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Barriers and facilitators to the introduction of digital pathology for diagnostic work

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Abstract

Cellular pathologists are doctors who diagnose disease by using a microscope to examine glass slides containing thin sections of human tissue. These slides can be digitised and viewed on a computer, promising benefits in both efficiency and safety. Despite this, uptake of digital pathology for diagnostic work has been slow, with use largely restricted to second opinions, education, and external quality assessment schemes. To understand the barriers and facilitators to the introduction of digital pathology, we have undertaken an interview study with nine consultant pathologists. Interviewees were able to identify a range of potential benefits of digital pathology, with a particular emphasis on easier access to slides. Amongst the barriers to use, a key concern was lack of familiarity, not only in terms of becoming familiar with the technology but learning how to adjust their diagnostic skills to this new medium. The findings emphasise the need to ensure adequate training and support and the potential benefit of allowing parallel use of glass slides and digital while pathologists are on the learning curve.

Keywords:

Informatics; Pathology; Microscopy; Qualitative Research; Learning Curve.

Introduction

While traditionally health informatics focused on the consulting room and the use of electronic patient records (EPRs) and computerised decision support systems, recent years have shown an interest in broader range of settings. Not only is the spread of EPRs and mobile technologies into secondary care leading health informatics researchers to explore ward settings, but we are gradually learning more about those areas of medicine whose work patients may not see but which play a key role in diagnosis, determining treatment, and assessing response to treatment, such as the work of clinical pathology laboratories [1]. This has led to studies of diagnosis around imaging systems, such as use of Picture Archiving and Communication Systems (PACS) in radiology [2,3]. At the same time, we are seeing interest in a broader range of technologies for diagnostic imaging, including increasingly pervasive wireless and sensor-based technologies [4,5]. In this paper, we turn to the underexplored area of cellular pathology: the diagnosis of disease through microscopic examination of tissue.

Cellular pathologists diagnose cancer and other diseases using a microscope to examine glass slides containing thin sections of human tissue. The tissue will have been stained using a chemical or immunologically based method. Haematoxylin and Eosin (H&E) is the most common stain and it highlights the most significant tissue structures well, while special stains use histochemical reactions to identify specific tissue components or organisms, that are less easily identifiable with an H&E stain.

It is now possible to digitise glass slides so that they can be viewed on a computer; the field of digital pathology is concerned with the development and evaluation of technologies that support this. Digital pathology promises a number of benefits, both in terms of efficiency and safety. Advocates of digital pathology highlight the potential for improved workflow; a digital system would allow the pathologist to be alerted to when new cases are ready to be viewed, as well as allowing the pooling of cases, resulting in a revolution of the workflow similar to that seen in radiology [6]. There is also the ease of obtaining second opinions electronically from a national or international source rather than having to send the glass slides through the post with the delay and the risk that they will get broken or lost in transit [7]. Slides can be simultaneously sent to several people for second opinions, which is not possible with glass slides. There is the reduced risk of getting slides mixed up so that a patient receives the wrong diagnosis, something that happens rarely but can have devastating consequences when it does [8], and there is the option to integrate decision support technology [9, 10].

Despite this potential, uptake of digital pathology for diagnostic work has been slow. While there have been positive reports about the use of digital pathology within education and training [11,12] and for teleconsultation [10], in relation to routine diagnostic work, research suggests scepticism and uncertainty amongst pathologists [13,14]. In a recent survey conducted in the United States, while 59% of respondents agreed that the benefits of digital pathology outweigh concerns, 78% perceived digital slides as currently being too slow to view for use in routine diagnostic work [15]. This fits with the findings of experimental studies which have found that it takes significantly longer to make a diagnosis on a digital slide compared to a glass slide [16,17]. A study of barriers and facilitators to the use of digital images in clinical practice that involved interviews with two radiologists and three pathologists, found a key barrier in pathology to be the perception that diagnostic performance is inferior with digital slides [9].

As part of a larger study concerned with the design and evaluation of a digital microscope for use in routine diagnostic

work [18-21], we undertook an interview study to better understand the barriers and facilitators to the introduction of digital pathology. In this paper, we present the findings of that study and discuss the implications of these findings for the implementation of digital pathology.

Methods

Data collection

Semi-structured, face-to-face interviews were conducted with nine consultant pathologists within our institution, a large teaching hospital. The interviewees were from a range of subspecialties and had varying levels of experience of digital pathology: two had almost no experience of digital pathology, three had used it for External Quality Assessment (EQA) schemes, one had used it for obtaining a second opinion, and two had experience of using it for research and/or teaching.

Interview questions explored what participants saw as the benefits and limitations of the conventional microscope and current workflow, benefits, limitations, anticipated impacts of digital pathology, and willingness to move to digital pathology. All interviews were audio recorded and later transcribed.

Analysis

An iterative approach was taken to data collection and analysis, to allow the collection of further data on emerging themes in subsequent interviews. Anonymised transcripts were entered in NVivo, software for qualitative data analysis. Data was analysed using thematically [22], with codes developed inductively.

Results

Here we present the findings from the interviews organised according to key themes. While interviewees discussed the benefits of digital pathology for multidisciplinary team meetings and teaching, we focus on attitudes towards digital pathology in the context of diagnostic work.

Benefits of digital pathology

The most commonly mentioned advantage of digital pathology was the ease of sharing digital slides in order to get second opinions, mentioned by eight of the nine interviewees:

'I have sent slides to others for second opinion and it works brilliantly. First of all we don't have to pack slides. Recently I had to send a case to Boston [...] and I didn't have to pack any slides. The main problem was packing slides across to America, it's so difficult now. So I scanned the slides […] and sent it across and within half an hour I got the reply. So he emailed me saying yeah the report I think it's fine. And the thing is we don't choose any particular area as when you take images and send it to another person […] This is you're sending the entire slide as you would be seeing down the microscope. So that is a big advantage.' (HC6)

While most comments were about the ability to share slides with other sites, a couple of interviewees also mentioned benefits in terms of being able to look at slides with colleagues:

'When you're getting a second opinion, it's much much easier if you're all looking at a screen, you can all point at it and know you're all looking at the same thing. Um, and that you can all point at it whether you're steering or not, whereas on this [microscope] the only person who can point really very easily is the person steering it.' (HC5)

Interviewees were also very positive about the idea of having remote access to slides, both for on call work but also to allow more general flexibility:

'The scope for it is for the very specialised stuff, if you're looking to get cover for cases around the country, that sort of thing, that's the one diagnostic role I can see.' (HC3)

Another perceived benefit, mentioned by four of the interviewees, is the ease of access to slides, so that previous slides can easily be viewed:

'The nice thing about electronic images is that you can store them, you can access them rapidly, so if I needed to go back to look at something I don't have to go back to the file to get it out. In theory. If there's a secure server, I could go straight to it and find the one that I want with some rapidity. […] that would be grand. […] it would allow laboratories to store large amounts of glass off site. Rather than having to keep it all on the premises. So that people can review stuff very quickly, scanned images, and very rarely have to go back to the original bit of glass, which is quite labour intensive.' (HC4)

The interviewees mentioned the benefit of being able to have multiple people using the slide at the same time, mentioned by one interviewee when discussing EQAs but also by two interviewees in the context of diagnostic work:

'I suppose now I have to complete a case and then give it to a colleague because then as long as a colleague is working on it I can't look at it, so I suppose that would be an advantage, […] it's more easy to share cases.' (HC7)

Two interviewees mentioned the durability of digital slides, that they do not get broken or lost, while also mentioned by two interviewees was the removal of 'glass work':

'You don't have all the glass work, filing, you don't have to constantly file loads of glass work and pull it out and refile it and so on.' (HC2)

Two interviewees also mentioned that the ability to have an overview of the whole slide which is not possible with the microscope:

'I like the way it can be navigated where you can see in a wider view the entire biopsy or pieces of tissue that you see on the glass slide. That is definitely an advantage.' (HC6)

Limitations of digital pathology

The most commonly mentioned disadvantage, mentioned by three of the interviewees, was the lack of familiarity with digital slides:

'It just takes a bit of getting used to, open it up, zooming in and out and going round. And sitting at a computer screen as opposed to looking down a microscope.' (HC2)

One interviewee felt that it was not just a case of learning to use the technology but also adapting her diagnostic skills:

'I can't imagine someone who's so used to this as me would want to change for my routine work to a digital way of reporting. [...] Because, yeah, I'd be relearning a lot of diagnostic skills but wouldn't have the time to do it. I wouldn't see any need to do it.' (HC3)

While the ability to share slides with other sites was seen as a benefit, one pathologist was concerned that digital slides could result in less interaction amongst pathologists within the department.

An issue which came up in the first two interviews and which we explored further in subsequent interviews was the impact digital pathology would have on the sense of 'immersion' that some pathologists report experiencing when working at the microscope. One of the interviewees felt that a move to digital pathology would have a negative impact on the sense of immersion. However, two of the interviewees were unsure whether or not the loss of immersion would have a negative impact:

'I think when you're starting with something new, you've got the distraction of the vehicle which it's presented in and so you're not immersed because you're also worrying about, 'Am I doing it right? Is it the right way round?' And the immersion's all about being able to focus on the thing that you're interested in and that's because you're not having to worry about other things [...] I think people would feel more immersed if they did it more often because they would start to be familiar with it and they then wouldn't notice.' (HC4)

Interesting in the interviewees' comments was the different ways in which they conceptualised the sense of immersion – whether it comes from having all visual attention focused on the slide, or from the physical connection with the microscope, or simply from familiarity with the technology of the conventional microscope, so that the user does not have to think about what they are doing. However, five of the interviewees did not present this as a concern.

Perceived impact on efficiency

When asked whether they thought that the introduction of digital pathology would have an impact on efficiency, three interviewees said that they felt the impact on efficiency would be a positive one, although all three identified different sources for this improvement. One interviewee talked about efficiency in terms of not having to wait for referred cases (assuming that the referring site also used digital slides), while another talked of removing the physical transfer of slides. Another focused on the benefits of looking at a screen as opposed to looking down a microscope:

'So [the microscope] is a […] kind of tunnelled vision or tunnelled thinking process which could be easily distracted. Whereas if […] you're looking down the screen, even if for a moment I want to look out of the window you can still come back and that is still there in a wider view staring at you.' (HC6)

Willingness to move to digital

There was huge variation in interviewees' enthusiasm for digital pathology in relation to routine diagnostic work. While most could be described as open to the idea, one interviewee rejected the idea strongly:

'We haven't got enough money to do what we're doing now. And the investment that you'd need to really make digital pathology taken on as for routine I think is unjustifiable.' (HC3)

At the other extreme, we had one interviewee who was very keen to move to using digital pathology as soon as possible:

'These [gesturing to microscope] can all go in the scrap heap. I just think it liberates us so much as well. […] I think it's just going to be revolutionary actually, quite frankly, I really do.' (HC9)

One interviewee acknowledged that there would be a learning curve but did not see this as a problem:

'So if you are going to give a diagnosis to a patient, are you ready to sign out on the screen? I said yeah, maybe if I start using it, it's only a question of getting used to it, I can't see any great difficulty there.' (HC6)

Generally, the impact on safety was not a concern amongst the pathologists that we interviewed. Four of the interviewees felt that there would not be a negative impact on safety, with three of the four saying that safety might be improved by reducing the risk of mixing up slides, while one interviewee was unsure what the impact on safety would be. There was little concern regarding image quality:

'An image on a computer if it's high quality is no more or less real than you know a section that's been stained and has light shone through it really, […] it's just a representation of what was happening in life anyway, isn't it? Not really live tissue, just a thin slice of it that's been stained.' (HC5)

Concerns regarding safety related to lack of familiarity with the technology:

'There's the patient safety from getting it wrong using a system you're not used to or haven't been trained in and therefore there could be some drawbacks which we're just not used to. […] Stain deposits, dodgy staining, […] how does dodgy staining look? 'cos we're so used to looking down the microscope. And you've been looking at it for like 10 years.' (HC2)

Three of the interviewees said that they would want the opportunity to try it out for themselves:

'I'd just have to had seen quite a number [of digital slides] I think, probably in parallel [with glass slides], or alternate, or something like that. Just to see if you would have made the same diagnosis. And er, yeah, just to get a feeling for it, 'cos it's a different system. The trouble is, with the glass, you've been doing it for so long you're used to all the flaws and you compensate for all the flaws. Whereas with the computer system, you haven't used it, you might not know all the niggles and glitches and flaws.' (HC2)

One interviewee said that he would like to see data regarding the time it takes to become familiar with the system:

'I think the kind of data to be after would be, that would be worth getting, would be to be able to demonstrate to people who have not used it very much that there is a learning curve and that people can approach the diagnostic speeds that they are used to.' (HC4)

One interviewee was more concerned about the processes surrounding the technology, in terms of the training and support that would be provided. This seemed to be influenced by their experience of other IT systems within the hospital:

'I just think you've got to have that IT support to sort it out straight away. [...] and you need to pay people proper money to support it. And our IT guy's just had a 20% pay cut because he's been down-banded, you know? [...] That's going to impact on how well your system works. [...] That's the other thing, we get [lab system] or whatever and you start learning new things about it years later. 'Oh I didn't know you could do that.' Quite earth shattering things that can drastically reduce your amount of time. So, you know, people need to be trained properly in it...' (HC5)

Robustness was an issue mentioned by three of the interviewees, two of whom explicitly linked this to their experience of hospital IT systems:

'I think that's probably my main concern. […] They're very good at being optimistic but the delivery's always a major disappointment.' (HC7)

Discussion

Interviewees were able to identify a range of potential benefits of digital pathology in the context of diagnostic work, with a particular emphasis on easier access to slides and the efficiency gains this could bring. Amongst the barriers to use of digital pathology, a key concern was lack of familiarity, not only in terms of becoming familiar with the technology but learning how to adjust their diagnostic skills to this new medium. This reflects similar findings from radiology, where the reading of images takes place in light of readers' knowledge of the principles of the production of the image as well as specific local practices, allowing them to distinguish between artifacts of the screening process and those that have diagnostic significance [23]. Findings from the experimental studies we have undertaken suggest that pathologists need to relearn what they should expect to see at each magnification level, as it may be that it is necessary to view digital slides at a higher level of magnification than would typically be required for viewing glass slides on a conventional microscope [18].

Interestingly, interviewees did not express concern about diagnostic performance, in contrast to previous studies [9]. They also did not have concerns about the speed of digital slides, despite this being highlighted as an issue in previous studies [15-17], instead focusing on the potential efficiency gains of a digital workflow. This may be due to the interviewees' lack of familiarity with digital slides, their responses suggesting a belief that, with experience, the speed and accuracy of their diagnoses would increase. On this basis, we would suggest that the majority of the interviewees in this study were fairly positive about the idea of using digital pathology for diagnostic work but were rightly cautious about its impact on their work, wanting more opportunity to try the technology themselves, alongside the microscope so that they could judge for themselves the accuracy of their diagnoses, and aware that it is not just an issue of learning to use the technology but potentially has implications for how they make diagnoses.

Where negative attitudes to digital pathology were expressed, was on the basis that glass slides work adequately and so it may be difficult to justify the investment of money and time (in learning to use the technology) that a move to digital pathology for routine diagnostic work would require. Greater evidence of cost savings that digital pathology can provide may go some way to overcoming such concerns. However, challenges often arise in adoption of technology when the users of the technology are not those who will benefit most. The key benefits of digital pathology are currently predicted to be in workflow efficiency, which benefits the organisation, and potentially the patient, rather than providing any efficiency benefit to the individual. However, developments such as the integration of decision support could provide benefit to the user [9,10]. Perception of benefits is likely to vary according to organisational factors; our institution is a tertiary centre providing specialist expertise, and so pathologists do not often need to seek advice from pathologists at other institutions where digital pathology would provide a benefit.

Another challenge is that, while previous studies have compared adoption of digital images in radiology and pathology [9], in radiology the images begin as digital data, whereas for digital pathology the need to create the glass slide remains, so that digital pathology introduces an extra step into the process [10]. However, in the future it may be possible to produce digital slides without the need to first produce a glass slide, for example by using spectral domain optical coherence tomography (SD-OCT) to scan tissue blocks [24].

Implications for practice

The findings suggest, as with any health IT system, adequate training and support need to be in place for digital pathology to be effectively integrated into diagnostic work. Before transitioning to a totally digital workflow, pathologists may benefit from the opportunity to review glass slides alongside digital images as well as learn to use the technology, that can help to adjust their diagnostic skills and gain confidence in their ability to make a correct diagnosis with a digital slide. There is a need for further research on the learning curve associated with digital pathology, to reassure pathologists about the time investment required to work in this new way. This is work that we have begun to undertake [25].

Strengths and limitations

This is a small scale study, conducted within a single institution, so we cannot judge to what extent the findings reflect the attitude of pathologists in general. However, our participants were from a range of subspecialties and had varying levels of experience of digital pathology.

A strength of our study is that it provides detailed qualitative data on the barriers to integrating digital pathology into diagnostic work, with larger number of participants compared to previous studies, and provides guidance for those who seek to implement such systems.

Conclusion

Interviewees were able to identify a range of potential benefits of digital pathology in the context of diagnostic work, with a particular emphasis on easier access to slides and the efficiency gains this could bring. They were predominantly positive about the idea of using digital pathology for diagnostic work but rightly cautious about its impact on their work, aware that it is not just an issue of learning to use the technology but potentially has implications for how they make diagnoses.

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References

[1] Georgiou A, Westbrook J, Braithwaite J. An empirically-derived approach for investigating Health Information Technology: the Elementally Entangled Organisational Communication (EEOC) framework. BMC Medical Informatics and Decision Making 2012; 12, 68.

[2] Hanseth O, Lundberg N. Designing Work Oriented Infrastructures. Computer Supported Cooperative Work (CSCW) 2001; 10, 347-372.

[3] Karasti H. Bridging Work Practice and System Design: Integrating Systemic Analysis, Appreciative Intervention and Practitioner Participation. Computer Supported Cooperative Work (CSCW) 2001; 10, 211-246.

[4] Johnson R, O'Hara K, Sellen A, Cousins C, Criminisi A. Exploring the Potential for Touchless Interaction in Image-Guided Interventional Radiology. CHI 2011. Vancouver, BC: ACM, 2011.

[5] Mentis H, O'Hara K, Sellen A, Trivedi R. Interaction Proxemics and Image use in Neurosurgery. CHI 2012. Austin, Texas: ACM, 2012.

[6] Gilbertson J, Ho J, Anthony L, Jukic D, Yagi Y, Parwani A. Primary histologic diagnosis using automated whole slide imaging: a validation study. BMC Clinical Pathology 2006; 6, 4.

[7] Della Mea V, Demichelis F, Viel F, Dalla Palma P, Beltrami CA. User attitudes in analyzing digital slides in a quality control test bed: A preliminary study. Computer Methods and Programs in Biomedicine 2006; 82, 177-186.

[8] Nakhleh RE. Patient Safety and Error Reduction in Surgical Pathology. Arch Pathol Lab Med 2008; 132, 181-185.

[9] Patterson ES. Barriers and facilitators to adoption of soft copy interpretation from the user perspective: Lessons learned from filmless radiology for slideless pathology. Journal of Pathology Informatics 2011; 2, 1.

[10] Pantanowitz L, Valenstein PN, Evans AJ, Kaplan KJ, Pfeifer JD, Wilbur DC, Collins LC, Colgan TJ. Review of the current state of whole slide imaging in pathology. J Pathol Inform 2011; 2, 36.

[11] Blake CA, Lavoie HA, Millette CF. Teaching medical histology at the University of South Carolina School of Medicine: Transition to virtual slides and virtual microscopes. The Anatomical Record Part B: The New Anatomist 2003; 275B, 196-206.

[12] Kumar RK, Velan GM, Korell SO, Kandara M, Dee FR, Wakefield D. Virtual microscopy for learning and assessment in pathology. The Journal of Pathology 2004; 204, 613-618.

[13] Dennis T, Start RD, Cross SS. The use of digital imaging, video conferencing, and telepathology in histopathology: a national survey. J Clin Pathol 2005; 58, 254-258.

[14] Furness P. A randomized controlled trial of the diagnostic accuracy of internet-based telepathology compared with conventional microscopy. Histopathology 2007; 50, 266-273.

[15]Onega T, Weaver D, Geller B, Oster N, Tosteson AA, Carney P, Nelson H, Allison K, O'Malley F, Schnitt S, Elmore J. Digitized Whole Slides for Breast Pathology Interpretation: Current Practices and Perceptions. Journal of Digital Imaging 2014; 27, 642-648.

[16] Treanor D, Quirke P. The Virtual Slide and Conventional Microscope - a Direct Comparison of Their Diagnostic Efficiency. The Journal of Pathology 2007; 213, 7a.

[17] Velez N, Jukic D, Ho J. Evaluation of 2 whole-slide imaging applications in dermatopathology. Human Pathology 2008; 39, 1341-1349.

[18]Randell R, Ruddle RA, Mello-Thoms C, Thomas RG, Quirke P, Treanor D. Virtual reality microscope versus conventional microscope regarding time to diagnosis: an experimental study. Histopathology 2013; 62, 351-358.

[19] 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, 504-510.

[20] Randell R, Ruddle RA, Thomas R, Treanor D. Diagnosis at the microscope: a workplace study of histopathology. Cognition, Technology & Work 2012; 14, 319-335.

[21]Randell R, Ruddle RA, Thomas RG, Mello-Thoms C, Treanor D. Diagnosis of major cancer resection specimens with virtual slides: impact of a novel digital pathology workstation. Human Pathology 2014; 45, 2101-2106.

[22] Pope C, Ziebland S, Mays N. Analysing qualitative data. In: Pope C, Mays N, eds. Qualitative Research in Health Care. Oxford: Blackwell Publishing/BMJ Books, 2006, p. 63-81.

[23] Jirotka M, Procter R, Hartswood M, Slack R, Simpson A, Coopmans C, Hinds C, Voss A. Collaboration and Trust in Healthcare Innovation: The eDiaMoND Case Study. Computer Supported Cooperative Work (CSCW) 2005; 14, 369-398.

[24] Fine JL, Kagemann L, Wollstein G, Ishikawa H, Schuman JS. Direct scanning of pathology specimens using spectral domain optical coherence tomography: a pilot study. Ophthalmic Surg Lasers Imaging 2010; 41 Suppl, S58-64.

[25] Blizzard R, Ruddle R, Thomas R, Randell R, Treanor D. A longitudinal evaluation of histopathologists' performance using the Leeds Virtual Microscope. 26th European Congress of Pathology. London, 2014.

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