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Investigation of the Effect of Virtual Microscopy on Pathology Education in a Medical Faculty

Sanal Mikroskopi Kullanımının Tıp Fakültesi Patoloji Eğitimi Üzerindeki Etkisinin Araştırılması

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Abstract

Aim: Virtual microscopy technology has been widely used in histopathological diagnosis and pathology education, replacing the traditional light microscope, which is considered an important visual tool in pathology education. Slides scanned and stored online for use in virtual microscopy were first described in 1985 and have experienced significant developments since 2000. In this study. The aim of this study was to determine how virtual microscopy affected medical school students' pathology education.

Methods: The study included the 3rd year students of Izmir Democracy University Faculty of Medicine. The study was conducted prior to the end-of-year pathology practice exam. As a result of the scanning performed by company received support, 102 slides were selected from the training archive and virtualized. Among them, forty slides representing lesions and organs from ten different systems, were chosen. The students were divided into two groups (group 1 and 2.) and the selected slides were used as educational material. Each student was given the opportunity to study both 20 virtual and 20 microscope slides. The students in the first group (G1) examined 20 slides (M1) of the ten systems with the light microscope and the other 20 slides on the virtual microscope (S1). On the other hand, the students in the second group (G2) examined with a light microscope (M2) the slides which shown to the first group in the virtual microscope (V1); and they examined with the virtual microscope (V2) the slides which shown to the first group in the light microscope (M1). This training course was completed in approximately eight hours. For the end-of-year pathology practice exam held the next day, the students were randomly divided into 4 groups and each group was asked questions about 10 slides from 10 different systems. These questions were about the descriptive characteristics of the organs and lesions that are examined. All slides were shown to the examinees one day later.

Results: Eighty-nine students in total [n:52 (58.4%) men, n:37 (41.6%) women] took part in the survey. The study found no significant difference in overall exam scores between students using traditional light

Keywords:
Medical Education, Pathology Education, Virtual Microscopy, Light Microscopy, Learning Methods

Anahtar Sözcükler:
Tıp Eğitimi, Patoloji Eğitimi, Sanal Mikroskopi, Işık Mikroskopisi, Öğrenme Metotları

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microscopy and those using virtual microscopy, with average scores being 17.2±7 on a scale of 5 to 40 points. Students who examined slides using light microscopy had an average score of 8.7±4.6, while those who used virtual microscopy had an average score of 8.6±4.1. It was found that the success rates were similar regardless of whether the students used traditional microscopy or virtual reality. Yet when the results were grouped by gender, female students had higher overall (p=0.05) and light microscopy scores (p=0.001). When the groups were investigated separately, the exam scores attained were comparable in terms of from the exam content related to major system disorders did not differ between the groups. based on learning method without any statistical significance between groups. However, while group 1 students who participated in studying with light microscopy training before the exam had higher exam scores in the exam content related to bone and soft tissue pathology compared to group 2 students studying with virtual microscopy (in bone and soft tissue pathology had a mean score of 3±1.5 vs 1.2±1.7) points, virtual learners had a mean score of 1.2±1.7 points, with a statistically significant intergroup difference according to the Mann- Whitney U test (p=0.027).

Conclusions: Virtual microscopy is a crucial component of medical students' pathology training in undergraduate medical education in terms of providing opportunities for medical students to see the rare cases and standardization of the training in different institutions. Particularly in undergraduate education, it is crucial for the understanding of rare cases and standardization of the pathology education.

But as our study's findings on the pathology of bone and soft tissues showed, conventional light microscopy is still essential for understanding the pathology of some systems. Moreover, one's gender may affect student's capacity for virtual learning. Understanding the distinction between genders in terms of learning capacity may aid in providing students a better education.

Özet

Amaç: *Sanal mikroskopi teknolojisi, patoloji eğitiminde önemli bir görsel araç olarak kabul edilen geleneksel mikroskopun yerini alarak histopatolojik tanı ve patoloji eğitiminde sıkça kullanılmaya başlanmıştır. Sanal mikroskopide kullanılmak üzere taranan ve çevrimiçi olarak depolanan slaytlar, 1985 yılında ilk kez tanımlandı ve 2000 yılından itibaren önemli gelişmeler yaşadı. Bu çalışmada sanal mikroskobun tıp fakültesi öğrencilerinin patoloji öğretimini nasıl etkilediği belirlenmeye çalışılmıştır.*

Yöntem: *Çalışmaya İzmir Demokrasi Üniversitesi Tıp Fakültesi 3. sınıf öğrencileri, dahil edilmiştir. Araştırma yıl sonu sınavı öncesi uygulanmıştır. Eğitim arşivinden 102 slayt seçilerek destek alınan firma tarafından tarama yapılmış ve preparatlar sanallaştırılmıştır. Bu slaytlar içerisinden on farklı organa ait lezyonları ve organları temsil eden kırk slayt seçilmiştir. Öğrenciler iki gruba ayrılmış (Grup 1 ve 2) ve seçilen slaytlar eğitim materyali olarak kullanılmıştır. Birinci gruptaki öğrenciler (G1) on sistemin 20 lamını (M1) ışık mikroskobu ile diğer 20 lamı ise sanal mikroskopta (S1) incelemişlerdir. İkinci gruptaki öğrenciler (G2) ise birinci gruba sanal mikroskopta (V1) gösterilen lamları ışık mikroskobunda (M2); birinci gruba ışık mikroskobunda (M1) gösterilen lamları ise sanal mikroskopta (V2) incelemişlerdir. Bu eğitim kursu yaklaşık sekiz saatte tamamlanmıştır. Ertesi gün yapılan yıl sonu sınavı için öğrenciler rastgele 4 gruba ayrılmış ve her gruba 10 farklı sistemden 10 slaytla ilgili sorular sorulmuştur. Bu sorular incelenen organ ve lezyonların tanıtıcı özellikleri ile ilgilidir. Sınava giren öğrencilere bir gün sonra tüm slaytlar gösterilmiştir.*

Bulgular: *Çalışmaya toplam 89 öğrenci [n:52 (%58.4) erkek, n:37 (%41.6) kadın] katılmıştır. Sınav grupları arasında sınav puanları açısından anlamlı fark bulunmamıştır (Ki-kare p=0,158). Tüm öğrencilerin puan ortalaması 17,2±7'dır (minumum:5 maksimum:40). Işık mikroskobu yaklaşımı kullanılarak incelenen slaytlardan öğrenciler ortalama 8,7±4,6 puan, sanal mikroskopi kullanılarak incelenen slaytlardan 8,6±4,1 almışlardır. Öğrencilerin ister mikroskopla ister sanal gerçeklikle gözlemlemiş olsunlar başarı durumlarının benzer olduğu görülmüştür. Ancak sonuçlar cinsiyete göre değerlendirildiğinde, kadın öğrencilerin genel puanları (p=0,05) ve ışık mikroskobu puanları (p=0,001) anlamlı olarak daha yüksek bulunmuştur. Gruplara ve sorulara ayrı ayrı bakıldığında öğrenme yöntemine* *göre majör sistem bozukluklarında sınav ve soru bazında puanları benzer bulunmuş ve istatistiksel olarak anlamlı bulunmamıştır. Ancak kemik ve yumuşak doku patolojisinde ışık mikroskobu öğretimine katılan öğrencilerinin ortalama puanı 3±1,5 iken, sanal öğrenenlerin ortalama puanı 1,2±1,7'dir ve bu fark Mann Whitney U'ya göre istatistiksel olarak anlamlıdır (p=0.027).*

Sonuç: *Sanal mikroskopi, tıp öğrencilerinin patoloji eğitiminin çok önemli bir bileşenidir. Özellikle lisans eğitiminde nadir vakaların anlaşılması ve eğitim standardizasyonun sağlanması açısından önemlidir. Ancak çalışmamızın kemik ve yumuşak doku patolojisine ilişkin bulgularının gösterdiği gibi, bazı sistemlerin patolojisini anlamak için geleneksel ışık mikroskobu hala gereklidir. Ayrıca cinsiyet, kişinin sanal öğrenme kapasitesini etkilemektedir. Aradaki farkı anlamak, öğrencilere daha iyi bir eğitim vermede yardımcı olabilir.*

INTRODUCTION

Pathology training is a very important component of the medical education process, and it is based on the investigation of symptoms, development of the disease symptoms, and the mechanisms underlying this development through histopathological examination (1). Throughout the historical development of pathology as a branch of medical sciences versatile technological tools and equipment have been used, but the main pillar of pathology is light microscopy. The prototype of the microscope, first developed in the 16th century, was later replaced by simple hand-held microscopes with a powerful single objective lens. In the mid-nineteenth century, the increased resolution and ergonomic design of microscopes revolutionized histopathological examination (1-3). Optical microscope has become the basic laboratory tool for histopathological examination, and today, with the development of hybrid technologies, different types of microscopes such as electron and fluorescence microscopes have been added to the armamentarium (4). The role of pathology is very important in diagnosing diseases. For this reason, pathology education should be given importance in medical faculties and up-to-date technologies should be followed. However, the teaching, and learning the use of light microscopy by novice users, including medical students is a difficult and tedious task, as they must master the skills to obtain the best magnification of the image. A novice user's effort to obtain a clear image by adjusting the field of view and condenser, and the best image from the right field of vision requires more knowledge, and assistance provided by a knowledgeable academic staff (4-7).

Today, the ability to transmit large-scale images to the other end of the world within seconds via the Internet has led to the emergence of groundbreaking virtual microscopy in pathology consultation (2). Special scanning devices developed for virtual microscopy enable microscopic preparations to be converted into high-resolution digital images and allow the user to remotely examine all areas in the preparation at any size. When it was first developed, the time to convert each preparation to digital image, that is, the preparation time of digital preparations was measured in minutes, but nowadays this time interval has been reduced to seconds (2,3). Especially in developed countries where the wages of qualified labor provided by educated people are very high, instead of employing eminent pathologists specialized on very specific subjects in peripheral pathology laboratories, virtual preparations are digitized and consultation with experts is preferred. Similarly, standardization among institutions providing pathology training is very difficult due to discrepancies in the number and variety of cases. For this reason, it is very useful to create and share a virtual education archive especially for rare cases in the education of pathology among undergraduates and pathology specialists (7,8). Again, the Covid-19 pandemic, which has been prevalent all over the world for 2 years since 2020, has increased the use of virtual microscopy in distance learning in medical education and histopathological examinations (9-11).

As can be understood from the literature, virtual microscopy is considered an important visual tool in making histopathological diagnoses and pathology education. However, there are still many question marks about which method is more effective in pathology education.

Our zero hypothesis suggests that students trained with virtual microscopy will have similar levels of success on the end-of-year pathology practice exam than those trained with traditional light microscopy.

At the first hypothesis regarding the fact that studying with a light microscope necessitates extra skills to obtain an optimal image, we hypothesized that studying with clearly shown virtual microscopy preparations may yield better learning outcomes. The other hypotheses are positing that gender or attendance may have an impact on students' virtual learning capacity.

In this study, we aimed to evaluate the effect of using light and virtual microscopy during the pathology training on learning of 3rd-year medical school students who received basic and systemic pathology education.

METHODS

This study adopted a prospective cross-sectional approach. It was carried out with students from the 2021-2022 academic year at the Faculty of Medicine, Izmir Democracy University, specifically targeting all students in their third year. A total of 982 hours of theoretical and practical courses exist in the 3rd year. At the end of the spring semester, 3rd year medical students who did not take the pathology practice exam were excluded from the study. The reason for choosing 3rd year medical students was that they have already completed theoretical and practical courses during 3 years.

For the preparations transferred to the digital environment, the pathology preparation training archive of the pathology department, which was created from the unidentified preparations of the patients with typical lesions was used. A total of 102 preparations belonging to 10 organs/tissues (respiratory, excretory, central nervous system (CNS), skin, bone and soft tissue, liver-biliary tract, endocrine organs, gastrointestinal system (GIS) and hematopathology) were selected from 102 preparations transferred to digital media. Selected among the unidentified preparations were scanned by company received support and turned into virtual (digital) preparations.

The primary outcome variable of the study was to find out the organ, tissue/lesion that the student examined using virtual or conventional light microscopy. The secondary outcome variable of the study was the student's ability to comment on the lesion/disease/tumor examined. First of all, 3rd year students were divided into 2 groups according to their student numbers. They are explained and showed 4 slides from each system, two of them are examined under the microscope and the other two slides in digital images. The second group learnt the same slides with an opposite learning method. For the student groups (group 1 and 2), the topics and the methods of learning of the slides related to the topics (light or virtual microscopy) were recorded. Afterwards, each group was randomly divided into 2 groups within itself and thus A, B, C, D exam groups were formed by randomized. While distributing the groups, it was ensured that there were equal numbers of students who learnt each system preparation with different methods. In the exam, the questions related to the learning method used for each student and the other method were distributed equally. Then 40 slides from 10 different systems were selected for 4 exam groups; half of them is for light microscope half of them is for virtual microscope. This method was preferred to ensure that students are equally affected by the environment and process variables. Thus, in each exam group, there were equal numbers of students (from Group 1 and 2) who learnt each organ system in different ways. A total of 40 preparations belonging to four typical lesions from each system related to respiratory, excretory, central nervous system (CNS), skin, bone and soft tissue, liver-biliary tract, endocrine organs, gastrointestinal system (GIS) and hematopathology were selected from 102 preparations transferred to digital media. An information guide for the research and the end-of-year exam has been prepared for the students. The procedural steps of the research could be summarized as follows: The students in the first group (G1) examined 20 slides (M1) of the ten systems with the light microscope and the other 20 slides on the virtual microscope (S1). On the other hand, the students in the second group (G2) examined with a light microscope (M2) the slides which shown to the first group in the virtual microscope (V1); and they examined with the virtual microscope (V2) the slides which shown to the first group in the light microscope (M1). This training course was completed in approximately eight hours.

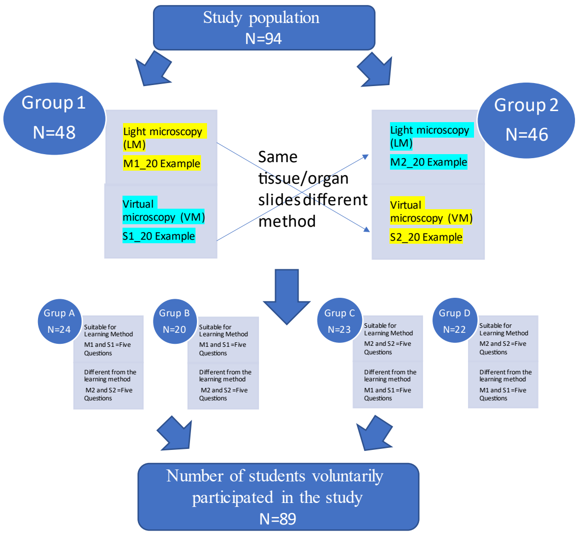

Chart 1. Workflow Chart (Note: M1=S2 and M2=S1 refer to the same organ/tissue slides, but different teaching methods were used.)

Written or illustrated materials were not given to the students for homework, and they were especially asked not to do additional work at home in terms of the standardization of the education given. The next day, the students were divided into four mixed groups. The reason for dividing the students into groups was to ensure that students could be easily managed and waiting times were kept short during the exam. Each group was given a separate preparation with questions from each system and a three-minute examination time was allowed for each preparation, then they were asked to fill in the form prepared for measurement and evaluation under the light microscope. Each group received five questions related to the preparation they learned about studied under the light microscope and five from the preparations they learned studied in the virtual environment. The questions that students are asked to answer can be exemplified simply as follows.

1) What is the examined organ? Exemplary response: **Kidney**

2) What are the descriptive features of the organ/tissue? Exemplary response: **Glomeruli were detected**
3) What is the lesion you are examining? Exemplary response: **Wilms Tumor**
4) Why do you think so? Exemplary response: **Because it is a triphasic tumor.**
The end-of-year pathology practice exam scoring system was as follows: All exam forms were scored by the same pathologist. Each question was given 4 points (max score was 40). In this exam, the student is expected to describe the organ and the lesion and give an explanation about both the organ and the lesion. Each description and explanation is assigned one point. If the student described only the organ or only the lesion and did not give an explanation, he/she received only one point. Or if he/she made an explanation without describing the organ or lesion, he/she received one point. The student with the highest score for motivation was rewarded by being among the authors for the next research team. The announcement about this award was made at the stage of obtaining permission from the students for the study. Within the scope of the study, the scores obtained by the students were evaluated numerically. The effect Seven percent of the year-end grade was devoted to of the pathology practice exam score.
In our research, we evaluated the effects of two important variables such as gender and course attendance on students' success according to the way they use the microscope. Attendance status was analyzed according to students' participation in the pathology practical course. If more than 80% participation in theoretical and practical lessons is achieved, "participate"; Since participation in practice courses is compulsory, if the participation rate is over 70% and participation in theoretical classes is below 70%, it is considered "irregular participation", and if participation in both theoretical and practical courses is 70% or less, it is considered "not participate".
In the medical faculty education and examination directive, the final exam passing grade is determined as 50 points. The maximum total score of the application exam is 40 points. Those who get 20 points and above from the exam are considered successful.

Statistical Analyzes

Statistical analyzes were performed using the SPSS 25.0 program, and a p value of <0.05 was considered statistically significant. Besides descriptive statistics, the success scores of the students who examined the preparations of different systems and lesions using different microscopic examination methods were listed and the difference between training methods regarding exam scores effect of method of training on the school achievement grades was examined investigated by making comparisons using methods of multiple using nonparametric analyzes Mann-Whitney U test. Additionally, correlation between attendance hours and exam scores was investigated using Spearman Correlation analysis. The data in qualitative scale were compared with Chi square test.

RESULTS

A total of 89 participants including 52 male (58.4%), and 37 (41.6%) female students were enrolled in the study. Among the study group, four students (4.5%) repeated at least one year, six (6.7%) students made were transferred from other medical faculties, and the other remaining 79 (88.8%) students who completed their education at our faculty without repeating the year, successfully passed all exams without any loss of time in their medical education duration. Considering the school attendance status, 44 students (49.4%) did not participate in the pathology classes. Interestingly, the group that did not participate in the pathology classes had significantly lower exam scores compared to the regular participants, as indicated by the Kruskal-Wallis H test results (p=0.003). Thirty-one students (34.8%) did not participate in the classes regularly in pathology classes, and 14 students (15.7%) participate all pathology classes. In terms end of year pathology practice exam results, the total scores obtained by all students varied between 5 and 40 points, and the mean score was 17.2±7 points. The standard error was 0.7 and the median of the exam score was 17 points.

Theoretical and practical pathology hours per student for Term 3 is 148 hours. Attendance to the pathology courses, on the other hand, varied between 1 and 140 hours (mean: 71.1±40.8 hours). Spearman's correlation analysis revealed a significant positive correlation between the number of hours attended in pathology classes and the exam scores ($p<0.001$, $R=0.472$). Furthermore, in the Mann-Whitney U test, the lesson attendance rate of 29 students with exam scores above 20 were found to be statistically significantly higher ($p<0.001$). When analyzing the relationship between course participation and exam scores, a significant difference was found in both overall exam scores ($p=0.003$) and conventional light microscopy scores ($p=0.004$), but no significant difference was noted in virtual microscopy scores ($p=0.089$). (Table 1)

Table 1. Comparison Between Rates of Participation in Pathology Courses and Exam Scores

Participation in pathology courses		N	Mean Rank	Kruskal-Wallis H	df	p
Exam Score	not participate	44	35.69	11.390	2.000	0.003
	irreguler participate	31	53.45			
	participate	14	55.54			
Microscopy score	not participate	44	35.93	11.289	2.000	0.004
	irreguler participate	31	55.65			
	participate	14	49.93			
Virtual microscopy score	not participate	44	39.64	4.841	2.000	0.089
	irreguler participate	31	47.58			
	participate	14	56.14			

Considering the success rates of the students according to the examination groups, although most of the students in groups A and D groups scored below 19 points, the intergroup difference between groups was not statistically significant (Figure 1) ($p=0.158$).

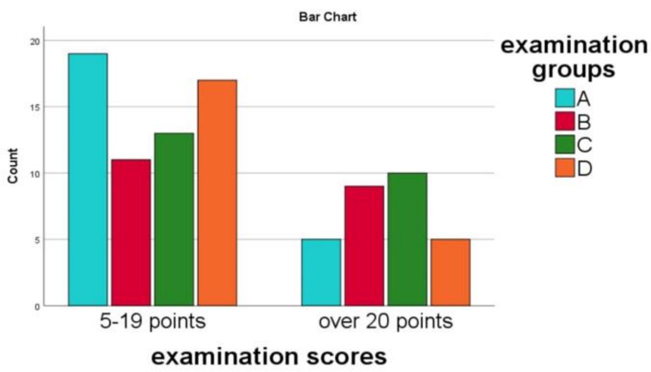

Figure 1. Success Rates of the Students According to Exam Groups

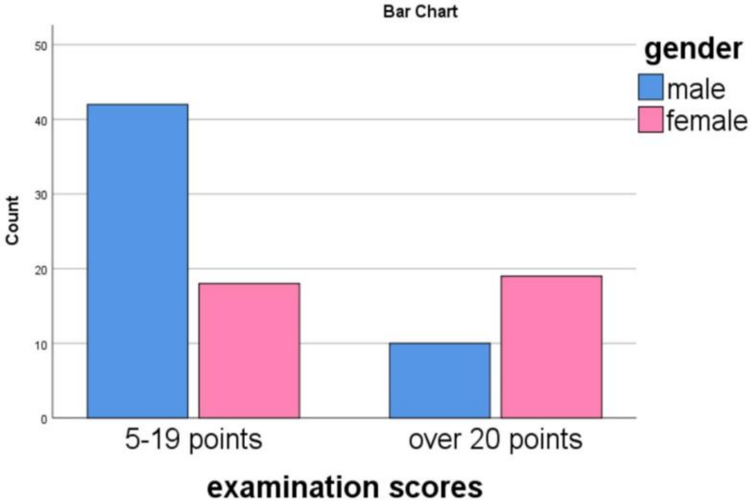

Figure 2. Comparison of Total Exam Scores by Gender

When the total exam success rates were analyzed by gender, it was observed that female students were statistically significantly more successful than males (p=0.004) (Figure 2).

Table 2. Comparison Between Gender Of The Students And Exam Scores

Mann-Whitney U Test						*p*
Gender		n	Mean	Standard Deviation	Standard Error	
Exam score	male	52	15.48	6.372	0.884	0,050
	female	37	19.73	7.187	1.181	
Light microscopy score	male	52	7.46	4.198	0.582	0,001
	female	37	10.54	4.811	0.791	
Virtual microscopy score	male	52	8.02	4.007	0.556	0,184
	female	37	9.41	4.362	0.717	

When the exam scores were compared according to the learning method, the mean scores of were 8.7±4.6, and 8.6±4.1 points were obtained from the preparations identified using the light, and virtual microscopy, respectively. In summary, the use of either virtual or conventional light microscopy as a learning method did not significantly change the exam performance rates as a whole. Any significant difference could not be found when the mean scores of each student obtained using virtual or light microscopy methods were examined and compared according to Wilcoxon sequential test, (p=0.752) (Table 2).

However, when compared according to gender, the virtual microscopy score did not show significant variation by gender in the non-parametric Mann Whitney-U test (p=0.184), while the light microscopy score was significantly higher in female students (p=0.001), indicating a gender-based disparity in performance in this area (Table 2).

When each question was examined separately according to the student's method of learning the question and according to groups 1 and 2, the scores obtained based on the responses given to the questions were close to each other according to the learning method in system pathology, and no significant p value was observed in the nonparametric Mann- Whitney U test. However, in specific areas such as bone and soft tissue pathology, students who participated in light microscope teaching scored significantly higher (mean score of 3±1.5 points) compared to those learning through virtual microscopy (mean score of 1.2±1.7 points), as per the Mann-Whitney U test (p=0.027).

DISCUSSION

In this study, it was aimed to evaluate the effect of using optical or virtual microscopy on learning during the pathology practice training of the 3rd year medical school students. who received basic and systemic pathology training. Especially after the importance of distance education that was acknowledged during the Covid-19 pandemic, and the fact that the virtual microscopy can be performed from a distance has made virtual microscopy indispensable in the pathology education of medical and residency students. In this study, it was found that the use of light microscopy and virtual microscopy in learning pathology preparations did not show a significant difference in terms of exam results. However, light microscopy is more effective in questions related to bone and soft tissue pathology. This result supports the idea that such system tumors may have common histopathological features, which may complicate differential diagnosis. However, the reasons behind drawing these conclusions are a matter of considerable debate. Our result doesn't compatible in the literature. In a study Foad compared the efficacy of light (LM) and virtual microscopy (VM), methods and found a statistically significant difference between the LM and VM groups in favor of VM regarding the performances of students in both the multiple-choice question and the practice exams (14). In particular, a study conducted in Germany shows that students appreciate VM for its "Whole Page View functionality, points of interest, helpful informative texts and explanations." (14,16). Nauhria & Ramdass, compared exam results of LM and VM groups and found significantly higher exam scores in the VM group. This study supports that virtual microscopy is a successful alternative in histopathology education. (15). In this study, however, no significant difference was observed between LM and VM groups when compared in terms of the practice exam scores.

In the literature, survey studies present the findings of students who prefer virtual microscopy to traditional light microscopy in histopathology education. This preference suggests that virtual microscopy is a successful alternative effective tool in histopathology learning, especially for medical students. It is observed that students and instructors positively evaluate this technology and enjoy using it. The findings in the literature support that virtual microscopy should be more widely used in medical education and should be considered as an alternative teaching tool to traditional microscopy (17,18). However, in our study, the results were obtained by looking at the effectiveness of both methods through measurement and evaluation without taking the opinions of students and faculty members. The results of this study may provide important guidance for future medical education.

In a study by Foad on the use of VM in pathology and basic science education at Saudi Arabian Universities, based on a sample of male students only, it was found that students in the VM group performed better than the traditional LM group. However, it can be said that this study is different because both types of microscopes were used and the sample was obtained from students of both genders (14). In particular, it was observed that the light microscope exam results of female students were significantly higher than those of male students and that the use of virtual microscopes did not reflect gender differences. These results support the hypothesis that the use of virtual microscopes may be more suitable for men. However, further research is necessary because the results may involve the interaction of many factors and guide future research.

Lakhtakia's study described the successful integration of virtual microscopy (VM) into undergraduate pathology teaching and its impact on students. Notably, the introduction of VM correlated with a high level of student engagement, as reflected in the nearly 100% attendance (19). In this study, a significant correlation was observed between the amount of time students attended pathology courses and their exam scores. Increasing participation rate seems to increase the success score in the light microscope. However, while it is stated in the literature that the use of virtual microscope increases student motivation and increases course participation, in our study, it is concluded that course participation increases student success and increases the light microscopy score.

In the literature, it is stated that light microscopy is challenging and boring for histopathological examination, especially for new users such as medical students, while virtual microscopy offers an easier and more entertaining option. However, it is pointed out that virtual microscopy cannot be used in every center due to the cost of scanning systems. It is emphasized that virtual microscopy has a great potential in the standardization of medical education and pathology specialty training. Therefore, universities, training and research hospitals and organizations such as the Federation of Turkish Pathology Societies should cooperate to determine the topics to be learned in pathology education and to create a common pathology virtual education archive (20-23).

Virtual microscopy can play an important role in medical education, even if it does not completely replace the traditional light microscope. Therefore, the best approach may be to expose students to both modern and traditional pathology learning, focusing on both traditional and virtual microscopy. In this way, students can develop both technological and basic laboratory skills.

CONCLUSIONS

In conclusion, this study shows that learning pathological preparations via light microscopy and virtual microscopy yield comparable outcomes. However, it has been discovered that light microscopy is more useful for understanding bone and soft tissue pathologies. These findings can serve as a guide for choosing and creating instructional strategies for pathology education. It should also be mentioned that students should create an integrated strategy for scenarios where clinical and radiological aspects need to be considered. The results of additional research may be crucial in further enhancing these instructional approaches.

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Ethical Approval: The study was approved by the Buca Seyfi Demirsoy Hospital Non-Invasive Ethics Committee (Decision No: 2022/07-94, Date: 6 July 2022)

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