

ORIGINAL ARTICLE

Offline telepathology diagnosis of colorectal polyps: a study of interobserver agreement and comparison with glass slide diagnoses

S S Cross, J L Burton, A K Dubé, K M Feeley, P D Lumb, T J Stephenson, R D Start

J Clin Pathol 2002;**55**:305–308

See end of article for authors' affiliations

Correspondence to:
Dr 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;
s.s.cross@sheffield.ac.uk

Accepted for publication
13 November 2001

Background/Aims: Technological advances have produced telepathology systems with high quality colour images and reasonable transmission times. Most applications of telepathology have centred on the remote diagnosis of frozen sections or remote real time expert opinions. This study investigates the reproducibility and accuracy of offline telepathology as a primary diagnostic medium for routine histopathology specimens.

Methods: One hundred colorectal polyps (50 hyperplastic, 50 adenomatous) were presented in a randomised order to five histopathologists as offline images on a telepathology workstation. Six images of each case were used: the slide label, a low power scan of all material on the slide, and four higher magnification views. The times taken to prepare the images, and to make the diagnoses, were recorded. Interobserver agreement was measured with κ statistics and compared with the glass slide diagnoses.

Results: The κ statistics for the interobserver agreement on the telepathology images lay in the range of 0.90–1.00, which is interpreted as excellent agreement, and were significantly higher than those for the glass slide diagnoses (range, 0.84–0.98; $p = 0.001$). The median time taken to capture the images for a case was 210 seconds. The median time taken to make a diagnosis from the telepathology images was five seconds, which was significantly shorter than for the glass slide diagnoses (median, 13 seconds; $p < 0.0005$).

Conclusions: Offline telepathology has the potential to be a primary diagnostic medium for routine histopathology with a high degree of reproducibility and short diagnosis times. Further studies are required to validate offline telepathology for different types of specimens and different operators of the image capture system.

The technical requirements for telepathology have been largely solved by improvements in technology in the past five years.^{1–3} It is now possible to view high quality real time colour images and to control all aspects of a robotic microscope at a remote location.⁴ With the availability of usable telepathology systems there is a need to research the uses that can be made of such systems and the human factors that are important in their use. The initial uses of telepathology centred on real time diagnosis of frozen section material at hospitals that did not have resident histopathologists. It was shown to be a useful method of diagnosis in this setting, but consultations often took as long as 20 minutes for each case.^{5–9} Telepathology systems have been used to obtain real time expert opinions from distant histopathologists, which provides a more immediate opinion and better educational feedback for the referring pathologist, but again takes longer than a conventional glass slide consultation.¹⁰ An alternative modality is offline (also known as static or store and forward) telepathology, where still images are captured and sent to pathologists. This mode of usage has disadvantages, in that the observer cannot control viewing of the specimen,¹¹ but could have advantages of increased speed of the diagnostic process and convenience of use (because both users do not have to be online simultaneously). There have been studies using offline telepathology as a second opinion service for a variety of “difficult” cases, which have shown reasonable degrees of concordance between the telepathology and glass slide diagnoses (~75%).^{12–14} There has been one published study using offline telepathology to make diagnoses in a large series of prostate needle core biopsies, but these cases were all secondary referral consultations.¹⁵ We have not identified any

published studies using offline telepathology as a primary diagnostic modality for routine histopathology specimens.

“Studies using offline telepathology as a second opinion service for a variety of “difficult” cases have shown reasonable degrees of concordance between the telepathology and glass slide diagnoses (~75%)”

We have previously reported an interobserver agreement study on the glass slide diagnosis of colorectal polyps.¹⁶ In our present study, we investigate the interobserver agreement and concordance with glass slide diagnosis of colorectal polyps by five observers using offline telepathology.

MATERIALS AND METHODS

Slides of 50 consecutively received endoscopically resected colorectal polyps originally reported as hyperplastic polyps and 50 consecutively received colorectal polyps originally reported as tubular, villous, or tubulovillous adenomas were retrieved from the files of the department of histopathology, Royal Hallamshire Hospital from the beginning of April 1998. Serrated adenomas were not represented in this series. There was a single haematoxylin and eosin stained slide for each case. By chance, exactly 50 of each type were received during the same time period.

Three observers were histopathology consultants and two were trainees working in the department of histopathology, Royal Hallamshire Hospital. The length of time that each had spent in histopathology was recorded. Each observer was given the 100 glass slides in the order in which they were

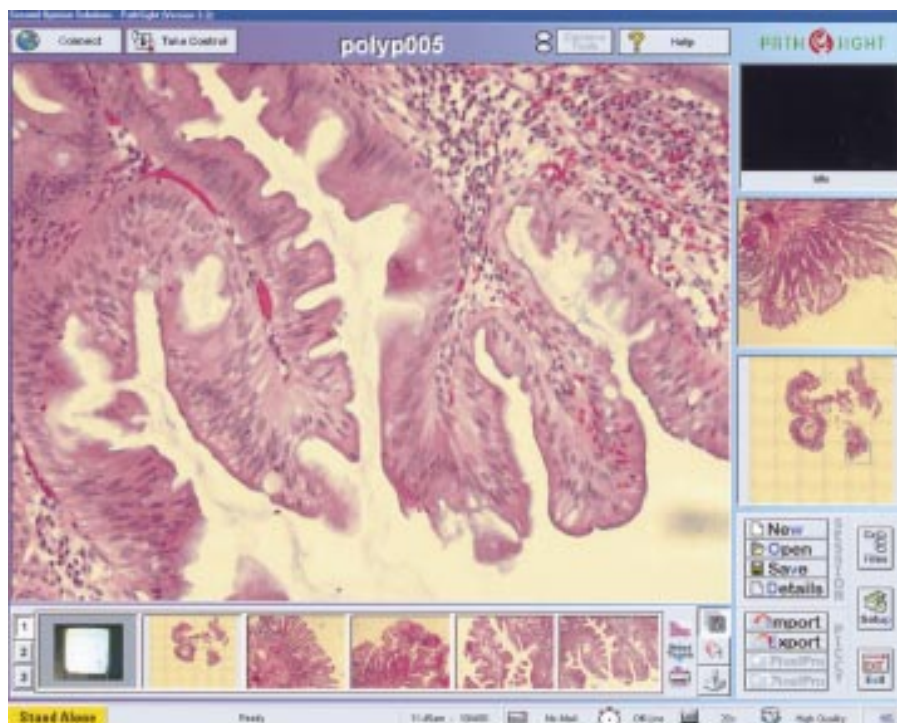


Figure 1 The screen of the telepathology workstation with a case loaded. The six images are displayed as thumbnails at the bottom of the screen and can be dragged and dropped into the main window (here shown with a higher power view of the polyp epithelium). The locations of the higher power views are displayed dynamically on the low power image at the right side of the screen.

received in the laboratory. The observer was asked to assign each polyp to the category of hyperplastic or adenomatous after light microscopic examination, but to make no other assessment (such as grade of dysplasia). The observers were asked to carry out the assignment as accurately as possible. The time taken for each observer to make each diagnosis was recorded.

Eighteen months after the glass slide observations the polyps were presented to the observers as offline telepathology images. The images were captured and presented using a telepathology workstation (PathSight, Fairfield Imaging Limited, Tunbridge Wells, Kent, UK). The images were stored in the Joint Photographic Experts Group (JPEG) format,¹⁷ with a compression ratio of 26 : 1, at a resolution of 1024 by 768 pixels, in 24 bit red green blue colour. The images were displayed on an 18 inch flat panel monitor in normal office ambient lighting conditions. The images were captured by a consultant histopathologist, who was not an observer in the study, using a set protocol. For each case, six images were produced—a macroscopic view of the slide label (to confirm the identity of the case), a low power scan of all the material on the slide, two images of the polyp epithelium using a $\times 2.5$ objective lens, and two images of polyp epithelium using a $\times 10$ objective lens. Each case was saved as a separate session. On loading a session into the telepathology system the six images appeared as thumbnail versions at the bottom of the screen and could be displayed at full size in the main viewing window by a drag

and drop action with the computer's mouse (fig 1). A window on the right side of the screen displayed the position of each higher magnification image on an image of the whole scanned specimen. The order of presentation was randomised. None of the observers had any experience of telepathology. Each was given a single 15 minute training session using 10 additional cases. The diagnostic category assignment was identical to the glass slide observations and the time taken to process each case, from the start of loading a session to the written diagnosis, was recorded.

The agreement between all the observers on glass slides and offline telepathology images and the consensus diagnoses were assessed using κ statistics with 95% confidence intervals.¹⁸

RESULTS

The results are summarised in tables 1 to 4. The median time taken to produce the offline telepathology images of each case was 210 seconds (range, 112–478). The times taken to make the diagnoses on the offline telepathology images (table 1) were significantly shorter than the times taken to make the diagnoses on the glass slides (Mann-Whitney U test, $p < 0.0005$). The κ statistics for the interobserver agreement on the offline telepathology images were significantly higher than those for the interobserver agreement on the glass slides (Mann-Whitney U test, $p = 0.001$). For the glass slide diagnoses, 90 cases had a unanimous consensus diagnosis, six

Table 1 Histopathology experience of the observers and the time taken to make diagnoses on the glass slides and offline telepathology images

	Histopathology experience at time of telepathology diagnoses (months)	Median time taken to make glass slide diagnosis (seconds)	Median time taken to make telepathology diagnosis (seconds)
Observer 1	72	13	5
Observer 2	223	13	4
Observer 3	40	25	4
Observer 4	54	13	6
Observer 5	72	17	5

Table 2 κ Statistics (with 95% confidence intervals in parentheses) for the interobserver agreement on the glass slides

	Observer 1	Observer 2	Observer 3	Observer 4	Observer 5	Consensus diagnosis
Observer 1		0.88 (0.79 to 0.97)	0.88 (0.79 to 0.97)	0.84 (0.73 to 0.95)	0.98 (0.94 to 0.99)	0.92 (0.84 to 0.99)
Observer 2			0.92 (0.84 to 0.99)	0.88 (0.79 to 0.97)	0.90 (0.81 to 0.99)	0.96 (0.90 to 0.99)
Observer 3				0.96 (0.90 to 0.99)	0.90 (0.81 to 0.99)	0.96 (0.90 to 0.99)
Observer 4					0.86 (0.76 to 0.96)	0.92 (0.84 to 0.99)
Observer 5						0.94 (0.87 to 0.99)
Consensus diagnosis						

Table 3 κ Statistics (with 95% confidence intervals in parentheses) for the interobserver agreement on offline telepathology images

	Observer 1	Observer 2	Observer 3	Observer 4	Observer 5	Consensus diagnosis
Observer 1		0.98 (0.94 to 0.99)	1.00	0.92 (0.84 to 0.99)	1.00	1.00
Observer 2			0.98 (0.94 to 0.99)	0.90 (0.81 to 0.99)	0.98 (0.94 to 0.99)	0.98 (0.94 to 0.99)
Observer 3				0.92 (0.84 to 0.99)	1.00	1.00
Observer 4					0.92 (0.84 to 0.99)	0.92 (0.84 to 0.99)
Observer 5						0.92 (0.84 to 0.99)
Consensus diagnosis						

Table 4 κ Statistics (with 95% confidence intervals in parentheses) for the intraobserver agreement for the diagnoses made on glass slides and offline telepathology images

Observer 1	0.98 (0.94 to 0.99)
Observer 2	0.88 (0.79 to 0.97)
Observer 3	0.90 (0.81 to 0.99)
Observer 4	0.86 (0.76 to 0.96)
Observer 5	1.00
Consensus diagnosis on glass slides and telepathology images	0.94 (0.87 to 0.99)

had a 4 : 1 majority consensus, and four had a 3 : 2 majority consensus. For the offline telepathology diagnoses, 96 cases had a unanimous consensus diagnosis and four had a 4 : 1 majority diagnosis.⁶

DISCUSSION

Our study shows that, in the restricted diagnostic domain examined, the skills required to use offline telepathology are learnt very quickly (in 15 minutes), that diagnoses from offline images can be made quickly (median time, five seconds), and are highly reproducible (range of κ statistics for interobserver agreement, 0.90–1.00). These results are for a restricted domain with only two discrete categories with no other considerations (which in colorectal polyps could include grade of dysplasia, completeness of excision, and absence/presence of stalk invasion). They are thus likely to represent the maximum level of performance, in terms of reproducibility and speed, that can be obtained using an offline telepathology system, but because the level of performance is so high, this suggests that there is considerable potential for offline telepathology as a diagnostic medium in histopathology.

The results of our study also give an insight into the diagnostic process in this domain. The short time taken to make the diagnosis by offline telepathology (median, five seconds, including verification of case identity and written diagnosis) suggests that the diagnosis is made by pattern recognition rather than heuristic algorithms,¹⁹ which is to be expected because the system contains only two discrete diagnostic

categories.²⁰ The finding that the κ statistics for interobserver agreement on the offline telepathology images were significantly higher than for the glass slide diagnoses suggests that the process of examining the glass slide has more potential for sampling error than offline telepathology images captured by an experienced histopathologist. When examining a glass slide, a histopathologist has to move the microscope stage to look at all the material on a slide because this cannot be seen in a single field of view for any sizeable specimen. Sampling error can be introduced if the histopathologist does not look at all the material, either by choice or by lack of feedback as to which areas have been viewed during the process. The pathologist then has to select areas within a specimen to examine at higher magnification to discern further information, such as the type of epithelium in colorectal polyps. The offline telepathology images in our study eliminated sampling error at the lowest magnification by scanning all the material with a $\times 2.5$ objective lens and constructing a composite registered image. The sampling at higher magnification was made by an experienced consultant histopathologist and therefore might provide more reproducible sampling than that of less experienced trainees. The restrictive sampling of the offline images could give a higher degree of interobserver agreement than glass slide diagnosis but a lower degree of accuracy if misleading areas were selected for higher magnification examination.^{15 21} However, our study included only hyperplastic and adenomatous polyps (no serrated adenomas were present), and because the epithelium in these diagnostic categories is distinctive, it is unlikely that misleading images could be selected.

“The process of examining the glass slide has more potential for sampling error than offline telepathology images captured by an experienced histopathologist”

The high degrees of reproducibility and speed of diagnosis in our study suggest that offline telepathology is a feasible medium for routine diagnostic histopathology, but further work is required to refine the protocols for working in such an environment. The time taken to capture the images for each case was not excessive (median, 210 seconds) but was carried out by a consultant histopathologist who could have made the diagnoses on glass slides in the same length of time as the observers in the study (median, 13 seconds), so there would be

Take home messages

- Offline telepathology has the potential to be a primary diagnostic medium for routine histopathology because the skills can be learnt very quickly and it has a high degree of reproducibility with short diagnosis times
- There are several situations where offline telepathology would be very useful—for example, the double reading of slides and when there is no histopathologist available to provide a diagnostic service
- Further studies are required to validate offline telepathology for different types of specimens and different operators of the image capture system

no justification for using this methodology where a consultant histopathologist was available to make the primary diagnosis. However, there are other situations where offline telepathology could be useful. In several countries at present, especially the UK, there is a severe shortage of trained histopathologists and there are hospitals with few or no histopathologists to provide a diagnostic service. This problem could be ameliorated by sending glass slides to services with adequate histopathologists, but this study suggests that offline telepathology could be used as a faster, and possibly more accurate, alternative. In such a system the images would be produced by a trained technician in the originating laboratory, rather than a consultant histopathologist as in our study, who would follow a well defined protocol for each type of specimen. There would not be any change in the quality of the low power scan of all the material on the slide with a non-histopathologist operator, but there could be a less directed sampling of images at higher magnification. This needs to be investigated in further studies. If sampling at higher magnifications by a technician, rather than a histopathologist, does produce less accuracy on a single set of offline images, then a further iteration could be added—histopathologists would annotate areas on the low power scan which they wished to view at higher power and return these to the originating laboratory for further image sampling. Another area where offline telepathology could play a role in diagnostic histopathology is the referral of cases to specialist centres for treatment where there is no uncertainty about the histopathology diagnosis, but where confirmation is required at the receiving centre, perhaps with discussion at a multidisciplinary team meeting, such as in the Calman-Hine model of cancer services that is used in the UK.²³ In this context, a consultant histopathologist in the referring hospital could prepare offline telepathology images that could be viewed by pathologists in the receiving hospital and shown at meetings. With diagnostic errors in histopathology receiving more attention by regulatory bodies and in the media,²⁵ there is discussion of double reading of slides, such as occurs in some areas of radiological practice.²⁴ Such double reading would effectively double the work of histopathologists if carried out using glass slides, but this increase in work could be minimised by the use of offline telepathology images, which could be captured during the initial glass slide examination by the first pathologist.

ACKNOWLEDGEMENTS

We are grateful for the financial assistance of the medical charity NEDSCAN, which funded the purchase of the telepathology system at Chesterfield Royal Hospital.

Authors' affiliations

S S Cross, J L Burton, 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

P D Lumb, Academic Unit of Forensic Pathology, University of Sheffield
A K Dubé, K M Feeley, T J Stephenson, Department of Histopathology, Royal Hallamshire Hospital, Sheffield Teaching Hospitals NHS Trust, Glossop Road, Sheffield S10 2UL, UK

R D Start, Department of Histopathology, Chesterfield Royal Hospital NHS Trust, Calow, Chesterfield S44 5BL, UK

REFERENCES

- 1 **Sowter C**, Wells CA. Telepathology: assessment of the implications and applications of telepathology for practical diagnostic pathology. *J Clin Pathol* 1998;**51**:714–15.
- 2 **Leong FJW-M**, Graham AK, Gahm T, et al. Telepathology: clinical utility and methodology. In: Lowe D, Underwood JCE, eds. *Recent advances in histopathology 19*. Edinburgh: Churchill Livingstone; 1999;217–39.
- 3 **Wells CA**, Sowter C. Telepathology: a diagnostic tool for the millennium? *J Pathol* 2000;**191**:1–7.
- 4 **Zhou J**, Hogarth MA, Walters RF, et al. Hybrid system for telepathology. *Hum Pathol* 2000;**31**:829–33.
- 5 **Nordrum I**, Engum B, Rinde E, et al. Remote frozen section service—a telepathology project in northern Norway. *Hum Pathol* 1991;**22**:514–18.
- 6 **Agha Z**, Weinstein RS, Dunn BE. Cost minimization analysis of telepathology. *Am J Clin Pathol* 1999;**112**:470–8.
- 7 **Dawson PJ**, Johnson JG, Edgemon LJ, et al. Outpatient frozen sections by telepathology in a Veterans Administration Medical Center. *Hum Pathol* 2000;**31**:786–8.
- 8 **DeYoung BR**, Niemann TH, Hitchcock CL. Using telepathology to assess frozen sections of breast lesions. *Am J Clin Pathol* 2000;**114**:91.
- 9 **Wellnitz U**, Fritz P, Voudouri V, et al. The validity of telepathological frozen section diagnosis with ISDN-mediated remote microscopy. *Virchows Arch* 2000;**437**:52–7.
- 10 **Dunn BE**, Almagro UA, Choi HY, et al. Dynamic-robotic telepathology: department of veterans affairs feasibility study. *Hum Pathol* 1997;**28**:8–12.
- 11 **Della M**, Cataldi P, Boi S, et al. Image sampling in static telepathology for frozen section diagnosis. *J Clin Pathol* 1999;**52**:761–5.
- 12 **Halliday BE**, Bhattacharyya AK, Graham AR, Davis JR, et al. Diagnostic accuracy of an international static-imaging telepathology consultation service. *Hum Pathol* 1997;**28**:17–21.
- 13 **Eusebi V**, Foschini L, Erde S, et al. Transcontinental consults in surgical pathology via the Internet. *Hum Pathol* 1997;**28**:13–16.
- 14 **Dietel M**, Nguyen-Dobinsky TN, Hufnagl P. The UICC Telepathology Consultation Center—a global approach to improving consultation for pathologists in cancer diagnosis. *Cancer* 2000;**89**:187–91.
- 15 **Weinstein MH**, Epstein JI. Telepathology diagnosis of prostate needle biopsies. *Hum Pathol* 1997;**28**:22–9.
- 16 **Cross SS**, Betmouni S, Burton JL, et al. What levels of agreement can be expected between histopathologists assigning cases to discrete nominal categories? A study of the diagnosis of hyperplastic and adenomatous polyps. *Mod Pathol* 2000;**13**:941–4.
- 17 **Marcelo A**, Fontelo P, Farolan M, et al. Effect of image compression on telepathology—a randomized clinical trial. *Arch Pathol Lab Med* 2000;**124**:1653–6.
- 18 **Cross SS**. Kappa statistics as indicators of quality assurance in histopathology and cytopathology. *J Clin Pathol* 1996;**49**:597–9.
- 19 **Underwood JCE**. *Introduction to biopsy interpretation and surgical pathology*, 2nd ed. London: Springer-Verlag, 1987.
- 20 **Cross SS**. Grading and scoring in histopathology. *Histopathology* 1998;**33**:99–106.
- 21 **Weinstein RS**, Bhattacharyya AK, Graham AR, et al. Telepathology: a ten-year progress report. *Hum Pathol* 1997;**28**:1–7.
- 22 **Expert Advisory Group on Cancer to the Chief Medical Officer of England and Wales**. *A policy framework for commissioning cancer services*. Department of Health, 1995.
- 23 **Foucar E**, Foucar MK. Error in anatomic pathology. http://www.ajcp.com/special_article.html. Accessed on 10th April 2001.
- 24 **Kopans DB**. Double reading. *Radiol Clin North Am* 2000;**38**:719–24.



Offline telepathology diagnosis of colorectal polyps: a study of interobserver agreement and comparison with glass slide diagnoses

S S Cross, J L Burton, A K Dubé, et al.

J Clin Pathol 2002 55: 305-308

doi:

Updated information and services can be found at:

<http://jcp.bmj.com/content/55/4/305.full.html>

References

These include:

This article cites 20 articles, 2 of which can be accessed free at:

<http://jcp.bmj.com/content/55/4/305.full.html#ref-list-1>

Article cited in:

<http://jcp.bmj.com/content/55/4/305.full.html#related-urls>

Email alerting service

Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Topic Collections

Articles on similar topics can be found in the following collections

[Histopathology](#) (87 articles)

[Cancer: small intestine](#) (20 articles)

Notes

To request permissions go to:

<http://group.bmj.com/group/rights-licensing/permissions>

To order reprints go to:

<http://journals.bmj.com/cgi/reprintform>

To subscribe to BMJ go to:

<http://group.bmj.com/subscribe/>