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LETTER TO EDITOR

Revolutionizing Traditional Pathology Practice in Today's Computer Age

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(On 1st Jan. 2012, India's first and only digital pathology was installed at OncoPath Diagnostics, Pune (www.OncoPathDx.com). The following article is written to let readers know about the digital pathology system and its applications).

Abstract:

Technology for acquisition of virtual slides was developed in 1985; however, it was not until the late 1990s that desktop computers had enough processing speed to commercialize virtual microscopy and apply the technology to education. By 2000, the progressive decrease in use of traditional microscopy in medical student education had set the stage for the entry of virtual microscopy into medical schools. Since that time, it has been successfully implemented into many pathology courses in the United States and around the world. In addition to education virtual microscope plays important role in getting second opinion on difficult cases and in research.

Introduction:

Modern pathology practice has reached a critical juncture in venturing beyond the conventional gold standard of age-old optical microscopy, as it experiences worldwide exploration of digital technology. Telepathology, the practice of pathology at a long distance, has advanced continuously since 1986. Today, fourth-generation telepathology systems, so-called virtual slide telepathology systems, are being used for education applications. Multiple medical schools have implemented this novel technology, and virtual microscopy is being introduced into the continuing educational and self-assessment programme of pathology educational organizations. Virtual microscopy is very attractive to educators because it nearly perfectly emulates the pan and zoom features of traditional microscopy, with the added advantages of the efficiency, accessibility, and versatility of computer-assisted education.

Digital pathology, which involves the scanning of whole histopathology or cytopathology glass slides into digital images interpretable on a computer screen, along with data management, translates to additional functionalities such as web accessibility, annotations, automated image analysis, and a host of breakthrough applications in the practice of pathology and health care systems as a whole.

'Virtual microscopy' is the commonly used term that generally connotes interpreting high-resolution digital images of microscopic glass slides on a computer screen, with panning and zooming capabilities simulating moving the stage and the low to high power magnification of an optical microscope.

The usage of the term has apparently evolved from the now obsolete implication of sending static histopathology images via electronic mail for online atlases or image collections of portions of tissue sections or cytological smears in various magnifications.

Virtual microscopy encompasses digitizing complete glass slides, called 'whole slide imaging' through rapid and sophisticated scanning equipment and visualisation software, and the acquisition and archiving of these digital images, or 'virtual slides'. Since the scanned slide represents an exact image replica of the physical slide, a suggested more accurate term is 'digital microscopy', alluding also to the technology behind the acquisition of microscopic fields in square matrix (tile method) or linear strips (stripe method), resulting in a seamless digital slide of superior image quality, which is permanent, superseding glass slides that are subject to faded stains, breakage and loss. It allows rapid retrievability and accessibility for long-distance consultations in present generation telepathology, or pathology work from a distance. But regardless of semantics, this merging of pathology and digital technology shall inevitably incorporate such jargon of computer-related terminologies; perhaps to an extent that pathology informatics may become a necessary competence in diagnostic practice.

The earliest use of telepathology dates back to 1968, when real-time transmission of black-and-white histological images was sent by mail. In the 1990s, along with the flourish of personal computers came the rapid expansion of telepathology networks in a few institutions, especially in Europe, the United States and Japan, mainly for remote frozen section service and expert consultations. Since then, telepathology has been applied in two ways: the simple and common static image, using still photos of histology from camera-equipped microscopes; or the more expensive and complex dynamic image type, whereby the robotic functions of a microscope can be performed by a distant operator. In the late 1990s, the innovation of digital scanning of histopathology slides along with a visualisation tool that could manipulate a 'dynamic, static image' in a more technically advanced format, resulted in telepathology growing exponentially, with an even more widespread acceptance, especially in the fields of education and research. To date, the number of digital slide systems for pathology has grown to more than 30 commercially available imaging devices, competing in their scanning speed, image quality, file size, functionality, diagnostic tools, and user-friendliness. The digitised whole slide image renders itself versatile and apt in today's computer era, such that digital pathology solutions are gradually trying to assert themselves in diagnostic pathology practice which has been accustomed to predominantly manual workflow processes.

For the past 30 years, generations of telepathology systems have represented the evolution of digital microscopy: video microscopy and robotic microscopy in the first 20 years, have upgraded to virtual slide processing systems in the last 10 years. The recent successful widespread implementation of teleradiology as an exemplary digital imaging tool, elevating medical practice to a higher level in terms of patient care, has further created a milieu for digital pathology imaging to likewise establish itself and complement the radiological counterpart in electronic patient records, notwithstanding the limitations that include the complexity of the field of pathology itself, having varied histological parameters for diagnosis per organ system per surgical procedure, unfamiliarity by pathologists, variable resistance to modification of established pathology practices, and the common fear of high cost and technical unfeasibility. Because of its tremendous potential, current practice standards are compelled to adapt to include digital microscopy, and vice versa, since this novel technology still warrants validation studies of its various clinical applications.

Virtual microscopy versus traditional (real) microscopy:

Because virtual microscopy can nearly perfectly emulate traditional microscopy, it can be applied to almost any discipline or educational venue where traditional microscopy is currently used.

The cost of virtual microscopy in medical student education may be quite comparable with traditional microscopy. Although the cost for virtual microscopy remains high, the cost should eventually come down with innovation and competition among vendors. In addition, there can be cost sharing as virtual microscopy becomes integrated into education, clinical service, and research in the same institution. Finally, for continuing education (and competency evaluation), costs saved by not having to create and mail glass slides can offset acquisition and serving costs.

Virtual microscopy versus digital photomicrographs:

Because virtual slides are single (although complex) giant images, they can be placed on a server with a URL and thus can be used in Web-based education. Although photomicrographs can be nested to provide the semblance of pan and zoom, and annotations can be added, these functions are much more readily performed with virtual slides and associated annotation editors.

The disadvantages of virtual microscopy versus digital photomicrographs are primarily cost related. Cost is a minimum of about $80,000 for scanner, and serving and viewing software. Cost for serving and viewing software, with commercial scanning of slide sets at approximately $40/slide, can be less than $10,000 startup. Compared to teaching with digital photomicrographs, the transmission speed, technical complexity, reliability, and relative lack of standards in the virtual microscopy industry are still some of the issues, but these have significantly improved over the last 8 years (1).

Current Clinical Applications:

To date, digital microscopy application in the diagnostic service has been strategically implemented in specific niches, addressing first and foremost the critical, relatively low to moderate volume areas, compensating for the physical unavailability of a pathologist. Among these are intra operative frozen sections and second opinion consultations.

For frozen section services, diagnostic accuracy has been reportedly high, and current digital slide scanners have been preferable to the previous robotic microscopy, in view of their improved image quality and viewing convenience [1-2]. The experience of Evans et al. with both robotic microscopy and digital microscopy has resulted in superior user satisfaction and faster turnaround time with the latter, although both remote viewing methods in general maintained a diagnostic accuracy of 98% and a turnaround time that satisfied the College of American Pathologists' laboratory accreditation criteria [3]. In another recent abstract, diagnosis of 174 frozen tissue sections from various organs by digital microscopy compared to glass slides resulted in a 93.6% concordance rate, and a 97.6% accuracy rate when compared with the final diagnosis [4]. The 4% deferral rate and 2.4% discrepancy rate were said to fall within the same range as conventional frozen section evaluation using glass slides [4]. Described as almost equivalent to conventional microscopy for frozen section cases digital microscopy may even supersede conventional microscopy in certain tissue samples; for example, in measuring isolated tumour cells and micro metastasis using annotation tools in digitised frozen sections of sentinel lymph nodes in contemplating axillary clearance during breast surgery.

The usefulness and practicality of rapid slide scanners within the frozen section room is easy to imagine. Given that most frozen tissue samples are relatively small and thin, slide scanning inserted in the workflow need not be time-consuming. There is cost savings related to time and travel if the surgical procedure is off-site, or if it is an odd time referral outside office hours. Frozen section referrals through a telepathology network spares the pathologist a ride or a long walk to the operating theatre, converts waiting time to productive time in the office base, and also allows group decision-making. Evans et al's frozen section service scans single tissue sections measuring 0.5–1.0 cm in maximum dimension, at 20× magnification at an average speed of 12 minutes [3]. He and his colleagues jointly report neurosurgical frozen sections from a nearby hospital, discuss the slide over the telephone, make consensus decisions with regard to deferred diagnosis for difficult lesions, interpret and report frozen tissue including cytological smears within 2–4 minutes, with total turnaround time averaging 16 minutes [3]. Another obvious intangible benefit rendered by such a referral network is the increased confidence in decision making and diagnosis, through simultaneous interpretation and consensus approach. However, frozen section reporting using telepathology is somewhat less useful in cases of larger specimens with tissue heterogeneity, such as ovarian tumors, which require careful gross examination and sampling of the specimens for accurate diagnosis. In such cases, selection of blocks for frozen sections is usually undertaken by a pathologist who needs to be physically present at the site receiving the specimens, who can then report the frozen sections.

Through image transfers via Web servers for subspecialists' opinion, the accessibility of digital microscopy remarkably provides previously unavailable subspecialty expertise for institutions where there is a clinical demand [5]. Quality assurance programmes requiring second opinion review of biopsies can benefit from rapid remote access and consensus review of digitised biopsy images, decreasing turnaround time of official reporting [6] and contributing to overall enhanced patient care. Archived diagnostic biopsy images can be rapidly retrieved for multidisciplinary team meetings or tumor board conferences, as well as comparison with sequential specimens, offering immense time savings compared to glass slide retrieval, not to mention cost savings on physical space for hospitals that priorities clinical services to accommodate increasing patient population in the limited confines of expensive square footage (7).

The inconveniences that accompany adjustments in accommodating innovative technology including cost and training the pathologists to read digital slides, are temporary and are surmountable. The benefits and value of digital microscopy far outweigh all of these and are worth revolutionizing traditional pathology practice in today's computer age.

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