

# Successful Use of Virtual Microscopy in the Assessment of Practical Histology during Pandemic COVID-19: A Descriptive Study

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## Abstract

**Background:** Practical knowledge and skills of microscopy has classically been delivered for medical students using conventional microscopes (CMs). Using virtual microscopy (VM) in teaching practical histology was established during distance learning for Taif medical students during COVID 19 pandemic period. However, the suitable assessment methods for student performance during distance learning are still debatable. We focused on how to ensure the learner's achievement of course practical outcomes and learning domain. **Aims and Objectives:** This study aimed to ascertain whether using VM to evaluate student learning in practical Histology during distance education programs and if moving to VM affecting students' scores. **Materials and Methods:** For the first time, we used VM during online objective structural practical examination (OSPE) of 3<sup>rd</sup> year medical students. Different sets of virtual slides were given for students at the time of assessment, then different tasks were described and each student was asked to finalize his/her task during the designed time. A specific rubric was designed for the evaluation of student work. Moreover, student perceptions of VM as teaching and assessment method were assessed using online survey. Post examination psychometric analysis of VM OSPE was done and compared with previous OSPE results of the same batch of students. **Results:** The average student score was  $4.63 \pm 0.51$  with no significant difference from previous student's scores. The net students' feedback was positive. Their average satisfaction on all items ranged from 3.7 to 4.25 on Likert scale. Students recorded the easy image access at any time and place with VM as the most distinctive feature. **Conclusion:** Our results indicated that VM is not only an effective method in teaching histology but also it is an assessment method for measuring student performance during online assessment.

**Keywords:** Assessment, distance learning, virtual microscopy

## INTRODUCTION

Practical sessions with light microscopy are a basic tool in biological and medical education. The classical delivery practical methods of knowledge and skills of histology discipline were using conventional microscopes (CMs) and traditional histological slides. The practical classes in Histology are aimed at teaching learners to identify different cells and tissues. The reason behind this is that learners must know what normal tissues and cells look like so that they can recognize pathological tissues<sup>[1]</sup> and draw the structure-function relationships. Unfortunately, medical students in integrated curriculum did not receive enough time for training on CM usage skills.<sup>[2]</sup>

Virtual microscopy (VM) is an emerging technology for use in histologic/pathologic education. Acquisition of VM image involves digital photographing of tissue sections on ordinary glass slides using different microscope objectives at different planes. Then, the computer software will compress the large image files and generate a composite

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Received: 26-06-2020 Accepted: 24-07-2020 Published: 10-12-2020

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DOI:  
10.4103/JMAU.JMAU\_67\_20

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**How to cite this article:** Amer MG, Nemenqani DM. Successful use of virtual microscopy in the assessment of practical histology during pandemic COVID-19: A descriptive study. J Microsc Ultrastruct 2020;8:156-61.

image suitable to be viewed on computer monitors. After that, students will be able to navigate the specimen by moving the computer mouse and scan the tissue section freely. Moreover, clicking on the mouse will magnify and focus the required section.<sup>[3]</sup>

Previous report described different teaching programs of histology that partly incorporated VM while retaining CM for specific parts of the course.<sup>[4]</sup> Others made a gradual shift from CM to VM<sup>[5]</sup> and monitored the effect of adopting VM for a large class of 1<sup>st</sup> year medical students.<sup>[3]</sup>

Using VM in teaching practical histology was established during distance learning for Taif medical students during COVID 19 pandemic period. Implementation of teaching microscopic histology with virtual slides was successful. However, a suitable assessment method for student performance during distance learning is still debatable. We focused on how to ensure the learner's achievement of course practical outcomes and learning domain and at the same time accommodate the special circumstances of online distance assessment during COVID 19 Pandemic.

All of our students were made to face the conventional pattern of histology examination during objective structural practical examination (OSPE) stations of previous modules. For the first time, we used VM in the assessment during OSPE online assessment.

The purpose of this work was to ascertain whether using VM to evaluate student learning in practical histology during distance education programs differ from original method and if moving to VM affecting students' scores. We hypothesized that the effects of this change would be positive and VM would significantly improve learning efficiency and students' performance.

## MATERIALS AND METHODS

VM was used in learning and assessment of Histology interpretation skills in endocrine module for 3<sup>rd</sup> year medical students at College of Medicine, Taif University during March 2020. The endocrine course had 166 students. Histological slides were chosen based on their quality and digitized using Aperio AT2 – High Volume, Digital Whole Slide Scanning (Leica Biosystems Division of Leica Microsystems Inc.,1700). The students are loaned the virtual slides where they can view them through (Aperio's ImageScope) on their personal electronic devices (laptops, ipads, PCs). Students were trained on using VM in the examination of histological slides during practical sessions in online distance learning program.

For the assessment of students' skills, different sets of virtual slides were given for students at the time of assessment, then different tasks were described and each student was asked to finalize his/her task during the designed time. The tasks include using the virtual microscope on laptop, scan the histological slide, detect a specific tissue, and search for a specific part then point to a specific cell or structure within the organ. Final output

will be a snap shot taken by students and sent to the instructor for evaluation against the three items rubrics.

The objective was to measure students' interpretation skills in using virtual histological slides in differentiation between different body tissues and cells and applying knowledge in identification of their characteristic microscopic feature. Hence, a specific rubric was designed for evaluation of student work based on three evaluation criteria including: 1 - ability of student to use VM and detect the organ from the given slides, 2 - scanning the slides and accurate pointing to the asked cell or specific structure, and 3 - the third item is punctuality in uploading the required task on time. Three levels of student's performance were described for each evaluation criteria and used in the evaluation of student work (novice, competent, and proficient).

To evaluate the consistency of results across alternate versions of examination tasks, all tasks versions must contain items that probe the same construct, skill, knowledge base, and the scores from different versions are then be correlated. After the examination, psychometric analysis of different versions was done for identification of difficulty difference and higher and lower "cut scores."

Comparison of the results of the students in OSPE using VM with the results of same batch of students in OSPE using CM is done for measuring stability of student scores. Students' scores in previous module (GIT) where students evaluated based on CM only and the current VM practical examination of the same batch of students were compared. The scores from both modules can then be correlated to evaluate the test for stability. Paired Student's *t*-test was used to compare mean  $\pm$  standard deviation (SD) of both students' scores.

Moreover, student feedback about using VM in teaching and assessment was assessed using online survey. Five-point Likert scale was used as follow: 5 means Strongly Agree, 4 means Agree, 3 means neutral, 2 means Disagree, and 1 means Strongly Disagree. Students were asked to record their level of satisfaction about using VM in learning histology.

### Statistical analysis

All analyses were performed using SPSS version 18.0 (SPSS Inc., Chicago, IL, USA). One-way analysis of variance (ANOVA) and the *t*-test were used to compare the means. The cutoff for statistical significance was set at  $P < 0.05$ .

Discrimination index is a measure to differentiate between good and poor students and used to distinguish between knowledgeable examinees and other or between masters students and non-masters. The value of the discrimination index is to range between 1 and - 1. Discrimination index of 0.40 and up is considered as very good items, 0.30–0.39 is reasonably good, 0.20–0.29 is marginal items (i.e., subject to improvement), and 0.19 or less is poor items (i.e., to be rejected or improved by revision).<sup>[6,7]</sup> (IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp). was used to calculate the discrimination index.

Difficulty index (P) refers to the percentage of the total number of students who answer an item correctly. The used formula considers all correct answers from the higher potential group and the lower potential group.<sup>[8]</sup> The difficulty index has a value between (0.00- and 1.00). The bigger the value for difficulty index, the easier the questions will be. On the other hand, if the value for the difficulty index is getting smaller, it means that the question is getting harder.<sup>[9]</sup>

## RESULTS

One hundred and sixty-six students of 3<sup>rd</sup> year were responded to their tasks (77 males and 89 females). The mean and SD of marks obtained of rubrics evaluation of students' work in VM OSPE was  $4.7 \pm 0.15$ . The mean  $\pm$  SD of students' scores in the ten tasks were ( $4.7 \pm 0.09$ ,  $4.7 \pm 0.12$ ,  $4.6 \pm 0.20$ ,  $4.6 \pm 0.09$ ,  $4.6 \pm 0.19$ ,  $4.7 \pm 0.11$ ,  $4.6 \pm 0.19$ ,  $4.6 \pm 0.23$ ,  $4.7 \pm 0.1$ , and  $4.6 \pm 0.21$ ). One-way ANOVA between the task groups revealed non-significant ( $P = 0.1$ ). This ensures that overall scores represent the same levels of achievement, regardless of which version of the exam a student takes.

### Regarding psychometric analysis of both examinations virtual microscopy Objective Structural Practical Exam and conventional microscopes Objective Structural Practical Exam [Table 1]

Discrimination index is 0.98 and difficulty index is 0.73 for OSPE with VM. While discrimination index is -0.11 and difficulty index is 0.91 for OSPE with CM. This means that OSPE VM is of moderate difficulty and its discrimination is excellent.

Correlation and cross-tabulation between the students' performance in OSPE while using CM and OSPE while using VM indicated no significant variation in mean  $\pm$  SD of both modules (CM OSPE;  $4.63 \pm 0.51$  with VM OSPE;  $4.7 \pm 0.15$ ) with  $P > 0.05$ .

### Regarding questionnaire analysis results [Table 2]

About 70% of 3<sup>rd</sup> year medical students were responded to the

	CM OSPE GIT module	VM OSPE Endocrine module	P
Number of students	166 (3 <sup>rd</sup> year students)	166 (3 <sup>rd</sup> year students)	-
Students (score), mean $\pm$ SD	4.63 $\pm$ 0.51	4.7 $\pm$ 0.15	0.09
Lowest of score (%)	70	40	
Highest of score (%)	100	100	-
Discrimination index	-0.11	0.98	
Difficulty index	0.91	0.73	

SD: Standard deviation, CM: Conventional microscopes, OSPE: Objective structural practical exam, VM: Virtual microscopy, GIT: Gastro Intestinal Tract

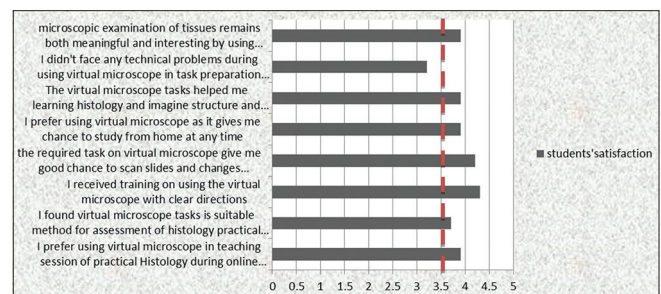
questionnaire during April 2020 (53.1% females and 46.9% males). About 72% of respondents' preferred (agreed and strongly agreed) using VM; 61.5% found online tasks using VM are suitable for assessment during distance learning; 72% agreed on the ability of the virtual microscope tasks in learning histology and imagine structure and applying knowledge. The most valued feature of using virtual microscope as indicated by students was the ease of image access at any time and place and the ease navigation with the VM than with CM [Figure 1]. The only item that received low satisfaction of students is the encountered technical problems during setup of the program on their laptops as the software is not suitable for iOS and MACiOS.

## DISCUSSION

This study aims to test the validity of using VM in learning and assessment of histology for medical students during pandemic COVID 19 where distance learning is established and to detect student's perception of using VM in teaching and assessment of practical learning outcomes of histology in comparison to CM.

The students' performance in our study in the VM OSPE was similar to their performance in CM OSPE. Students prefer using VM in teaching session of practical histology during online distance learning. Similar results were recorded by Foad.<sup>[10]</sup> They compared students who used VM with those who used CM. They found that students swiftly acquired VM skills, which ameliorated any favoritism bias regarding the use of the CM. This observation reflected improvement in students' achievement after using VM. They recorded that during the sessions, valuable time was dedicated to adjusting the power and fields of microscopes when using ordinary CM. Students' feedback identified VM as an easy method to be used in education. Performance of students was more uniform in VM group than the CM group, approved by small SD and narrow scores' range in OSPE.<sup>[11]</sup> Furthermore, a recent study worked on veterinary students and confirmed that CM is an effective method of teaching cytology for them and can be used to design a real case scenario.<sup>[12]</sup>

The recent trends in education are to validate E-learning methodology within a suitable environment that put an end to bias<sup>[13]</sup> and to implicate an ongoing verification of simulation-based education. Ordi *et al.*<sup>[14,15]</sup> affirmed that



**Figure 1:** Five points Likert scale results regarding students response to questionnaire on their perception toward virtual microscopy

**Table 2: Student's responses to the questionnaire regarding the use of virtual microscope and the conventional microscope**

Items	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Rating scale (out of 5)
I prefer using virtual microscope in teaching session of practical Histology during online distant learning	37.5	34.4	6.3	15.6	6.4	3.9
I found virtual microscope tasks is suitable method for assessment of histology practical skills during online distant program	34.4	28.1	12.5	18.8	6.3	3.7
I received training on using the virtual microscope with clear directions	50.1	31.3	12.5	6.3	0	4.25
The required task on virtual microscope give me good chance to scan slides and changes magnification power as the ordinary microscope	46.9	34.4	12.5	36.3	0	4.2
I prefer using virtual microscope as it gives me chance to study from home at any time	43.75	25	15.6	9.4	6.25	3.9
The virtual microscope tasks helped me learning histology and imagine structure and applying knowledge	37.5	34.5	15.6	6.3	6.3	3.9
I didn't face any technical problems during using virtual microscope in task preparation and upload on blackboard	28.1	9.4	18.8	37.5	6.3	3.2
Microscopic examination of tissues remains both meaningful and interesting by using virtual microscope	37.5	31.3	21.9	6.25	3.12	3.9

using VM in learning pathology can effectively replace the traditional light microscopy methods. The use of VM helped in reduction of expenses while maintaining learning outcomes.<sup>[3]</sup> The classic CM devotee disputes against the use of simulators and VM. Their claiming depends on that simulators in medical education could fundamentally alter the quintessence of medical education. In contrast, technology enthusiast may be obsessed with new inventions and adopt any new technologies without validation.<sup>[16]</sup> This can affect the ability of students to deal and adapt with situations in real-life. Collier *et al.* advocated the use of VM besides providing access to LM.<sup>[17]</sup>

In the present work, post examination comparison of the psychometric properties of OSPE while using CM alone with that of OSPE while using VM revealed that using VM made OSPE more reliable and had better discrimination index. Negative discrimination index was recorded in OSPE with CM.<sup>[7]</sup> Rahim illustrated that negative discrimination of an item means that the knowledgeable students get the item incorrectly and the least knowledgeable students get the item correctly. Negative discrimination index indicates that the item is measuring different thing other than what measured by the rest of the test.<sup>[18]</sup>

Downing<sup>[19]</sup> confirmed a reciprocal relationship between difficulty and discrimination indices. In general, question items with high and low difficulty indices were sometimes associated with low discrimination indices. Most of the students get the easy items correctly and thus this item cannot differentiate between students and unable to identify the average students and those below average. On the other hand, top and outstanding students only get correctly the difficult question items thereby these items are bunching the average with below average students. The best discriminators are the questions' items with moderate difficulty index. The present results are in line with these principles highlighted in the work by Nauhria and Hangfu.<sup>[20]</sup>

Student perceptions are important because they provide their vision regarding the factors that impede learning as beginner in clinical training and their suggestion for improvement.<sup>[21]</sup> Hence, the present work asked students to respond to questionnaire for measuring their perception toward using VM and CM. The general student's feedback was positive. Their average satisfaction on all items ranged from 3.7 to 4.25 on Likert scale. They complemented the ease of use of VM as a new technology. Students felt they worked faster with VM, and over 70% thought that the navigation with the VM was easier than with the CM. Students recorded the easy image access at any time and place as the most distinctive feature of VM. The only item that recorded less satisfaction among students was the encountered technical problems during using virtual microscope in task preparation and upload on blackboard because of unsuitability of the software to iOS or MACiOS and its working only on Microsoft and we solved this issue by asking the responsible company to update the program software to be suitable for them.

Students in the present work recorded their satisfaction about the training they received on using VM. Training on new technology is an essential step before its inclusion and application in order to make a clear and fair judgment.<sup>[20]</sup> Nauhria and Hangfu considered technology requirements and initial setup of suitable software as important practical tips for the successful use and implementation of Virtual Microscope technology. They proved that using VM in learning and assessment of histopathology is reliable and valid pedagogy method. The current transformation toward virtual reality has brought educators around the world towards achieving the goal of competence in medical education. Similar opinions were recorded by our students in the current work. They found VM a suitable method for assessment of Histology

learning outcomes and the required VM tasks provide them good chance to scan slides and change magnification power as the ordinary microscope, imaging the structures and applying knowledge. They found microscopic examination of tissues remains both meaningful and interesting by using VM. Moreover, most of the respondents preferred VM than CM. they found it is suitability to be used freely at any time from home as advantage.

Previous studies in different areas tested the effectiveness of VM. German students appreciated the imaging functionality and annotations of VM.<sup>[22]</sup> Other study in US Brueggeman *et al.*<sup>[23]</sup> recorded superior performance of students by using VM in hematology course. Lam *et al.*<sup>[24]</sup> and Tian *et al.*<sup>[25]</sup> stated that VM is an effective educational strategy and recorded better students' performance with VM. The possible advantages of VM include active engagement of students in learning sessions include one student on his own PC or up to three on one PC within the lab, practical application of self-learning and increased depth and breadth of learning outcomes covering.<sup>[26]</sup> A recent study by<sup>[10]</sup> Foad compared using VM and CM practical sessions and defined VM as an effective educational tool that can add to conventional microscopy in practical sessions, and its application is advantageous for both staff and students.

Advantages and disadvantages of using VM for medical students have been studied in few works. Paulsen *et al.*<sup>[27]</sup> clarified the advantages of VM in instruction of histology and presented a conviction of how to use VM in teaching of microscopic structure in several steps. Initially, the microscopic specimens would be digitalized and made available on-line without limitations and the contents could be connected online with other clinical, radiological and anatomical contents, thus establishing for students new learning perspectives of medically related courses either human, dental, or other medical courses. However, Dee<sup>[28]</sup> considered disregard of CM skills and recurrent technical problems are an important drawbacks of VM. Moreover, the virtual microscopic slides necessitate tremendous memory storage amount within the computer.<sup>[10,29]</sup> Szymas *et al.* and Foad stated that students found the off-campus use of VM slides convenient and suitable to revision before examination.

## CONCLUSION

Our results indicated that VM is not only an effectual method in histology instruction but also it's an assessment method for measuring student performance during online assessment without affecting student scores. It maintains students' performance during distance learning which could be related to increase in students' interest in microscopic study and the availability at home that makes study histopathology is available at any time. Using VM was proven as an empirical solution and has the prospective to improve and renew teaching and learning process of histopathology in an easy way of implementation.

We recommend wider use of VM in learning and assessment at basic science level and even in online group discussion of clinical cases to reach valuable implemented tool for improving the reliability, validity standardization in the histopathology education and pedagogy.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

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