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Whether it is consultation between two sites in the UK or the provision of a remote diagnosis for a patient aboard a hospital ship off the coast of Africa, modern telepathology offers a range of opportunities and facilities. In fact, the uses of the technology are virtually limitless, as Chay Keogh explains.

Telepathology in the twenty-first century

Once viewed as the exclusive domain of a few people working in remote locations, telepathology is quickly gaining importance in the modern healthcare environment. Offering a host of innovative benefits and applications, modern telepathology systems now help to deliver more accurate remote diagnoses and are tending to replace traditional consultancy methods using light microscopy.

'Today's telepathology systems are capable of image resolution that approaches that of optical devices'

Telepathology is the subdiscipline of telemedicine that deals with the capture, transmission, and viewing of pathological and histological images by telecommunications channels such as the internet or telephone, as opposed to the conventional methods of microscopy. Originally, telepathology was reserved for those who worked in isolated areas and needed expert guidance on complex pathology cases. Although this remains one of its most important uses, telepathology has progressed through a transitional period and recent advances are now broadening the practical uses and appeal of the technology. In fact, as new systems pervade every aspect of the science, the current definition of telepathology is simply 'the processes of pathology using digital images'.

Modern telepathology systems present images as live video and the motorised stage permits objective selection, focusing and other functions remotely.

Given the rapid pace of advancement, it is not surprising that the biggest hurdle that telepathology faces is scepticism about its practical application. Early studies demonstrated that concerns about the resolution and diagnostic accuracy achievable with digital imaging have hindered the establishment of telepathology in urban hospitals. Such concerns may have had some merit a decade ago, but today's systems are capable of image resolution that approaches that of optical devices.[1]

With the accelerated growth of high-speed internet connections, videoconferencing, security systems and the active development of more intuitive software and hardware, telepathology systems are now capable of providing clear economic and operational benefits to the modern pathology laboratory. In fact, in a recent study of attitudes to the use of telepathology, image quality was only perceived to be low among those who do not actively use a digital system.[2]

However, deciphering the different types of telepathology system available and the advantages they present to both urban and rural hospitals need not be a challenge. This article explains some key considerations that need to be borne in mind when exploring the field of modern telepathology and searching for a system that is suitable to individual needs.

Types of telepathology

In today's laboratories, histopathologists can expect their microscopes to be within arms reach of a telephone and computer equipped with internet access. With these basic components in place, little additional hardware is required to provide the simplest form of telepathology, passive–static. Also known as 'store-and-forward', it involves taking a still digital image at one site and then viewing it at a second location. At its most basic, this can be performed using a microscope that has been fitted with a digital camera, with the captured images transmitted to the second location via email. The obvious advantages of static image transmission are its low capital cost and ease of set up.

For applications that require near-live telepathology, passive–dynamic systems offer a range of new possibilities. In this technique the microscope operator positions the slide so that the microscope focuses on the region of interest, and then the sending and receiving parties examine the specimen simultaneously. Consultations can then be undertaken over the telephone.

This type of system is generally very simple to learn, requires only low bandwidth and is extremely stable. Passive–dynamic systems utilise dedicated cameras that can be networked and are suited to the needs of those working in the life and materials sciences. Cameras should be suited to a variety of illumination techniques, including brightfield, darkfield and fluorescence.

Active–dynamic telepathology affords the same benefits available with the static–dynamic option, with the added benefit of remote control of the microscope. This means that the microscope can be located at one site and operated by someone at a remote location. With modern systems, such as Nikon's COOLSCOPE, images are presented as live video, while a motorised stage permits control from a remote site. Objective selection, focusing and other functions can likewise be managed by the remote operator through on-screen graphical user interface (GUI) controls that replicate the conventional counterparts. Although such functions require significantly greater bandwidth than does passive telepathology, the increasing prevalence of broadband and satellite internet access has diminished the significance of this issue.

Where access to broadband services are limited, active–static systems, otherwise known as 'virtual slides' are now available. With this type of telepathology, a host laboratory can capture optical specimen details of an entire slide in the X, Y and Z planes. These images can be stored digitally and transmitted for study by the receiving party ahead of a telepathology session. Thus, the time required for the 'live' portion of a telepathology session is reduced and thus bandwidth resources are used more efficiently. Use of virtual slides is under constant review and manufacturers are striving to improve capture speeds and storage efficiency. However, current thinking suggests that use for educational purposes is more prevalent than for consultation and diagnosis.

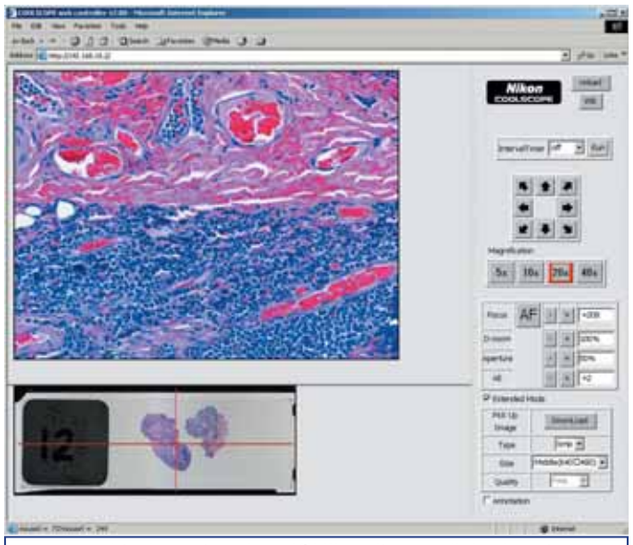
> 'Remote consultation remains one of the most important uses of telepathology'

Practical uses

A recently published report from the British Medical Association recommended that "the use of telemedicine should be encouraged, as it gives increased flexibility to healthcare service providers and allows them to expand the scope and quality of services".[3] Although the range of applications for telepathology networks is still evolving, some current common uses are clearly of considerable benefit to the service.

Remote consultation

As the initial motivation for the technology's development, remote consultation remains one of the most important uses of telepathology, providing clinicians in remote areas with instant access to expert opinions from histopathologists worldwide. For example, Mercy Ships, a non-governmental charity that operates a small fleet of hospital ships, provides much-needed medical services to coastal communities around Africa using onboard telepathology systems. These systems are used regularly for planned preoperative diagnosis, as well as intraoperatively in emergency situations. In both cases, patients benefit enormously from expertise that would not otherwise be available.[4] These same benefits can be transposed directly to any rural, or urban, medical facility.



A graphical user interface (GUI) replicates all the functions necessary for the remote control of the system.

Routine diagnoses and expert referral

No longer regarded as the exclusive property of a pioneering few working in isolation, telepathology provides many important advantages to histopathologists working in modern hospitals. First, telepathology systems can provide immediate backup for those working on urgent cases for which there is no time to send samples to other specialists for a second opinion. Second, telepathology can provide immediate access to subspecialty expertise, which would otherwise necessitate the transport of specimens to a second site. Third, and perhaps most important, it allows histopathologists to share their specimens with colleagues to encourage convergent diagnosis.

Integration of international expertise

One of the most progressive uses of telepathology is in aligning the expertise of histopathologists worldwide, helping to standardise diagnostic practices. This is likely to be of greater value in subspecialty areas and for the identification of rare conditions in which differential diagnoses are more common.

Education

Currently, there are two ways in which telepathology systems can be used for educational purposes. One is on-the-spot training received by referring histopathologists as field experts guide them through a particular diagnosis. This is typical of cases being viewed over an interactive system in which the remote expert is able to control slide movement. As the two parties view the slide simultaneously on-screen, the situation becomes analogous to a double-headed microscope that allows the viewers to discuss the specimen as if they were in the same room.

The second method of training involves the establishment of a library of images and videos that can be saved for subsequent peer review or for the instruction of trainee pathologists and field specialists. Although storing such images and videos requires a considerable amount of computer storage space, modern computers and the low cost of alternative storage methods (recordable CDs,

DVDs, removable hard drives etc) have increased the practicality of this option.

Virtual microscopy

One of the limitations of passive–static transmission is the issue of the representative sample. In capturing specimen images, a microscopists might not be able to select the optimal sample region for referral or consultation and a series of images may need to be taken to obtain an accurate remote diagnosis. Although this problem can be solved by passive–dynamic and active–dynamic telepathology, it can also be addressed by the new practice of virtual microscopy (virtual telepathology).

With this technique, a section is prepared and viewed under a microscope with a motorised stage and automated focus and scanning facilities. In a matter of minutes the entire specimen is captured at high resolution, creating a perfect digital reproduction of the original specimen in a single image. This can be transmitted to a remote site where viewers can move around the virtual slide, selecting both the sample region and desired objective power. The image can also be saved and recalled for review at a more convenient time, or sent to other experts for a coordinated diagnosis.

In view of the fact that the interface of most telepathology systems permits collection of a macro image of the entire sample and snapshot close-up views, virtual microscopy provides benefits that go well beyond those of conventional microscopy.

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Telepathology in focus

By today’s standards, the requirements for most high-resolution telepathology systems are relatively modest, and standard domestic PCs generally come equipped with more than adequate technical specifications. It is the program interface that often presents the most important condition for rapid uptake. Non-intuitive programs may be frustrating and dissuade users from applying the system in anything but the most crucial of circumstances. In contrast, well-designed systems offer functional similarities to light microscopes that are easy to adapt to and consequently have grown in popularity among pathologists at all levels of experience and in all specialties.

Finally, it should be remembered that telepathology systems are now capable of bringing significant efficiencies to the diagnostic workload in a modern laboratory. Where secondary opinions once required the time-consuming transport of specimens or that the consultant travel from one site to another, images can now be emailed downloaded across the internet to colleagues in order for advice to be obtained instantly. As digital imaging and network technology advance, the possibilities for further savings in time and cost will continue to grow. n

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