Virtual Dermatopathology: Current Technology and Use

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This article provides an overview of virtual dermatopathology, its development and usefulness. It also summarizes its current use and distribution, based on an informal survey by the authors of current use of the technique, which is not intended to be complete or all-encompassing.

"Virtual microscopy" is the software-assisted manipulation of high-definition digital images of tissue sections, to simulate the experience of examining glass slides under a standard optical microscope. Magnifications of up to ×40 can be achieved.

The advantages of using digital images are that they are easily duplicated and do not deteriorate. In addition, they can be stored, catalogued and managed with relative ease. Digital images can be used in multiple formats for teaching, testing and assessment.

Since computers are now readily available in educational institutions and are cheaper than microscopes, it is possible to provide students or residents with access to slides from rare cases that they would not traditionally see, and without the risk of breaking valuable glass slides. All of the participants can view the same slide, ensuring that they benefit from exposure to the correct information. With suitable software it is possible to incorporate annotations, such as circles and arrows, gross morphology or clinical photographs, as well as radiological images, with the slide data. In addition, this technique is useful for independent study (e-learning) and, with additional software, can provide instant real-time feedback, allowing learners to assess their own performance. Once the images and ancillary material are online, they can be accessed for review and further study at any time of day, and consultation around the globe is easily manageable. By attaching a discussion, multimedia, web links and references, the usefulness of the images as teaching tools can be enhanced further.

This technique is also useful in continuing medical education (CME) or continuing professional development (CPD) and external quality assurance (EQA). The incorporation of examinations with integrated multiple-choice questions, make it possible to accrue CME credit online. Accruing CME credit is becoming increasingly important for specialists. In some countries it provides higher salaries, as is currently the case in Europe. In other countries, it is necessary for renewal of licensure and maintenance of specialty certification and is mandatory. The latter is already the case in the USA, and is being discussed in the European Union of Medical Specialists (UEMS) along with mandatory certification examinations. Digital pathology has been proven globally as a strong tool for CME, CPD and EQA type programmes. Several key organizations, including the College of American Pathologists, the American Society for Clinical Pathology and the Royal College of Pathologists of Australasia (RCPA), are already using digital pathology to deliver accredited CME exercises. In addition, a number of pathology subspecialty EQA programmes in the UK use digital pathology.

Using virtual dermatopathology (VDP) negates many of the problems incurred when using glass slides for consultation, such as cracking, breaking and chipping. Archival digital copies also get round the problem of small tissue specimens, which may not provide sufficient tissue to generate reserve slides to send for consultation should the initial slide be lost or damaged. There are no delays incurred in sharing digital files, as when sending the glass slides, and there is a minimal interval between viewing/reading of specimens and receiving final feedback from the reviewer. All of this expedites final diagnoses (Fig. 1).

Finally, some institutions use virtual pathology for filing purposes. With increasing problems of storage space availability for histopathological slides, scanning pertinent slides and then discarding the glass slides while keeping the blocks has become an option. This also reduces salary costs for employees, who no longer need to retrieve glass slides from storage.

Past problems have included the fact that very few centres had invested in histopathology slide scanners, but these are now becoming more common. It is also possible to send slides for scanning at commercial centres for a set fee. The secondary problem of incompatibility of digital slides scanned by
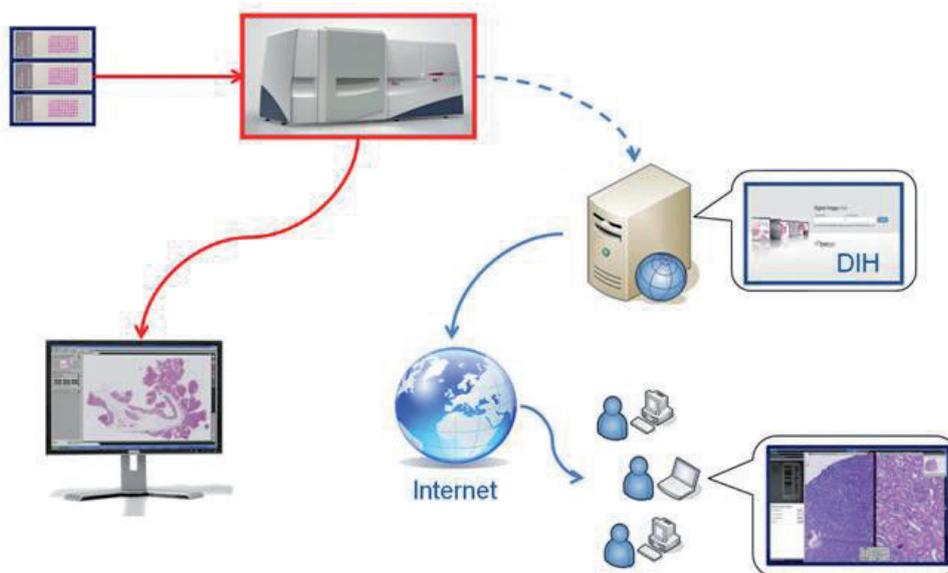
Fig. 1. Sample work-flow for store & share digital pathology from Leica Microsystems Total Digital Pathology

different brands of scanners with software used for viewing the images is also a problem of the past, since current software can accommodate most types of digital slides, regardless of origin. In addition, software allowing 360-degree rotation of images allows them to be reviewed in any orientation; this was not possible in the past and was problematic when using slides for teaching. Some software is also compatible with tablet computers (pads), except for the iPad™, due to the fact that the software relies on the use of Flash Player™.

Current use of Virtual Dermatopathology in Scandinavia

Sweden

In Sweden, the first use of virtual slides was in June 2005, when Stefan Cajander gave an international course in dermatopathology in Uppsala with invited speaker Phillip McKee. Approximately 100 delegates attended the meeting, which included a pre-course composed of 15 cases with virtual slides (Aperio) stored on a central server with international access. The delegates submitted their answers online. In the same year a course in breast pathology was held, followed by gynaecological pathology in 2006, both using virtual slides.

At the Department of Dermatology at Karolinska Institutet, Solna, an annual clinicopathological conference, initiated by the late Professor Thyresson, has been held since the late 1970s. There are 25–35 attendees from all the Nordic countries, who have special interest in dermatopathology. Initially, the

attendees submitted 25–35 glass slides and case histories on each case they were to present. A collection of case slides was then sent to each participant to analyse prior to the meeting. This arrangement was expensive, time-consuming and laborious. At the last two meetings, the case slides were pre-scanned (Mirax) and converted to digital slides, transferred to DVDs and posted to participants. A survey answered by 21 participants, showed that 14 of them preferred virtual slides, 4 preferred traditional glass slides, and 3 did not express a preference. For the organizer and senior author of this article, the virtual format is much easier to arrange.

At the Department of Pathology in Kalmar, the 5 pathologists have been using virtual microscopy for several years. The Department of Pathology at University Hospital in Malmö–Lund is planning to install the technique in 6–12 months at 50 working stations, with accessibility from the 4 pathology laboratories in Skåne. This will enhance the diagnostic capacity and increase the availability of clinicopathological conferences and clinical rounds. The most critical part, however, is the storage capacity on servers, according to Jens Enoksson, who is the head of the department.

Finland

In Finland, the Biomedical Informatics Research Group from the University of Helsinki arranged a seminar using virtual slides during the 21st European Congress of Pathology in Istanbul on 8–13 September 2007. It was the first time a microscopy slide set from a major pathology conference was made viewable on the web, and it included dermatopathology. The techno-

logy used at the conference was the result of a joint research and development project between the Biomedical Informatics Research Group, headed by Johan Lundin at the University of Helsinki, and Professor Jorma Isola, one of the pioneers of virtual microscopy, who is from the Institute of Medical Technology at the University of Tampere in Finland. The slide seminars of the 23rd European Congress of Pathology, which was held in Helsinki on 27 August to 1 September 2011 and included dermatopathology, are available on the web-based virtual microscope run by the University of Helsinki and University of Tampere and powered by Primed Info (http://www.webmicroscope.net/). Furthermore, slide seminars in dermatopathology at the Department of Pathology, University of Helsinki have been available in digital format since 2007 on the same website. In Finland, VDP is used in annual residents' training courses. It is used in annual national meetings, but rarely at university or hospital meetings or in consultation.

Denmark

In Denmark, VDP has been used in residents' training courses, which have been held once or twice a year since 2007. In 2010, two clincopathological courses using VDP, which were available to dermatology residents and faculty, were held in Copenhagen. In Aarhus, part of the dermatopathology training for medical students is delivered using virtual slides. To some extent, VDP is used in consultations; however, in the majority of cases, the preference is for traditional glass slides. VDP has been used in clincopathological conferences at Odense University Hospital and Aarhus University Hospital. Odense University Hospital is currently accruing experience with VDP for filing purposes, with the aim of solving increasing problems with space for filing glass slides. They intend to scan the pertinent slides and subsequently discard all glass slides, but retain the blocks. Thus, in addition, staff time taken up with filing and retrieving glass slides (a process which often needs to be repeated several times) can be spared.

Norway

In Norway, there are plans to use digital pathology in the near future in Akerhus and Bergen, and in Stavanger it is being used for research purposes. VDP is currently used only occasionally in residents' training courses. It is also used occasionally in national meetings and university or hospital meetings, but rarely in consultation.

Iceland

In Iceland, two international studies on VDP were conducted from 2008 through 2010. The first was on comparative diagnostic accuracy in VDP, comparing digital and glass slides. The abstract was presented at the annual meeting of the Interna-

tional Society of Dermatopathology in Santiago, Chile, in 2009 (1). The second study compared diagnostic accuracy using photomicrographs vs virtual slides. The abstract was presented at the annual meeting of the American Society of Dermatopathology in Atlanta, USA, in 2010 (2). The first author of this article organized two VDP courses in Copenhagen, which were available to residents and faculty, and, subsequently, a European Academy of Dermatology and Venereology Fostering Course for trainees, entitled "Introduction to Virtual Dermatopathology" in Iceland in 2011. The Informatics Committee of the American Society of Dermatopathology elected her as a member in 2011.

Use of Virtual Dermatopathology in Europe

Comparative studies using VDP and glass slides have been conducted with participants in Austria and Italy (3, 4). In Austria, virtual slides are used in the dermatopathology course for dermatology residents, and the dermatopathology examination for dermatologists (which is part of the residency requirements). VDP is also used occasionally in national meetings.

In Switzerland, a faculty member of the University of Zürich participated in comparative studies on VDP (1, 2) and, along with a faculty member at the University of Geneva, was on the faculty in an EADV Fostering Course in VDP for dermatology residents. At the University of Basel, there is a collection of virtual slides online, which includes dermatopathology images. The Department of Pathology at the University of Zürich is considering using virtual pathology for storage.

In Germany, VDP has been used occasionally in residents' training courses and at national meetings. The chief of the Dermato-Venereology Clinic of Hildesheim participated as a faculty member in an EADV Fostering Course in VDP for dermatology residents. Virtual slides are used very occasionally for consultation in Germany.

In the UK, VDP is sometimes used in residents' training courses and in conference settings at universities and hospitals, but rarely at national meetings. It is seldom used in consultations.

In France, VDP is used intermittently in consultation.

The Web-based Virtual Microscope run by the University of Helsinki University of Tampere, and powered by Primed Info (http://www.webmicroscope.net/), also has a European Virtual Microscopy Network with servers in Helsinki, Poznan, Madrid and Nijmegen.

Use of Virtual Dermatopathology in the USA

Virtual microscopy is being used increasingly in settings such as in-training examinations in dermatology, certification examinations in pathology and recertification examinations in dermatopathology in the USA. In addition, it is being used for teaching medical students and residents in US training programmes. The American Society of Dermatopathology has been converting their slide collection to digital format and is planning the increased use of VDP for resident/fellow teaching and self-assessment in CME. As previously reviewed, the College of American Pathology and American Society for Clinical Pathology are using digital pathology to deliver accredited CME exercises.

Use of Virtual Dermatopathology in Australia

In Australia, VDP is used regularly in residents' training courses, always used at national meetings and occasionally at university or hospital meetings, but rarely in consultation. The RCPA uses digital pathology, including VDP, in its CME exercises.

The *International Academy of Digital Pathology* (IADP) is a new organization formed by scientists, pathologists and academics from around the globe with the mission of promoting the development of information technology to help pathologists in their clinical work, research activities, education and quality assurance programmes. The 1st Congress of the International Academy of Digital Pathology was held on 3–5 August 2011 in Quebec City, Canada.

In summary

VDP is an evolving medical technology, which, over the last decade, has undergone numerous technological improvements due to new innovations in image capture and web-based delivery. Although traditionally delivered by specialist companies, such as Slidepath, global multinationals such as Philips and General Electric are now offering digital pathology solutions, illustrating a growing demand for digital pathology in the research and clinical market sectors. Increasing requirements for CME/CPD and EQA, which are now being implemented worldwide, will ensure the continuing use of this technology, which will lead to further technical advances. The use of this technique is most apparent in countries where there is strict regulation of EQA, licensure, specialist certifications and maintenance of certification, with concurrent examinations and CME. Also, VDP has been used in research and is increasing in popularity for storage of archival slides.

Acknowledgements

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