Distance reporting in digital pathology: A study on 950 cases

Aleksandar Vodovnik

Department of Pathology, Førde Central Hospital, Førde, Norway

E-mail: *Dr. Aleksandar Vodovnik - cellpath@icloud.com*

*Corresponding author

Received: 02 January 15  
Accepted: 15 March 15  
Published: 30 April 15

This article may be cited as:
Vodovnik A. Distance reporting in digital pathology: A study on 950 cases. J Pathol Inform 2015;6:18.

Available FREE in open access from: http://www.jpathinformatics.org/text.asp?2015/6/1/18/156168

Copyright: © 2015 Vodovnik A. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract

**Background:** Increased workload, case complexity, financial constraints, and staffing shortages justify wider implementations of digital pathology. One of its main advantages is distance reporting. **Aim:** A feasibility study was conducted at our institution in order to achieve comprehensive pathology services available by distance. **Methods:** One senior pathologist reported 950 cases (3,650 slides) by distance during 19 weeks. Slides were scanned by ScanScope AT Turbo (Aperio) and digital images accessed through SymPathy (Tieto) on a 14” laptop. Mobile phone, mobile broadband, broadband over Wi-Fi and broadband were used for internet connections along with a virtual private network technology (VPN). Lync (Microsoft) was tested for one case consultation and resident’s teaching session. Larger displays were accessed when available. Effects of ergonomics and working flexibility on the user experience were observed. Details on network speed, frequency of technical issues, data usage, scanning, and turnaround, were collected and evaluated. Turnaround was compared to in-office microscopic reporting, measured from the registration to sign off. **Results:** Network speeds varied 1–80 Mbps (median download speed 8–65 Mbps). 20 Mbps were satisfactory for the instant upload of digital images. VPN, image viewer, and laptop failed on two occasions each. An estimated data usage per digital image was 10 MB (1–50 MB). Two cases (15 slides) were deferred to microscopic slides (0.21/0.41%) due to scanty material and suboptimal slide quality. Additional nine cases (15 slides) needed to be rescanned for various reasons (0.95/0.41%). Average turnaround was shorter, and the percentage of cases reported up to 3 days higher (3.13 days/72.25%) comparing with in-office microscopic reporting (3.90 days/40.56%). Larger displays improved the most user experience at magnifications over ×20. **Conclusions:** Existing IT solutions at our institution allow efficient and reliable distance reporting for the core pathology services in histology and cytology. Stable network speeds, fully integrated laboratory information management system, technical reliability, working flexibility, larger displays, and shorter turnaround contributed to the overall satisfaction with distance reporting. A further expansion of our pathology services available by distance, diagnostic and educational, rely on gaining experience in digital reporting and marginal IT investment. Adjustments to the organization of pathology services may follow to fully benefit from the implementation of digital pathology.

**Key words:** Digital pathology, distance reporting, turnaround
INTRODUCTION

Digital pathology offers a wider accessibility to microscopic slides improving a working flexibility of pathologists.\(^1\) One of its main advantages against traditional microscopy, in addition to ergonomics and immediate access to slides, is distance reporting. Large validation studies were limited to the diagnostic accuracy and cost-effectiveness of the remote frozen section and consultation services, some briefly mentioning remote access for local pathologists and management of excessive workload by private clinic, however, without a detailed analysis of the technical and professional issues with distance reporting.\(^3\)\(^6\)

In an era of increased workload, case complexity, financial constraints, and staffing shortages, many pathology departments worldwide are experiencing, a wider implementation of digital pathology is seen as justifiable. A major incentive to our digital pathology project was to make comprehensive pathology services available by distance. In order to achieve that we have conducted a feasibility study in distance reporting at our institution, looking in-depth into practical professional (turnaround) and technical (network, virtual private network (VPN), laptop, user experience, larger display, image viewer, scanning) issues for the efficient and reliable digital pathology service outside hospital networks. Technical issues were seen as potential feasibility obstacles and shortened turnaround desired benefits.

METHODS

One senior staff pathologist, experienced in digital reporting, reported 950 consecutive cases (3,650 slides) by distance during the period of 19 weeks, between September 2013 and August 2014, for Department of Pathology, Førde Central Hospital, Norway [Table 1].

Microscopic slides were prepared by standard techniques and scanned daily overnight by ScanScope AT Turbo digital scanner (Aperio), for the following day reporting. Digital images were accessed through the fully integrated laboratory information management system (LIMS) SymPathy (Tieto), and viewed in Image Scope (Aperio) on an E6430 laptop with inbuilt HD web camera [Dell, Table 2].

Larger displays were accessed where available [Table 2]. A VPN technology was used through the locally developed application for Windows 7 (Microsoft), as an intermediate step for added security. Mobile phone, mobile broadband, broadband over Wi-Fi and broadband were used for internet connections. Internal LIMS instant messaging system, internal e-mail, and external text messaging were used to maintain contact with the laboratory personnel during the period of distance reporting. Lync (Microsoft) was tested for one case consultation and resident’s teaching session. HD web cameras (Logitech) were used on the receiving end. Effects of ergonomics, level of disruption during reporting and working flexibility with a time shift on the user experience were observed and recorded as a structured weekly log. Details on network speed, data usage, scanning, turnaround and technical reliability of VPN, laptop and image viewer, per reporting session or period, were collected and evaluated. Turnaround data were collected from LIMS, measured from the registration to sign off, and compared to the in-office microscopic reporting for the same pathologist with matching number of cases, specimen type, and reporting period.

RESULTS

Network speeds and stability for various types of internet connections and costs varied as shown in Table 3.

An instant upload of digital images in the image viewer has been used as a basic measure and default requirement for the best working experience in digital reporting. It has been achieved at 20 Mbps irrespective of the connection type, however, at low traffic, network speeds as low as 8 Mbps were satisfactory. At speeds below 8 Mbps, delays in the image upload became considerable and image

| Table 1: Case workload during 19 weeks of distance reporting |
|-----------------------------------------------|
| Skin                                          | 207 |
| Gastrointestinal                              | 202 |
| Genitourinary                                 | 161 |
| Gynecological                                 | 133 |
| Respiratory                                   | 96  |
| Lymphoid                                      | 65  |
| Endocrine                                     | 63  |
| Cardiovascular                                | 3   |
| Central nervous                               | 2   |
| Fine-needle aspiration cytology               | 9   |
| Nongynae cytology                             | 9   |
| **Total**                                     | 950 (932 histology; 18 cytology) |

| Table 2: Technical specifications for laptop used for distance reporting |
|-----------------------------------------------|
| Make and model                                | Dell E6430 |
| ROM                                           | 118 GB     |
| RAM                                           | 8 GB       |
| Display size and resolution                   | 14”, 1600x900 |
| Operative system                              | Windows 7 Enterprise SP1 64-bit |
| Processor                                     | Intel Core i5-3320M 2.60 GHz |
| Alternative display                           | 55” Ultra HD 4K LED TV (3840x2160) |

ROM: Read-only memory, RAM: Random access memory
viewing time-consuming. VPN, image viewer, and laptop failed on two occasions each [Table 4].

An estimated data usage per digital image was 10 MB (1–50 MB), depending on case complexity and pattern of work. Two cases were deferred to microscopic slides with additional nine cases needed to be rescanned for various reasons [Table 5].

Access to larger displays with higher resolution through HDMI improved the most working experience in cases requiring examination at magnifications over x20, where the image viewer’s digital magnifier had been used to achieve x40. Turnaround data and contributing factors for improved turnaround in distance reporting are detailed in Table 6.

**DISCUSSION**

To fully utilize advantages of digital pathology, individual feasibility studies are necessary, as organizations and infrastructures vary locally. Professional turnaround efficiency and reliability of existing technical solutions in the real-time routine diagnostic setting, outside hospital networks, were the major objectives studied. Although our study differed in setup and main objectives, its common denominators with previously published works on distance reporting included a general increase in use of digital reporting, decrease in turnaround time for frozen sections and consultations and improved user experience. Previous works were however lacking a deeper insight into technical issues and turnaround analysis in the wider routine diagnostic setup.

Number of cases and length of time were seen as this study’s strengths. As enrollments in this type of study require experience in digital reporting and IT skills, this study involved one departmental pathologist fulfilling those criteria. The validation study on 600 cases, conducted by the same pathologist previously, showed 99% intra-observer correlation between digital and microscopic diagnosis (unpublished data). That study was fully compliant to the College of American Pathologists recommendation.

Public and private networks were used to connect the internet along with VPN in this study. Network speeds varied considerably; however, median speeds were satisfactory for the instant upload as a cornerstone of the efficient viewing of digital images. 20 MBps were seen as a lower threshold, although, at low traffic, 8 MBps allowed comfortable and time effective digital reporting. At times, working hours needed to be adjusted (time shift) due to high traffic or low network speeds, however, without significant delays in reporting, owing to internet connection alternatives.

As expected, a broadband offered the most stable network speeds, followed by broadband over Wi-Fi.

| Table 3: Internet connection types, network speeds (median/variation) and costs |
|----------------------------------|-----------------|-----------------|-------------------|
| Internet connection type | Download speed (MBps) | Upload speed (MBps) | Costs |
|--------------------------|---------------------|---------------------|-------|
| Mobile phone | 8/1-23 | 7/1-10 | $20/month$^1,d |
| Mobile broadband | 10/1-25 | 8/1-10 | $20/$35^e |
| Broadband over Wi-Fi | 25/10-50 | 20/8-40 | Free of charge |
| Broadband | 65/30-80 | 60/20-80 | $15-25^f,g |

*Unlimited data usage, ^a Data usage limited to 7/35 GB/month, ^b Public networks, ^c Corporate cost

| Table 4: Technical issues reported to our IT customer service during 19 weeks of distance reporting |
|----------------------------------|-----------------|-----------------|-------------------|
| Unit | Issue | Action taken | Time | Number of occasions |
|--------------------------|------------------|-----------------|-------|
| Laptop | System failure | Multiple restarts | 15 min | 2 |
| VPN | Application failure | Application work up | 24 h | 2 |
| Image viewer | Disk storage overload | Deletion of temporary files | 15 min | 2 |

VPN: Virtual private network technology

| Table 5: Scanning issues recorded during 19 weeks of distance reporting |
|----------------------------------|-----------------|-----------------|-------|
| Issue | Number of cases/slides | Reasons |
|--------------------------|------------------|------------------|-------|
| Deferral to microscopic slides (%) | 2/15 (0.21/0.41) | Scanty material (urine cytology), suboptimal slide quality (mastectomy) |
| Slide rescanning (%) | 9/15 (0.95/0.41) | Focusing error, slide loading error, incomplete scan area |

| Table 6: Turnaround data for current in-office microscopic and distance reporting working set up with contributing factors |
|----------------------------------|-----------------|-----------------|-------|
| Current set up in-office microscopic | Study set up distance digital |
|--------------------------|-----------------|-----------------|-------|
| Average | 3.90 days | 3.13 days |
| 1-3 days | 40.56% | 72.25% |
| 4-7 days | 59.44% | 27.75% |

Mobile phone and mobile broadband connections have been shown as less reliable, due to frequent variations in network speeds, but still deemed as a useful alternative, for shorter reporting sessions. Majority of reporting
in this study was done accessing free of charge public broadband over Wi-Fi. The use of broadband over Wi-Fi was also preferable by our corporate IT policies requiring authorized pre-installations of all new software. Mobile broadband, mobile phone, and broadband expenses were acceptable and are expected to fall, directly through the increased competition among network providers.

Timely and competent technical support services play a crucial role in the implementation of digital pathology, especially when reporting by distance. Our regional IT department has successfully dealt with a low number of incidents, however, with potentially significant clinical implications associated with delays in reporting. VPN technical issues were closely linked to network speed and stability. As a result of this study, a number of internal routines were put in place, cutting down the response time and increasing customer service quality in this technically new, highly specific, and challenging field. Those included a regular maintenance of disks assigned to the storage of temporary images and making detailed VPN protocols widely available, especially to the temporary staff during the holiday season.

By reason of the high quality of laboratory work and reliable scanner, deferral, and rescanning rates were low. Further improvements are however expected, gaining experience in ever-changing laboratory routines and digital scanner software updates. In this digital age, the use of mobile technology in medicine is encouraged and becoming more frequent. Ways of communicating with the lab in this study were simple, safe and uneventful, including the external text messaging, used in urgency.

A secure exchange of patient data is our paramount as medical professionals. VPN has been accordingly recommended by health authorities as a standard for the outside access to hospital networks and patient data. This would allow the wider use of existing private and public networks affecting network expenses in distance reporting.

It is important to address the impact of distance reporting on our customers. Although experiences from this study are encouraging, improvements in working stations, teleconferencing and gained experience in distance reporting are expected to further advance the quality of collaboration with clinicians and provide a better service to our patients in this new working setting.

Recent works on potential long-term cost savings with the implementation of digital pathology are encouraging. The use of existing software and hardware, where available, offers further savings to already constrained hospital budget. Lync (Microsoft) has been namely used for audio and video conferencing in our organization for years. Its functionality for case consultations and resident’s teaching sessions has been confirmed in this study.

Securing satisfactory network speeds has been a default requirement for successful implementation of digital pathology. Another major contributing factor was, as also shown in this study, a full integration of digital scanning system and LIMS, providing a single step access to request forms, digital images, and patient history. Although initially a considerable investment (custom made), this was essential to improve working experience in digital reporting. It was made possible through the consolidation of multiple tasks, as the analysis of the activities involved in diagnostic pathology has previously shown.

Turnaround in digital reporting has been addressed in this study from the aspect of technical issues (network, VPN, laptop, image viewer) and working environment. By default, technical issues directly affect turnaround in digital reporting. The low frequency of technical issues in this study led to no significant delays in distance reporting. Time between dictation and typing often contributes to the large portion of a turnaround out of pathologist’s control. The current routine for the in-office microscopic reporting in our institution is digital dictation typed in by secretaries. Due to issues with the stability of digital dictation module in our LIMS and understaffing on the secretarial side, prior to the study start, all reports in this study were typed in by the reporting pathologist himself, contributing additionally to shorter turnaround.

Voice recognition has been made locally available, however, still considerably slower than digital dictation or typing for the reporting pathologist. Distance reporting has also been personally seen as more flexible and less disruptive working experience in this study, with a positive effect on productivity, compared to the in-office reporting, digital or microscopic. Longer undisrupted reporting sessions and lesser need for breaks were achieved in this setting due to better ergonomics, increasing the productivity as well, comparing to microscopic in-office reporting. This also led to the easier implementation of the time shift in routine reporting by distance, which allowed a majority of the workload being reported in the evening of the same day, improving the turnaround further. Time shift and typing in reports are surely applicable to the in-office reporting as well. However, from the personal experience so far, it was more difficult to implement the time shift in an in-office setting. It certainly has its value in discussions on the future organization of pathology services. Furthermore, typing in reports by pathologists is closely linked to the personal preference, reporting style and experience, and therefore not necessarily widely accepted. On the other side, time savings through the better ergonomics, less disruption, and more working flexibility with a time shift seem to be more than sufficient to compensate for additional activities by pathologists, such as typing in reports, when logistically necessary. Variations in working patterns related to the level of experience for pathologists have been studied.
in traditional microscopy, affecting diagnostic accuracy and turnaround time.\(^\text{[10]}\) Those variations are expected to affect data and time usages in digital reporting as well. Digital diagnostic time comparing with traditional microscopy has been a subject of the separate study and therefore not specifically addressed here. It has been shown that digital diagnostic time can be faster than microscopic, additionally increasing productivity in the routine in-office diagnostic setup (accepted abstract, USCAP 2015). Adequate and stable network speeds, fully integrated LIMS, absence of physical slide handling, better ergonomics, and larger viewing field have been suggested as contributing factors to improvements in diagnostic and non-diagnostic time in digital reporting.

The slides were routinely scanned, and most of the diagnostic work was successfully done at magnifications up to \(\times 20\), on the existing laptop. Accessing larger displays was beneficial in cases requiring examinations over \(\times 20\) (e.g., nuclear features, microorganisms), due to larger viewing field and higher resolution, although, the viewing of small specimens at lower magnifications was also improved. The viewing speed was, however, affected. The routine use of the existing larger displays should be certainly encouraged. Scanning at \(\times 40\) seems to be, however, more justifiable than purchasing expensive displays, assuming only temporary data storage. At the moment, we erase digital images 3 months after the sign off. In our validation study, we have also tested multiple displays available on the market and chose 23” displays for in-office digital reporting, as the best price to quality value.

Observations from this study on the overall satisfaction with distance reporting were encouraging, for the reporting pathologist and department, including the core pathology services in histology and cytology, case consultation, and resident’s teaching session. As a result, a full expansion of our pathology services available by distance is under way, including video link consultations in surgical pathology. Accessing larger displays was beneficial in cases requiring examinations over \(\times 20\) (e.g., nuclear features, microorganisms), due to larger viewing field and higher resolution, although, the viewing of small specimens at lower magnifications was also improved. The viewing speed was, however, affected. The routine use of the existing larger displays should be certainly encouraged. Scanning at \(\times 40\) seems to be, however, more justifiable than purchasing expensive displays, assuming only temporary data storage. At the moment, we erase digital images 3 months after the sign off. In our validation study, we have also tested multiple displays available on the market and chose 23” displays for in-office digital reporting, as the best price to quality value.

Observations from this study on the overall satisfaction with distance reporting were encouraging, for the reporting pathologist and department, including the core pathology services in histology and cytology, case consultation, and resident’s teaching session. As a result, a full expansion of our pathology services available by distance is under way, including video link consultations for residents at cut-up and autopsy rooms, fine-needle aspiration cytology reporting for one-stop clinics, reporting sessions with residents, clinical conferences, internal teaching, and external consultations. Those rely on an estimated additional \$350 investment in two HD web cameras (cut-up and autopsy rooms), the latter with an additional USB extension cable.

CONCLUSIONS

Existing IT solutions at our institution allow an efficient and reliable distance reporting for the core pathology services in histology and cytology. Stable network speeds, fully integrated LIMS, technical reliability, working flexibility, larger displays, and shorter turnaround contributed to the overall satisfaction with distance reporting. A further expansion of our pathology services available by distance, diagnostic and educational, rely on an increased experience in digital reporting and marginal IT investment. Software updates, ready-made purchases, and broadened use of existing IT technology are expected to have effect on the future expenses. Once comprehensive pathology services are made available by distance, adjustments to their organization may follow to benefit fully from the implementation of digital pathology.

ACKNOWLEDGMENTS

This material was supported by Digital Pathology Project at our institution, sponsored by the Health Authority West (Helse vest), project number 795421. The author is grateful to Ståle Sund, MD PhD, and Sverre Nordgård, BMS, for their support and encouragement, as well as members of the project group and the regional IT Department (HVIKT) for their valuable contributions to the success of our project.

REFERENCES

1. Bauer TW, Schoenfield L, Slaw RJ, Yerian L, Sun Z, Henricks WH. Validation of whole slide imaging for primary diagnosis in surgical pathology. Arch Pathol Lab Med 2013;137:518-24.
2. Thorstenson S, Molin J, Lundström C. Implementation of large-scale routine diagnostics using whole slide imaging in Sweden: Digital pathology experiences 2006-2013. J Pathol Inform 2014;5:14.
3. Ribback S, Fiessa M, Gromoll-Bergmann K, Evert M, Dombrowski F. Virtual slide telepathology with scanner systems for intraoperative frozen-section consultation. Pathol Res Pract 2014;210:377-82.
4. Romero Lauro G, Cable W, Lesniak A, Tseytlin E, McHugh J, Parwani A, et al. Digital pathology consultations—a new era in digital imaging, challenges and practical applications. J Digit Imaging 2013;26:668-77.
5. Pantanowitz L, Sinard JH, Henricks WH, Patheeree LA, Carter AB, Contis L, et al. Validating whole slide imaging for diagnostic purposes in pathology: Guideline from the College of American Pathologists Pathology and Laboratory Quality Center. Arch Pathol Lab Med 2013;137:1710-22.
6. Ho J, Ahlers SM, Stratman C, Airdor O, Pantanowitz L, Fine JL, et al. Can digital pathology result in cost savings? A financial projection for digital pathology implementation at a large integrated health care organization. J Pathol Inform 2014;5:33.
7. Randell R, Ruddle RA, Quirke P, Thomas RG, Treanor D. Working at the microscope: Analysis of the activities involved in diagnostic pathology. Histopathology 2012;60:504-10.
8. Treanor D, Lim CH, Magee D, Bulpit A, Quirke P. Tracking with virtual slides: A tool to study diagnostic error in histopathology. Histopathology 2009;55:37-45.