OphthWeb—cost-effective telemedicine for ophthalmology

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'OphthWeb' is an ophthalmic electronic medical record that can be accessed locally and globally via the Internet. OphthWeb can provide secure multimedia patient data to doctors, patients, and health care providers at any time and in any place. Patients have secured access to their own records in the convenience of their homes or during any health emergency at any time or place around the world. OphthWeb provides interactive educational information and answers frequently asked questions by way of multimedia images on the Worldwide Web. A data transmission trial was conducted between the Xiamen Eye Centre in Fujian province in southern China and Singapore. Clinical records, voice messages, and fundus and slit-lamp images were transmitted from Xiamen and an off-line dialogue by e-mail and Internet-relay chat was conducted. The time delay from transmission to receipt was 30 minutes, which would be adequate to respond to most ophthalmic emergencies. This pilot project will promote computer literacy among doctors, and inter-institutional interaction in the health care profession. OphthWeb can provide telemedicine and electronic medical records at low cost and great convenience.

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Introduction

A Worldwide Web (WWW)-based and security-encoded medical database would provide doctors and surgeons around the world with round-the-clock information about their patients. No special hardware or software is needed. In the face of escalating health care costs, increased efficiency in medical care can be provided by telemedicine.[1] The Internet provides myriad medical databases and journals, many of which are free to registered subscribers. The Internet makes possible a new structure for information exchange and changes the traditional vertical hierarchy to a horizontal one, where patients and primary health care providers, rather than hospitals, coordinate the medical data. This new arrangement reduces the inconvenience, time, and expense of unnecessary specialist referrals.[2,3] It also bridges the gap between patients and their doctors, and between health care providers at all levels.

In radiology and pathology, teleconferencing has traditionally been the main medium of multimedia communications. However, high initial and recurring costs have forced many telemedicine service providers to change from live videoconferencing to store-and-forward methods that use the WWW. Using ubiquitous and often non-proprietary software, both ophthalmologists and patients already use e-mail with file attachments to share images. Our developing telemedicine test site—'OphthWeb'—takes advantage of these attributes to provide patient-oriented as well as physician-oriented Internet-based telemedicine.

Ophthalmology is an ideal specialty for testing electronic medical records (EMRs) because of the use of images and objective measures during diagnosis of eye diseases. In ophthalmology, unlike in general medicine and surgery, tactile contact by palpation is

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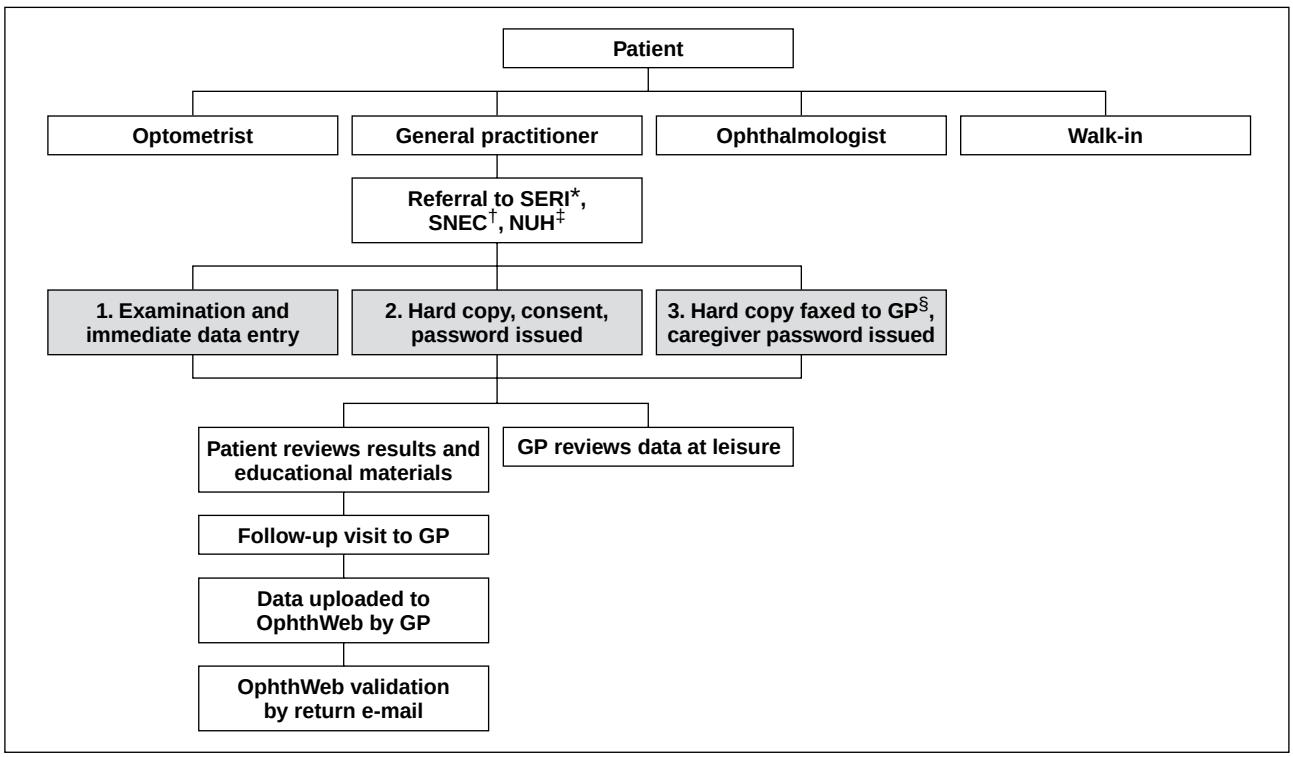
unnecessary for a diagnosis to be made. Most EMRs falter because of the time needed by doctors to enter data using unfamiliar hardware and software. In ophthalmology, text data entry is minimal as images and objective tests are more frequently used. These are already being digitally recorded; examples are photographs of the fundus, optic disc, and cornea. Many ophthalmic instruments have digital data outputs, such as perimeters, fluorescein angiograms, electrophysiology, autorefraction, and ultrasound biometry.

Novel patient-oriented database

The concept of the OphthWeb system was developed by the Singapore Eye Research Institute at the Singapore National Eye Centre and Kent Ridge Digital Laboratories, Singapore, in collaboration with The Chinese University of Hong Kong. The design requirements are such that by using OphthWeb, patients consulting an optometrist, a general practitioner, or any specialist may access their records immediately on a home or office computer. Access by patients to their own data breaks monopolistic practices by some tertiary health care institutions that normally do not encourage patient data being available to the patient. By providing the images and photographs, OphthWeb will reduce the duplication of tests where possible. It may thereby save time and cost for both patients and health care providers.

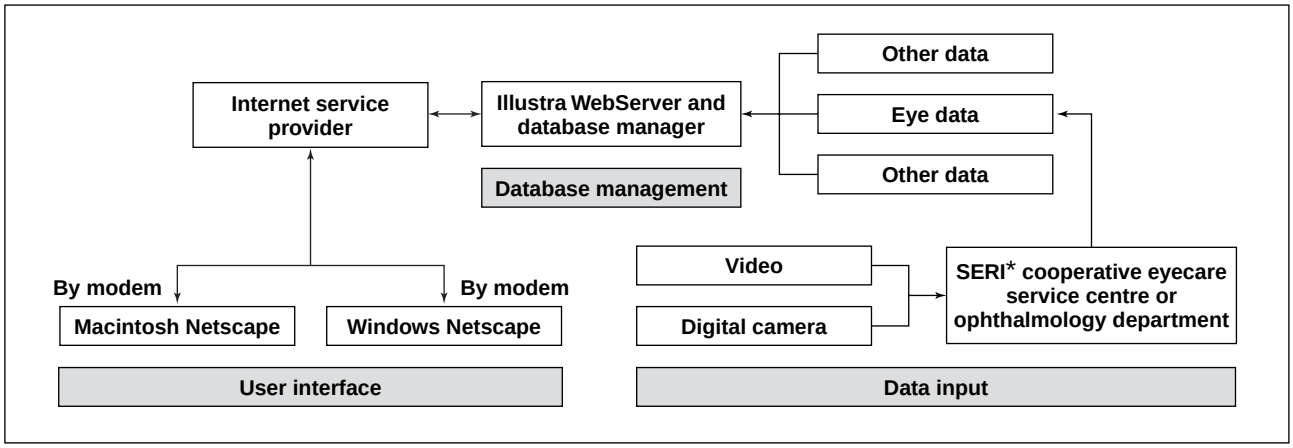
After a consultation with an ophthalmologist, a patient may request that the medical information be released for inspection, much like the way a typical medical report is provided (Fig 1). At a patient's request, OphthWeb's services are made available at a tertiary institution or central service site, to digitise the current examination results and to update the Internet patient record (Fig 2). The log-in code and password are provided to the patient and the primary doctor. The patient may share the password with any doctor, enabling the doctor to view the data and colour images (Figs 3, 4, and 5). The referring primary health care physician would thus be able to access the records. The glossary and the atlas provide patient and physician education that are hyperlinked to the record (Fig 6). The high costs and inconvenience of copying, distributing photographs, and producing record sheets are eliminated. OphthWeb gives both the patient and family physician greater control for good coordination of care.

When a patient is cared for by an international team, the foreign surgeon who performed the operation can use OphthWeb to monitor the results of treatment and



* SERI Singapore Eye Research Institute
† SNEC Singapore National Eye Centre
‡ NUH National University Hospital
§ GP general practitioner

Fig 1. Information flow in OphthWeb



* SERI Singapore Eye Research Institute

Fig 2. Data capture and flow in OphthWeb

the follow-up provided by doctors in the patient's home country. By taking maximal advantage of store-and-forward technology rather than real-time telemedicine, OphthWeb avoids major telecommunications costs, and the costs and time limitations of fixed consultation hours of attending physicians in different locations.

Use of the Worldwide Web for database access

Worldwide Web browsers are pre-installed in new computers and have become a familiar program and mode of Internet access. OphthWeb provides a user-friendly interface to the WWW for both doctors and patients. All image formats are integrated into the network and can be viewed readily by any WWW-browser software. Costs are kept low and the hardware is readily available in clinics and offices. The display card and monitor, however, must be of a certain standard for the accurate reproduction and interpretation of colour images. By being easy to use and by being available cheaply, this EMR system will serve as a predecessor for the implementation of a multidisciplinary medical database. The EMR must include the optimisation and standardization of image resolution and quality, as well as photographic techniques that will be adequate for an accurate and reproducible clinical diagnosis, comparable to that achieved in a conventional clinic consultation.

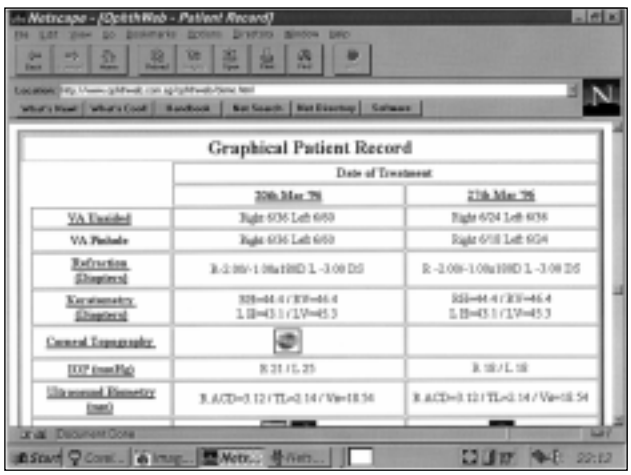


Fig 3. Personalised medical record webpage

Hardware requirements

The hardware and software required to access the database are minimal (Box). Many doctors will already have all the hardware they need to access the database, perhaps with the exception of a modem. In private practices and in hospitals, the database would often be used for financial and drug records in addition to tracking patient appointments. No proprietary software or hardware will be needed to gain access to the database apart from Internet access and the accompanying packaged WWW-browser software.

Evaluation of international transmission time

Data transmission was evaluated between Singapore and Xiamen, Fujian province, southern China. Full-colour ophthalmic images from a database were trans-

Computer requirements for electronic medical record system

(1) MS-DOS Operating System, Version 6.2 / Windows 95 or Windows NT
(2) Intel Pentium microprocessor
(3) 16 megabytes of random access memory
(4) At least 5 megabytes of disk drive–free space
(5) Mouse or other pointing device, ideally a touch screen
(6) Small variable goods applications (SVGA) monitor with colour adapter capable of 24-bit colour at SVGA resolution
(7) NetBIOS-compatible network system (recommended)
(8) 28.8 kilobytes per second modem

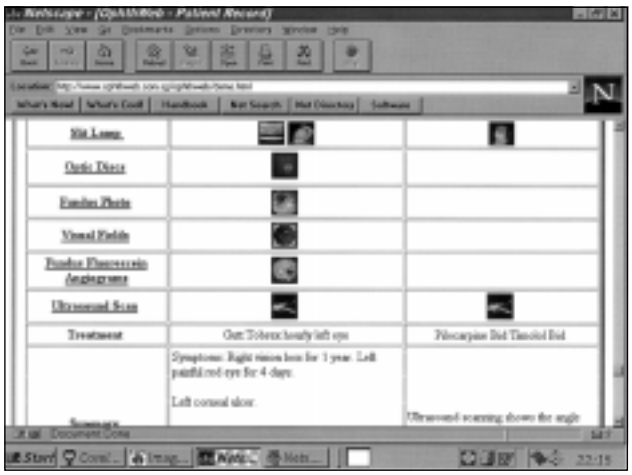


Fig 4. Graphic patient database linked to image database

Fig 6. Cross-referenced glossary linked to the patient record

mitted on the WWW along with the case history and a brief personal verbal message from the referring doctor. Patient identification was not included, to ensure patient confidentiality and to protect data security. The patient code number was provided only by fax and hard copy, and only to the patient and the personal physician.

The store-and-forward information and e-mail were retrieved within 30 minutes of transmission from Singapore or Xiamen. Full-colour images were sent as 24-bit images of 100 to 200 kilobytes—the resolution was judged to be of diagnostic quality. The resolution chosen for the test was higher than that typically used in Topocon Imagenet digital angiograms.

Discussion

OphthWeb stores all the text and image entries associated with a complete ophthalmic examination. Compared with the 'smart card' system, OphthWeb does not require specialised, expensive card readers and is not limited in storage space; as much text

Fig 5. Slit lamp photographs of high resolution that can be printed with a colour printer

or images as desired may be entered in narrative fields. The system allows flexibility in the preparation of ophthalmic records. In addition, records are structured—one can choose from the main categories of ophthalmic examinations available—and automated; digital images are directly captured into the database; data entry is assisted by using pull-down screens; default descriptions of normal examination elements can be user-defined; and an entry from a prior examination can be accessed and edited.

Previous computer systems used in eye care have concentrated on recording the diagnosis of patients[4-6] but not report generation. The EMR system automates the preparation of reports for distribution. Default recipients (eg medical records office, doctor's clinic, referring doctor) can be defined, and a copy of the report can be printed automatically. While complete elimination of the paper record is desirable, it is not yet feasible from both technical and legal perspectives. A paper record is permanent, has a life expectancy exceeding that of the patient, and is not subject to the relatively short life cycle of computer systems. A paper record, signed by the provider, is also a legal document—a definitive record of the physicians' observations and plans for treatment.

Other store-and-forward software systems similar to OphthWeb are emerging as effective interfaces for tele-ophthalmology. These include the systems developed by the Joslin Visitor Network, the East Carolina University Telemedicine Project, the New York Eye and Ear Infirmary, and the University of Southern California Advanced BioTelecommunications and BioInformatics Center. OphthWeb does not require a high bandwidth and uses a transmission frequency of only 28.8 kilobytes per second. However, real-time videoconferencing is available as an option

on the Singapore-ONE Network, which uses integrated services digital network lines and includes educational videos on contact lens care. OphthWeb also does not require proprietary software interfaces and is not limited by proprietary optical or electronic hardware devices. We designed OphthWeb for the convenience of the patient at home and for general practitioners, who often have no access to high-bandwidth transmission. In addition, we have also provided for high-bandwidth use, which is now becoming readily available at home and in the office.

Conclusions

The OphthWeb project is a multicentre and multidisciplinary effort to develop a regional (and global), high-performance networked EMR that supports the holistic care of ophthalmic patients, as well as to develop telemedicine. There is no forerunner of this novel concept.

The EMR is no longer just a paper-free office that doctors generally view as time wasted in data entry. Instead, patient information is brought to their desk or home for review, at their own convenience, at any time of the day or night. The doctor can carefully evaluate a patient's investigations and the treatment strategy, and consult with colleagues to determine the best options for treatment. Patients have access to their own health records and indirectly help to promote the use of EMR to their health care providers. Multinational corporations with many members or key personnel in different foreign countries would find this ubiquitous EMR a useful backbone to their employees' health care plans. With the employee's permission, the same material can also be simultaneously viewed at two or more locations, thus providing accurate and efficient resource information for any doctors in the same or in different fields. Finally, the object-oriented relational database will allow complex queries of the multimedia data to be answered—even questions about images with similar appearances. These design goals and system features will facilitate and improve health care at all stages—from diagnosis and treatment, to follow-up.

The successful pilot application of the OphthWeb in Singapore opens the route to integrating telemedicine into routine clinical practice. A similar scheme may be considered by eye care professionals in Hong Kong.

References

1. Muller C, Marshall CL, Krasner M, Cunningham N, Wallerstein E, Thomstad B. Cost factors in urban telemedicine. Med Care 1977;15:251-9.
2. Blackwell NA, Kelly GJ, Lenton LM. Telemedicine ophthalmology consultation in remote Queensland. Med J Aust 1997; 167:583-6.
3. Mertz M, Mann G, Zahlmann G, Obermaier M. Scientific role of German ophthalmology in the European telecommunication project OPHTEL. Ophthalmology 1997;94:523-8.
4. American Medical Association. Physicians' Current Procedural Terminology: CPT '94. Chicago, IL: American Medical Association; 1993:1-855.
5. Miller JM, Thompson JT, Caprioli J. Computerized database to identify patient populations for clinical research. Ophthalmology 1988;95(Suppl):6S-10S.
6. Soroka M. The development of a standardized data base at the University Optometric Center of the State College of Optometry, State University of New York. Am J Optom Physiol Opt 1982;59:469-77.