

# Improving Medical Students' Learning Experience of Pathology by Online Practical Sessions through Virtual Microscopy

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## Author's Contribution

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<sup>1,2,3,4</sup> Experimentation/Study conduction

<sup>1,3,4,5</sup> Analysis/Interpretation/Discussion

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## Article Processing

Received: 03/11/2021

Accepted: 14/01/2022

**Cite this Article:** Ahmed, S., Habib, M., Naveed, H., Mudassir, G., Bhatti, M.M., Ahmad, R.N. Improving Medical Students' Learning Experience of Pathology by Online Practical Sessions through Virtual Microscopy. *Journal of Rawalpindi Medical College*. 31 Mar. 2022; 26(1): 122-127.  
DOI: <https://doi.org/10.37939/jrmmc.v26i1.1824>

**Conflict of Interest:** Nil

**Funding Source:** Nil

**Access Online:**



## Abstract

**Objective:** To assess the positive impact of interactive virtual pathology slides in teaching pathology to undergraduate students.

**Materials & Methods:** The study was conducted at Shifa College of Medicine, Islamabad. The class of 3<sup>rd</sup>-year MBBS, comprising 111 students, was divided into two groups during two teaching modules. All students received online lectures prior to practical sessions. In the first module, one group was taught virtual slides through online interactive sessions, whereas the second group was taught the same set of slides, using light microscopy and glass slides. Both groups were assessed at the end of the module by an online test and their scores were compared. A similar exercise was repeated in the second module in which the control group became the test group to remove the selection bias. Questionnaire feedback was taken from students to get their perceptions. The results were compared by applying a t-test and the p-value was calculated.

**Results:** The mean score of the test group (group-1) in the first module was 14.90 whereas the mean score of the control group (group-2) was 10.99. The t-test was applied, and the p-value calculated was significant (p=0.04). In the second module, the groups were flipped. The mean score of the test group (group-2) was 14.29 whereas the control group (group-1) was 10.09. The p-value was calculated which was again significant (p=0.04). The students gave their feedback through a questionnaire.

**Conclusion:** Evidence shows that the microscopic practical skills achieved by virtual microscopy are comparable to or even better than those achieved by light microscopy.

**Keywords:** Education, medical, pathology, undergraduate, virtual microscopy.

## Introduction

Online e-modules have increasingly been integrated into medical education over the past few years. Due to the current pandemic situation, online curriculum delivery has now become a necessity of the time. Lectures, interactive sessions, and case-based discussions all are being effectively delivered virtually. However, a knowledge gap is felt especially in the field of pathology as practical sessions cannot be conducted online through light microscopes and glass slides.<sup>1,2</sup>

Virtual microscopy has emerged as a new and effective way in which practical sessions can be delivered online. This can help students correlate histopathology of diseases, giving them a better understanding of the subject.<sup>3,4</sup>

Although viewing glass slides with traditional microscopes has always been part of pathology curriculum delivery for undergraduate medical students. However, the use of conventional light microscopy has many drawbacks and limitations. It requires multiple microscopes, laboratory equipment, and archives of glass slides to teach different pathological lesions to the students. The replacement of damaged glass slides and maintenance of high-quality slides as well as microscopes is a cumbersome task. Trained personnel are required to deliver practical sessions to all students. Practical sessions are usually taken in small groups to enable hands-on experience by every student which increases the time and energy spent by the teachers.<sup>5,6</sup>

Therefore, the use of virtual microscopy has become popular in many medical institutions. Virtual slides are made by digitally capturing high-resolution images of a glass slide which can be viewed on a computer screen. It enables students to scan entire glass slides and study the pathological lesion at different magnifications. A large number of students can easily be taught using a virtual image, without using microscopes, laboratory equipment, and trained personnel. It saves time and energy for the teachers and helps students in easy accessibility of the slides for revision.<sup>6,7</sup>

The rapid progress and multiple potential benefits of virtual microscopy will result in a shift from conventional to virtual microscopy in teaching pathology. Although many studies have documented its potential, very limited data is available on the impact of virtual slides on undergraduate teaching of pathology, especially in the institutes of Pakistan.<sup>8</sup> The purpose of the present study is to assess whether

interactive virtual pathology slides would increase students' understanding of pathological disease processes.

**Objective:** To assess the positive impact of interactive virtual pathology slides on students' understanding of pathology.

## Materials and Methods

This comparative study was conducted at Shifa College of Medicine, Islamabad after approval from the ethical committee. The teaching methodology in Shifa College is based on an integrated modular system. The class of 3<sup>rd</sup>-year MBBS, comprising 111 students, was divided into two groups during two modules, after taking consent. Non-probability random sampling was used. The first group had 55 students and the second group had 56 students. All students received online theory sessions prior to practical sessions. The mode of delivery included lectures, small group discussions, and problem-based learning. In one module, the first group was taught virtual slides through online interactive sessions by downloading virtual images from a free web browser (Figure 1), whereas the second group was tutored a similar set of slides, using light microscopy and glass slides. Both groups were assessed at the end of the module by taking an online quiz on google classroom. The quiz included short essay questions and Multiple-Choice Questions (MCQs) based on clinical features, microscopic descriptions, and static images of pathological lesions. The data was analysed by using SPSS-23, and the mean values of their scores were assessed. The results were compared by applying a t-test and a p-value was calculated. P-value <0.05 was considered significant. A similar exercise was repeated in the second module in which the control group became the test group to remove the selection bias. Questionnaire feedback was taken from students to get their perceptions. The questionnaire included twelve questions assessed on a five-point Likert scale, where point-1 meant "strongly agree" and point-5 meant "strongly disagree". Students were also given the option to give comments and additional feedback. These questions were also analysed on SPSS-23.

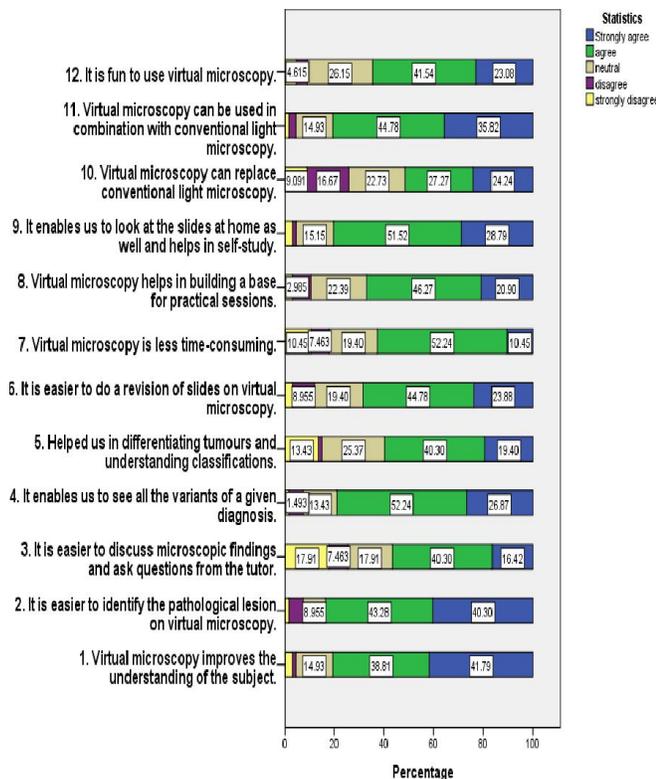
## Results

The mean score of the test group (group 1) in the first module was 14.90 out of 16 whereas the mean score of the control group (group-2) was 10.99 out of 16. The t-test was applied, and the p-value calculated was significant (p=0.04). In the second module, the groups were flipped. In this module, the mean score of the test group (group-2) was 14.29, whereas, of the control group (group 1) was 10.09. The p-value was calculated (p=0.04), which was statistically significant (Table 1). The students gave their feedback through a questionnaire and their responses are shown in Figure

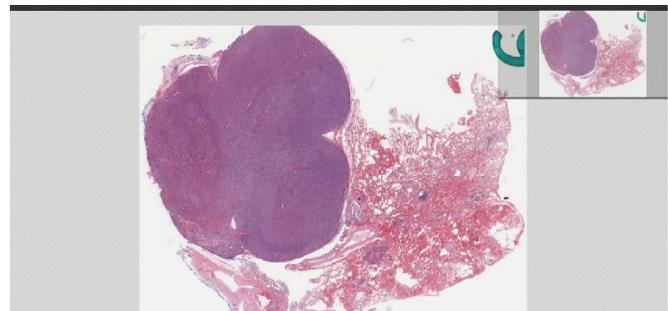
1. The evaluation was overall positive. Frequent comments by the students were, “virtual microscopy is beneficial as the teacher directly points at the structures.....”, “Virtual microscopy is far more effective than conventional microscopy.....”, “I feel it is easy to understand from virtual slides.....”, “virtual microscopy is fun and easy way to understand the concepts.....”, “Incorporation of technology in medical science is always good.....”, “Please make it a part of each pathology practical.....”, “It was such a good way of learning histopathology.....”, “On virtual slides, all aspects of the slide could be seen properly.....” etc.

**Table 1: [Mean score of 02 groups in two modules]**

	Mean score (Group-1)	Mean score (Group-2)	t-test (P-value)
First Module	14.90±1.78 (test group)	10.99±3.29 (control group)	0.04
Second Module	10.09±3.15 (control group)	14.29±1.79 (test group)	0.04



**Figure 1: Students’ responses to questions asked about virtual microscopy. (1: strongly agree, 2: Agree, 3: Neutral, 4: Disagree, 5: Strongly disagree)**



**Figure 2: A virtual image of a lung tumour**

## Discussion

Virtual microscopy is revitalizing histopathology at both undergraduate and post-graduate levels. In medical colleges, integrated group learning, and case-based activities are very popular among students. The use of virtual slides enhances and promotes the integration of theoretical knowledge of the disease process with practical slide images. Students develop a better understanding of the subject by looking at pathological lesions through virtual slides. The present study shows that students who were taught through digital slides outperformed those who were taught by traditional microscopy. A study conducted on oral pathology students in Sheffield, UK shows that virtual pathology helps to deliver an integrated oral pathology curriculum effectively.<sup>9</sup> Another study done by Krippendorff BB showed that a rapid and complete switch from light microscopy to virtual microscopy in

medical histology had a favourable impact on students' performance and learning efficiency.<sup>10</sup>

Virtual slides are high-resolution digital images that can be viewed in a web browser. It removes the skill barrier which students usually face when using light microscopy. The virtual image is always in focus with adjusted contrast and resolution, and it is easy to rotate and scan through the whole slide. Web microscope allows the students to zoom in and out and adjust the brightness as well as annotate the slide. Virtual microscopy is an exceptional way of reforming the laboratory environment. It creates a real-world laboratory environment and helps students explore slide images.<sup>10</sup> The students hold a very favourable opinion about using virtual slides in teaching pathology courses. Digital microscopy makes learning

more meaningful and interesting for the students. It helps them to understand the basis of the disease process and interpret the changes that occur in affected tissue. A study done by Kumar RK et al in 2006 at the University of New South Wales, in which they designed practical classes around virtual slides integrating histology and pathology, showed that students strongly supported the integrated approach and displayed considerable interest in comparing the microscopic features of diseases with normal tissues.<sup>11</sup> In the current study, students also rated the virtual slides superior to traditional slides as they could easily identify the pathological lesions and reach a diagnosis. The advantages of virtual slides over microscopic slides are presented in a tabulated form (Table 2).

**Table 2: Advantages of virtual microscopy over light microscopy**

<i>Application</i>	<i>Virtual microscopy</i>	<i>Light microscopy</i>
	Easy navigation of virtual images	Difficult to navigate all fields under a light microscope
	Annotations help to understand different microscopic features	Difficult to highlight area of interest with markers
	Slides can be viewed in high resolution	Slides can be viewed at three (4x, 10x, 40x) objectives
<b>Storage</b>	A large number of virtual slides can be stored easily online	Glass slides need to be stored in boxes and kept safe from any damage
<b>Student and faculty responses</b>	No fear of loss of virtual images	Fragile glass can easily break
	Students show more interest	Old and cumbersome method
	Helps in self-study and study at home	Sessions must be on-campus
	Easy to discuss lesions online with tutors and colleagues	Limited interaction
	Lesser effort by faculty	More effort by faculty
	Easy integration of theoretical knowledge with practical skills	Theory and practical sessions are separate

During this era of the pandemic, curriculum delivery is being reformed to reduce the number of contact hours and to avoid overcrowding of students on campuses. Emphasis is laid on independent learning. Virtual microscopy enables students to learn pathology by minimally exposing themselves. This interactive technology makes microscopy more efficient, portable, and independent of a class timetable. Covid-19 also had a profound effect on pathology diagnostic services; therefore, many institutes opted for digital pathology to prevent delays in critical patient care. UK Royal College of Pathologists issued guidelines for reporting digital pathology slides during times of need.<sup>12</sup> A study done by Kim shows that many aspects of training dermatopathology residents were successfully

implemented through digital microscopy. Residents can develop their diagnostic skills by searching through the whole virtual slide and they can easily compare different cases. A similar approach can be used for undergraduate teaching.<sup>13,14</sup>

Virtual microscopy is easily accessible and efficient as a student can see the image with a click, at anytime and anywhere, as compared to sitting on a traditional microscope in a proper laboratory setup. It offers self-paced learning and students can easily revisit the material as often as required.<sup>15,16</sup> Easy management of the web slides and their high quality make them students' preference. In our study, students appreciated that same by agreeing to the statements that virtual slides help them to look at the slides from home and they can easily do self-study. Moreover, it

helps them to revise the lessons at any time. (Figure 1) A study done by Blake et al in 2003 stated that students could view all the virtual images on the CD-ROMs at any time and any place with their laptop computers.<sup>17</sup> Furthermore, virtual microscopy has the advantage of reduced cost and maintenance. It can reduce logistic issues associated with glass slides such as replenishing broken glass slides and obtaining sufficient tissue to cut multiple sections for teaching sets.

Faculty can take advantage of digital images as it is easy for them to prepare the session from their home or office, and they can teach more students at one time. The teacher can easily make students understand the pathological lesion by pointing to the exact lesion. It is easy to discuss structures of interest seen simultaneously by a student as well as a teacher through virtual microscopy and their time can be effectively used. As multiple students can see the image at the same time, it enables generate discussion among peers as well as with the teacher. A study by Blake CA showed that students could easily help each other in reading virtual images and faculty could explain features to a group of students rather than to an individual student.<sup>17</sup> In the present study, the students agreed that it is easy to ask questions during virtual microscopy than in conventional microscopy. However, Lab instructors and teachers need to get basic training to learn the software and navigate through the virtual slides. Faculty should also explain the use of this technology on multimedia and ensure that all students can access the slides and know how to navigate them. It is always useful to provide a clinical case-based vignette, Lab values, or radiological findings, before showing the slides to prompt discussion among students. A study done by Fonseca FP, et al showed that simplicity of the software and high-quality slides were deemed important for a better teaching process.<sup>18</sup>

Virtual microscopy has a wide range of potential applications. In undergraduate medical education, it can be used to conduct online quizzes and in grading tutorials as a new and innovative educational tool. Virtual slides can be used as a supplement in research articles. It helps in easy documentation of results in the paper. Digital microscopy can make scientific reporting transparent where viewers can easily access slides of the described lesions. Virtual slides can potentially be used in board certification examinations where identical specimen sets are needed for students at different centres. Similarly, in undergraduate medical education, there have always been efforts to

improve visual aids in teaching and assessing the students. A study done by Foster K states that digital microscopy is a great opportunity to revolutionize both teaching and learning.<sup>19,20</sup>

Although virtual microscopy opens many unmatched possibilities for modernizing teaching in pathology, however, many challenges still need to be countered. The adoption of such technology may raise the issues of affordability, image quality, slide navigation, storage costs, and scanning time. Efforts are already being done to overcome these issues. It is well known that the adoption of any new technology requires sustained collaboration between the developers and the consumers. Previous studies indicated that start-up costs for virtual microscopy can be considerable.<sup>21,22</sup>

## Conclusion

Evidence shows that the microscopic practical skills achieved by virtual microscopy are comparable to or even better than those achieved by light microscopy. Therefore, Digital imaging is a powerful educational tool that can effectively replace traditional methods of teaching. Given a significantly higher rating to virtual microscopy by the students clearly shows the endorsement of the students of this new approach to the practical part of the pathology.

## Limitation

This study is done on a limited sample and a shorter period of duration. More studies should be done in this field to further see the impact of virtual microscopy. Moreover, the higher expense required for buying a slide scanner poses a major limitation in the step toward the digitalization of pathology slides.

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