

ORIGINAL ARTICLE

The use of digital imaging, video conferencing, and telepathology in histopathology: a national survey

T Dennis, R D Start, S S Cross

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See end of article for authors' affiliations

Correspondence to:
Dr S Cross, Academic Unit of Pathology, Section of Oncology and Pathology, Division of Genomic Medicine, School of Medicine and Biological Science, University of Sheffield, Beech Hill Road, South Yorkshire S10 2RX, UK; s.s.cross@sheffield.ac.uk

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Aims: To undertake a large scale survey of histopathologists in the UK to determine the current infrastructure, training, and attitudes to digital pathology.

Methods: A postal questionnaire was sent to 500 consultant histopathologists randomly selected from the membership of the Royal College of Pathologists in the UK.

Results: There was a response rate of 47%. Sixty four per cent of respondents had a digital camera mounted on their microscope, but only 12% had any sort of telepathology equipment. Thirty per cent used digital images in electronic presentations at meetings at least once a year and only 24% had ever used telepathology in a diagnostic situation. Fifty nine per cent had received no training in digital imaging. Fifty eight per cent felt that the medicolegal implications of duty of care were a barrier to its use. A large proportion of pathologists (69%) were interested in using video conferencing for remote attendance at multidisciplinary team meetings.

Conclusions: There is a reasonable level of equipment and communications infrastructure among histopathologists in the UK but a very low level of training. There is resistance to the use of telepathology in the diagnostic context but enthusiasm for the use of video conferencing in multidisciplinary team meetings.

Images of tissue viewed through a light microscope form the primary diagnostic medium of histopathology. Histopathology is also a discipline that recognises the importance of consultation with colleagues, expert second opinions, and collective postgraduate education, so that these images are distributed between many different centres. At present, the most common method of sharing images is by sending the glass slides themselves, a system that works satisfactorily in many contexts, but that does not produce live consultation between the sender and the recipient, and may take a few days.

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The electronic capture and distribution of images has been proposed as an alternative, possibly more efficient, system but the feasibility of this has not been fully explored. The operational efficacy of telepathology, video conferencing, and digital imaging in pathology is under evaluation in several different clinical contexts at present.^{1,2} Most of this research has been undertaken in relative isolation, with the result that the introduction of these technologies has been uncoordinated and sporadic. More information is needed on the current availability and use of digital imaging, video conferencing, and telepathology equipment across the UK. This may be particularly relevant if histopathology services are to be delivered via local area networks in the future. More specialised areas of histopathology are already forming national networks to maintain services during the present consultant staffing crisis. These new technologies have the potential to facilitate remote service delivery. A strategic overview of current digital imaging, telepathology, and video conferencing provision would assist feasibility studies of future schemes, and would provide a national assessment of potential training requirements.

Our study sampled a large number of histopathologists in the UK by postal questionnaire to assess the level of equipment, training, and use that currently exists.

METHODS

A postal questionnaire was designed to assess attitudes towards the current availability and future usage of digital imaging, video conferencing, and telepathology equipment in histopathology laboratories across the UK. Five hundred consultant histopathologists, selected at random from the membership of the Royal College of Pathologists, were invited to participate in our study. No reminders were sent. Tables 1 and 2 summarise the questions in the questionnaire.

RESULTS

Two hundred and thirty seven questionnaires were returned completed (overall response rate, 47%). Table 1 shows the responses relating to digital imaging and table 2 shows those relating to telepathology and video conferencing.

Digital imaging

Although most respondents have access to basic digital imaging equipment for both microscopy and macroscopic work, many admitted to being unable to make maximum use of this equipment in their work. Respondents were often unaware of the outputting equipment available within their laboratory and lacked basic knowledge of the methods and processes used in digital image data transmission. The reported use of images in presentations was variable, but many histopathologists with access to digital cameras appeared to use them rarely, if ever, for this purpose. Formal training from equipment suppliers or employing institutions was rare. A high proportion of respondents indicated that training in digital imaging technology would be desirable. Legal concerns regarding the use of digital images were common.

Telepathology/videoconferencing

Many respondents reported exposure to telepathology either by a demonstration at a trade show or in the laboratory. Most histopathologists do not routinely use or have access to a telepathology workstation. Consequently, telepathology was

Table 1 Results of the questions about digital imaging

Question	Answer categories	Response selected (N)	% Of respondents
What digital imaging equipment do you have in your laboratory?	None	28	12%
	Microscope mounted video camera and link to computer	102	43%
	Digital camera for macroscopic photography	171	72%
	Microscope mounted digital camera and link to computer	151	64%
	"Virtual double headed microscope" set up	10	4%
	Commercially produced telepathology workstation	20	8%
	Video conferencing equipment	33	14%
What means of outputting digital images do you have in your laboratory?	None	34	15%
	Colour inkjet printer	154	66%
	Colour laser printer	65	28%
	Dye sublimation printer	11	5%
	35 mm slide maker	51	22%
	Data projector	92	39%
What modes of electronic communication do you have in your laboratory?	None	6	3%
	Modem and ordinary telephone line	100	45%
	T1 (hardwired hospital or university internet connection)	160	71%
	ISDN telephone lines	49	22%
	ASDL telephone lines	2	1%
	Cable network telephone lines	10	4%

never used in daily diagnostic work and was rarely used on a weekly or monthly basis.

Most respondents identified a role for telepathology/video conferencing in facilitating remote attendance at multi-

disciplinary cancer team meetings and educational seminars. Interest was greater in the attendance at educational meetings rather than in the broadcasting of such meetings. There was potential for use in the referral of cases for

Table 2 Results of the questions about telepathology and video conferencing

Question	Answer categories	Response selected (N)	% Of respondents
How much experience do you have in telepathology?	None	71	30%
	Demonstration at trade shows	91	38%
	Demonstration in own laboratory	70	30%
	Email attachment of digital images	85	36%
	Use of full telepathology workstation in other laboratory	13	5%
	Use of full telepathology workstation in own laboratory	17	7%
	How often do you use telepathology in your diagnostic work?	Never	179
Once a year		21	9%
Once a month		26	11%
Once a week		10	4%
Once a day		0	0%
If you had a telepathology facility in your laboratory, what use would you make of it?		None	36
	Referral of cases for expert opinion	128	55%
	Receipt of cases for expert opinion	74	32%
	Referral of cases from cancer unit to cancer centre	74	32%
	Receipt of cases from cancer unit to cancer centre	54	23%
	Remote attendance at multidisciplinary team meeting	140	60%
	Central broadcast of joint multidisciplinary team meetings	68	29%
	Remote attendance at postgraduate education/EQA meetings	103	44%
	Central broadcast of postgraduate education/EQA meetings	50	22%
	Remote reporting of routine cases at another hospital in the same trust	26	11%
	Remote reporting of cases at any hospital	22	9%
Based on your current knowledge of telepathology, indicate any of the following possible disadvantages of telepathology that you feel are important?	Image quality is not sufficiently high to make a secure diagnosis	132	57%
	Cost of equipment is too high to justify purchase	71	31%
	Telepathology takes too long compared with slide and paper referral	91	39%
	Cost of electronic transmission is too high (e.g. ISDN line costs)	29	13%
	Medicolegal implications of duty of care	134	58%
What is your prediction of the use of telepathology in 5 years time?	None, it will have been shown to be a white elephant	6	3%
	Low usage in special situations	70	30%
	High usage by enthusiasts, low usage everywhere else	142	60%
	High usage by all histopathologists in an integrated national network	17	7%
If you had a video conferencing facility in your laboratory, what use would you make of it?	None	41	18%
	Remote attendance at multidisciplinary team meetings	157	69%
	Central broadcast of multidisciplinary team meetings	70	31%
	Remote attendance at postgraduate education/EQA scheme meetings	107	47%
	Central broadcast of postgraduate education/EQA scheme meetings	49	21%

EQA, external quality assurance.

expert opinion but little interest in routine use for remote reporting.

The most commonly expressed concerns over the use of telepathology were those related to medicolegal issues and image quality. Many respondents predicted future high usage by enthusiasts but low usage elsewhere except for special situations. Examples given frequently involved geographical limitations and specialist areas of diagnostic practice.

DISCUSSION

Our study was based on data from a postal questionnaire and the rate of return of these questionnaires was in line with other studies using similar methodology. However, it is possible that participants who have an interest in digital imaging were more likely to return the questionnaires than those who do not, so that the results of our study may represent the maximum amount of interest and infrastructure for digital imaging in the UK.

Most histopathologists appear to have access to basic digital imaging equipment for personal use. This commonly includes macroscopic imaging cameras, microscope mounted cameras, and microscope mounted video cameras. Therefore, it could be expected that the use of digital images in routine practice would be commonplace.³ This survey has revealed that this is not the case. Although other factors may be involved, it is evident that the surprisingly low levels of usage are principally a result of the lack of appropriate training in the use of such technology.

Few histopathologists have been able to access even basic forms of training in digital image technology. Most would appear to be self taught enthusiasts and this is reflected in skill levels that are often restricted to the most basic functions. Even if they are capable of capturing high quality digital images, many histopathologists appear unable to use these data for further applications. Manufacturers have been slow to respond to meet these training needs, and this presumably reflects a lack of demand from many individual and institutional purchasers. The recent expansion of commercial and domestic digital imaging markets is producing change. Some manufacturers have recently introduced product specific training courses.⁴ A relevant educational programme is being developed by the Royal College of Pathologists after a successful recent pilot course. Access to training should not be restricted to medical staff, and relevant skills could usefully be incorporated into extended roles for biomedical scientists. All potential users must be helped to develop the necessary skills and confidence to capture, manipulate, and transmit high quality images efficiently.

Our study highlighted known concerns relating to the legality of various forms of patient related photography. Any uncertainty regarding the lawfulness of digital images captured for use in pathology related applications has been removed with the publication of clear new national guidelines.⁵ These guidelines cover all forms of audio and video recordings with specific reference to pathological material. Consent is not required for images of pathological material from which patients are not identifiable. One additional but unrelated legal consideration arises from the practice of image data manipulation for publication purposes.⁶ The potential for scientific fraud is self evident and may increase with technological advancement. Current guidance suggests that retention of the original captured digital image data file is essential, together with a clear explanation of any subsequent manipulation.⁷

Digital images are currently used in various educational and clinical forums, including regular multidisciplinary cancer team meetings. The use of macroscopic images, particularly those involving complex surgical resection speci-

mens, can greatly facilitate the appreciation of disease distribution and its relation to local resection margins. Relevant digital images can be placed on local or central computer networks, allowing remote access by other healthcare professionals involved in the patient care pathway. The flexibility of digital images has the potential to facilitate the creation of accessible local, national, or international educational resources—a concept that is readily confirmed by visiting appropriate pathology related Internet sites.^{2, 8}

Telemedicine has been defined as “rapid access to shared and remote medical expertise by means of telecommunications and information technologies, no matter where the patient or the relevant information is located”,⁹ or more recently as “the use of telecommunications for medical diagnosis and patient care”.¹⁰ Neither of these definitions does justice to the broad range of possible applications offered by telemedicine for diagnosis, treatment, health education, and research.¹ Telemedicine has been in use for some years and yet the concept still polarises the healthcare profession. Individuals are rarely neutral about it: they are either enthusiastic proponents or vehement opponents.^{11, 12} Histopathologists in our present and previous studies appear to confirm such beliefs.¹³

“Even if they are capable of capturing high quality digital images, many histopathologists appear unable to use these data for further applications”

Histopathologists often incorrectly use the terms telepathology and video conferencing synonymously. High quality video conferencing is available in many stand alone formats. Capital and operational costs are low compared with those for telepathology. Our present study provides further support for a range of applications for video conferencing.¹ Central pathology modernisation initiatives have created much interest in the development of local, regional, and national networks for the delivery of pathology services. Video conferencing is an ideal technology to support communication both within and between such networks. The active nature of this visible medium when combined with its ability to link multiple user sites simultaneously is far superior to email or conventional telecommunication methods. Video conferencing could be used for network administration functions, medical and technical education, quality assurance, and research. Undergraduate medical education could be supported remotely by regular links to home medical schools.

Video conferencing offers potential cost benefits to a range of applications within clinical medicine, including pathology. The development of cancer networks and cancer site specific multidisciplinary teams now requires coordinated input from a wide range of healthcare specialists. These human resources are often limited but could be maximised by remote participation via video conferencing. Physical attendance at multidisciplinary teams is not always necessary to determine patient outcomes. Central multidisciplinary teams for specialised low incidence cancer types often require limited and intermittent input from several distant cancer units. Remote participation could be more efficient with removal of the need to travel.¹

Research into telepathology has been in progress for a decade and various formats are available.^{2, 13} All have inherent problems, yet interest continues to increase worldwide, with a growing consensus regarding acceptable applications, particularly those related to quality assurance and teaching. Our present study confirms the belief of many histopathologists that telepathology remains a technology looking for an application.²

Our study shows that practical experience of telepathology is uncommon among histopathologists in the UK. Consequently, there is an understandable scepticism with regard to the technology and its ability to enhance conventional methods of practice. Capital costs are high and there are considerable reservations regarding time implications, image quality, and the medicolegal implications of providing opinions using telepathology. Many of these fears arise through unfamiliarity with the technology and can be overcome by on site technical assistance combined with protocol driven referral pathways.^{14–15} Image quality is already high and constantly improving, together with the necessary software applications. Virtual slide technology is already in development. Telepathology is already integrated into histopathology services in other countries, despite similar initial reservations.^{14–20} The ultimate role for telepathology in UK histopathology service delivery remains unclear. More evaluation and education are essential before significant resources are directed towards this technology. Defined standards of operation supported by an acceptable evidence base will be mandatory before widespread implementation.¹

“Telepathology is already integrated into histopathology services in other countries, despite similar initial reservations.”

Like video conferencing, telepathology could also serve pathology and cancer networks. Rapid remote initial diagnosis is possible, as is consensus diagnosis for problematic cases. Telepathology offers the possibility of communication with experts about any diagnostic problem. Many referrals to histopathology specialists are undertaken to satisfy national requirements for diagnostic confirmation. These could be processed more efficiently by passive telepathology connections, with consequent savings in time. Telepathology could assist in the national delivery of specialist diagnostic services—for example, neuropathology, ophthalmic, and transplant related pathology. Immediate local access to such specialist services is clearly desirable, and telepathology may be a useful method by which 24 hour access could be maintained with the limited human resources currently available. Instant access to international expertise is also possible.¹⁹ The technology could be used to maintain frozen section services to peripheral units without on site histopathologists.^{18–20} With these potential advantages the uptake of telepathology has been low, with only 12% of respondents in our survey having access to a telepathology system, and 76% never having used a telepathology system. Bamford *et al* report a similar low level of usage in the UK national telepathology network, which they created.²¹ They analysed the factors that led to this low usage and concluded that they were complex but were mainly human, rather than technological. Excessive workloads for pathologists in the UK left little time to learn and use new technologies, and information technology staff did not perceive telepathology systems as part of their remit.²¹

Histopathologists, like most individuals, have had to come to terms with the daily reality of computers, email, and the Internet. Digital image related technology is unquestionably here to stay. Our new challenge is to evaluate, develop, and use these new forms of technology to the benefit of the services that we provide. More input from histopathologists is integral to the success or rejection of these developments. Resources will probably be available for any acceptable forms of technology that not only support proposed models of service delivery but also offer potential for improved efficiency. Video conferencing is already having some impact on the delivery of cancer care through the linking of multi-

Take home messages

- Although there is a reasonable level of equipment and communications infrastructure among histopathologists in the UK there are surprisingly low levels of usage
- Although other factors may be involved, these low levels of usage are principally a result of the lack of appropriate training in the use of such technology
- There is resistance to the use of telepathology in the diagnostic context but enthusiasm for the use of video conferencing in multidisciplinary team meetings

disciplinary team meetings across different centres, and this use will probably expand rapidly in the next five years. Telepathology has great potential for use, but is unlikely to be widely used until the systems become quicker and more user friendly; this might occur when the digitisation of whole slides and “virtual microscopy” become more readily available.^{22–23}

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Authors' affiliations

T Dennis, R D Start, Department of Histopathology, Chesterfield and North Derbyshire Royal Hospital, Calow, Chesterfield S44 5BL, UK
S S Cross, Academic Unit of Pathology, Section of Oncology and Pathology, Division of Genomic Medicine, School of Medicine and Biological Science, University of Sheffield, Beech Hill Road, South Yorkshire S10 2RX, UK

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