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REVIEW

Digital slides: Present status of a tool for consultation, teaching, and quality control in pathology

Rafael Rocha[a,b,c,*], José Vassallo[b,d], Fernando Soares[b], Keith Miller[c], Helenice Gobbi[a]

[a]*Department of Pathology Universidade Federal de Minas Gerais, Brazil*
[b]*Department of Pathology, Hospital do Câncer A. C. Camargo, Brazil*
[c]*University College London, UK*
[d]*Laboratory of Investigative and Molecular Pathology, CIPED, State University of Campinas Medical School, Brazil*

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Abstract

In the last few years, telepathology has benefited from the progress in the technology of image digitalization and transmission through the world web. The applications of telepathology and virtual imaging are more current in research and morphology teaching. In surgical pathology daily practice, this technology still has limits and is more often used for case consultation. In the present review, we intend to discuss its applications and challenges for pathologists and scientists. Much of the limitations of virtual imaging for the surgical pathologist reside in the capacity of storage of images, which so far has hindered the more widespread use of this technology. Overcoming this major drawback may revolutionize the surgical pathologist's activity and slide storing.

Keywords: Telepathology; Review; Surgical pathology; Teaching; Morphometry

Contents

*Corresponding author at: Cancer Hospital, Department of Pathology, Rua Professor Antônio Prudente, 109, Depto Anatomia Patológica, 1º andar, Liberdade, São Paulo – SP, CEP: 01509-900, Brazil.
E-mail address: rafael.malagoli@gmail.com (R. Rocha).

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Introduction

Despite numerous advances in the understanding of disease processes, most basic aspects of Anatomic Pathology have changed relatively modestly over time. The pathologist supervises the gross dissection of the tissue, which is fixed, dehydrated in organic solvents, embedded in paraffin, sectioned, and stained. The tissue specimen is typically examined directly using a light microscope. Then the pathologist renders a diagnosis, and the glass slide and paraffin blocks are inevitably relegated to some cumbersome archives. A similar system is employed for Cytopathology, a method that presents the additional problem of being mostly irreplaceable. Thus, the distribution of material for consultative, investigative, or teaching purposes remains laborious, and, to a large extent, pathologists only have access to locally available case material for comparison in difficult cases [2].

With the introduction of *in situ* molecular methods in daily practice, especially immunohistochemistry in the 1970s, this scene has begun to change. The year 2000 marked a turning point at which pathologists began to spend less time in front of light microscopes rendering diagnoses and more time multitasking in front of computers. Although pathologists and their microscopes have been a hallmark of quality medical care for more than a century, the march of time and supervening technologies may alter the way Pathology will be practiced in the years ahead [35]. Telepathology surely represents one of such technologies.

The term ''telepathology'' was first used in 1986, in an editorial of a Journal of Pathology [46]. It was followed shortly thereafter by a report in another journal foreseeing in which way telepathology should be used to create the diagnostic networks that were implemented a decade later [11,50]. Over the past 15 years, there has been increasing interest in technologies that make it possible to examine specimens at a distance.

Up to the 1990s, there used to be two forms of telepathology imaging: static and dynamic [4,45,47,30]. In static image, the referring pathologist captured a small set of digital images that were transmitted and visualized at real time. The dynamic form of telepathology could be carried out by a remotely controlled real microscope. The remote consultant pathologist was able to control the microscope stage and to select the images to be viewed. Some microscopes provided the functionality for selecting various color filters or applying different illumination modes. They also allowed the simultaneous viewing of a slide by multiple clients, although only one client could control the microscope [2].

The new era of telepathology has brought a novel technology concept: the digital slides. Digital slides are virtual entire microscope specimens that can be viewed on a computer screen. They can be accessed from the computer's hard disk, transportable media (CD-ROM, DVD or memory sticks), or, more practically, from a network server used for image archiving and distribution [9,18,24,28,34,42]. Digital images of adjacent fields in cyto- and histopathological slides are assembled together to form a giant image montage, using a computer-controlled scanning stage. Although this technology has existed for more than a decade, this process, also called whole-slide digitization, has been commercially available for standard desktop computing only since 1998, when sufficient memory and processing speed became available. As the user can explore the entire microscopic section, the digital slides substitute with advantages the real ones in educational venues, remote consultation, and may replace cabinets full of slides [9]. Retrieving a slide becomes just a matter of accessing the proper database [13]. It can provide simultaneous access to the slides by multiple users, away from each other, who can access and individually manipulate the same slide or different slides at the same time. In addition, new software modules can be added to perform various types of further processing, as three-dimensional image reconstruction from data found in multiple focal planes and on multiple microscope slides, image segmentation and pattern recognition to better characterize known malignancies, and content-based image retrieval to find all slides with features similar to those in a sample slide [14,34,49]. Digital slides can also be used in interlaboratory quality assurance programs. Technical solutions for a web-based digital slide viewing system also have been presented, and some examples are available for public evaluation [10,12,18,24,34,37,40].

In the present review, it is intended to present the applications and challenges for pathologists and scientists with the advent of this new technology.

Web-based virtual microscopy

A digital slide system for public web access is composed of 3 parts: a digital slide acquisition system that acquires the images, a digital slide server that makes the acquired images available on the web, and finally a digital slide client that enables the user to browse the digital slide. The maximum quality of a digital slide is defined by the following factors:

1. quality of the section,
2. completeness: the real slide should be accessible as a whole,
3. image quality: sharpness, contrast, colors, and other attributes of the digital slide should not rank behind those of a real microscope, and
4. usability, for example, smoothly scrolling images, short access times, orientation, several options of magnification.