underwent home self-monitoring during allotted sessions using instruments, such as glucometers, pulse oximeters, weighing scales and symptom questionnaires. This approach led to a lower 12-month admission rate and mortality at 12 months. Recently, however, doubts have been raised as to whether the strategy was cost effective when compared with standard care.<sup>17</sup>

Primary open-angle glaucoma (POAG) is a chronic condition with a prevalence of 2% in people over 40 years of age,<sup>18–22</sup> rising to over 10% in some populations over 80 years of age.<sup>22 23</sup> There is a significant burden of disease, with up to 10% of UK blind registrations being attributable to glaucomas.<sup>24</sup> Hospital eye services are considerably challenged by the influx of new glaucoma referrals, while continuing to monitor existing stable patients. There is, therefore, an argument to try and minimise hospital visits by reviewing stable glaucoma patients outside the hospital clinic setting.



Open Access  
 Scan to access more  
 free content



CrossMark

**To cite:** Strouthidis NG, Chandrasekharan G, Diamond JP, et al. *Br J Ophthalmol* 2014;**98**:1605–1611.

**Table 1** Summary of the current healthcare technological integration strategies and standards

Standard/organisation	Nature	Purpose	Detail
HL7 (Health Level 7) <sup>2</sup>	International non-profit organisation	Involved in developing international open health informatics standards	Develops messaging, clinical document and other health informatics interoperability standards to enable exchange of healthcare information
HL7- V.2.X, V.3.0, CDA <sup>3</sup>	HL7 V.2.X, V.3.0 and Clinical Document Architecture. These standards developed by HL7 enable information exchange and structuring of clinical documents	V2.X and 3.0 are messaging standards and can be used when real-time transfer of information is needed. HL7 V3 CDA allows representation and processing of clinical documents that makes it machine and human readable. The CDA document can include free text, images and other multimedia content. Telemedicine consultations can involve clinicians or patients sending patient summaries, referral letters or other clinical documentation between multiple entities and the CDA document can ensure interoperability even in the presence of legacy systems	Depending on the requirements of the telemedicine system, both these standards can coexist. Several clinical information systems have adopted HL7 and other standards are in the process of conversion but there needs to be wider acceptance to ensure complete interoperability
DICOM (Digital Imaging and Communication in Medicine) <sup>4</sup>	Administered by the Medical Imaging and Technology Alliance, a division of the National Electrical Manufacturers Association (NEMA)	International standard developed to ensure interoperability between imaging systems. DICOM has existed as a standard since 1993, and this has been one of the key developments in enabling the communication of radiological tests	Most new devices used in ophthalmology today have DICOM compatibility. This allows the device to integrate seamlessly with an electronic health record system and with a Picture Archiving and Communication System (PACS). Digital transfer of optic disc photography has been shown to have no significant effect on image quality and does not impact upon the clinician's ability to interpret the images <sup>5</sup>
ANSI (American National Standards Institute) <sup>6</sup> H.32x	Private non-profit standards development organisation	H.32x is a standard that enables video conferencing and allows clinicians and patients to communicate with each other regardless of the video conferencing hardware used, and are needed where real-time telemedicine video-conferencing applications are required	
Continua Health Alliance <sup>7</sup>	Non-profit open industry alliance of leading healthcare technology companies and device manufacturers. The alliance consists of fitness/wellness device and chronic disease personal health management device manufacturers	Members of this alliance select appropriate standards and establish strict interoperability guidelines that allow these devices and home monitoring systems to share information. Personal health and home monitoring devices which have undergone the Continua Certification Process should collect and exchange the health and wellness information with other certified devices in an efficient manner	The data collected with the help of these telehealth devices can then be exchanged with the patient's care team using Integrating the Healthcare Enterprise (IHE) Profiles developed for this purpose. The ISO/IEEE 11 073 Personal Health Data (PHD) Standards developed for interoperability of personal health devices (also used by Continua Health Alliance) does not have a device-specific standard for self-tonometry devices. <sup>8 9</sup> None of the self-tonometry or IOP home monitoring devices are certified by Continua Health Alliance at present. <sup>10</sup> Development of device-specific standards and active participation of self-tonometry device manufacturers in organisations facilitating interoperability will make these devices more user friendly, interoperable and enable wider adoption
IHE <sup>11</sup>	Integrating the healthcare enterprise. International consortium of clinicians, vendors and health informatics professionals	Promotes the use of existing standards (DICOM, HL7, web services, etc.) IHE working group formulates technical framework specifications called IHE Profiles which allow vendors to independently develop solutions that meet requirements of this framework. These profiles address common yet difficult interoperability issues affecting healthcare information exchange and interoperability. IHE also participates in testing and validation of these profiles and vendor implementations so that they work in real-life scenarios, and actively promotes their use. IHE accelerates adoption of Electronic Health Records and allows exchange of information between disparate clinical environments and information systems and helps address the problem of information silos	There are 8 clinical domains covered by IHE, and ophthalmology is one of them. <sup>12</sup> Telemedicine practitioners should consider IHE Integration Statements during implementation that describes the conformance of a particular product to the domain-specific technical framework (eg, IHE Eye Care Technical Framework). Most glaucoma imaging device manufacturers are members of IHE and have produced IHE Integration Statements (eg, Basic Eye Care Workflow). <sup>13</sup> IHE Eye Care Planning Committee has prioritised glaucoma and is currently working on producing CDA profiles specific for glaucoma and other subspecialties in the coming years. <sup>14</sup> This should solve some of the interoperability problems within glaucoma clinical management and subsequently improve teleglaucoma applicability, although further work is needed before all interoperability issues are addressed

CDA, clinical document architecture; IOP, intraocular pressure.

Most reported teleglaucoma schemes have been used in remote areas where specific glaucoma expertise is not available.<sup>25–27</sup> The number of staff at a remote site can be minimised, with potentially a ‘dedicated’ technician overseeing tonometry, imaging and perimetry at each testing station. Any potential teleglaucoma scheme’s management team will need to devise a specific training programme and competency assessments (along with continuing education and appraisal) for any staff undertaking testing at a remote site.

## TELEGLAUCOMA-FRIENDLY TECHNOLOGY

### Intraocular pressure measurement

Therapies for glaucomas are predominantly focused on lowering intraocular pressure (IOP), hence, this is a crucial element of any follow-up assessment. For detection of disease, IOP measurements above 21 mm Hg have a reported sensitivity of 47% and specificity of 92% for detecting POAG, and this does not improve when confined to high-risk groups.<sup>28</sup>

Goldmann applanation tonometry (GAT) is now available with a digital output (AT 900D, Haag-Streit International, Koeniz, Switzerland). Non-contact tonometers (NCT), rebound tonometers (iCare, Helsinki, Finland) and hand-held applanation tonometers (Tonopen, Reichert, Depew, New York, USA) have the advantage that less skilled operators can use them effectively, and they are portable. Repeated measurements with GAT are, however, more reproducible than automated methods of IOP measurement.<sup>29</sup> Non-contact methods may be subject to systematic bias (rebound tonometry was found to overestimate IOP by a mean of 2.3 mm Hg<sup>30</sup> up to 3.4 mm Hg<sup>31</sup> compared to GAT) non-systematic bias (there is a tendency for tonopen to underestimate IOP at high IOP levels<sup>32–35</sup>) and other sources of bias (pneumotometry and rebound tonometry are prone to overmeasurement with increasingly thicker corneas<sup>31 36 37</sup>). However, recent studies have shown marked improvement in measurements between rebound tonometers and GAT.<sup>38</sup>

Since the management of IOP is relative in each individual, provided the same method of assessment is used for comparison, systematic bias should be of less importance. Of greater importance is non-systematic bias and the reproducibility of results. Automated measurement devices are not necessarily interchangeable substitutes for GAT.

In due course, home monitoring may become a possibility. iCare ONE has been developed specifically for home use.<sup>39 40</sup> There is also a contact lens sensor device for measuring IOP (Sensimed Triggerfish CLS, Sensimed AG, Lausanne, Switzerland).<sup>41</sup> A systematic review and meta-analysis of studies comparing GAT with other tonometers revealed that NCT had the least amount of variability in measurements, and the Ocuton-S (an applanation ‘self’ tonometer) had the lowest agreement with GAT.<sup>42</sup> The review also showed that rebound tonometers had better agreement with GAT than Ocuton-S, but still lower than NCT. They identified the need for further evidence comparing tonometers and standardisation of reporting to better assess the results of studies. Ocuton S\*TT-MV, a reconfigured version of the Ocuton S has apparent improved functionality.<sup>43</sup> However, there remains an inconsistent range of differences in measurement as compared with GAT among patients performing self-tonometry.<sup>43 44</sup> Other innovations enabling self-tonometry are currently under development.<sup>45 46</sup> In future, adaptations to smartphones may enable patients to automatically record their IOP and transmit the data to clinicians.<sup>47</sup>

## Optic disc and retinal nerve fibre layer imaging

### Disc photographs

Since glaucomas are progressive optic neuropathies it is imperative that teleglaucoma strategies should employ a method for structural (optic disc and/or nerve fibre layer) assessment. Stereoscopic disc images have been regarded as the reference standard for clinical trials in glaucoma where a high degree of reproducibility has been achieved using dedicated reading centres.<sup>48</sup> Bergua *et al*<sup>49</sup> have demonstrated that stereoscopic optic disc images may be transferred via the internet using a personal computer equipped with stereoscopic liquid crystal display shutter glasses, or using an LCD display in combination with red-cyan goggles for viewing.

Subjective interpretation of optic disc stereophotographs can be highly variable. In a study of sequential stereophotographs, three expert glaucoma specialists could only achieve a ‘slight to fair’ agreement as regards structural progression.<sup>50</sup> In a study of European ophthalmologists, asked to assess stereoscopic slides from healthy and glaucoma eyes, an overall ‘diagnostic accuracy’ of 80.5% was achieved.<sup>51</sup> In that study, the best performing algorithms for the Heidelberg Retina Tomograph (HRT) (Heidelberg Engineering, Heidelberg, Germany) and GDx (Carl Zeiss Meditec, Dublin, California, USA) generally outperformed most clinicians in terms of diagnostic accuracy. Appropriate training or engagement of a reading centre, should be considered if stereophotographs are to be used in a teleglaucoma scheme.

### HRT and optical coherence tomography: glaucoma ‘classification’

The pre-eminent imaging modalities in glaucoma are confocal scanning laser ophthalmoscopy (CSLO, as performed using the HRT) and optical coherence tomography (OCT). A third modality, scanning laser polarimetry (GDx and its derivatives, Carl Zeiss Meditec, Dublin, California, USA), is as effective in terms of glaucoma ‘classification’ as HRT and OCT, but has largely been superseded by OCT technology in terms of clinical practice and in active research.

HRT uses two classification algorithms—the Moorfields Regression Analysis (MRA) and the Glaucoma Probability Score (GPS). MRA is based on the understanding that rim area varies with disc size, may decline with advancing age and may narrow in any sector of the disc in glaucoma. Very large and very small discs confound MRA.<sup>52 53</sup> Atypical optic nerve head (ONH) morphology may lead to such discs falling outside the normative range without necessarily being glaucomatous. Sensitivities of 58–84% and specificities of 81–96% have been reported depending on inclusion and cut-off criteria.<sup>54–56</sup>

GPS uses a mathematical model of ONH shape to discriminate between normal and glaucomatous eyes.<sup>57</sup> The method is operator-independent as it does not require contour line placement. GPS does not confer any advantage over the MRA in terms of sensitivity and specificity.<sup>52 58</sup> There is a dependency on disc size for MRA and GPS classification.<sup>52</sup>

Several studies have demonstrated the performance of time domain OCT (TDOCT) in discriminating between normal and glaucomatous eyes.<sup>59–66</sup> Comparisons between TDOCT, CSLO and scanning laser polarimetry have failed to identify a significant advantage of one device over another.<sup>61 63 67</sup> A comparison between the retinal nerve fibre layer (RNFL), ONH and macular thickness parameters of the STRATUS<sub>OCT</sub> (Carl Zeiss Meditec) found that RNFL thickness and optic nerve head parameters had similar performance in differentiating between healthy and glaucomatous eyes and both outperformed macular thickness parameters.<sup>60</sup> In all these studies, performance was

assessed using well-defined case controls with established repeatable glaucomatous visual field defects, a scenario that is much more clear-cut than is usually encountered in the normal clinical setting.

A large number of studies have now assessed the 'diagnostic' capability of the more recently available spectral domain OCT (SDOCT) devices, and most of these have made a comparison with the performance of TDOCT.<sup>68–75</sup> In all cases, SDOCT has been found to have a good diagnostic capability but no major advantage over TDOCT.<sup>68 71–75</sup>

The macula contains approximately 50% of all retinal ganglion cells,<sup>76</sup> hence macular thickness may be useful for glaucoma diagnosis.<sup>77 78</sup> The RNFL, the ganglion cell layer and the inner plexiform layer together make up the ganglion cell complex (GCC). GCC has significantly higher diagnostic power than macular thickness as measured by SDOCT or TDOCT, and the best performing GCC parameters have been found to be equivalent to mean RNFL thickness as measured by TDOCT.<sup>79 80</sup>

OCT technology is now also used widely for the assessment of the anterior segment, and this could potentially be used as a proxy test for gonioscopy. OCT cannot pick up features, such as peripheral anterior synechiae, neovascularisation or pigmentation that are detectable by gonioscopy.

#### HRT and OCT: monitoring change

The current HRT3 software features two progression algorithms, trend analysis and topographical change analysis (TCA). Interpretation of the trend is empirical and a 'rate' of change cannot be generated. The importance of estimating a rate of change is highlighted by the results of the CSLO Ancillary Study to the Ocular Hypertension Treatment Study.<sup>81</sup> A five times faster rate of rim loss was identified in eyes converting to glaucoma than those that did not. TCA assesses progression by measuring changes in the height of superpixels generating a 'change probability map' with red pixels representing significant height depression.<sup>82</sup> TCA tends to identify more subjects as progressing than stereophotographic assessment.<sup>83</sup> TCA has also been shown to be predictive of future visual field damage.<sup>84</sup>

The rapidity by which OCT technology is evolving means there are a few longitudinal studies investigating progression.<sup>85–88</sup> In teleglaucoma, it may therefore be preferable to employ stereophotographs and a semiautomated imaging technology. Stereophotographs are largely 'future-proof', but they lack automated quantification and progression algorithms, of which HRT TCA is the most mature and well established.

#### Functional testing

Static automated perimetry (SAP) is the most widely accepted functional test for the evaluation of glaucoma. SAP invariably requires a degree of patient learning for reliable performance and it is time consuming, even when using the Swedish Interactive Thresholding Algorithm (SITA). Ideally, for teleglaucoma purposes, a functional test should be easy to use and quick in order to maintain a high throughput. Objective (electrodiagnostic) perimetry would, therefore, be impractical. Frequency doubling technology (FDT), however, may offer a realistic alternative to SAP. Studies report sensitivities for FDT of between 35% and 93% in early to moderate glaucoma, greater than 97% in severe glaucoma, with a specificity of 90% for early glaucoma and greater than 97% for advanced disease.<sup>89–91</sup> FDT may detect glaucomatous visual field loss earlier than SAP,<sup>92</sup> but learning effect remains a problem in subjects without prior perimetric experience.<sup>93</sup> Despite these advantages, SAP's smaller test-retest variability and larger dynamic range make it

currently the optimal choice for monitoring glaucomatous visual field progression.<sup>94</sup> Some newer perimetric techniques, such as the Moorfields Motion Displacement Test, are being developed for use on multiple computer monitor platforms.<sup>95</sup> It is conceivable that perimetry will become available for use in the domiciliary setting.

Clinicians are much better at detecting field progression when their decision making is augmented by using a computer algorithm.<sup>96</sup> Event analyses ascribe progression when a predetermined threshold has been achieved. The native event analysis for the Humphrey Field Analyser (HFA, Carl Zeiss Meditec, Dublin, California, USA), Guided Progression Analysis (GPA), is based on the strategy used in the Early Manifest Glaucoma Treatment study.<sup>97</sup> Trend analyses monitor the behaviour of a specific parameter over time, allowing a rate of change to be calculated. A 'global' trend analysis, that monitors change in the visual field index (VFI) over time, is included in the GPA package. An alternative approach is to perform pointwise linear regression analysis which is the technique adopted by PROGRESSOR (Medisoft, Leeds, UK). Trend analyses provide better receiver operator characteristic curves than event analyses.<sup>98</sup> From a teleglaucoma perspective, there is a good argument for adopting external software, such as PROGRESSOR, as analysis is performed on a different computer from the perimeter following data transfer. This overcomes the issue of lack of Digital Imaging and Communication in Medicine (DICOM) compatibility when using older perimeters.

#### TELEGLAUCOMA IN PRACTICE

In glaucoma management and case detection, the outcome of most interest is the number of false negatives, that is, the number of those who are true cases or are progressing cases that are not detected. Detection of false negatives is a major challenge. Both outcomes are relatively rare. The normal methodology to approach such a scenario is to undertake studies determining the sensitivity and specificity using an enriched population. Sensitivity and specificity are independent of prevalence, therefore, improved estimates may be obtained by having large proportions of outcomes of interest in the study group. There is a notable lack of such assessments, meaning that there is a risk of accepting an unsafe system. If glaucoma has a prevalence of 2%, screening 6000 would yield 120 cases. Were only 80 cases detected, the system could be hailed a success, and yet, there are 40 cases undetected. A major factor in favour of decreasing false negatives in chronic disease screening is the opportunity for a 'second bite at the cherry' with repeat screening over time. All these issues are, as yet, inadequately explored. The proportion of false positives is also of interest, but much more easily determined.

#### Regular monitoring

There are a few published reports of teleglaucoma applied to routine care. The first reported teleglaucoma pilot study was undertaken in Finland, a country where large remote areas have had a chronic lack of ophthalmologists.<sup>25</sup> The study used a video slit lamp, an automated perimeter and a non-mydriatic fundus camera, with real-time videoconferencing. A group in Canada has recently described a strategy to service people with, or at risk of, glaucoma in the rural setting and living near the university eye centre.<sup>26</sup> The authors describe four main components to their service: enthusiastic staff, secure reliable software, appropriate hardware (a minimum of retinal camera, IOP, central corneal thickness and either FDT or HFA), and national guidelines for glaucoma management. Huatala and colleagues

describe a teleophthalmology mobile unit that provides diabetic retinopathy screening and follow-up of stable glaucoma patients in Northern Finland.<sup>27</sup> Patients undergo visual field testing using HFA and digital fundus photography. A nurse measures IOP and compares the measurement to a preset target. Images and visual fields are assessed offline by the glaucoma specialist. Online help is available by telephone. A similar approach is being applied within the UK in urban and rural centres. The Newmedica glaucoma service began at Bristol Eye Hospital in 2007 and has provided nearly 100 000 glaucoma review appointments to date from eight mobile sites. The service uses a proprietary electronic medical record software called Electronic Medical Management Application (EMMA), which allows online virtual reviewing over a secure internet connection. An optometrist and two technicians man each mobile clinic. The patient has visual acuity and HFA data collected. The optometrist then takes a history, examines the patient (including pachymetry and GAT), and acquires a dilated fundus photograph (monoscopic) or HRT image. All data are uploaded into EMMA including archive fields and disc images. At the end of the consultation, the optometrist provides a provisional management outcome made final within five working days after review of the data online by a glaucoma specialist working online in a virtual clinic. Once the outcome has been decided, the clinic software automatically writes to the patient and their general practitioner, and the next appointment is booked.

### Detection of new cases

A systematic review of diagnostic tests for glaucoma failed to identify a particular advantage of a single test for the purposes of glaucoma screening.<sup>99</sup> Indeed, a Health Technology Assessment suggested that screening for open-angle glaucoma would not be cost effective although targeted screening of subjects in high-risk groups (eg, family history, black ethnicity) might be worthwhile.<sup>100</sup> A number of groups have tried to apply a targeted approach to glaucoma screening using teleglaucoma.

In Rotterdam, 10 community optometric practices were equipped with GDx, and patients considered 'at risk' were offered imaging.<sup>101</sup> The images and clinical details were transferred to the eye hospital for assessment. From 1729 patients screened, 467 (27%) were called to the hospital and 80 new cases of glaucoma were identified giving a positive predictive value of only 18%. In a study undertaken in Tasmania, visual acuity, autorefractometry, SAP, IOP measurement using the Tonopen and stereoscopic disc photographs were all acquired at remote sites then amalgamated into a summary PDF file that was transferred electronically to a glaucoma specialist.<sup>102</sup> First-degree relatives of patients with a confirmed diagnosis of glaucoma were screened and one new case of glaucoma was identified for every 19 participants. There was, however, a very low take-up of the scheme among subjects at risk.

### Glaucoma data archiving

Managing glaucoma patients via a remote clinic necessitates the electronic archiving of historic clinical data, including visual fields and images. Visual field data and images can be electronically assimilated into the teleglaucoma notes relatively easily. However, archiving paper notes can present a significant problem where the patient population has been under the care of a clinic for many years, and where paper notes are commensurably bulky. Three potential methods for incorporating historic notes into a paperless teleglaucoma clinic include:

- ▶ To make historic paper notes available for the first few visits to the teleglaucoma clinic to allow an overlap, whereby the

teleglaucoma notes progressively replace the paper notes (which are eventually archived).

- ▶ To make a full electronic copy of the paper notes and incorporate that archive into the teleglaucoma notes (usually in the form of PDF documents).
- ▶ To manually transcribe a summary of the salient events from the paper history into the electronic notes.

Each approach represents a compromise. Even the option of scanning the old notes in their entirety can overload the teleglaucoma clinic with data which can be hard to identify and is often of minimal value.

### Postoperative review

Another area where telehealth may be useful is in postsurgical management. Crowston *et al*<sup>103</sup> assessed the interobserver agreement for clinical signs in post-trabeculectomy eyes when evaluated by real-time video images compared with face-to-face consultation. Remote assessment provided high levels of agreement for bleb vascularity, anterior chamber depth, and the existence of a bleb leak; it was much more variable for bleb height and bleb wall thickness. More recently, a Japanese group has similarly shown images acquired using a remote controlled slit lamp to be of use in postoperative management.<sup>104</sup>

### CONCLUSIONS

Glaucomas remain enigmatic conditions in which a diagnosis cannot consistently be made using a single test, or indeed a battery of tests. The proliferation of teleglaucoma-'friendly' devices, for IOP measurement and quantitative disc assessment have not necessarily increased our ability to detect glaucomas in the absence of a face-to-face consultation. In that regard, teleglaucoma is perhaps not yet 'ready to go'. These technologies are, however, likely to be useful in the monitoring of patients with an established diagnosis of glaucoma, and it is in this context that a few teleglaucoma schemes have already become successfully established. Given the increasing age of the population, and the constraints upon already stretched hospital eye services, it is likely that reliance on teleglaucoma will increase. This may be despite the fact that the diagnostic and monitoring capabilities of currently available technologies will not necessarily meet the ambitions of the teleglaucoma schemes from the outset. There is a strong case for further robust studies investigating the positive and negative predictive power of all systems of glaucoma detection and monitoring.

**Acknowledgements** NGS acknowledges a proportion of his financial support from the Department of Health through the award made by the National Institute for Health Research to Moorfields Eye Hospital NHS Foundation Trust and UCL Institute of Ophthalmology for a Biomedical Research Centre for Ophthalmology. The views expressed in this publication are those of the authors and not necessarily those of the Department of Health.

**Contributors** NGS provided critical revision, original draft, interpretation, oversight and final draft. GC provided original draft, concept revision, oversight and final version. JPD provided critical revision, draft oversight and final draft. IEM provided concept, revising several drafts, oversight and final version. He is guarantor.

**Competing interests** NGS has received lecture fees from Heidelberg Engineering and MSD as well as author and lecture fees from Allergan. He is an unpaid medical adviser to Moorfields Pharmaceuticals. JPD is Medical Director of New Medical Systems Ltd (Newmedica) which provides Glaucoma follow-up via Virtual Clinic service.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Open Access** This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 3.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is

properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/3.0/>

## REFERENCES

- 1 ATA. What is Telemedicine? [Internet]. [cited 2013 Nov 12]. <http://www.americantelemed.org/learn/what-is-telemedicine>
- 2 HL7. Introduction to HL7 Standards [Internet]. [cited 2013 Nov 12]. <http://www.hl7.org/implement/standards/index.cfm?ref=nav>
- 3 HL7. HL7 Standards—Section 1: Primary Standards [Internet]. [cited 2013 Nov 12]. [http://www.hl7.org/implement/standards/product\\_section.cfm?section=1](http://www.hl7.org/implement/standards/product_section.cfm?section=1)
- 4 DICOM [Internet]. [cited 2013 Jul 28]. <http://dicom.nema.org/>
- 5 Khouri AS, Szirth BC, Salti HI, et al. DICOM transmission of simultaneous stereoscopic images of the optic nerve in patients with glaucoma. *J Telemed Telecare* 2007;13:337–40.
- 6 American National Standards Institute—ANSI [Internet]. [cited 2013 Jul 28]. <http://www.ansi.org/>
- 7 Continua Health Alliance. About the Alliance [Internet]. [cited 2013 Nov 12]. <http://www.continuaalliance.org/about-the-alliance>
- 8 ISO/IEEC. IEEE SA—Healthcare IT Standards [Internet]. [cited 2013 Nov 12]. [http://standards.ieee.org/findstds/standard/healthcare\\_it.html](http://standards.ieee.org/findstds/standard/healthcare_it.html)
- 9 ISO/IEEC. IEEE SA—PHD—Personal Health Device [Internet]. [cited 2013 Nov 12]. <http://standards.ieee.org/develop/wg/PHD.html>
- 10 Continua Health Alliance. Certified Products [Internet]. [cited 2013 Nov 12]. <http://www.continuaalliance.org/products>
- 11 IHE. Integrating the Healthcare Enterprise (IHE) [Internet]. [cited 2013 Nov 12]. <http://www.ihe.net/>
- 12 IHE. IHE Eye Care [Internet]. [cited 2013 Nov 12]. [http://www.ihe.net/Eye\\_Care/](http://www.ihe.net/Eye_Care/)
- 13 IHE. Resources [Internet]. [cited 2013 Nov 12]. <http://www.iheeyecare.org/resources.asp>
- 14 IHE. Eye Care—IHE Wiki [Internet]. [cited 2013 Nov 12]. <http://wiki.ihe.net/index.php?title=EyeCare>
- 15 McConnell I. Why the NHS must embrace telehealth on a larger scale [Internet]. *TheGuardian* 2012 [cited 2013 Jul 28]. <http://www.guardian.co.uk/healthcare-network/2012/feb/09/nhs-telehealth-long-term-conditions>
- 16 Steventon A, Bardsley M, Billings J, et al. Effect of telehealth on use of secondary care and mortality: findings from the Whole System Demonstrator cluster randomised trial. *BMJ* 2012;344:e3874.
- 17 Henderson C, Knapp M, Fernandez J-L, et al. Cost effectiveness of telehealth for patients with long term conditions (Whole Systems Demonstrator telehealth questionnaire study): nested economic evaluation in a pragmatic, cluster randomised controlled trial. *BMJ* 2013;346:f1035.
- 18 Klein BE, Klein R, Sponsel WE, et al. Prevalence of glaucoma. The Beaver Dam Eye Study. *Ophthalmology* 1992;99:1499–504.
- 19 Cedrone C, Culasso F, Cesareo M, et al. Prevalence of glaucoma in Ponza, Italy: a comparison with other studies. *Ophthalmic Epidemiol* 1997;4:59–72.
- 20 Bonomi L, Marchini G, Maraffa M, et al. Prevalence of glaucoma and intraocular pressure distribution in a defined population. The Egna-Neumarkt Study. *Ophthalmology* 1998;105:209–15.
- 21 Antón A, Andrada MT, Mujica V, et al. Prevalence of primary open-angle glaucoma in a Spanish population: the Segovia study. *J Glaucoma* 2004;13:371–6.
- 22 Tielsch JM, Sommer A, Katz J, et al. Racial variations in the prevalence of primary open-angle glaucoma. The Baltimore Eye Survey. *JAMA* 1991;266:369–74.
- 23 Leske MC, Connell AM, Schachat AP, et al. The Barbados Eye Study. Prevalence of open angle glaucoma. *Arch Ophthalmol* 1994;112:821–9.
- 24 Bunce C, Wormald R. Leading causes of certification for blindness and partial sight in England & Wales. *BMC Public Health* 2006;6:58.
- 25 Tuulonen A, Ohinmaa T, Alanko HI, et al. The application of teleophthalmology in examining patients with glaucoma: a pilot study. *J Glaucoma* 1999;8:367–73.
- 26 Kassam F, Amin S, Sogbesan E, et al. The use of teleglaucoma at the University of Alberta. *J Telemed Telecare* 2012;18:367–73.
- 27 Hautala N, Hyytinen P, Saarela V, et al. A mobile eye unit for screening of diabetic retinopathy and follow-up of glaucoma in remote locations in northern Finland. *Acta Ophthalmol* 2009;87:912–13.
- 28 Kumar S, Giubilato A, Morgan W, et al. Glaucoma screening: analysis of conventional and telemedicine-friendly devices. *Clin Experiment Ophthalmol* 2007;35:237–43.
- 29 Tonnu P-A, Ho T, Sharma K, et al. A comparison of four methods of tonometry: method agreement and interobserver variability. *Br J Ophthalmol* 2005;89:847–50.
- 30 Halkiadakis I, Stratos A, Stergiopoulos G, et al. Evaluation of the Icare-ONE rebound tonometer as a self-measuring intraocular pressure device in normal subjects. *Graefes Arch Clin Exp Ophthalmol* 2012;250:1207–11.
- 31 Poostchi A, Mitchell R, Nicholas S, et al. The iCare rebound tonometer: comparisons with Goldmann tonometry, and influence of central corneal thickness. *Clin Experiment Ophthalmol* 2009;37:687–91.
- 32 Iester M, Mermoud A, Achache F, et al. New Tonopen XL: comparison with the Goldmann tonometer. *Eye (Lond)* 2001;15:52–8.
- 33 Foster PJ, Wong JS, Wong E, et al. Accuracy of clinical estimates of intraocular pressure in Chinese eyes. *Ophthalmology* 2000;107:1816–21.
- 34 Kao SF, Lichter PR, Bergstrom TJ, et al. Clinical comparison of the Oculab Tono-Pen to the Goldmann applanation tonometer. *Ophthalmology* 1987;94:1541–4.
- 35 Bradfield YS, Kaminski BM, Repka MX, et al. Comparison of Tono-Pen and Goldmann applanation tonometers for measurement of intraocular pressure in healthy children. *J AAPOS* 2012;16:242–8.
- 36 Bhan A, Browning AC, Shah S, et al. Effect of corneal thickness on intraocular pressure measurements with the pneumotonometer, Goldmann applanation tonometer, and Tono-Pen. *Invest Ophthalmol Vis Sci* 2002;43:1389–92.
- 37 Browning AC, Bhan A, Rotchford AP, et al. The effect of corneal thickness on intraocular pressure measurement in patients with corneal pathology. *Br J Ophthalmol* 2004;88:1395–9.
- 38 Sakamoto M, Kanamori A, Fujihara M, et al. Assessment of IcareONE rebound tonometer for self-measuring intraocular pressure. *Acta Ophthalmol* Published Online First: 16 Apr 2014. doi:10.1111/aos.12108
- 39 Flemmons MS, Hsiao Y-C, Dzau J, et al. Home tonometry for management of pediatric glaucoma. *Am J Ophthalmol* 2011;152:470–8.e2.
- 40 Gandhi NG, Prakashakorn SG, El-Dairi MA, et al. Icare ONE rebound versus Goldmann applanation tonometry in children with known or suspected glaucoma. *Am J Ophthalmol* 2012;154:843–9.e1.
- 41 Mansouri K, Medeiros FA, Tafreshi A, et al. Continuous 24-hour monitoring of intraocular pressure patterns with a contact lens sensor: safety, tolerability, and reproducibility in patients with glaucoma. *Arch Ophthalmol* 2012;130:1534–9.
- 42 Cook JA, Botello AP, Elders A, et al. Systematic review of the agreement of tonometers with Goldmann applanation tonometry. *Ophthalmology* 2012;119:1552–7.
- 43 Lanfermann E, Jürgens C, Grossjohann R, et al. Intraocular pressure measurements with the newly reconfigured Ocuton S\*TT-MV self-tonometer in comparison to Goldmann applanation tonometry in glaucoma patients. *Med Sci Monit* 2009;15:CR556–62.
- 44 Witte V, Glass Ä, Beck R, et al. [Evaluation of the self-tonometer Icare ONE in comparison to Goldmann applanation tonometry]. *Ophthalmologe* 2012;109:1008–13.
- 45 Liang SY-W, Lee GA, Shields D. Self-tonometry in glaucoma management—past, present and future. *Surv Ophthalmol* 2009;54:450–62.
- 46 Chitnis G, Maleki T, Samuels B, et al. A minimally invasive implantable wireless pressure sensor for continuous IOP monitoring. *IEEE Trans Biomed Eng* 2013;60:250–6.
- 47 Dobkin BH, Dorsch A. The promise of mHealth: daily activity monitoring and outcome assessments by wearable sensors. *Neurorehabil Neural Repair* 2011;25:788–98.
- 48 Parrish RK, Schiffman JC, Feuer WJ, et al. Test-retest reproducibility of optic disk deterioration detected from stereophotographs by masked graders. *Am J Ophthalmol* 2005;140:762–4.
- 49 Bergua A, Mardin CY, Horn FK. Tele-transmission of stereoscopic images of the optic nerve head in glaucoma via Internet. *Telemed J E Health* 2009;15:439–44.
- 50 Jampel HD, Friedman D, Quigley H, et al. Agreement among glaucoma specialists in assessing progressive disc changes from photographs in open-angle glaucoma patients. *Am J Ophthalmol* 2009;147:39–44.e1.
- 51 Reus NJ, Lemij HG, Garway-Heath DF, et al. Clinical assessment of stereoscopic optic disc photographs for glaucoma: the European Optic Disc Assessment Trial. *Ophthalmology* 2010;117:717–23.
- 52 Coops A, Henson DB, Kwartz AJ, et al. Automated analysis of Heidelberg Retina Tomograph optic disc images by glaucoma probability score. *Invest Ophthalmol Vis Sci* 2006;47:5348–55.
- 53 Zangwill LM, Jain S, Racette L, et al. The effect of disc size and severity of disease on the diagnostic accuracy of the Heidelberg Retina Tomograph Glaucoma Probability Score. *Invest Ophthalmol Vis Sci* 2007;48:2653–60.
- 54 Wollstein G, Garway-Heath DF, Hitchings RA. Identification of early glaucoma cases with the scanning laser ophthalmoscope. *Ophthalmology* 1998;105:1557–63.
- 55 Ford BA, Artes PH, McCormick TA, et al. Comparison of data analysis tools for detection of glaucoma with the Heidelberg Retina Tomograph. *Ophthalmology* 2003;110:1145–50.
- 56 Miglior S, Guareschi M, Albe' E, et al. Detection of glaucomatous visual field changes using the Moorfields regression analysis of the Heidelberg retina tomograph. *Am J Ophthalmol* 2003;136:26–33.
- 57 Swindale NV, Stjepanovic G, Chin A, et al. Automated analysis of normal and glaucomatous optic nerve head topography images. *Invest Ophthalmol Vis Sci* 2000;41:1730–42.
- 58 Ferreras A, Pajarín AB, Polo V, et al. Diagnostic ability of Heidelberg Retina Tomograph 3 classifications: glaucoma probability score versus Moorfields regression analysis. *Ophthalmology* 2007;114:1981–7.
- 59 Jaffe GJ, Caprioli J. Optical coherence tomography to detect and manage retinal disease and glaucoma. *Am J Ophthalmol* 2004;137:156–69.

- 60 Medeiros FA, Zangwill LM, Bowd C, *et al.* Evaluation of retinal nerve fiber layer, optic nerve head, and macular thickness measurements for glaucoma detection using optical coherence tomography. *Am J Ophthalmol* 2005;139:44–55.
- 61 Deleón-Ortega JE, Arthur SN, McGwin G, *et al.* Discrimination between glaucomatous and nonglaucomatous eyes using quantitative imaging devices and subjective optic nerve head assessment. *Invest Ophthalmol Vis Sci* 2006;47:3374–80.
- 62 Bowd C, Weinreb RN, Williams JM, *et al.* The retinal nerve fiber layer thickness in ocular hypertensive, normal, and glaucomatous eyes with optical coherence tomography. *Arch Ophthalmol* 2000;118:22–6.
- 63 Zangwill LM, Bowd C, Berry CC, *et al.* Discriminating between normal and glaucomatous eyes using the Heidelberg Retina Tomograph, GDx Nerve Fiber Analyzer, and Optical Coherence Tomograph. *Arch Ophthalmol* 2001;119:985–93.
- 64 Williams ZY, Schuman JS, Gamell L, *et al.* Optical coherence tomography measurement of nerve fiber layer thickness and the likelihood of a visual field defect. *Am J Ophthalmol* 2002;134:538–46.
- 65 Greaney MJ, Hoffman DC, Garway-Heath DF, *et al.* Comparison of optic nerve imaging methods to distinguish normal eyes from those with glaucoma. *Invest Ophthalmol Vis Sci* 2002;43:140–5.
- 66 Schuman JS, Hee MR, Puliafito CA, *et al.* Quantification of nerve fiber layer thickness in normal and glaucomatous eyes using optical coherence tomography. *Arch Ophthalmol* 1995;113:586–96.
- 67 Medeiros FA, Zangwill LM, Bowd C, *et al.* Comparison of the GDx VCC scanning laser polarimeter, HRT II confocal scanning laser ophthalmoscope, and stratus OCT optical coherence tomograph for the detection of glaucoma. *Arch Ophthalmol* 2004;122:827–37.
- 68 Leung CK-S, Cheung CY-L, Weinreb RN, *et al.* Retinal nerve fiber layer imaging with spectral-domain optical coherence tomography: a variability and diagnostic performance study. *Ophthalmology* 2009;116:1257–63, 1263.e1–2.
- 69 Sung KR, Kim DY, Park SB, *et al.* Comparison of retinal nerve fiber layer thickness measured by Cirrus HD and Stratus optical coherence tomography. *Ophthalmology* 2009;116:1264–70, 1270.e1.
- 70 Chang RT, Knight OJ, Feuer WJ, *et al.* Sensitivity and specificity of time-domain versus spectral-domain optical coherence tomography in diagnosing early to moderate glaucoma. *Ophthalmology* 2009;116:2294–9.
- 71 Park SB, Sung KR, Kang SY, *et al.* Comparison of glaucoma diagnostic Capabilities of Cirrus HD and Stratus optical coherence tomography. *Arch Ophthalmol* 2009;127:1603–9.
- 72 Moreno-Montañés J, Olmo N, Alvarez A, *et al.* Cirrus high-definition optical coherence tomography compared with Stratus optical coherence tomography in glaucoma diagnosis. *Invest Ophthalmol Vis Sci* 2010;51:335–43.
- 73 Cho JW, Sung KR, Hong JT, *et al.* Detection of glaucoma by spectral domain-scanning laser ophthalmoscopy/optical coherence tomography (SD-SLO/OCT) and time domain optical coherence tomography. *J Glaucoma* 2011;20:15–20.
- 74 Sehi M, Grewal DS, Sheets CW, *et al.* Diagnostic ability of Fourier-domain vs time-domain optical coherence tomography for glaucoma detection. *Am J Ophthalmol* 2009;148:597–605.
- 75 Jeoung JW, Park KH. Comparison of Cirrus OCT and Stratus OCT on the ability to detect localized retinal nerve fiber layer defects in preperimetric glaucoma. *Invest Ophthalmol Vis Sci* 2010;51:938–45.
- 76 Curcio CA, Allen KA. Topography of ganglion cells in human retina. *J Comp Neurol* 1990;300:5–25.
- 77 Zeimer R, Shahidi M, Mori M, *et al.* A new method for rapid mapping of the retinal thickness at the posterior pole. *Invest Ophthalmol Vis Sci* 1996;37:1994–2001.
- 78 Zeimer R, Asrani S, Zou S, *et al.* Quantitative detection of glaucomatous damage at the posterior pole by retinal thickness mapping. *A pilot study. Ophthalmology* 1998;105:224–31.
- 79 Tan O, Chopra V, Lu AT-H, *et al.* Detection of macular ganglion cell loss in glaucoma by Fourier-domain optical coherence tomography. *Ophthalmology* 2009;116(12):2305–14.e1–2.
- 80 Seong M, Sung KR, Choi EH, *et al.* Macular and peripapillary retinal nerve fiber layer measurements by spectral domain optical coherence tomography in normal-tension glaucoma. *Invest Ophthalmol Vis Sci* 2010;51:1446–52.
- 81 Zangwill LM, Jain S, Dirkes K, *et al.* The rate of structural change: the confocal scanning laser ophthalmoscopy ancillary study to the ocular hypertension treatment study. *Am J Ophthalmol* 2013;155:971–82.
- 82 Chauhan BC, Blanchard JW, Hamilton DC, *et al.* Technique for detecting serial topographic changes in the optic disc and peripapillary retina using scanning laser tomography. *Invest Ophthalmol Vis Sci* 2000;41:775–82.
- 83 Kourkotas D, Buys YM, Flanagan JG, *et al.* Comparison of glaucoma progression evaluated with Heidelberg retina tomograph II versus optic nerve head stereophotographs. *Can J Ophthalmol* 2007;42:82–8.
- 84 Chauhan BC, Nicoleta MT, Artes PH. Incidence and rates of visual field progression after longitudinally measured optic disc change in glaucoma. *Ophthalmology* 2009;116:2110–18.
- 85 Medeiros FA, Zangwill LM, Alencar LM, *et al.* Detection of glaucoma progression with stratus OCT retinal nerve fiber layer, optic nerve head, and macular thickness measurements. *Invest Ophthalmol Vis Sci* 2009;50:5741–8.
- 86 Wollstein G, Schuman JS, Price LL, *et al.* Optical coherence tomography longitudinal evaluation of retinal nerve fiber layer thickness in glaucoma. *Arch Ophthalmol* 2005;123:464–70.
- 87 Leung CK, Cheung CYL, Weinreb RN, *et al.* Evaluation of retinal nerve fiber layer progression in glaucoma: a study on optical coherence tomography guided progression analysis. *Invest Ophthalmol Vis Sci* 2010;51:217–22.
- 88 Na JH, Sung KR, Lee JR, *et al.* Detection of glaucomatous progression by spectral-domain optical coherence tomography. *Ophthalmology* 2013;120:1388–95.
- 89 Delgado MF, Nguyen NTA, Cox TA, *et al.* Automated perimetry: a report by the American Academy of Ophthalmology. *Ophthalmology* 2002;109:2362–74.
- 90 Johnson CA, Samuels SJ. Screening for glaucomatous visual field loss with frequency-doubling perimetry. *Invest Ophthalmol Vis Sci* 1997;38:413–25.
- 91 Tribble JR, Schultz RO, Robinson JC, *et al.* Accuracy of glaucoma detection with frequency-doubling perimetry. *Am J Ophthalmol* 2000;129:740–5.
- 92 Ferreras A, Polo V, Larrosa JM, *et al.* Can frequency-doubling technology and short-wavelength automated perimetries detect visual field defects before standard automated perimetry in patients with preperimetric glaucoma? *J Glaucoma* 2007;16:372–83.
- 93 Centofanti M, Fogagnolo P, Oddone F, *et al.* Learning effect of humphrey matrix frequency doubling technology perimetry in patients with ocular hypertension. *J Glaucoma* 2008;17:436–41.
- 94 Gardiner SK, Johnson CA, Spry PGD. Normal age-related sensitivity loss for a variety of visual functions throughout the visual field. *Optom Vis Sci* 2006;83:438–43.
- 95 Moorfields Motion Displacement Test (MDT) [Internet]. [cited 2013 Jul 28]. <http://www.moorfieldsmtd.co.uk/Clinicians.asp>
- 96 Viswanathan AC, Crabb DP, McNaught AI, *et al.* Interobserver agreement on visual field progression in glaucoma: a comparison of methods. *Br J Ophthalmol* 2003;87:726–30.
- 97 Heijl A, Leske MC, Bengtsson B, *et al.* Measuring visual field progression in the Early Manifest Glaucoma Trial. *Acta Ophthalmol Scand* 2003;81:286–93.
- 98 Vesti E, Johnson CA, Chauhan BC. Comparison of different methods for detecting glaucomatous visual field progression. *Invest Ophthalmol Vis Sci* 2003;44:3873–9.
- 99 Mowatt G, Burr JM, Cook JA, *et al.* Screening tests for detecting open-angle glaucoma: systematic review and meta-analysis. *Invest Ophthalmol Vis Sci* 2008;49:5373–85.
- 100 Burr JM, Mowatt G, Hernández R, *et al.* The clinical effectiveness and cost-effectiveness of screening for open angle glaucoma: a systematic review and economic evaluation. *Health Technol Assess* 2007;11:iii–iv, ix–x, 1–190.
- 101 De Mul M, de Bont AA, Reus NJ, *et al.* Improving the quality of eye care with tele-ophthalmology: shared-care glaucoma screening. *J Telemed Telecare* 2004;10:331–6.
- 102 Staffieri SE, Ruddle JB, Kearns LS, *et al.* Telemedicine model to prevent blindness from familial glaucoma. *Clin Experiment Ophthalmol* 2011;39:760–5.
- 103 Crowston JG, Kirwan JF, Wells A, *et al.* Evaluating clinical signs in trabeculectomized eyes. *Eye (Lond)* 2004;18:299–303.
- 104 Kashiwagi K, Tanabe N, Go K, *et al.* Comparison of a remote operating slit-lamp microscope system with a conventional slit-lamp microscope system for examination of trabeculectomy eyes. *J Glaucoma* 2013;22:278–83.



## Teleglaucoma: ready to go?

N G Strouthidis, G Chandrasekharan, J P Diamond and I E Murdoch

*Br J Ophthalmol* 2014 98: 1605-1611 originally published online April 10, 2014

doi: 10.1136/bjophthalmol-2013-304133

---

Updated information and services can be found at:  
<http://bjo.bmj.com/content/98/12/1605>

---

*These include:*

### References

This article cites 88 articles, 25 of which you can access for free at:  
<http://bjo.bmj.com/content/98/12/1605#BIBL>

### Open Access

This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 3.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/3.0/>

### Email alerting service

Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

---

### Topic Collections

Articles on similar topics can be found in the following collections

[Open access](#) (184)  
[Angle](#) (945)  
[Glaucoma](#) (930)  
[Intraocular pressure](#) (942)  
[Public health](#) (444)

---

### Notes

---

To request permissions go to:  
<http://group.bmj.com/group/rights-licensing/permissions>

To order reprints go to:  
<http://journals.bmj.com/cgi/reprintform>

To subscribe to BMJ go to:  
<http://group.bmj.com/subscribe/>