Brief Research

The Role of Online Virtual Microscopy in Improving Medical Students' Performance and Preference in Pathology: Experience from a Medical School in Thailand

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Abstract

Introduction: Virtual microscopy (VM) has emerged as a promising alternative to conventional light microscopy (CLM) in teaching human pathology. However, data on such adoption in developing countries is limited. This study aims to compare medical students' performance and preference in practical sessions of systemic pathology by using different learning and teaching strategies.

Methods: Participants were second-year medical students enrolled in systemic pathology classes (as part of different courses in the curriculum) at Chulabhorn International College of Medicine, Thammasat University, Pathum Thani, Thailand, during the academic year 2019. Different educational modalities, including CLM for both demonstration and practicing for skin and musculoskeletal pathology; VM for demonstration and CLM for practicing for cardiothoracic pathology (combined VM-CLM); and VM for both demonstration and practicing for alimentary pathology, were integrated into the pathology curriculum for second-year medical students. Students' performance and preference were evaluated by constructed response questions (CRQs) and online evaluation forms.

Results: Participants were 31 second-year medical students. The CRQs scores (mean ± SD) of CLM, combined VM-CLM, and VM sessions were 10.8 ± 5.8, 12 ± 3.2, and 15.1 ± 3.6, respectively. Paired t-tests revealed significant differences between students' performance in VM compared with both CLM and combined VM-CLM sessions ($P < .01$). However, the performance in CLM and combined VM-CLM sessions demonstrated no difference ($P = .19$). Students' preference for these different educational tools was comparable.

Conclusions: VM is associated with better students' performance in pathology. Such an innovative tool also provides several advantages to conventional light microscopy. Students' preference for these different educational tools was similar to each other.

Keywords: Virtual microscopy, Pathology, Education, Medical students

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Introduction

For almost two centuries, conventional light microscopy (CLM) has been the preferred learning and teaching modalities in practical pathology sessions for medical students. Despite its educational popularity, CLM possesses several limitations. First, students generally only have access to low-quality teaching microscopes for pathology slide analysis. This leads to poor image quality and difficulty understanding the findings. Second, the cutting, staining, selecting, sorting, and storing of the slides is a logistical difficulty, time-consuming and costly. The third drawback is that a substantial reserve of paraffin-embedded tissues is necessary because slides must be replaced due to color bleaching or physical degradation. Lastly, students rarely can access the slides outside of office hours.[1]

Digital pathology (DP), also known as virtual microscopy (VM) or whole slide imaging (WSI), is the technique that provides precisely scanned images of the tissues from glass slides by assembling the data into a single digital image file that resembles the original glass slide. Given the broadly applicable uses of DP, it has emerged as a promising alternative to CLM in teaching human pathology, with high levels of satisfaction indicated by both students and teachers.[2] According to recently published systematic reviews, undergraduate students' performance improved when VM was integrated into the curriculum.[2-3]

However, data on such adoption is limited in developing countries. This study aims to compare medical students' performance and preference in practical sessions of systemic pathology by using different learning and teaching strategies.

Methods

Study Setting

Participants were all second-year medical students enrolled in systemic pathology classes (as part of different courses in the curriculum) at Chulabhorn International College of Medicine, Thammasat University, Pathum Thani, Thailand, during the academic year 2019.

All procedures performed in the study were approved by the human ethics committee of Thammasat University No. 1 (Faculty of Medicine; COA No. 77/2020) in accordance with the 1964 Helsinki declaration and its later amendments. Formal written informed consent was not required with a waiver by the appropriate human ethics committee.

Teaching Methods

Different educational modalities, including CLM for both demonstration and practicing for skin and musculoskeletal pathology; VM for demonstration and CLM for practicing for cardiothoracic pathology (combined VM-CLM); and VM for both demonstration and practicing for alimentary pathology, were integrated into the pathology curriculum for second-year medical students. Whole slide images were acquired by scanning the original glass slides in the Aperio CS2 whole slide scanner (Leica Biosystems, Germany) with a 40x lens and one focus layer without Z-stacking. Digital slides were then uploaded on PathPresenter (URL: https://pathpresenter.net). This web-based service allows users to upload their digital slides, to serve as learning materials for the students.

Evaluation Methods

Students' performance and preference were evaluated by constructed response questions (CRQs) and online evaluation forms. CRQs consisted of clinically oriented questions derived from diseases mentioned in practical sessions of systemic pathology. A brief clinical history, gross photographs, or photomicrographs were given. Students were asked to provide short answers, including diagnosis, description, and clinical presentation of a particular disease.

Students were asked to complete the evaluation form after finishing the course. Five topics regarding the student's preference in teaching and learning modalities were included in the survey questions with a five-point Likert-style scale from 1 to 5 (5 = strongly agree, 4 = agree, 3 = not sure, 2 = disagree, and 1 = strongly disagree). If needed, students could provide additional comments. Their performance, preference, and additional feedback were analyzed.

Results

Participants were 31 medical students who enrolled in three mandatory courses during their second year of study. There were 2-3 facilitators attending each practical session to assist the students and supervise the class. Photographs taken from classes using different educational modalities were illustrated in Figure 1. Organs and diseases included in the summative examination were shown in Table 1.

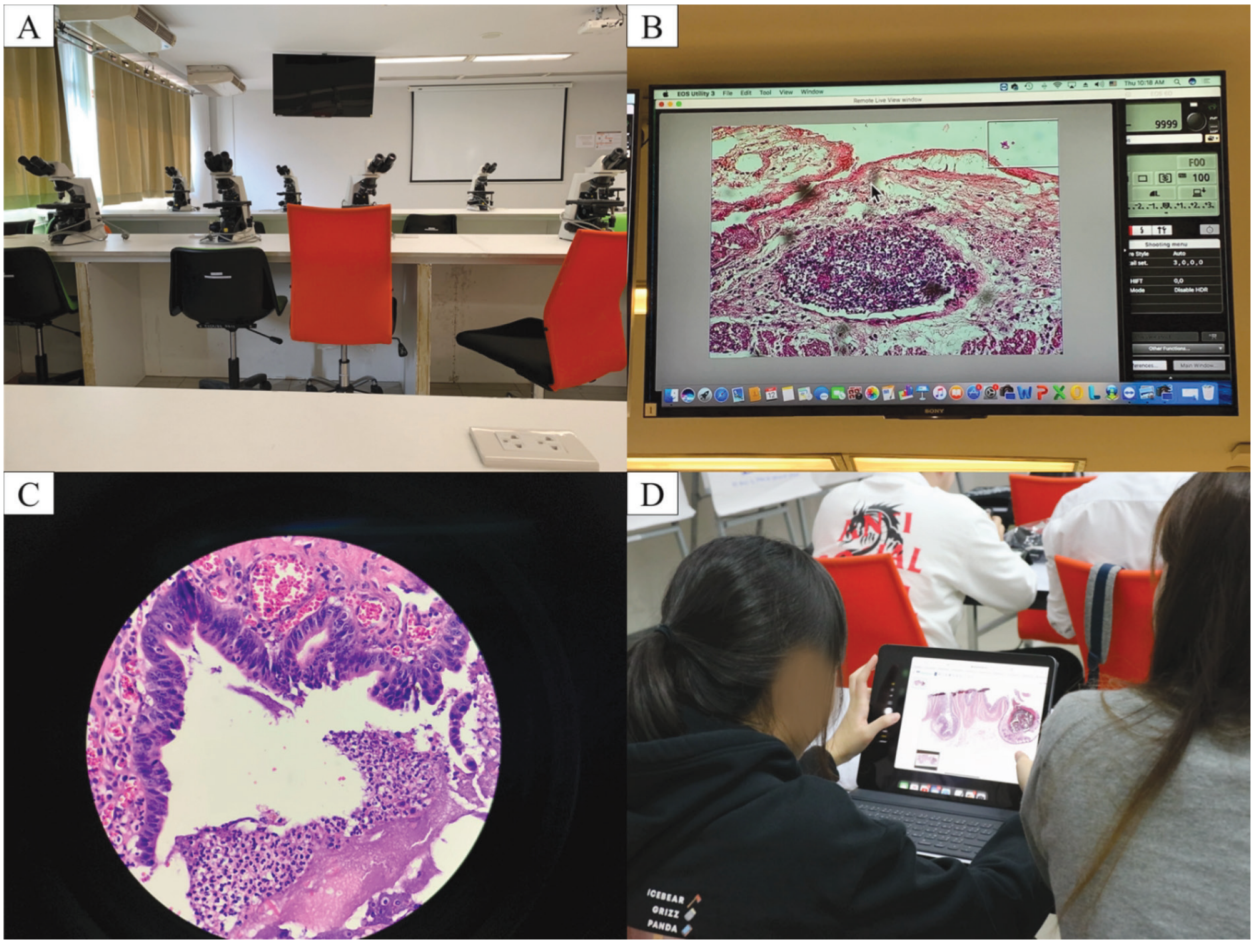

Figure 1 Photographs taken from practical pathology classes using different educational modalities. (A) Multiple microscopes are required to arrange a traditional practical pathology session. (B) An image from the light microscope handled by a pathology teacher is demonstrated on the screen where the slides can only be moved by the teacher. Due to improper maintenance of glass slides and the microscope, dust and other particles are observed on the screen. (C) The field of view of a light microscope is relatively limited, leading to difficulty in tissue orientation. (D) The adoption of digital slides allows students to learn from better quality slides.

Table 1 Organs and diseases included in the summative examination

Organ	Disease
1. Skin	Basal cell carcinoma
2. Skin	Melanocytic nevus
3. Skin	Squamous cell carcinoma
4. Skin	Melanoma
5. Skin	Seborrheic keratosis
6. Soft tissue	Schwannoma
7. Bone	Osteonecrosis
8. Bone	Osteosarcoma

Table 1 Organs and diseases included in the summative examination (cont.)

Organ	Disease
9. Bone	Fibrous dysplasia
10. Joint	Chronic tophaceous gout
11. Blood vessel	Aortic dissection
12. Heart	Myocardial infarction
13. Lung	Adenocarcinoma
14. Lung	Emphysema
15. Salivary gland	Warthin tumor
16. Esophagus	Squamous cell carcinoma
17. Colon	Familial adenomatous polyposis
18. Colon	Adenocarcinoma
19. Liver	Metastatic carcinoma
20. Liver	Cirrhosis
21. Liver	Hepatocellular carcinoma

A box plot showing the distribution of summative examination scores was shown in Figure 2. The CRQs scores (mean ± SD) of CLM, combined VM-CLM, and VM sessions were 10.8 ± 5.8, 12 ± 3.2, and 15.1 ± 3.6, respectively. Paired t-tests revealed significant differences between students' performance in VM compared with both CLM and combined VM-CLM sessions ($P < .01$). However, the performance in CLM and combined VM-CLM sessions demonstrated no difference ($P = .19$). Therefore, students' performance improved when using VM compared to CLM.

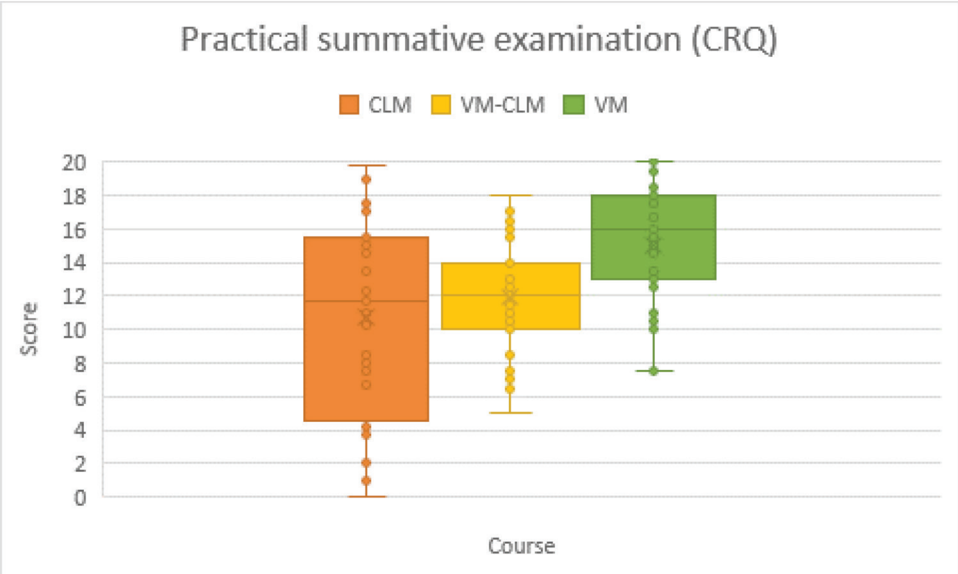

Figure 2 A box plot showing the distribution of summative examination scores. The y-axis represents the score of the practical examination, in which the perfect score is 20. The x-axis is systemic pathology courses using different educational modalities, including CLM for both demonstration and practicing for skin and musculoskeletal pathology; VM for demonstration and CLM for practicing for cardiothoracic pathology; and VM for both demonstration and practicing for alimentary pathology.

Abbreviations: CLM, conventional light microscopy; VM-CLM, combined virtual microscopy and conventional light microscopy; VM, virtual microscopy.

After completing each course, students finished the survey questions in the course evaluation form. Course evaluation scores and students' comments, if any, were gathered and reported back to the lecturers and facilitators by the academic affairs. Evaluated topics and mean scores were shown in Table 2. According to the practical session evaluation forms, these sessions' overall average scores (mean, a 5-point Likert scale) were 4.5, 4.5, and 4.6. Thus, students' preference for these different educational tools was comparable ($P > .05$).

Although the mean scores from the evaluations did not indicate any distinct differences in terms of students' preference, additional feedback showed that students preferred using digital slides to glass slides as they could access the images anywhere, anytime, and from any devices. In addition, the image quality and the field of view of the digital slides were superior. These made tissue orientation and inspection of tissue during the class easier for students with less experience in the pathological study. Furthermore, using digital slides also allowed them to learn in less time.

Table 2 Evaluated topics in the online course evaluation form. Survey questions with a five-point Likert-style scale from 1 to 5 (5 = strongly agree, 4 = agree, 3 = not sure, 2 = disagree, and 1 = strongly disagree) were used

Evaluated topics	**Mean ± SD (CLM)**	**Mean ± SD (CLM-VM)**	**Mean ± SD (VM)**
1. Experiments/practices complemented lecture materials.	4.5 ± 0.4	4.6 ± 0.3	4.6 ± 0.2
2. Adequate and high-quality utensils/equipment were supplied.	4.5 ± 0.5	4.5 ± 0.4	4.5 ± 0.4
3. Availability of facilitators was enough to answer questions during experiment/practicing.	4.5 ± 0.4	4.5 ± 0.4	4.6 ± 0.3
4. Facilitators answered questions clearly.	4.4 ± 0.4	4.5 ± 0.4	4.5 ± 0.3
5. This section developed my abilities and skills for the subject.	4.6 ± 0.3	4.5 ± 0.4	4.5 ± 0.3

Abbreviations: CLM, conventional light microscopy; VM-CLM, combined virtual microscopy and conventional light microscopy; VM, virtual microscopy.

Discussion

The present study showed that VM adoption in practical pathology sessions improved medical students' performance. They viewed such an innovative tool as a potential educational modality due to its accessibility, adequate slide quality, and learning in less time. Connecting the morphological alterations to clinical features is necessary for the pathology learning curve. Thus, a clear visual representation of diseases in tissues helps make sense of knowledge and ideas that cannot be learned through theory alone.

The results of our study were similar to those in previous literature. VM was associated with better undergraduate students' performance.[2,3] However, the course evaluation forms showed students' preferences for these different educational modalities were similar. According to additional feedback, several students realized some advantages of VM. Such feedback was similar to previous studies showing that most students thought VM could help them learn better and faster.[3,4] Of note, the reliability of these results may be adversely affected by diverse evaluation techniques, learners with varying levels of knowledge and experience, and a lack of prior teaching on how to handle these devices.[5-7] Of note, these results cannot be generalized to graduate students. Resident learners performed similarly when using CLM or VM. CLM was the preferred slide-viewing modality.[2]

One of the most significant advantages of using VM in practical pathology sessions is its flexibility. Students can access and study the images whenever, wherever, and using their devices. Medical education was affected by the Covid-19 pandemic, which shifted its focus to emergency remote learning delivery. The incorporation of VM in the curriculum could help relieve the situation.

The internet connection quality was significantly associated with the student's performance on the final examination. Most students favored a hybrid rather than an entirely on-campus or online approach.[8]

Of note, the advantages of VM in pathology education should not be overemphasized. A few critical disadvantages of VM should be noted.[9] First, technical aspects (i.e., high-speed internet connection and a server with sufficient capacity) may hinder the use of VM in limited resource settings. However, an affordable whole slide imaging (WSI) system composed of a low-cost virtual slide scanner (i.e., 30,000 USD) and consumer-grade laptops offers good quality digital slides in which the average scan time was 2 minutes.[10] Therefore, such a WSI system can be used for pathology education. Second, students cannot learn how to handle CLM if VM is exclusively used. Nevertheless, students should focus on learning pathology (i.e., tissue morphology of various diseases) instead of getting familiar with the technical aspects of managing the microscope. Furthermore, medical students will not see histopathology slides during their clinical practice.

There were several limitations to this study. First, the number of participants was relatively small. Therefore, facilitators could help these students easily understand these practical sessions' basic concepts. The present study results might not be generalized to a larger group of students. Second, students' performances might vary because of several factors, including different organ systems, course sequences, and the expertise of pathology teachers. Nevertheless, this is the first study demonstrating the emergence of VM as a potential alternative to CLM in practical pathology sessions at the authors' institution.

Being similar to previous studies, the present study revealed that VM was associated with better student performance. Such an innovative tool provides several advantages to CLM. Therefore, VM should be used in practical pathology sessions for undergraduate students. Adoption of digital slides is essential for a high-quality pathology course.

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References

1. Merk M, Knuechel R, Perez-Bouza A. Web-based virtual microscopy at the RWTH Aachen University: Didactic concept, methods and analysis of acceptance by the students. *Ann Anat. 2*010;192(6):383-387.
2. Kuo KH, Leo JM. Optical versus virtual microscope for medical education: A systematic review. *Anat Sci Educ.* 2019;12(6):678-685.
3. Rodrigues-Fernandes CI, Speight PM, Khurram SA, et al. The use of digital microscopy as a teaching method for human pathology: A systematic review. *Virchows Arch.* 2020;477(4): 475-486.
4. Lakhtakia R. Virtual microscopy in undergraduate pathology education: An early transformative experience in clinical reasoning. *Sultan Qaboos Univ Med J.* 2021;21(3):428-435.
5. Fernandes CIR, Bonan RF, Bonan PRF, et al. Dental students' perceptions and performance in use of conventional and virtual microscopy in oral pathology. *J Dent Educ.* 2018;82(8): 883-890.
6. Nauhria S, Ramdass P. Randomized cross-over study and a qualitative analysis comparing virtual microscopy and light microscopy for learning undergraduate histopathology. *Indian J Pathol Microbiol.* 2019;62(1):84-90.
7. Mirham L, Naugler C, Hayes M, et al. Performance of residents using digital images versus glass slides on certification examination in anatomical pathology: a mixed methods pilot study. *CMAJ Open.* 2016;4(1):88-94.
8. Nikas IP, Lamnisos D, Meletiou-Mavrotheris M, et al. Shift to emergency remote preclinical medical education amidst the Covid-19 pandemic: A single-institution study. *Anat Sci Educ.* 2022;15(1):27-41.
9. Saco A, Bombi JA, Garcia A, Ramirez J, Ordi J. Current Status of Whole-Slide Imaging in Education. *Pathobiology.* 2016;83(2-3):79-88.
10. Kantasiripitak C, Laohawetwanit T, Apornvirat S, Niemnapa K. Validation of whole slide imaging for frozen section diagnosis of lymph node metastasis: A retrospective study from a tertiary care hospital in Thailand. *Ann Diagn Pathol.* 2022;60:151987.