#### A Pilot Study Comparing Resident's Performance Using Digital and Glass Slides for the Royal College of Physicians and Surgeons of Canada Certification Examination in Anatomical Pathology

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Running Title: Digitizing the Canadian Royal College Examination in Pathology

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#### Abstract

Digital Pathology is an evolving niche in clinical practice. Moreover, using digital images for examination purposes offers many advantages including wider case selection, easier handing and eliminating the need to carry the microscope to the examination. The Anatomical Pathology Examination Board of the Royal College of Physicians and Surgeons of Canada is contemplating fully digitizing the Pathology certification examinations. To evaluate the feasibility of a digital examination, a pilot study was performed comparing diagnostic performance of pathology residents across Canada on glass vs. digital slides. The performance of senior residents was compared when using glass slides (2 minutes/slide) vs. digital slides (2 vs. 3 minutes /slide). 50% of residents from each program performed the glass slide portion of the test and the remaining 50% completed the test using an identical digital version of the same set. An online survey was completed by all residents. The mean score was 4% higher when glass slides were used compared to digital images. However, this was not statistically significant (p=0.312). There was no apparent advantage of the additional time for the digital slides. Survey showed the majority of residents express concerns towards digitizing the examination, especially with the low current level of exposure to digital slides during training. A number of advantages of digital examination were acknowledged by the residents. The results of the test and the survey indicated that performance in a digital setting is comparable to glass slides and that more training might be needed before the idea is fully implemented.

#### Key words:

Pathology; informatics; digital pathology; Royal College Certification; whole scan slides,

Pathology residents; telepathology.

#### Non-standard abbreviations:

**PGY :** Post graduate year (of training)

**AP:** Anatomical Pathology

**GP:** General Pathology

RCPSC: Royal College of Physicians and Surgeons of Canada

#### Introduction

The evolution of information technology has revolutionized the practice of pathology. After many years of traditional glass slide-based practice, we are stepping into a new era of digital images and telepathology [1]. Digital pathology can be defined as an image-based information environment enabled by computer technology that allows for the management of information generated from a digital slide. Digital pathology is enabled in part by virtual microscopy, which is the practice of converting glass slides into digital slides that can be viewed, managed, and analyzed [2,3]. The range of applications of digital pathology is wide and includes primary diagnosis, intraoperative and remote consultation through telepathology [1,4-6], quality assurance, archiving, education and conferences, examinations, automated image analysis, research and publications [1,7].

Traditionally, education and training in pathology have been delivered using glass slides and conventional microscopy. Recently, there has been a gradual switch to digital images and web-based pathology resources at the different levels of medical education from medical students to residents [8]. Whole slide imaging technology allows glass slides to be scanned and viewed on a computer screen at different magnifications as an exact replica of the glass slide. This has created enormous opportunities in pathology training and education [9]. Several major initiatives are also underway introducing online competency and diagnostic decision analysis using virtual microscopy and have important future roles in accreditation and recertification [10].

For examination purposes, replacing glass with digital whole scan images offers a number of advantages including a wider range of case selection and the availability of rare cases and small biopsy specimens where it is difficult to obtain multiple identical copies for a glass-based examination. It also allows easier handling and storage, and ensures uniformity of the examination for all candidates. Furthermore, it eliminates the need to carry a microscope to the examination center. There are, however, challenges experienced with digital pathology in general, including quality of images [11], ease of navigation, and the unfamiliarity of many pathologists and pathology residents with the technology [1,12]. Another concern is the authenticity of digital images and the ability to alter their details [11,13,14].

Anatomical Pathology (AP) residency training in Canada is a 5-year program with 4 years devoted to pathology. Training is mainly through the traditional approach of shadowing an attendant pathologist in evaluating glass slides using conventional light microscopes. There is variable exposure to digital pathology among different centers. At the end of training, residents are required to successfully pass the Royal College of Physicians and Surgeons of Canada (RCPSC) Certification Examination to obtain license for independent practice as a specialist. In the past, the practical component of the examination involved assessment based entirely on glass slides. Recently, certain components of the examination, including oral discussion slides, gross pathology and cytopathology are administered through digital whole scan images. Looking forward to the future, the Examination Board of the Anatomical Pathology Royal College Examination is currently contemplating fully digitizing the examination, including the glass slide diagnostic component.

Before implementing this major change, it is of prime importance to test the efficiency of this new system and to fully understand the needs, concerns and reaction of the examination candidates towards this emerging technology. In the current study, we performed a pilot test for senior residents to assess their performance using glass slides compared to digital images, and measure the optimal time needed for diagnosis of digital whole scan images. We also analyzed their reaction, needs, concerns, and expectations through a post-test questionnaire.

#### **Subjects and Methods**

#### Subjects

The pilot slide examination was performed by Canadian residents in their final years of training (postgraduate year 4-5). Participating residents were from 7 accredited Anatomical Pathology training programs across Canada including University of Toronto, McMaster University, University of Calgary, Dalhousie University, Western University, University of British Columbia, University of Montreal and Memorial University of Newfoundland. The study was approved by the research Ethics Committee of St. Michael's Hospital. The first survey was offered to Anatomical Pathology residents in all years of training (PGY1-5). A second, post-test survey was offered to residents who participated in the pilot examination.

#### The pilot examination

We compared resident diagnostic performance using glass slides (2 minutes/slide) vs. digital whole scan images (2 vs. 3 minutes/slide). 50% of senior residents from each program

performed the glass slide portion of the test and the remaining 50% from the same program performed the test using a digital version of the identical set of slides.

All patient information was removed from the slides. The examination was administered under the supervision of a staff pathologist and digital whole scan slides were accessible through a central server. Participating residents from each center were randomized to the arms of the study. Examination style glass slides were obtained from participating examination board members and were randomized for each section by the study coordinator. Case variety included resections in addition to biopsy specimens. The slide selection included a variety of cases representing the range of subspecialties of Anatomical pathology.

For the digital part of the study, a total of 24 digitalized slides, scanned at 40 X resolution using an Aperio slide scanner, were uploaded on a University of Calgary server together with an answer sheet that requests the participating resident to provide the most probable diagnosis for each slide. Only one answer was allowed for each slide. The slides were divided into two groups; A) 12 slides with two minutes allocated for each slide for a total duration of 24 minutes, and B) 12 slides with three minutes allocated for each slide, for a total duration of 36 minutes. The total duration of the digital test was 60 minutes.

For the glass slide portion of the test, a total of 24 slides were used, identical to the two groups of slides in the digital portion of the test. Each slide was allocated the standard two minutes for diagnosis. Exact replica re-cuts were processed from each slide and distributed to all the contributing centers across Canada.

#### Statistical analysis

Analyses of results for the pilot test were conducted using SPSS Version 21 for Macintosh. Differences between groups were assessed with unpaired t-tests and P value <0.05 was considered to be statistically significant.

#### The online survey

The online survey consisted of 18 questions of different formats. The requested answers were in the form of yes/no, multiple choice questions, and free text questions. A copy of the questionnaire is included in **Supplementary Document 1.** A second part of the survey was only accessible to residents who performed the pilot test.



#### Results

#### **Results of the pilot test**

The test was performed using 24 glass slides and an identical set of 24 digital whole scan images. Fifty percent of participating residents from each center performed the glass slide portion of the test and the remaining fifty percent performed the digital part. In each category the slides were divided into two groups A and B, each consisting of 12 slides. For the glass slide portion; the slides in both groups A and B were allocated the standard two minutes /slide for diagnosis. With regards to the digital portion, slides in group A were allocated two minutes/ slide and slides in group B were allocated three minutes / slide. Half of the participating residents from each program underwent the glass slide portion (Each resident reviewed the entire set of 24 slides) and the other half underwent the digital portion of the test (Each resident reviewed the identical set of 24 slides). Details of the examination results are shown in **Supplementary Table 1**.

As shown in **Table 1**, for the "A" group of slides, 24 residents completed the exam using glass slides. The average score was 61%. The same slides were interpreted in digital format by a different group of 26 residents with an average score of 57%. The difference was non-significant (t-test, p=0.312). For the "B" group of slides, 25 residents completed the exam using glass slides with an average score of 78%. The same slides were interpreted in digital format by 25 different residents with an average score of 74%. Again the significance was non-significant (t-test, p=0.207). Performance was comparable between the different centers.

Although for both the A and B groups of slides there were no significant differences in the digital and glass slide interpretation scores, it is interesting to note that in both groups

the mean score was 4% higher when glass slides were used compared to digital slides. As the groups differed in the time allotted for the interpretation of the digital slides (two minutes per slide for group "A" and three minutes per slide for group "B") there was no apparent advantage in allowing candidates the additional time with the whole slide scan (P=0.989).

#### **Examination feedback**

When the senior residents were asked about their feedback with regards to the digital portion of the pilot test; 80% of the participants felt more comfortable with glass slides compared to digital whole scan images in examination settings, while 15% had no preference (**Supplementary Figure 1**). 50% felt that three minutes were necessary for diagnosis of biopsy specimens, and 65% felt that three minutes are only needed for sections of large resection specimens. The majority of residents (95%) reported encountering problems during the digital portion of the test; namely software functioning too slowly, image blurring and poor detail of images, and nuclear features being unsatisfactory.

#### **Survey results**

75% of residents participating in the survey were in their final years of training (PGY 4-5). 50% of all residents were rarely /never exposed to digital whole slide images throughout their training (**Figure 1a**). Most of that exposure was during academic half days and in house exams (60% of residents). None of the residents were exposed to digital whole scan slides on a daily basis for routine sign out purposes (**Figure 1b**).

At all levels of training, when residents were asked about their comfort level regarding glass slides vs. digital whole scan images, 20% of residents stated that they were very uncomfortable with using digital whole scan images, whereas 10 % were very

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comfortable with using digital whole scan images. The majority of residents, however, were undecided ( **Figure 2**).

The main advantages and disadvantages of digital whole scan images, as perceived by the residents in the survey are summarized in **Box 1.** When comparing the overall advantages and disadvantages of digital whole scan images and glass slides, participants felt that the use of glass slides for routine pathology practice is more cost-effective than digital whole scan images. The majority of residents agreed that it is much faster (90%), and easier (80%) to navigate through glass slides as compared to digital whole scan images. 65% of residents felt that glass slides are more practical to use during training and in preparation for real life practice and 75% stated that the quality of images will be better using glass slides, especially for cytology cases. Anticipated advantages of digital whole scan images include easier transfer between centers for consultation purposes, conservation of storage space and for examination purposes, it surpasses the need to carry a microscope to the exam (**Figure 3**).

In preparation for the Royal College Exam; 100% of residents agreed that additional training is necessary to be familiar with digital imaging, 90% of those residents suggested that in house exams should be digitized starting at the PGY-1 level. 45 % of residents suggested that a one month rotation in digital pathology could also help in familiarizing residents with digital whole slide scans.

When asked about their feedback with regards to digitizing the Royal College Examination, 50% were not in favor, 20% were undecided, and 30% were in favor. If the Royal College Examination is to be digitized, 85% of residents suggested that the idea should be gradually implemented over at least 2-3 years.

#### Discussion

The results of our pilot test showed that the mean score was 4% higher when glass slides were used. However, this was not statistically significant (p= 0.312). This is in keeping with recent literature indicating that for diagnostic purposes, digital whole scan images are of comparable efficiency to glass slides [2,8,15,16]. There were no apparent advantages in allowing candidates the additional time with the digital whole scan images (3 minutes vs. 2 minutes). Interestingly, while results showed that performance is comparable between glass slides and whole scan images, the survey showed the majority of residents express concerns towards the idea of digitizing the Royal College Examination. This reflects the need for more communication and evidence-based discussions about the digital examination. The lack of understanding of the nature and limitations of digital pathology was highlighted as important challenge in previous studies [8,12].

The residents who underwent the digital portion of the examination faced a number of challenges. They had issues with uploading the slides and changing resolutions. The images were in some cases blurry and nuclear features were not appreciated. Some had difficulty navigating through the entire slides and felt that they were missing important diagnostic features. One resident was unable to take the examination because the system froze and he/she was not able to upload the slides. Many of the issues related to resolution are vanishing as the technology improves [17-19].

Our study highlights the need to enhance the level of exposure to digital whole slide scanned images during training. Additional training through digitizing in house examinations or through dedicating a month for digital training were thought to be important preparatory steps. A number of pathology informatics rotations are now in place in different countries including USA and Canada [20-22].

The use of digital pathology for educational purposes is not unprecedented. There are a growing number of digital pathology initiatives that are now being pursued. About a third of US medical schools have incorporated digital whole scan images into their pathology training with promising results [23]. Moreover, the USA Pathology Board examination is partially administered through digital slides [24].

Another important challenge that was highlighted in the survey is the balance between focusing on developing the skills or real life practice as independent pathologists (which is mainly glass slide practice) and the need to develop the skills to successfully pass the certification examination (through digital training). Although digital whole scan images are currently emerging as tools for consultation, education, quick section consults; most reports suggest that they are not ready yet for routine pathology sign out in Canada. More studies are needed to investigate if a digital-based examination can compromise the diagnostic ability of the pathology residents. Alternative approaches include a partially digital and partially glass slide-based examination.

A recent survey showed that the attitudes of pathologists and residents toward digital pathology in Canada are positive [11], especially for consultation type applications (frozen section or second opinion). However, this study also showed that only 25% of practicing pathologists were in favor of a fully digital certification examination.

In conclusion, our results show a comparable performance between glass slides and digital whole scan images for examination purposes. It also highlights a number of concerns that need to be carefully addressed before implementing the technology. The need for more training was a significant issue raised by our participants. A gradual switch to a fully digital examination can be considered so that residents are more comfortable with using the technology [25]. On the other hand, the study also highlights many of the advantages of a digital examination and shows that with adequate training, the idea of digitizing the Royal College Examination for pathologists might not be far beyond reality.

#### Box 1. The main advantages and disadvantages of digital whole scan images, as stated

by the residents in the survey.

#### Advantages

- Flexibility of exchange of material between centers
- Conservation of storage space
- Better quality of images (no fading slides)
- Rare cases become available for examination purposes

• No need to carry a microscope to the examination

#### Disadvantages

- Additional training is necessary
- High cost of processing
- Inappropriate for cytology cases
- More time is required to examine cases
- Poor nuclear details
- Technical difficulties

**Table 1**. Comparison of the performance of residents on glass slides and digital whole scan

 images.

	12 Glass slides	12 digital slides	12 digital slides	<i>p</i> value
	(2 minutes/slide)	(2 Minutes /slide)	(3 Minutes /slide)	
Group A	61%	57%	NA	0.312
Group B	78%	NA	74%	0.207

	Glass s	lides		Digi	tal slide	S
Center A	ID	A <sup>1</sup>	$B^1$	ID	A <sup>1</sup>	B <sup>1</sup>
	1	11	8	9	8	9
	2	2	8	10	7	10
	3	8	8	11	8	8
	4	8	11	12	4	9
	5	11	9	13	6	8.5
	6	0	9	14	7	8
	7	5	6			
	8	9	11			
Centre B	ID	A	B <sup>1</sup>	ID	A	B <sup>1</sup>
	1	8	10.5	3	7	6.5
	2	6	10	4	2	5
				5	4	6
Centre C	ID	A	B <sup>1</sup>	ID	A <sup>1</sup>	B
	1	9	12	4	9	11
	2	5	11	5	6	**
	3	5	8	6	10	10
Centre D	ID	$A^1$	B <sup>1</sup>	ID	A <sup>1</sup>	B <sup>1</sup>
	1	5	7	4	10	7
	2	7	11	5	9	9
	3	6	10	6	4	9

#### Supplementary Table 1. Examination results stratified by resident in both groups.

				7	4	7
Centre E	ID	A <sup>1</sup>	B <sup>1</sup>	ID	A	B <sup>1</sup>
	1	8	11	3	6	9
	2	7	12	4	5	10
				5	7	12
Centre F	ID	$A^1$	$B^1$	ID	A <sup>1</sup>	B <sup>1</sup>
	1	10	9.5	6	4.5	10
	2	11	11	7	11	11
	3	9	9.5	8	9	9.5
	4	5	8.5	9	8	10
	5	6.5	8.5	10	6.5	10
Centre G	ID	A <sup>1</sup>	B <sup>1</sup>	ID	A <sup>1</sup>	B <sup>1</sup>
	1	6	4.5	3	7	9.5
	2	8	8	4	8	8

\*\* resident was not able to upload slides and therefore had a score of zero

1. Results are displaced as total number of correct diagnosis out of 12 cases in each

group.

#### **Figure legends**

**Supplementary Figure 1. Residents' level of comfort in using glass vs. digital slides.** The majority of residents felt more comfortable with glass over digital whole scan slides for examination purposes.

**Figure 1. Residents' exposure to digital pathology during training. (A)** Frequency of exposure to digital pathology as reported by residents in the survey. Almost half of the residents are rarely/never exposed to digital whole scan slides during residency training. **(B)** The different aspects of digital pathology exposure during residency. Most exposure occurred during academic half days and in-service examinations.

**Figure 2.** Figure showing that only 10% of residents are very comfortable with whole scan slides.

**Figure 3**. Comparison between the advantages and disadvantages of glass slides VS. whole scan images as reflected by the residents who participated in the survey.

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#### Disclaimer : None

#### Previous presentations: None



Residents' exposure to digital pathology during training. (A) Frequency of exposure to digital pathology as reported by residents in the survey. Almost half of the residents are rarely/never exposed to digital whole scan slides during residency training. 171x120mm (96 x 96 DPI)



Residents' exposure to digital pathology during training. (B) The different aspects of digital pathology exposure during residency. Most exposure occurred during academic half days and in-service examinations.  $171 \times 112 \text{mm}$  (96 x 96 DPI)



Figure 2 Figure showing that only 10% of residents are very comfortable with whole scan slides.  $171 \times 140 \text{ mm}$  (96 x 96 DPI)



Comparison between the advantages and disadvantages of glass slides VS. whole scan images as reflected by the residents who participated in the survey. 171x834mm (96 x 96 DPI)



. Residents' level of comfort in using glass vs. digital slides. The majority of residents felt more comfortable with glass over digital whole scan slides for examination purposes. 171x106mm (96 x 96 DPI)

*1.	What is your year of training?
O F	PGY 1
O I	PGY 2
O I	PGY 3
O I	PGY 4
0	PGY 5
*2.	How often do you use digital whole slide images in your training?
0	Daily
0 1	Neekly
0	Monthly
0	Annually
0	Never

#### **\*3.** Prior to this study, how would you rate your comfort level with using digital wholeslide scans?

- C Very comfortable
- C Somewhat comfortable
- C Somewhat uncomfortable
- C Very uncomfortable

#### \*4. In what teaching environments does your program employ digital histology images?

- Academic half days
- $\Box$  One-on-one teaching with staff
- Interdisciplinary tumour boards
- Departmental rounds
- In-house exams

Other (please specify)

		or	Glass slides are sup
		similar.	Or both modalities aı
Glass slides are superior	Both are about equal	whole slide scans are superior	Dig
			Availability of rare cases for exams
			Consistency of tissue appearance among residents for exams
			Availability of small biopsy specimens in the exam
			Need to carry a microscope to exam
			Need for additional training prior to exam
			Predictability of exam
			Flexibility of exchange between centers
			Ease of identification of each slide
			Conservation of storage space in pathology departments
			Cost for use during general practice
			Representation of lesion
			Overall subjective quality of images
			Appropriateness for cytology cases
			Time for diagnosis
			Difficulty of navigation to different magnifications
			Preparation for real life practice
			Practicality for regular use during training
			Ease of navigating across the slides
			Practicality for regular use during training Ease of navigating across the slides Speed when examining cases



C Less than 25 %

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## \*11. If the Royal College exam is to be digitiized, what do you think is a good time frame for implementation of digital exams?

- .
- In 2-3 years
- In 5 or more years

### \*12. Do you feel that a one month rotation using only digital whole slide scans would be sufficient preparation for a digitalized exam?

- C Yes
- O No

<b>THE FOLLOWING SECTION IS TO BE ANSWERED ONLY BY CANDIDTATES THAT PARTICPATED IN THE PILOT TEST</B>

#### 13. Which portion of the test did you participate in?

- C Glass slide portion
- C Digital whole slide scan portion

#### 14. In an exam setting, do you prefer:

- O Digital slides
- C Glass slides
- O No preference

#### 15. How much time was necessary to reach a diagnosis for biopsy cases?

- 2 minutes
- 3 minutes

#### 16. How much time was necessary to reach a diagnosis for large resection specimens?

- O 2 minutes
- O 3 minutes

#### 17. What problems did you encounter during your exam?(please select all that apply)

- □ Software functioning too slowly
- Image blurriness or poor detail
- Nuclear features were not satisfactory

#### Other (please specify)

# 18. Please leave any other comments about the relative quality and practicality of glass vs. digital slides and about the prospect of digitizing the Royal College exam